## Snow Leopard. *Panthera uncia* Schreber 1776

**Local Names:** *Irbis* (Russian, Mongolian), *Sah* (Tibetan), *Shan* (Ladakhi), *BarJani chita* (Hindi, Urdu), *Heung chituwa* (Nepali).

### Taxonomy

Taxonomically, the snow leopard *(Panthera uncia)* is considered a member of the Felidae subfamily Pantherinae (Blomqvist 1978, Nowak and Paradiso 1983). However, on the basis of morphology and behavior, some authors place it alone in a separate genus, with the name *Uncia uncia* (Pocock 1917, Peters 1980, Rieger 1980b, Hemmer 1967, 1972, Anonymous 1987c). As in other Pantherinae, the diploid chromosome number in snow leopards is 38 and the fundamental number is 36. There are 17 metacentric and 2 acrocentric chromosomes (Soderlund et al. 1980). The karotypic banding pattern is almost identical to that in other Pantherinae (Gripenberg et al. 1982). There is virtually no fossil record of snow leopard, the only positive identifications being upper Pleistocene remains from Altay caves (Hemmer 1972).

### General Characteristics

#### Size

Adult snow leopards measure 100-130 cm from nose to tail, with a tail length of 80-100 cm (75-90% of body length). Shoulder height is about 60 cm. Weights appear to be generally about 35-45 kg for adults, with an overall range of 25-75 kg (Hemmer 1972, Schaller 1977, Wemmer and Sunquist 1988). The size of adult snow leopard foot-pads, as reflected in pug-mark dimensions, is 9-10 cm in length and 7-8 cm in width, with front paws slightly larger than rear ones (Fox, unpubl. data.). Cubs in captivity had pugmark sizes of 5 x 5 cm (length x width) at age 4 months, 7 x 6 cm at 9 months, and 8 x 7 cm at 12 months. Adult walking stride on level ground is 70-90 cm (Fox. unpubl. data).

## Coat

The coat of the snow leopard is white to cream-yellow in background color, mottled with grey to black spots and rosettes. Spots on the head and neck are solid. whereas larger rings or rosettes, most enclosing smaller spots, occur on the body and tail. Snow leopards can be recognized individually by their facial spot patterns (Blomqvist and Nystrom 1980). Compact elongated spots and two lateral rows of elongated rings extend along the center of the back *from* neck to tail base. In juveniles, these elongated rings are frequently consolidated into solid black stripes which break up into large spots as the animal grows (Hemmer 1972). The snow leopard's coat is long and thick. Molt occurs twice yearly, with longer hair present in the winter (Novikov 1956). In summer, belly and tail hair length is about 50 mm and hair on the flanks is about 25 mm; in winter hair on the back is 30-55 mm, on the sides about 50 mm, on the belly up to 120 mm, and on the tail up to 60 mm (Hemmer 1972).

## Morphology

The head of the snow leopard is short, broad and small relative to body size as compared to other large cats. The nasal bones are broad and the cavity is relatively enlarged. probably an adaptation to a cold environment (Hemmer 1972). Its skull is distinguished *from* other leopards *(Panthera* spp.) by a marked overall shortness. elevation of the frontal area, shortness of nasals. brain case that resembles common house cat, more rounded orbits and longer postorbital and zygomatic processes, longer and smaller infraorbital foramen. more rounded and longitudinally shorter nasal aperture, wider meso pterygoid fossa. flatter osseous bullae, and a shortness of palate (Ognev 1935). Some skull measurements (mm) are as follows: skull length 180-189 male 177 female. condylobasal length 165-173 male 162 female, zygomatic width 122-134 male 127 female, maximum skull width 79-84 male 79 *fe*-male. height in region of osseous bullae 71-76 male 69 female, skull width above canines 48-53 male 50 female, length of upper tooth row 58-63 male 57 female (Ognev 1935. Hemmer 1972). The dental formula is 13/3, C1/l. P3/2. M1/l (Pocock 1916b).

Both the tail and hind legs are relatively long and probably adapted to in-crease agility in the snow leopard's rugged habitat (Hemmer 1972, Rieger 1984a). Detailed descriptions of snow leopard skeletal structure, measure-ments, and coat and skin characteristics can be found in Haltenorth (1936, 1937), Hemmer (1966, 1972), Ognev (1935), Petzsch (1968), Pocock

(1916a. 1916b, 1917, 1930), Schaposchnikov (1956), Schmid (1940). Strogonov (1962), and Weigel (1961).

## Distribution and Numbers

### Historical Range

The historical range of the snow leopard is restricted to the mountains of Central Asia. with core areas in the Altay, Tien Shan, Kun Lun, Pamir, Hindu Kush, Karakoram, and Himalaya ranges. Its north to south distribution occurs within the countries of the Soviet Union, Mongolia, China, Afghanistan. Pakistan, India. Nepal, and Bhutan (Figure 1). Early reports of snow leop ards from as far west as Asia Minor and as far east as Sakhalin Island are ap parently incorrect (Rieger 1980c). The total area of suitable habitat within the region indicated by the range map (Figure 1) is approximately 1,230,000 km2. The area of suitable snow leopard habitat for each country in which it OCcurs has been calculated on the basis of published estimates and range maps, and where only general range descriptions are available, an assumption of the leopard's restriction to mountain ranges (Table I). In Bhutan, regions above 3000 m were included as suitable habitat, whereas in the Soviet Union all mountainous regions within its reported range were considered as suitable.

### Distribution and Population by Country

Numbers of snow leopards have been surveyed in only a few areas, and for some Countries there are no estimates available. Throughout the entire range of the snow leopard, available population estimates total about 3400 4100 (Green 1988) (Table I). However, this figure does not include num bers for Afghanistan, Bhutan, and parts of China and India.

**Afghanistan:** The snow leopard Occurs in the Hindu Kush and Pamir moun tains of northeastern Afghanistan (Habibi 1977, Petocz 1978, Sayer 1980). The total area of suitable habitat, on the basis of their range as mapped by Sayer (1980), is apprOximately 80,000 km2. There have been no estimates

**Bhutan:** Snow leopards occur all along the high Himalayan regions of northern Bhutan. The area of suitable habitat (I.e., above 3000 m elevation) is about 10.000 km2. It is reported to be relatively common (Blower 1986), but no estimates of population size have been made.

**China:** The snow leopard has a very large but dispersed distribution within China. It occurs in the trans-Himalayan and other widely scattered mountain ranges of the Xizang Autonomous Region (Tibet), the Kun Lun, Tien Shan, and Altay mountains of the Xinjiang Autonomous Region (Sinkiang), numerous ranges in Qinghai Province and neighboring Gansu Province, and the western mountains of Sichuan Province. The total area of suitable mountainous habitat within these regions is approximately 400,000 km2 which includes the estimates by Schaller et a!. (1988a,b) below, approximately 165,000 km2 in Tibet, and only small areas in Sichuan. Liao and Tan (1988) report an estimate of 350 snow leopards for a portion of Gansu Province and suggest that, given the extent of snow leopard range, China probably has the largest population of this species. Schaller et a!. (1988 a, b) estimate a population of less than 750 snow leopard in 170,000 km2 of suitable habitat in Xinjiang, about 650 in 65,000 km2 of habitat in Qinghai, with limited habitat and small numbers in Gansu. Estimates for Tibet and Sichuan are not available.

**India:** Snow leopards Occur along the Himalaya of India's northern border region within the states of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Sikkim, and Arunachal Pradesh. In the Ladakh district of Kashmir, their distribution includes the trans-Himalayan mountains as far north as the Karakoram Range. In Himachal Pradesh they occur as far south as the Pir Panjal Range. The area of snow leopard habitat in India is approximately *100,000* km2 (Chundawat et a!. 1988). Dang (1967) estimated *200-600* snow leopard in the entire Himalayan region. However, recent estimates of 100-300 just in Ladakh (Mallon 1984b, Fox et aI., in prep.) suggest that Dang's figures may be somewhat low.

**Mongolia:** The snow leopard occurs throughout western Mongolia, within the Altay, its subsidiary ranges, and the trans-Altay Gobi mountains (Mallon 1984a). The areal extent of snow leopard habitat in Mongolia is about 130,000 km2, on the basis of Mallon's (1984a) distribution map. Bold and Dorzhzunduy (1976) estimated 170-230 snow leopard in the southern Gobi region of Mongolia, Thornback and Holloway (1976) reported an estimate of less than 300 for the entire country, and recent estimates put the overall population at about 500-900 (Green 1988).

**Table I. Habitat Area and Population Estimates for Snow Leopard throughout its Range.**

| Country | Area of habitat (km2) | Estimated population | Literature source |
|---|---|---|---|
| Afghanistan | 80.000 | ? | Sayer 19801 |
| Bhutan | 10.000 | ? | Blower 19861 |
| China | 400.000 | 1400- ? | Schaller et a!.. 1988 a1.2. b1.2 |
| India | 100.000 | 200-600 | Dang 19672. Chundawat et al.. 19881 |
| Mongolia | 130.000 | 500-900 | Mallon 1984a1. *Green* 19882 |
| Nepal | 30,000 | 150-300 | Jackson 1979a1.2 |
| Pakistan | 80.000 | 100-250 | Schaller 19772, Roberts 19771 |
| Soviet Union | 400.000 | 1000-2000 | Braden 19822 Bannikov 19842 |
| TOTAL | 1.230.000 | 3350-4050 | |

1Source *for* habitat area estimate
2Source *for* population estimate

**Nepal:** Nepal's northern border regions *from* the main Himalaya northward comprise snow leopard distribution. with a broader band of suitable habitat in the west due to more extensive trans- Himalayan areas. The total area of suitable snow leopard habitat was measured at approximately 30.000 km2 and its population in Nepal has been estimated at 150-300 (Jackson 1979a).

**Pakistan:** Snow leopards occur all along the mountains of northern Pakistan. They are present in the Hindu Kush mountains of the Northwest Frontier Province's Chitral District, and eastward they occur in the Karakoram mountains within the districts of Gilgit, Hunza, and Baltistan of Pakistan's Northern Areas (Schaller 1976, 1977, Roberts 1977). The total area of snow leopard habitat in Pakistan is about 80,000 km2 based on Roberts' (1977) range map. Schaller (1977) estimated that 100-250 snow leopard occur throughout northern Pakistan.

**Soviet Union:** The snow leopard occurs in portions of the Union Republics of RSFSR (Russian Union Republic), Kazakhistan, Kirgizia, Usbekistan, Tadzhikstan, and possibly Turkmenistan (Braden 1982). Populations are centered within the Altay, Tien Shan, and Pamir mountain systems of this region (Andriuskevicius 1980). The area of suitable snow leopard habitat throughout this region is about 400,000 km2. Early estimates of 150-450 snow leopards in the Soviet Union (Pokrovskiy 1976) have been revised upward. Current estimates of snow leopard numbers for the Soviet Union range from 1000 to 2000 (Braden 1982, Bannikov 1984). The latest estimates include approximately 1400 snow leopards in the Tien Shan of Kirgizia, 200 in the Pamirs of Tadzhikistan, 50 in the Altay and Tuva of the Russian Union Republic, and 300 in Uzbekistan and Kazakhstan (Bannikov 1984).

## Ecology

### Energy/Food Requirements

On the basis of Kleiber's (1975) mass-related energy requirement equation for mammals. with allowance for maintenance activities (Moen 1973), and known requirements for captive leopards (Barbiers et al. 1982), an adult snow leopard (-45 kg) requires approximately 3000-4000 kcal per day, or alternatively about 40-45 g of food per kg body weight per day (Emmons

1987). Thus, within the range of estimated average adult weight (35-45 kg).

snow leopard food requirements are roughly 1.5-2.5 kg/day (Jackson and Ahlborn 1984, Schaller et al 1988a, Wemmer and Sunquist 1988). Thus, 550-900 kg of food are required per year, and because about 30% of wild prey weight is unusable (Hornocker 1970), between 700 kg and 1200 kg of prey are required to feed an adult snow leopard for a year. Using typical

wild sheep or goat prey species in snow leopard range (adult weight, 55 kg), it follows that 13-22 of these individuals would be required per year. Because a stable cropping rate of prey is about 10% (Emmons 1987, Wemmer and Sunquist 1988), a population of *130-220* adult sheep would be necessary to support one snow leopard over a year. However, other prey besides wild ungulates are taken by snow leopard, thus decreasing the population of wild ungulates necessary to sustain a leopard. This is demonstrated by the substantial contribution of marmots *(Marmota* spp.) to snow leopard diet (45% in summer; 23% annually) in some areas (Schaller et al. 1988a), and of domestic ungulates in other areas (Schaller 1977).

**Habitat**

**Vegetation:** Snow leopards inhabit the high mountainous regions of central Asia. Vegetation in areas where snow leopards occur ranges from timberline-alpine ecotones in the heavily forested southern slopes of the Himalaya, the mountains of western Sichuan (China), and parts of the Soviet Union ranges, through open forests and woodland habitats in many mountain sys tems on the outer arc of snow leopard distribution, and alpine zones in most all mountain systems, to scrubland and desert mountain habitats in the central portion of snow leopard range as one approaches the Gobi desert region (Novikov 1956, Schaller 1977, Jackson 1979a, Koshkarev 1984, Mallon 1984b). A large portion of their range is predominantly treeless due to either alpine or desert conditions. Snow leopards occur at elevations of about *600-4000* m in the northern part of their range to 1800-5800 m in the southern portions (Ognev 1935, Stroganov 1962, Dang 1967).

**Terrain:** The terrain used by snow leopards is typically extremely rugged (Schaller 1977, Koshkarev 1984, Mallon 1984b, Fox et al. 1988, Jackson and Ahlborn 1988). In the central portion of its range, however, snow leopards are known to occur in relatively gentle terrain characteristic of desert mountain foothills and oases (Zhirnov and Ilyinsky 1986). In Ladakh, India, snow leopard travel routes occurred on terrain averaging 24° in slope angle and 35 m from steep cliffs or other sharp breaks in terrain; 50% of all travel route locations were within 5 m of such cliffs (Fox et al. 1988). Snow leopards in western Nepal showed preference for cliffs, areas with slopes in excess of 40°, and areas within 25 m of edges such as cliffs. Preferred bedding sites were situated on or near ridges, cliffs and other sites with good views. Snow leopards preferred to move, bed, and mark along linear topographic features such as major ridgelines, bluff edges, gullies, and the base or crest of broken cliffs (Jackson and Ahlborn 1988).

**Marking sites:** Scrape markings are the most abundant type of sign left by snow leopards in the wild (Schaller 1977), and they are concentrated in ar eas where snow leopards spend most of their time (Ahlborn and Jackson 1988). In western Nepal and Ladakh, these areas were consistently associ ated with the confluences of river or stream gorges (Ahlborn and Jackson 1988. Fox et al. 1988). In Ladakh, 80% of scrapes were found at the base of cliffs, the remainder being found near free boulders. trees. or slight breaks in terrain (e.g.. streambank. trailside). The scrapes were usually located 80 100 em from the base of cliffs. boulders, or trees. Scrape substrates were loose materials such as snow or sandy and gravelly soil (Fox et al. 1988). Boulders. rock outcrops. and cliff-faces comprised 91-100% of the features which were spray-marked by snow leopards. with trees also occasionally being marked (Ahlborn and Jackson 1988, Fox et al. 1988). The spray marks were 80-100 cm above ground level and the angle of the surface sprayed. usually an overhang, averaged 1660 (Fox et al. 1988). Odor on spray sites sometimes could be detected more than 60 days following spraying.
Scrape sites were associated with 73% of spray-marked rocks (Ahlborn and Jackson 1988).

**HomeRange**

Snow leopards studied in an area of high prey density in western Nepal had home ranges of 12-39 km2, although the great topographic relief probably increased- actual home range size by 20-30%. There were no sex-related differences in home range size among 5 radio-tracked leopards and their home ranges overlapped almost entirely (Jackson and Ahlborn 1988); how ever. no adult males were included in this sample. The snow leopards travelled an average straight-line distance of 0.8 km per day, although actual distance moved in one day was greater due to the leopard's zig-zag routes. The longest distance moved in one day was 7 km (Jackson and Ahlborn 1988). Whereas the snow leopards studied in western Nepal did not have seasonal home ranges (Jackson and Ahlborn 1988). major seasonal move ments have been reported elsewhere (Novikov 1956. Roberts 1977). In the small study area in western Nepal. snow leopard density was estimated at about 5-10 per 100 km2 (Jackson and Ahlborn 1988). This is a relatively dense population compared with the 1.2 per 100 km2 estimated in another area of Nepal (Schaller 1977), 0.75 to 1.5 per 100 km2 in the Soviet Altai (Sopin 1977). and 0.2-4.0 per 100 km2 estimated for areas in central Ladakh (Mallon 1984b, 1988, Fox et al.. in prep.).

## Prey Species

The primary prey of the snow leopard are wild sheep and goats whose typical habitat is the rugged terrain of mountainous regions. The most common of these species throughout snow leopard range are the blue sheep *(Pseudois nayaur),* Asiatic ibex *(Capra ibex sibirica),* markhor *(Capra Jalconeri),* and several forms of argali sheep *(Ovis ammon).* Wild sheep and goat species with more restricted distributions within snow leopard range include the urial *(Ovis orientalis),* Himalayan tahr *(Hemitragus jemlahicus),* serow *(Capricornis sumatraensis),* and goral *(Nemorhaedus goral).* Other ungulates which have been reported to constitute snow leopard prey include the musk deer *(Moschus chrysogaster),* wild boar *(Sus scroJa),* Tibetan antelope *(Pantholops hodgsoni),* Tibetan gazelle *(Procapra picticaudata),* goitered gazelle *(Gazella subgutturosa),* wild ass *(Equus hemionus),* and wild yak *(Bas grunninus).* Snow leopards are also reported to have hunted or killed langur *(Presbytis en tell us)* (Green 1982) and bear *(Ursus* sp.) (Schaposchnikov 1956). Smaller mammals preyed on by snow leopard include marmots *(Marmota* spp.), hares *(Lepus* spp.), pikas *(Ochotona* spp.), and voles and mice. Snow leopards also prey on birds, including the snowcock *(Tetrogallus* spp.) and chukor *(Alectoris chukar).* Relatively long periods between kills of large prey suggest that small mammals and birds may be important in meeting overall energy requirements (Jackson and Ahlborn 1988). Domestic animals such as sheep, goats, donkeys, horses, and cattle also constitute snow leopard prey, and may be important components of their diet in some areas (Schaller 1977).

In northwestern Pakistan, 40% of snow leopard droppings had markhor remains. 5% had marmot remains, and 45% had livestock remains (Schaller 1977). In two areas of Nepal, 50-70% of snow leopard droppings had blue sheep remains, 9-31% had marmot remains, and 9-13% had remains of livestock (Schaller 1977). In western Nepal, Jackson (1979a) reported blue sheep remains in 82%, and livestock remains in 6% of snow leopard droppings. In western China blue sheep and ibex comprised 30-60% of snow leopard summer diet, with marmots being equally important and livestock a relatively minor constituent (Schaller et al. 1987, 1988a). During the winter of 1983-84 in Ladakh, India, there were 20 attacks by snow leopard in 15 of the 40 villages located in the central Indus valley near Leh; one female yak and at least 95 sheep and goats (including 34 in one house) were killed (Mallon, 1984b). In the year ending March 1986, 10 yak-cow hybrids and 130 sheep and goats (including 40 in one house) were killed by snow leopards and wolves in a 1000 km2 area of the Hemis National Park in

central Ladakh where the livestock population was about 3000 (Fox et a!. 1988). In a small area of Qinghai Province, China. where livestock total 2350 animals. 12 were lost to snow leopard and wolf In a year's time (Schaller et a!.. 1988a).

**Reproduction and**

**Ontogeny**

In the wild and in captivity snow leopards breed during late winter (January March). commonly with 2-3 (rarely 1-5) cubs bom In April-June following a 90-105 day gestation period. The female's estrous period lasts 2-8 days (Rieger 1984b). Captive-bom snow leopard cubs weigh 0.3-0.6 kg at birth. 1-2 kg after 25 days. 3-5 kg after 50 days. and continue to gain about 1 kg every 2 weeks until they weigh 25-30 kg at age 1 year (Juncys 1964. Marma and Yunchis 1968. Kitchener et a!. 1975. Gaughan and Doherty 1982. O'Conner and Freeman 1982). Young open their eyes after about 1 week. their ears after 2 weeks. walk at 2 1/2 weeks. retract claws at 3 1/2 weeks. eat voluntarily at 7 weeks. eat solid food and actively play at 8 weeks. and follow their mother at 12 weeks (Juncys 1964. Frueh 1968. O'Conner and Freeman 1982). Young are weaned at about 5 months (Petzsch 1968). The first teeth appear at about 3 weeks (Novikov 1956. Frueh 1968. Freeman and Hutchins 1978). and continue to erupt In the following order (upper and lower case Initials refer to upper and lower teeth): 11 or 11. 12 or 12. mI. P2. MI. 13. Cor c. P4. P3. p3. p4 (Pocock 19I6b, Marma and Yunchis 1968). Sexual maturity Is reached at the age of 2-3 years (Petzsch 1968, Koivisto et a!. 1977, Rieger 1980a). and females In captivity have success fully bred until about 15 years of age. In captivity snow leopards have lived up to 21 years (Wharton and Freeman 1988).

**Physiology and**

**Disease**

Captive snow leopards have shown susceptibility to pneumonia and feline enteritis (Marma and Yunchis 1968. Tan and Liao 1988). tuberculosis (Petzsch 1966). multiple ocular coloboma (Wahlberg 1978. Wahlberg and Tarkkanen 1980. Soderlund et a!. 1980. Wahlberg et al. 1982. Gripenberg et al. 1985). chronic liver disease (Ruedi et a!. 1978. 1980, van den Ingh et a!. 1981, Worley 1982b. spastic paraparesis (Haltia and Wahlberg 1984). and COx of em oral dysplasia (Leininger 1984, Karkkainen and Wahlberg 1984). For captive snow leopards. serum composition values have been measured. including total serum protein 6.2 g/dcl (SO=0.83). percent gammaglobulin of total protein 14% (SO=5.8). and total gammaglobulin 0.90g/dcl (SO=0.05) (Worley 1982a). Marma and Yunchis (1968) report some blood values for

snow leopard that are in accord with other large felidae and high altitude mammals.

## Behavior

### Spatial Distribution

Snow leopards are generally solitary. although groups of 2-4 may form during the breeding season or with the birth of cubs (Schaller 1977. Jackson and Ahlborn 1988. Fox et al. 1988). Females and cubs stay together for about 1-2 years (Novikov 1956. R. Jackson. pers. comm.). In western Nepal. Jackson and Ahlborn (1988) found no evidence that snow leopards are territorial. Home ranges of both sexes overlapped considerably and individuals shared central areas of activity with conspecifics. However. on a typical day these snow leopards averaged almost 2 km from the nearest other individual. They maintained this distance by actively avoiding each other. probably facilitated through scent-marking. scraping. and the deposition of other sign. Such marking was densest in the overlapping core areas. Typically. the snow leopards remained in one area for several weeks before shifting to another part of their home area (Jackson and Ahlborn 1988).

### Movement and Aggression

Walking. running. leaping. and climbing movements are as in other members of the Pantherinae (Hemmer 1972). The jumping ability appears to be highly developed (Ognev 1935. Hemmer 1972). The long tail appears to be important in balance. thermoregulation. and a number of communication functions that indicate current mood to nearby conspecifics (Reiger 1984a). Aggressive threat and attack postures of the snow leopard are similar to those in other Felidae (Leyhausen 1979).

### Food Procurement

Snow leopards stalk and kill their prey as in other large felids. Kills may be made with either a nape or throat bite. and suffocation associated with the throat bite appears common (Schaller 1977. Fox and Chundawat. 1988). Sub adult snow leopards (estimated 20 kg) can kill adult blue sheep weighing over 55 kg (Jackson and Hillard 1986). Schaller reported that large prey

are opened and eaten beginning with the chest and forelegs or lower abdomen, leaving the digestive tract intact, but Fox and Chundawat (in press) report initial feeding on the viscera. The snow leopard eats in either a squatting or lying position similar to other large cats (Schaposchnikov 1956, Hemmer 1972, Fox and Chundawat 1988). Snow leopard kills can be recognized by the characteristic bite marks on the throat. No evidence has been found that snow leopards cover the remains of their kills (Jackson and Ahlborn 1988). Snow leopards appear to commonly remain around kills for longer periods than do other large cats (Schaller 1977, Fox and Chundawat 1988).

**Vocalizations**

The vocal repertoire of the snow leopard is similar to that in other Felidae. Vocalizations include the non aggressive prusten (a puffing sound emitted through the nostrils), mew calls, the mew/main call, copulatory hissing, growling (females), and a loud cry (males), and agonistic spitting, hissing, growling, and screaming/roaring (Hemmer 1968, Peters 1978, 1980). The mew/main call, usually associated with the breeding period, and the copulatory cry are probably the vocalizations that can be most easily heard in the wild. In western Nepal, Jackson and Ahlborn (1988) occasionally heard the characteristic mew/main call during the January-March breeding season, usually in late evening.

**Marking Behavior**

Marking behavior includes scraping, claw raking, spraying (squirting) urine, and cheek/head rubbing (Wemmer and Scow 1977, Rieger 1978b, 1980a, Blomqvist and Sten 1982, Freeman 1983, Ahlborn and Jackson 1988). Snow leopards scrape their hind feet over horizontal surfaces (usually of loose material), sometimes urinating on the pile of material formed behind the scrape (Rieger 1978b). Trees are sometimes marked by snow leopards raking their claws vertically along the trunks (Ahlborn and Jackson 1988). They spray-mark by moving their tails vertically upright and squirting urine backwards and up against near-vertical surfaces or bushes. Captive males spray-marked more frequently than females, but both sexes scraped equally often (Rieger 1978b). Snow leopards rub their cheeks/heads against odorous surfaces such as spray marks, meat, or plants (Rieger 1978b).

In wild snow leopards, both sexes (age >1.5 yr) commonly make scrapes and spray marks, scraping being more frequent. Marking Occurs most

frequently during January-March (Ahlborn and Jackson 1988). Scrape dimensions averaged 36 cm total length. 20 cm pit length. 19 cm pit width. 5 cm pit depth. and 6 cm height of scraped up material (Fox et al. 1988). Detectable urine marking of scrapings was present at 18-20% of scrape sites (Ahlborn and Jackson 1988, Fox et al. 1988). In western Nepal, scrape sites were usually frequently reused; about 50% of scrape sites were single. but only 15% of all scrapes occurred at these sites (Ahlborn and Jackson 1988). New scraping occurred on about 86% of snow leopard visits along study transects. Fresh snow leopard scrapes occurred with a frequency of 0.71.0/km along travel routes during late winter (Ahlborn and Jackson 1988. Fox et al. 1988). On well-used snow leopard travel routes in western Nepal.
the maximum number of scrapes was 235/km. In long distance surveys of snow leopard sign in northwestern India. the frequency of scrapes ranged as high as 37/km of valley-bottom transect (Fox. unpubl. data). Most snow leopard feces (84%) were found at scrape sites. predominantly at well-used locations. Fresh feces were found with a frequency of 0.08/km along snow leopard travel routes (Ahlborn and Jackson 1988).

**Frequencies of Social Behaviors**

Captive male and female snow leopard pairs were found to be inactive about 70% of daylight hours (Freeman 1982a. 1983). About 15% of the time they were walking. 6% grooming or other active social contact. 4% sniffing and flehmen of either objects or mate. and the remaining 5% in marking activities. vocalizations (primarily prusten), or back-rolling (Freeman 1982a, 1983). Aggressive behaviors accounted for only a trace of observation time. Males performed social grooming and marking behavior (headrubbing. scraping. spraying) more frequently than females. whereas females did more back-rolling. autogrooming. and prusten vocalizing. Increases in active social contact for both sexes. back-rolling in females. and a decrease in marking by females were all associated with the female's estrous period (Freeman 1983).

**Sexual Behavior**

Snow leopards copulate in both ventral/dorsal and dorsal/dorsal postures, although the latter is more common (Freeman 1983). Copulation occurs over a 3-6 day period. The male usually grips the fur on the female's neck when he mounts. and at copulatory climax he gives a loud piercing yowl (Freeman 1983). The male only irregularly performs the characteristic felid copulatory bite. but usually utters the yowl (Rieger and Peters 1981).

## Conservation

### History of Hunting

The snow leopard has been and continues to be hunted for its pelt and bones. because of its depredations on livestock, and as a sport trophy. In China. snow leopards have been live-trapped with steel leg-traps and wire cable snare traps (Tan and Liao 1988). In western Nepal poison-tipped bamboo spears placed along trails were used to kill snow leopard (Jackson 1979b). Snow leopards occasionally are killed in various dead-fall, pit or steel traps set for predators (Nath 1982, Mallon 1984b, Schaller et al. 1988a). In Pakistan, they are sometimes poisoned at livestock kills (P.T.S. Whiteman. pers. comm.). They are also beaten or stoned to death when trapped in household livestock pens. Modern rifles are used by both trophy and local hunters in many areas, and in parts of western China the govern ment issues rifles to herders for livestock protection (Schaller et al. 1987).

In Mongolia. in the first half of this century typical figures for snow leopard skins taken per year were 80 in 1908, 40 in 1927, about 20 annually from 1929-1932. 10 in 1933, 40 in 1934, and 15-25 annually up to 1944 (Bannikov 1954, cited in Mallon 1984a). Hibbert (1967) reported that 40 50 snow leopards were killed annually in Mongolia during the 1960's. In the Radzhistan region of the Soviet Union, 375 snow leopards skins were taken during 1953-1963, and 50 from 1963-1968 (Pokrovskiy 1976). Animals were also caught in the Soviet Union for export, about 400 snow leopards from 1937-1969 and another 64 from 1963-1967 (Pokrovskiy 1976). More than 50 snow leopards were delivered to world zoos from the Soviet Union during 1971-1975 (Thornback 1978). In 1976 the export of snow leopards and their products from the Soviet Union was stopped.

In China. more than 150 snow leopards have been collected from central Qinghai Province and brought to zoos over the past 30 years (73 between 1968-84) (Liao and Tan 1988). Government fur records for the Chambo area of eastern Tibet show a total of 88 snow leopard skins purchased in the years 1968. 1970 and 1971 (Feng et al. 1986). In the Yining area of western Xinjiang Province, government purchases of snow leopard skins were about 30 annually from 1955-1965 (135 in 1965), with few or none in the years since then (Zhang 1985). In Bhutan, Thornback and Holloway (1976) re ported a statement by A. Wright in 1971 that 50-60 snow leopards were known to have been shot in the previous six years, and that the number of

skins coming into Calcutta from Bhutan was considerably higher. In the mid 1970's. about 70-80 snow leopard pelts were estimated to pass through the Kabul bazaar in Afghanistan per year (Rodenburg 1977).

**Commercial Value**

Snow leopards have long been hunted for their pelts. Recently, local hunters have received US $10-50 for skins in Nepal, an amount comparable to the yearly cash income for these villagers (Jackson 1979b). In the early 1980's snow leopard skins were valued at about US $350 in Srinagar, Kashmir, India (Osborne et al. 1983). Skins collected prior to international agreements banning trade and advertised in hunting magazines have been offered for US $9,000 (Anon. 1984). An American tourist recently bought a snow leopard coat in China for about US $1,100: it was confiscated by US Customs on arrival in the United States (Jackson and Hillard 1986). Other high quality coats have been valued at over US $50,000 (Freeman, pers. comm.). In China, snow leopard bones are in demand for their use in medicines, and probably represent their primary indigenous value today (Schell 1982, Liao and Tan 1988).

**Current Status**

**International**

The snow leopard is currently listed as an endangered species in IUCN's Red Data Book (Thornback 1978). It is listed on Schedule I of the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Thus, it is illegal to import into or export from any signatory country any part or product of the snow leopard. All countries with native snow leopards, except Mongolia, have signed the CITES agreement. The snow leopard is also listed as endangered in the 1979 Convention on the Conservation of Migratory Species of Wild Animals (also called the Bonn Convention), and its international trade is also prohibited by this convention. Efforts have begun to develop a recovery plan for snow leopards in the wild (Anon. 1988).

**National**

**Afghanistan:** Current legal status of the snow leopard is unknown, although any protection laws would be severely compromised by the country's present political situation. Afghanistan officially suspended its wildlife conservation program in 1980 (Habibi 1985).

**Bhutan:** The snow leopard is legally protected from hunting within the Jigme Dorge Wildlife Sanctuary, which covers virtually its entire range in Bhutan. Religious stipulations against the killing of animals offer some protection, but when snow leopards are a menace to livestock they are still sometimes killed (Blower 1986).

**China:** Although the snow leopard is legally protected, hunting for bones, skins. and retaliation for livestock predation is common. Pelts are still displayed for sale in towns and villages of western China (Anon. 1987a). However, in Qinghai Province a man was fined 13.000 yuan in 1985 for the capture of 12 snow leopards that he had sold to a local zoo, which was also fined 27.200 yuan (Anon. 1985). The recent establishment of new conservation areas in western China includes some substantial areas of snow leopard habitat (Schaller et al. 1987. 1988a.b).

**India:** The snow leopard is legally protected in India, but in practical terms it is often killed as a consequence of its predation on livestock. Over the past 5 years, about 10 snow leopards are known to have been killed for taking livestock in central Ladakh, India (Mallon 1984b, Fox, unpubl. data). However. also in Ladakh, during spring 1986 a snow leopard captured at a government sheep breeding station was released at a remote site (I. Ullah, pers. comm.). The state of Jammu and Kashmir recently announced the incorporation of three national parks in a "snow leopard recovery programme" (Anon. 1986a,b.c), with special emphasis on the Hemis National Park in Ladakh (Mallon and Nurbu 1988).

**Nepal:** In Nepal, the snow leopard is legally protected and new or proposed conservation areas are increasing the area of its range under protection (Jackson and Hillard 1986, Dunghal 1984). However, it is still locally hunted for its depredations of livestock.

**Mongolia:** Mongolia is the only country that has declared the snow leopard to be present in sufficient numbers to allow hunting (O'Gara 1988). In 1986 a trophy hunting program was carried out with a quota of five snow leopards, to be selected from individuals that were causing depredation to livestock (O'Gara 1988. B. DesClers. pers. comm.). The trophy hunting fees for snow leopard in 1986 were $11.200 per animal. and the first hunts have been successful (O'Gara 1988. Anon. 1987b). However, the skins or other products of the snow leopard are illegal to import into any of the CITES signatory countries, which include most of those from which trophy hunters come.

**Pakistan:** The snow leopard is a protected species; in Chitral district, signs announcing the snow leopard's endangered and legal protected status are present in some towns and villages (pers. obs., 1985). During the winter of 1985, a snow leopard captured in a household livestock pen in Chitral district was released into a wildlife sanctuary (Bernard 1985). However, hunting and poisoning of snow leopards preying on livestock still occurs (P.T.S. Whiteman, pers. comm., 1985).

**Soviet Union:** The snow leopard is currently considered rare, not in immediate danger of extinction, but possibly threatened with extinction under more adverse environmental conditions (Bannikov 1984). Well enforced hunting and trapping restrictions in protected areas effectively prevent any significant illegal hunting of snow leopard. However, outside of protected areas, increasing livestock numbers and human incursions into high mountain regions appear to be making more and more snow leopard habitat subject to conflict associated with livestock depredation and competition between domestic and wild sheep and goats (Braden 1988).

**Protected areas:** Separated by country, the areal extent (km2) of protected areas that are reported to include snow leopard populations is as follows: Afghanistan - 1,080, Bhutan - 7,810, China - 2,070, India - 6,550, Mongolia - 5,300, Nepal - 6,400, Pakistan - 3,190, Soviet Union - 10,090 (Green 1988). Thus, 42.500 km2 or 3.5 percent of the total estimated snow leopard range is currently within protected areas.

## Captivity

Since about 1970, the captive breeding of snow leopards has become very successful (Marma and Yunchis 1968, Koivisto et al. 1977, Weilenmann 1978, 1982, Freeman and Hutchins 1978, Rieger 1978a, 1982, Turner 1980, Schacter et al. 1980, Grittinger and Konrath 1981, Knowles 1982, Velte 1982, Vogt 1982, Wharton 1982, Ruedi 1984, Nardelli 1982, 1984). Whereas 141 snow leopards were obtained from the wild by zoos during 1960-1983, currently there are concerns of overproduction by captive snow leopards, and the only need for individuals from the wild might be to enhance genetic diversity (Blomqvist 1984). There are currently about 370 snow leopards in captivity; 236 in North America, 115 in Europe (including the Soviet Union), 35 in China, 2 in Australia, and 2 in India (Blomqvist 1988, Tan and Liao 1988). International cooperation in the worldwide maintenance of a genetically viable captive population through the compilation of a studbook and breeding exchanges has been established (Blomqvist

1984). In North America a Species Survival Commission associated with the American Association of Zoological Parks coordinates the breeding of snow leopards at member institutions (Foose 1982, Freeman 1982b, Wharton and Freeman 1988). The potential for reintroduction of captive snow leopards into depleted ranges has been discussed, but the obstacles to such a pro gram are formidable (Wemmer and Sunquist 1988), and in any event it has not been demonstrated to be necessary.

**Comments**

**Status**

Recent evidence that the total population of snow leopards is in the thousands indicates that this species is not severely endangered with extinction at present. However, trends in land use in some areas of its range (Braden 1988) suggest that core populations may become Isolated. In a species whose natural density may be less than 1 per 100 km2 over large areas, further population isolation could affect genetic viability and subpopulation ex tinction rate if interpopulation movements do not occur. More information on the status of snow leopard throughout its range clearly is needed.

**Research**

**Priorities**

**Taxonomy:** There is still considerable debate concerning the taxonomic position of the snow leopard. This needs to be resolved for the sake of name clarity as well as the consequent implications regarding the relative unique ness of genetic material associated with a threatened or endangered species, especially if the snow leopard were to be placed in a separate subfamily.

**Population and ecology:** Recognizing the lack of quantitative data on snow leopard ecology throughout much of its range, the primary initial research need lies in filling gaps in basic status information. Secondly, because the initial field study of snow leopard home range. activity, and spatial distribu- tion is from what appears to be prime habitat for the species, comparative studies are recommended in core areas of snow leopard habitat where prey abundance and human disturbance may be less favorable. Much of snow

leopard habitat may be in regions of sparser prey density. and consequent lower leopard densities than was found in Nepal.

In addressing the primary research need regarding procurement of snow leopard status information. some suggestions can be made. Habitat description and socioeconomic considerations in snow leopard conservation are important components of overall data-gathering and are addressed to some extent by Jackson and Ahlborn (1984) and Fox et. al. (1988). but the primary need appears to be in evaluating snow leopard presence and abundance. Snow leopard scrapes are the most prevalent type of sign to be found in their habitat. and they have been shown to be strongly associated with snow leopard density and spatial patterns of habitat use (Ahlborn and Jackson 1988). Scrapes can thus provide a useful measure of snow leopard abundance in an area.

In an area of prime snow leopard habitat in western Nepal. the frequency of snow leopard scrapes per kilometer averaged 60 along river confluences. 21 along major ridges. 7 on minor ridges. and 4 elsewhere (Ahlborn and Jackson 1988). It is therefore clear that the best chance for discovering and measuring snow leopard presence in an area would be to search valley bottoms in rugged terrain. especially in the vicinity of river confluences. This was the technique used in long distance surveys of snow leopard sign in northwestern India. Here. scrape markings were also concentrated at river confluences, and the area of densest sign frequency was 21 scrapes per km over one 2 km transect of valley bottom that included a major confluence (Fox unpubl. data).

The long distance surveys used in northwestern India are appropriate to discovering areas of snow leopard concentration. Subsequent transects in the sites found to have significant snow leopard sign could provide a statistical measure of relative abundance for comparing different areas that have snow leopard activity. The data from western Nepal indicate that these secondary surveys should be conducted using many short transects (250-800 m) (Ahlborn and Jackson 1988) in order to assure the sampling of similar terrain sections and to allow measures of variability. Care must be taken to select transect locations that are comparable in terrain characteristics from one site to another.

Along steep-sided valley bottoms, transect sign frequencies of greater that 20 scrapes per km would indicate a significant snow leopard presence in an area. However, several factors must be considered in attempting to

standardize such sign transects. In regions where livestock are common (which are most areas), scrapes tend to become obliterated from trampling by the livestock. Sheep and especially goats tend to move along the base of cliffs and overhangs where scrapes are found (pers. obs.). Thus, the timing of transect surveys must account for frequency and amount of livestock movement in an area.

Ahlborn and Jackson (1988) suggest that winter is the best time for scrape transects because of relatively dry conditions typical for their study area. However the best timing will depend on local weather conditions. Snow will greatly affect the results of sign surveys because scrapes that are not under overhangs will be covered by snowfall. Snow accumulation makes scrape transects unreliable, but can be useful for other surveys because it facilitates the determination of current presence and numbers of snow leopards in an area based on fresh tracks. Because the best time for surveys of scrape markings without livestock around coincides with the presence of snow cover, in some regions tracks in snow may provide the best means for de termining snow leopard abundance (Koshkarev 1984). If an area is devoid of livestock use through the winter, an ideal time for snow leopard scrape sur veys would be (if possible) after the snow has disappeared and before the livestock have arrived. This could give a measure of snow leopard use since the previous fall when livestock left the area.

Agencies with responsibilities for wildlife conservation and management

within snow leopard range could make a modest start in assessing snow leopard and ungulate prey abundance within their areas of jurisdiction. Standard techniques for census of wild sheep and goats are available and the suggestions here and elsewhere (Jackson and Ahlborn 1984, Ahlborn and Jackson 1988) regarding snow leopard sign surveys and habitat suitability measures can provide the background for developing a wildlife monitoring system. In an addendum to this review, a brief outline of suggestions for conducting snow leopard surveys is provided (Appendix I).

Within the mountains of Central Asia, the status of snow leopard and their prey reflect the general wildlife conservation values in a region and can be used as benchmarks of environmental health. Thus, concern should be raised if they are found to be rare in suitable habitat. The procurement of basic status information will be instrumental in determining to what extent the snow leopard is endangered throughout its range. And further field studies of the snow leopard and its prey will provide the necessary

background to develop wildlife conservation measures as the Central Asian highlands become more developed by people.

**Summary**

The snow leopard *(Panthera uncia)* is listed as an endangered species throughout its range by the International Union for the Conservation of Nature and Natural Resources (IUCN). It occurs in the mountainous regions of central Asia within the countries of Afghanistan, Bhutan, China, India, Mongolia, Nepal, Pakistan, and the Soviet Union. The overall area of snow leopard habitat is approximately 1,230,000 km2 and the total population is probably several thousand.

The snow leopard is a moderately large felid with a mass of approximately 40 kg, a length of about 200 cm (including a 80-100 cm tail), and a shoulder height of about 60 cm. It has been known to live up to 21 years in captivity.

Snow leopards are generally solitary in the wild, with pairing Occurring during breeding and female-young groups remaining together for 1-2 years. The primary prey of the snow leopard are the various species of wild sheep and goats present within its range, with smaller mammals and birds constituting secondary prey sources. Livestock appear to be important snow leopard prey in some areas.

Home range size of snow leopards has been measured at 12-39 km2 in an area of high prey density in western Nepal. Estimates of snow leopard population density range from 5-10 per 100 km2 in the above region to 0.2-4.0 per 100 km2 in other parts of Nepal, India, China and the Soviet Union. The population status of the snow leopard has only recently been addressed in any detail. and there is still a significant lack of information in this regard. Because data on the status of this predator and its prey are important to developing comprehensive conservation programs within its central Asian range, efforts to encourage on-site assessment of wildlife and habitat status are essential. Standard techniques for the census of major snow leopard prey and current development of survey methods for the determination of relative snow leopard abundance can be incorporated into the wildlife management programs of snow leopard range countries.

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## APPENDIX I. Snow Leopard Sign Surveys.

*This appendix* is an *introduction* to *various methodologies and* is *not meant* to *serve* as a *complete approach.* In *the futUre,* a *methodology handbook will* be *published by the International Snow Leopard Trust.*

### Scrape Survey - Relative Snow Leopard Abundance

### Long distance preliminary survey

Mean scrape frequency for a particular terrain type provides a measure of relative snow leopard use, or abundance, that can be compared with mea surements in similar terrain from other locations. Counts of snow leopard scrapes should be performed when the area to be surveyed is free of snow. Long distance surveys (>50 km) can be carried out along valley bottoms to identify areas with significant snow leopard sign. The transects are best lo cated along the edges of valley bottoms or river terraces, especially where there is a definite break in terrain between the valley bottom and valley slopes. These are locations that have been shown to be preferred snow leopard travel routes (Jackson and Ahlborn 1988, Fox et al. 1988, Mallon 1984b, Koshkarev 1984). Also, in very steep terrain, snow leopards often travel on or near man-made trails. Because snow leopard presence has been shown to be associated with confluences in narrow steep-sided valleys, these should be included in long distance surveys.

The long distance surveys can be performed during normal foot travel along the valley-bottom routes of established man-made trails. Survey description should provide the number and location of transects conducted along the valley-bottoms, and may include the following examples: 1) one transect on one side of valley, 2) one transect moving back and forth from one side of valley to another to take advantage of cliff edge or river confluence sites, 3) two transects, one on each side of the valley, or 4) more than one transect on a valley side. These variations will depend on terrain, and manpower and time constraints, but must be noted. Continuous transects divided into, for example, 1 km sections have some statistical drawbacks due to the lack of a random selection of sampling units, but are an acceptable and most efficient sampling design for systematically covering long distances. ln the long range surveys, snow leopard scrapes, spray sites, tracks, and scats should be tabulated for each 1 km transect segment. These transect segments should

be described with average habitat characteristics as outlined in Table A. Other factors associated with snow leopard habitat suitability on a large scale include data on prey species and various human land and resource uses (Table B). and should be documented during any snow leopard survey. Snow leopard scats may be collected for analysis of food habits. Once an area with substantial sign (e.g.. >20 scrapes per km) has been located. a more intensive second stage survey is recommended to more accurately measure scrape frequency.

**Table A. Habitat characteristics associated with transect segments on long distance snow leopard sign surveys.**

| Variables | Measurement Categories |
|---|---|
| Elevation | Meters (lOO's) |
| Valley width | Meters (lO's) |
| Valley depth | Meters (lOO's) |
| Valley-bottom cliffs | Percent |
| Valley-side slope | Angle degrees |
| Valley-side cliffs | Percent |
| Vegetation type | Use published types |
| Vegetation cover | Percent ground cover |

**Survey in area of significant snow leopard presence**

In the second stage of surveys. valley bottoms are again the prime site for transect location. One to two man-days probably are required to complete the suggested surveys. About 10 transects of approx. 0.5 km length should be situated in specific terrain types along the valley bottom. Note terrain characteristics such as distance from river confluence and amount of valley bottom (transect) bounded by cliffs so that comparable transects may be located at other sites. Additional transects along ridgelines are also recommended. again noting terrain characteristics such as major or minor ridgeline. valley to ridgeline elevation difference. distance from river confluence.

amount of transect associated with cliffs, and transect slope angle. Shorter transect lengths are appropriate in areas where sign is abundant (Ahlborn and Jackson 1988).

**Table B. General habitat suitability factors to be determined in conjunction with snow leopard sign surveys.**

| Variables | Measurement categories |
|---|---|
| **Prey data** | |
| Animal | Species |
| Population | Number (age, sex composition) |
| Habitat used | Same variables as for snow leopard, and as appropriate to the species |
| **Other general factors** | |
| Population isolation factors | Rivers, settlements, etc. |
| Human population | Number |
| Human settlement pattern | Clustered, scattered |
| Livestock population | Species, number, seasonal grazing patterns |
| Range condition | Production, use rating |
| Livestock depredation | Predator species, livestock species & number taken |
| Hunting | Type, season, species & number taken |

Adapted in part from Jackson and Ahlborn (1984).

The transects should be categorized by habitat variables (Table C) at least at 50 m intervals, and scrapes should be tabulated at the same intervals.
Multiple scrapes groupings can be tabulated, as well as estimated age of scrape (visibility or sharpness of scrape outline).
Note local factors that may influence scrape-mark longevity such as livestock presence and abundance, weather conditions (heavy rainstorms. flooding), and the prevalence of protected scrape locations (e.g.. under rock over hangs). When comparing survey sites, results from arrays of similar transect locations are most informative.

**Table C. Habitat variables associated with snow leopard sign to be quantified or described during snow leopard surveys.**

| Variables | Measurement categories |
|---|---|
| Terrain slope angle | Degrees |
| Terrain aspect | 45° compass intervals |
| Terrain ruggedness | Smooth. broken. very broken |
| Distance from cliffs (or other breaks in terrain) | Meters |
| Vegetation type | Use published types |
| Vegetation cover | Percent ground cover |

**Track Survey - Current Snow Leopard Presence**

-

Counts of fresh snow leopard tracks can provide an estimate of animals pre sent, although appropriate tracking conditions are infrequent and generally restricted to winter. Counts of snow leopard tracks are best performed when there is snow cover. Prime conditions occur when daytime tempera tures remain below freezing and tracks do not melt. *As* much ground as possible should be covered within a short period (1-3 days). and a team of observers will increase efficiency.

Note factors that may Influence the probability of finding tracks, such as number of days since the last snowfall, snow depth. percent of ground surface with snow cover. and rate of snow melt as related to the duration of a track that can be positively Identified.

Continuous belt transects are also the most efficient for counting tracks. Transects that cross expected snow leopard travel routes would be most appropriate for sampling. However. these would run against the lay of valleys and ridgelines. up and down rugged terrain, and would be extremely difficult and dangerous on snow covered ground. Therefore. the belt transects are most practical If run along valley bottoms. Care must be taken to prevent the counting of a set of tracks more than once. and to distinguish different sets of tracks. Individual travel routes should be noted so that long distance movements may be recognized. Sometimes individuals can be identified by their pugmarks and these should be noted in the surveys.

If tracks can be followed for long distances, and over all terrain types traversed. then characterization of habitat (Table C) along the travel routes (e.g.. 100 m Intervals) can provide a measure of snow leopard habitat use.

**About the Author.**

Dr. Joseph L. Fox has conducted research on mountain wildlife species in Alaska. Nepal. India, and Norway. He received his Ph.D. In Forest Resources and Wildlife Management from the University of Washington in 1983. Currently he Is living In Norway where he Is an Assistant Professor at the Department of Ecology, University of Troms0. He has been Research Director of the International Snow Leopard Trust for the past five years and is a member of the IUCN Species Survival Commission specialist group on cats.

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