Chapter Four B Snow Leopard Survey Methodology

Purpose and Background

Counts of tracks (also called pugmarks or spoor) or pellets (feces) have been used to monitor presence or absence and the relative abundance of wildlife ranging from elephants in Africa (Barnes and Jensen 1987), moose in Europe (Dzieciolowski 1976), ungulates in Sri Lanka (Eisenberg et al. 1970) to deer in North America (Mooty and Karnes 1984). Among carnivores, track counts and sign at bait stations have been used to determine distribution patterns and to crudely estimate relative abundance in mountain lions (Kutilek et al. 1983; Van Sickle and Lindzey 1992), coyotes (Roughton and Sweeney 1982), bobcats and other small predators (Conner et al. 1983). Stephenson (1986) described a technique for estimating lynx numbers from aerial surveillance of track sets during winter when snow-cover makes tracking reasonably easy in open country.

Van Dyke et al. (1986) in their study area in Utah concluded that roadside track counts detected all resident female mountain lions and most transient individuals although similar attempts at detecting resident and transient lions in California through tracking were not as successful (Kutilek et al. 1983). Panwar (1979) used differences in track size and characteristics to identify individuals and thereby census tigers based on their apparently distinctive tracks. Karanth (1987) noted that tracks of similar-sized animals are very comparable in size and shape, and that tracks of the same animal may vary greatly according to substrate condition and gait. Another factor is the skill of trackers in identifying tracks. Except possibly in areas of sustained snowfall, the extreme variation in substrate condition, slope steepness and other factors essentially precludes attempts at identifying individual snow leopards. Another constraint is its small track (compared to tigers), with little apparent individual distinctiveness. Studies have shown that snow leopards mark frequently, leaving relatively long-lived sign in the environment (Ahlborn and Jackson 1988).

While snow leopard numbers cannot be estimated from sign, one can determine relative abundance or relative density. Snow leopard sign consists of scrapings, scent-sprays on rocks (Figure 4-1), vegetation and tree trunks, feces and urination (usually deposited at or near scrape sites), and the occasional claw-rake left on a rock face, log, or upright tree trunk. Tracks are most readily visible when the ground is covered with soft, fresh snow (Figures 4-2 and 4-3). Under these circumstances, individual animals can be tracked for long distances. With a wide-ranging survey, one can determine the approximate number of individuals active in the area over the period of the survey. However, snow remains on the ground for long periods in only a few locations within the snow leopard's range. Snowfall may also hinder access to survey areas.

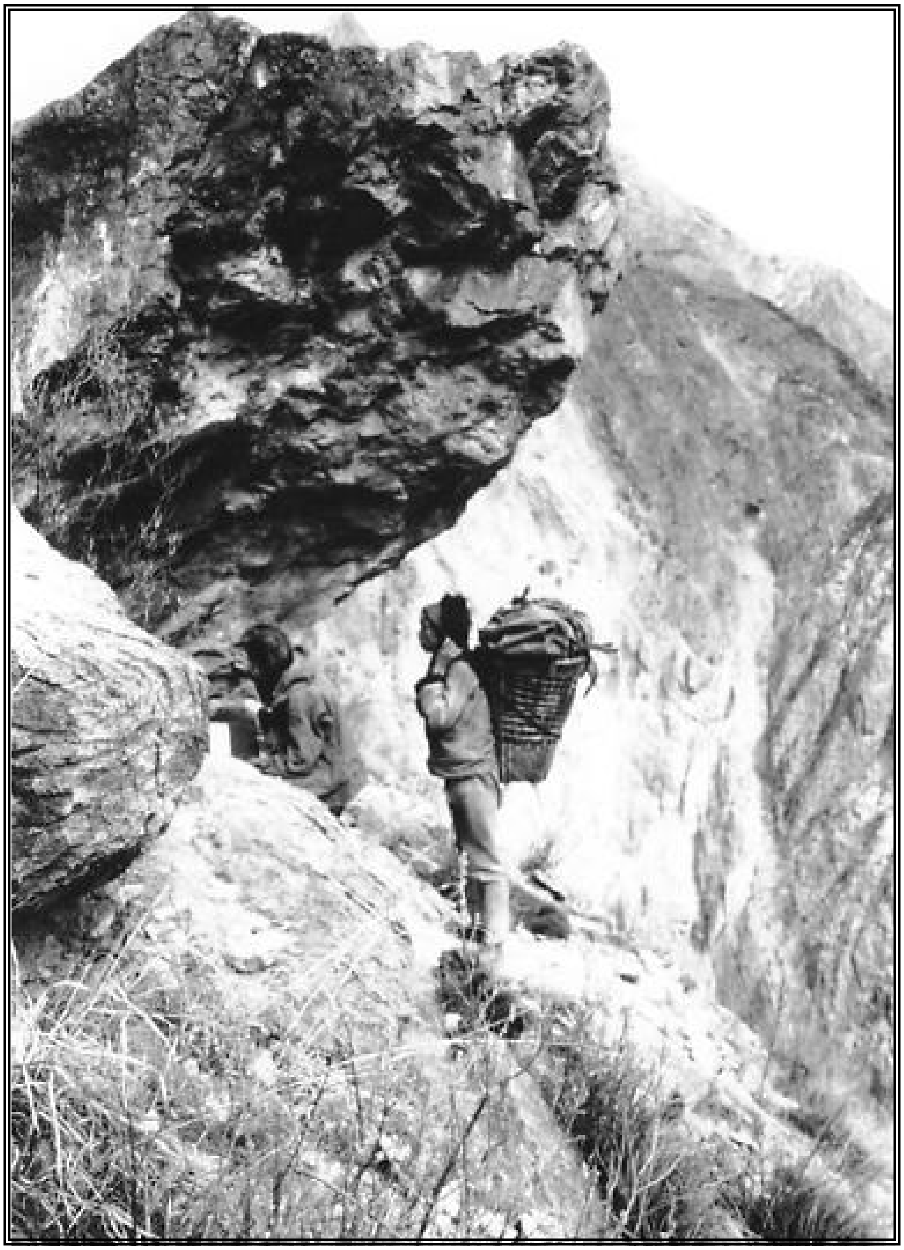

Figure 4-1. Snow leopards scent-spray on prominent overhanging bounders (Photo: Rodney Jackson).

Features of Marking in Snow Leopards

Scrapes:

- Scraping is the most frequent marking activity of snow leopards, followed by the deposition of feces, urination, and scent-spraying.

- Scrapes occur solitarily or in clumps of up to 24. While about 40% of sites may contain only one scrape, these may only represent about 15% of the total number of scrapes found in a particular area; the average number of scrapes per site was 2.8. The majority of scrapes left in an area are usually deposited at sites with more than one existing scrape (i.e., scrape clumps).

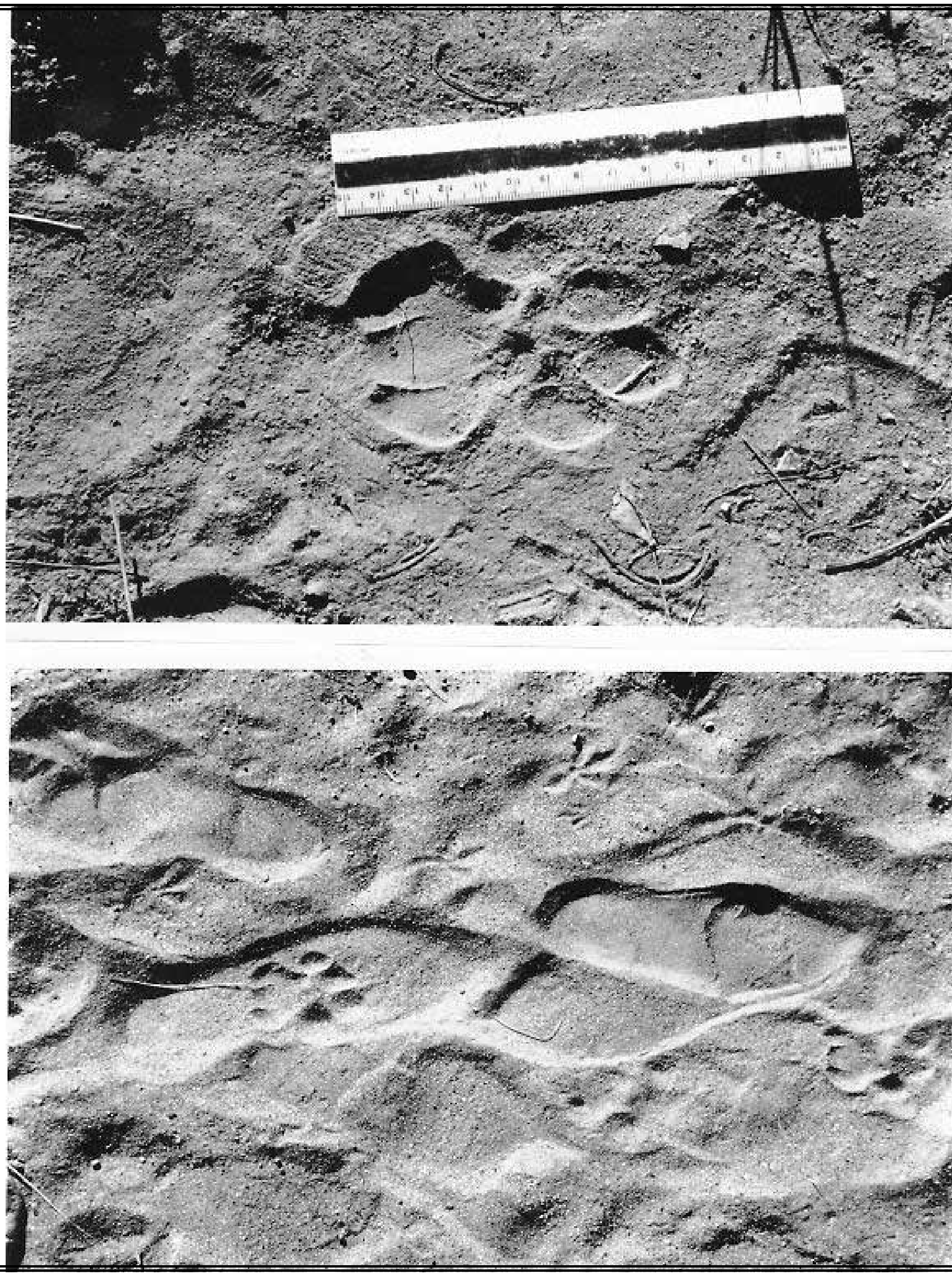

Figure 4-2. Snow leopard tracks – note this cat traveled along the same path used by people. Note also the distinctive three lobes to the heelpad (Photo: Rodney Jackson).

Figure 4-3. Snow leopard tracks in snow at the base of a cliff (Photo: Rodney Jackson).

- New scrape sites are established about 50% of the times a site is visited (0.8 sites per visit), and scrape on 86% of the times visited. More than 55% of existing scrape sites were revisited and marked again.

- As much as 40% or more of the total scraping activity may involve remarking of existing scrapes. As much as 75% or more of the scrapes in a well-used area may be left at relic sites. Most scrape sites which were reused are considered to constitute relic sites (i.e., animals have marked these over successive generations).

- Scrapes with a high visibility (i.e., 3 or 4) are far more likely to be remarked than scrapes with a low visibility (0, 1, or 2).

- Scraping activity peaks during the months of December and March, but occurs year-round. Marking activity probably reaches its highest frequency when there are one or more females in heat in a particular area.

- Marks may be more than four times as abundant in areas where core home range overlaps among different individuals.

Feces:

- Feces are long-lived, especially in sites with little precipitation and minimal insect activity. Feces or scats may be deposited solitarily (67%), or with other scats of varying ages.

- Feces are most likely to be found in association with scrapes (in the Langu Valley, less than 10% of the feces found were left in places without a scrape). Typically, feces are left on a scrape pile or within a meter of a scrape.

- Relic sites tend to contain more feces than non-relic sites or those used less frequently.

- Hair found on sprayed rock faces indicate where a snow leopard has cheek-rubbed.

- A majority of spray sites will have one or more scrapes within a distance of a few meters.

Urination:

- Urine may be deposited on some scrape piles (about 20%); the urine may be acrid or sweet in odor.

Scent Spraying:

- Snow leopards spray-mark the faces of upright or overhanging boulders and the base of cliffs; some sites are periodically revisited and resprayed. Freshly sprayed rock faces are best detected by their strong odor, because staining of the rock may in fact be the exception.

- The top of most spray marks are located about 70 to 85 cm above the ground surface, with the height of the average rock face being about 1.5 m, and an average width of about 2.0 m.

- Hair found on sprayed rock faces indicate where a snow leopard has cheek-rubbed.

- A majority of spray sites will have one or more scrapes within a distance of a few meters.

Ahlborn and Jackson (1988) found that scraping was a more reliable predictor of visitation than tracks in the Nepal Himalaya. Their intensive study of five radio-collared snow leopards showed that scraping predicted about 87% of snow leopard visits to an area compared to only about 30% to 60% (best conditions) for tracks. The main problem with tracks lies in their ephemeral nature: they are easily and quickly destroyed by weather (wind or snow), and the passage of wild ungulates, man or livestock along the same trail. Also, track visibility is highly dependent on the type of substrate, with few tracks being left on gravelly soils, compacted soils, or on frozen ground. Tracks are easily confused with other leopard sign at lower elevations.

Sign Placement

Snow leopards tend to leave scrapes in relatively predictable places, such as at the base of cliffs, beside large boulders, on knolls and promontories, at bends in trails, or along other well-defined landform “edges” (Schaller 1977; Koshkarev 1984; Mallon 1987; Ahlborn and Jackson 1988; Fox 1989b). Landform edges are defined as the sharp point of contact between two topographic features, such as a sharply profiled ridgeline that leads down toward a stream confluence, the entrance to a steep-sided gorge, the edge of a steep, abrupt river bluff, and the base of a cliff.

Sites with poorly defined topographic features and no obvious landscape edge tend to be used much less. In Nepal, sign density was greatest along transects located near well-defined stream confluences, at the entrance to gorges or along prominent, narrow ridgelines. Significantly more sign was deposited within the overlapping core use areas visited by different radio-tagged individuals (Ahlborn and Jackson 1988; Jackson and Ahlborn 1989).

Identification of Sign

It is not always easy to distinguish snow leopard sign from that left by lynx (*Lynx lynx*, formerly *Felis lynx*) or common leopard (*Panthera pardus*), and even some wolf (*Canis lupus*) sign. See Appendix B for clues to distinguishing snow leopard sign from that of other species. The presence of associated sign and how the sign has been placed are useful guides, but good field biologists always note when they are in doubt which species left a piece of sign. Please do likewise.

Assumptions of Sign Surveys

Following are *basic assumptions* regarding snow leopard marking behavior and use of sign to estimate relative abundance:

1. Because scrapes are long-lived, relatively easy to locate, and can be roughly aged, they can be used to predict snow leopard presence and visitation rates.

2. Individuals of comparable sex and age class mark at similar frequencies and patterns.

3. Different visit rates to marking sites of similar character are assumed to reflect differences in the number of individual snow leopards present, as well as the sex and age composition of the resident and transient population (more data is needed from other populations to assess these relationships).

4. From studies in Nepal, the intensity of marking is assumed to be greatest in areas of home range "core area" overlap. These represent sites where sampling is most profitably undertaken.

5. In Nepal, areas of overlap in snow leopard home range appear to be located at or immediately adjacent to well-defined stream or river confluences (other investigators have noted that snow leopard sign tends to be more abundant in such locations, but it is not known if these sites are also core use areas).

6. Sign can be aged consistently if the following characteristics are taken into account: differences in marking substrate and weathering rates due to exposure, climatic regime or other disturbances, and resulting sign longevity (use of relative age classes).

7. The habitat and travel lane preferences observed in Nepal are also representative of the species' behavioral and marking patterns elsewhere (studies are needed to determine the validity of this assumption).

8. Carnivore species can be accurately identified from their sign, an assumption that could be violated if observers are inadequately trained in animal tracking.

9. Survey bias due to differences in a person's ability to detect sign can be minimized with proper training, justifying field training workshops as proposed by ISLT and the SLIMS protocol.

These assumptions are mentioned so that readers can be aware of potential sources of error and bias. While snow leopard presence and absence is fairly easily established through "quick and dirty" searches for sign in suitable habitat, rigorous sampling is needed to establish relative abundance. SLIMS involves the use of transect sign counts as indices of snow leopard presence and relative population abundance. This handbook describes use of *"one-time only" sign transects*, which are placed in those areas most likely to be visited and marked by resident or transient snow leopards. For example, an observer walks along the base of a cliff and records all snow leopard and other predator sign encountered along a linear "belt" transect 10 m wide varying in length from several hundred meters to one or two kilometers.

This handbook does not offer precise sign frequency/density conversion factors because of the many confounding factors involved, including differential marking rates with respect to individuals, time of year and habitat, and variation in sign longevity due to local environmental factors and disturbances. However, with consistent data recording and relatively large samples, it is possible to monitor population trends over time. The value of these techniques ultimately depends on an understanding of marking patterns, factors affecting sign longevity, and methods used to locate and record such information.

Presence-Absence Survey

Objectives

1. Determine presence-absence of snow leopard.

2. Summarize status of snow leopard and prey species.

3. Prepare range maps for snow leopard and prey species.

4. Identify major habitat types.

5. Identify important management concerns.

Outputs

1. Completed presence-absence survey forms (Form No. 1).
2. Report on the general status and distribution of snow leopards and prey species.
3. General description of habitat types present in survey area.
4. Black-and-white photos of survey area.
5. Map that shows survey sites and where signs were observed.

Identify Survey Areas

As discussed in Chapter 3, the first task is to decide which area to survey. This task can be daunting when confronted with an entire mountain range or protected area that has never been surveyed. Survey areas are large blocks of land that need not be as geographically precise as survey blocks and search sites (Figure 3-1). A lot of time can be wasted looking in wrong locations. If snow leopards have been present for a long time, local villagers are likely to have seen them or suffered livestock losses over the years. Therefore, interview someone who knows, for local residents can save time by helping locate the key areas to survey. Also, it is good to know as much as possible about the study area, such as road quality, seasonal weather, grazing pressure, and so forth.

Time and funding are the most common factors that limit the scope of surveys. With presence-absence surveys, the main objective is to get into an area and determine whether or not there are snow leopards, requiring less time and more qualitative analysis than in abundance surveys (Figure 3-1). Large blocks of mountains may take years to survey, so when possible, target strategic areas first such as core areas or high-density prey areas. Over time, presence-absence surveys will fill in the blanks on snow leopard range and help target sites that call for more detailed abundance surveys.

Schedule and Prepare for the Survey

While winter may be the optimal time for detecting snow leopard sign (see Chapter 3), other factors may influence the schedule of a survey. Access and harsh field conditions make winter surveys more difficult, while summer surveys are often hampered by the presence of livestock and human disturbance. A balance must be struck based on the objectives and conditions of each survey. Once the survey schedule is set, the importance of preplanning and a good check list cannot be overstated. Chapter 3 provides a suggested list of equipment. Good quality maps are essential to a well-planned and executed survey. While maps do not show

Form No. 1. Snow leopard presence-absence survey.

Observer Name: ______________________ Date: ______________

Survey Block No./Name: ______________________ Elevation (min/max): ____________

Latitude/Longitude: ____________ MAP ______________ GPS ____________

Administrative District: ______________________________________

Biogeographic Zone/Unit: ______________________________________

Size & Configuration: ______________________________________

1. Summary of snow leopard sign observed in this survey block.

Column 1 Search site number	Column 2 Type and amount of sign	Column 3 Search effort (km^2)/time	Column 4 Dominant landscape

Threats to snow leopard: ______________________________________

____

Comments (attach location map): ______________________________________

____

Snow leopard sign:

PUG = pugmarks; SC = scrape; FE = scat or feces; UR = urination; RC = rock scent spray
Age of sign: OLD = old or very old sign (> 1 month); FRE = fresh or very fresh sign (1 day to 1 month)

Dominant landscape:

PLA = plain; GROL = gently rolling; SROL = steeply rolling; BTER = broken terrain; WVAL = wide valley; NVAL = narrow valley; GORG = gorge; OTH = other (describe)

Prey species information:

OBS = confirmed by sighting made by observer(s); R = reported present by local people; S = presence based on sign (pellets, tracks, or other sign) seen by observer

Form 1. Concluded.

2. Summary of prey species and their sign observed.

Column 1 Prey species	Column 2 Type and amount of sign	Column 3 Relative abundance	Column 4 Major threats

Comments: ____

____

3. Summary of habitat assessment for this survey block.
   Vegetation types present: ____
   Habitat types present: ____
   ____
   Major disturbances: ____
   Key natural resources harvested: ____
   Local attitudes to wildlife: ____
   ____

RECOMMENDATIONS: Is an abundance survey required? Yes _______ No ________

4. Summary of management issues.
   Protection/management of snow leopard: ____
   ____
   Protection/management of prey (name species): ____
   ____
   Protection/management of rare wildlife (name): ____
   ____
   Other recommendations: ____
   ____

everything, they are the best guide when one is unfamiliar with the survey area. Once the area is identified, transportation routing helps estimate the time to and from survey sites. If search sites are away from roads, as most often occurs, then plan a little extra time for travel. When possible, it is a good idea to send reserve staff or aides ahead of the main survey group to arrange for local transportation, food, shelter, and so forth. They can also locate the appropriate village elder who can answer questions.

From a review of previous reports, the scientific literature, and interviews with local experts, develop a list of wild prey species that snow leopards may subsist on and that could be expected to occur in the proposed survey area. The list should include small-bodied prey such as game birds (pheasants, snowcocks, and partridges), and small mammals (hares, mouse-hares, and marmots); medium-sized mammals (goral, musk deer, and gazelle); and large-sized mammals (white-lipped or Thorold's deer, red deer, argali, urial, blue sheep, markhor, ibex, and Himalayan tahr).

Contact experts in the local university and academy of sciences to identify a suitable vegetation and wildlife habitat classification system for the region. The goal is to identify the biogeographic zone or bioecological units in the survey area. Because there is no standard ecosystem or biotic classification system that applies throughout snow leopard range, use the most widely accepted ecotype or natural vegetation classification system developed by botanists and other scientists. Include the name and citation of the classification system when reporting survey results. The International Snow Leopard Trust hopes to eventually develop a standard classification that will apply range-wide.

Conduct the Field Survey

Travel to the study area and delineate the survey blocks and search sites (Figure 3-1). Survey blocks help organize the survey, generally encompassing a watershed or portion of a large valley (50 to 250 km^2 in area) determined as suitable snow leopard habitat. They are defined as distinct and contiguous areas that are too large to search entirely; therefore, search sites are specific access points that represent the terrain and habitat of the survey block. Thus, search sites are small areas 5 km or less in length or width inside survey blocks that are most likely to have snow leopard scrapes, scents, and feces. These sign are concentrated and serve better for delineating snow leopard range than tracks which may occur anywhere. Typically, search sites consist of well-broken and rocky terrain, sharply defined ridgelines, bluffs or cliffs near river confluences, and the entrances to gorges and steep-sided valleys. Topographic maps and local villagers are helpful in locating these sites. As snow leopards in different areas may use different terrain, some areas of flat terrain should be included as search sites, especially where mountain ridges extend down to plains or wide valleys. In general, search sites should be 5 to 25 km apart to maximize coverage and ensure that a variety of terrain conditions are included in the survey. Both reputed "hotspots" and marginal areas should be included in the survey.

Complete a separate data form (Form No. 1) for each survey block. Enter observer name, date of survey, name and number of the survey block, approximate latitude and longitude, the highest and lowest elevations present, and name of administrative district. Note the approximate size (square kilometers), general shape (square, round, narrow, linear) and dimensions (greatest length and width in kilometers) of the survey block. Note the biogeographic zone or bioecological units, using the most widely accepted classification for the region. Mark search sites on a topographic map and keep a daily account (field notes) of all activities, areas surveyed, and observations. These notes often prove invaluable when analyzing data and recalling survey specifics months or years later. If there are many observers in the survey party, it is a good idea to review the basics of the survey before setting out to collect data. Review the survey form, ensuring everyone has the same understanding of the terms, units, codes, and methodology used. It may be helpful to start with some group exercises on the use of compasses, maps, clinometers, and so forth. Invariably, each individual has a different feel for estimating distances, so a few practice exercises help to calibrate the eye and mind. The goal is to have all surveyors collecting data the same way - or as close as possible.

Snow leopard. In each search site, walk along the base of cliffs or ridgelines near stream confluences and make a wide-ranging "quick and dirty" search for snow leopard sign. Using the data form (Form No. 1), record findings, distinguishing between personal observation and local resident interview. Keep a simple list for each discrete sign (track, scrape, scat, etc.) observed. Sign codes are shown on the form. If possible, mark sign locations on a topographic map, noting the approximate age (new or old). Each piece of sign found is a single "presence record". On completing the search, total the numbers of each type of sign and enter in Column 2. Each search site is given a consecutive number starting with 1 noted in Column 1. In Column 3 list the approximate area searched (square kilometers) and the total time spent at each search site (in hours to the nearest half hour). If no sign is found, enter 0 in Column 2. Column 4 is for the dominant landscape at each search site. Codes for dominant landscape are found on the data form and are more fully described below:

(a) Plain (flat terrain, no hills or mountains).

(b) Gently rolling (low hills and valleys without distinct ridgelines).

(c) Steeply rolling (slopes are steep or very steep, more than 30 m).

(d) Broken terrain (land surface broken by irregular slopes, cliffs, rocky outcrops, gullies, and well-formed mountain slopes and ridges).

(e) Wide valley (wide, level floor more than 1 km wide).

(f) Narrow valley (steep sides less than 1 km wide).

(g) Gorge (extremely steep-sided and deep valley with cliffs and bluffs along its edge).

(h) Other (describe or photograph).

Major threats are noted in Column 4 and include such things as evidence of hunting, heavy livestock use, human activity, and so forth. Often this evidence comes through careful observation or skilled interviews with local residents. For example, the relative abundance of guns among villagers is usually (but not always) a good indicator of hunting pressure. When visiting herding camps or remote villages, take note of animal remains lying about such as horns, skins, and bones. If poaching is evident, try to learn how widespread the problem is and how many persons are involved. An occasional animal poached for killing livestock is much less serious than a poaching ring that hunts far and wide.

Prey species. Information on prey species is obtained in two ways: (1) interviews with local residents, and (2) noting all species observed or their sign (tracks, droppings, and carcasses). Because animals may be disturbed while searching for snow leopard sign, a separate morning or afternoon should be devoted to searching for prey animals. From prominent ridges or hill tops, but well-hidden from view, scope the area with a spotting scope or binoculars. When possible, use the same search sites for snow leopard, recognizing that prey species use less-rugged terrain such as a wide valley or gently rolling hill slopes.

Prey species data are recorded much the same as for snow leopard (Form No. 1). All prey species observed or confirmed by sign are entered in Column 1, with the kind of evidence (interview, sighting, or sign) and amount entered in Column 2. Column 3 is for relative abundance and distribution, such as frequency of observation. For example, record the number of herds seen at the search site or the number of days a particular species or sign were seen. Another approach is to use categories such as rare, common, uncommon, very common. Different observers, however, are likely to choose different definitions for the same observations. Thus, when using this approach, each observer should define their definitions on the data form. Note your observations and opinion on whether the prey species populations are low, average, or high. Note changes over past years or shifts in age classes, which might signal excessive poaching. Also note the presence of other constraints such as forage availability, escape cover, and breeding sites.

Threats to prey are similar to snow leopards. If there is evidence of poaching, try to find out how widespread it is, who is involved, and where the products are sold. Whenever possible gather all information on livestock use throughout the year. You may find no livestock present at the time of the survey but at other times they might be over-abundant. If poisons are used for rodent control, ask where they are used. Interview local residents to learn how much predation there is on prey species and livestock. Caution should be used when asking questions and interpreting responses of local residents. Residents who sense the possibility of compensation are likely to grossly inflate actual numbers. The Comments Section can be used to augment notes on any aspect of the survey.

Habitat assessment. Habitat assessments can coincide with snow leopard and prey surveys, using the same survey blocks and search sites. Habitat data are also obtained through observation and interviews with local residents. Interview questions target land-use, human resource demands, and livestock herding practices. On the form, list all major vegetation types encountered. If you cannot identify a major type, draw a picture of relevant features or photograph it for later identification. Ascertain the general condition of the habitat and support your conclusions with notes on the form. For example, if you conclude the habitat is poor and declining, state the evidence and how you reached this conclusion. Note evidence of major habitat alterations such as forest loss and over-grazing. Local herders are usually quite knowledgeable about habitat trends.

Management issues. An important objective in presence-absence surveys is to identify the negative influences affecting snow leopard, its prey, and habitat. For example, knowing the attitude of local inhabitants toward predators, including snow leopards, can help guide the type of management for the area. Often simple measures can improve community attitude and stewardship of local natural resources, especially rangelands and forests. Good surveys may help promote sustainable tourism or other revenue-generating activities. If snow leopards are present but in serious danger, management action is needed quickly and must be backed by valid, objective data.

Analyze Survey Data

After all surveys are completed the next task is to analyze and interpret the data. This task is not as straightforward as it might seem. Presence-absence surveys are not statistically based, relying instead on the analyst's knowledge of survey techniques and snow leopard ecology. For example, negative snow leopard sign for a survey block may not necessarily mean there are no snow leopards in the area. If the survey took place in the summer and there was livestock in the area, all sign may have been destroyed. Good habitat and plentiful prey species would make it even more difficult to conclude there are no snow leopards in the area. This is where the analyst must look at all the data collectively to draw conclusions.

Unlike abundance surveys, presence-absence surveys do not attempt to estimate population size, but rather simply establish whether or not snow leopards occur in a certain area. The analyses are personal, qualitative judgments supported by the physical evidence of the surveys. There are no numeric parameters or statistical tests. Presence-absence surveys are designed to achieve as much uniformity as possible while remaining straightforward and easy to use.

Because surveys are conducted in suitable habitat, the general assumption is that snow leopards are present until proven otherwise, a conclusion that can be hard to reach, especially when animal numbers are low. In truth, there are two obvious conclusions: they are present or they are not. From survey results the analyst seeks one or the other conclusion based on data that represent a small subset of the area. There is always the chance the analyst misinterprets the data, but positive data (evidence of sign) is more conclusive than negative data (no evidence of sign). Larger sample sizes (number of search sites) lend greater strength to one's conclusions.

To begin the analyses, collect all forms for each survey block. Check the header information to be sure data forms are not mixed up. The premise behind presence-absence surveys is that search sites represent survey blocks of similar habitat in the survey area. So, the search site summaries for each search block build the case for presence-absence in a search block. If there is abundant snow leopard sign in all search blocks it is easy to support the conclusion that there are snow leopards in the survey area. It is more difficult, however, to reach this conclusion when little or no sign was found in the survey blocks. In this situation, prey species data summaries and habitat summaries must enter the reasoning process. It is very helpful to plot data on a map. Often, trends emerge that help with conclusions. For example, sign abundance might align with mountain ranges or elevation gradients, or sign scarcity may be closely associated with village distribution. Just remember, the presence of abundant sign is a good indication of presence; the absence of sign does not always lead to the conclusion snow leopards are absent.

In addition to judging presence-absence for snow leopard and prey species, the analyst should summarize major threats and management recommendations. Here again, the data summaries are the basic units for drawing conclusions. When concluding there are threats, it is important to be geographically explicit: are threats present in all survey blocks or only in specific blocks? Generalizing threats makes it more difficult to find reasonable management solutions.

Report Survey Results

On returning from the field, prepare a small scale map (1:1,000,000 or 1:500,000) indicating the survey area and locations of sightings (snow leopards and prey species). Distinguish actual sightings from sign. Outline the approximate range for snow leopards and prey species. It may be necessary to approximate range limits for hard-to-observe animals such as game birds and musk deer, or animals with patchy distribution such as marmot and argali. These maps should be updated as new information accrues from more surveys or other sources such as zoological surveys, scientific expeditions, and government reports.

A final report of one to three pages should include who, when, where, and how the survey was undertaken as well as the conclusions reached after data analysis. Whenever possible include relevant photos taken during the survey; often, they convey a message better than words. In addition to local reporting, send a copy of the report to ISLT so they can enter the data into the SLIMS database. ISLT encourages articles on the survey for *SNOWLINE*, its biannual periodical.

Abundance Survey

Objectives

1. Estimate snow leopard relative abundance from sign transects.

2. Identify parts of the survey area that support the greatest snow leopard numbers so that targeted prey species and habitat evaluations can be undertaken, which may lead to creating a new protected area.

Outputs

1. Completed abundance survey forms (Form No. 2).

2. Report describing status, relative abundance, and distribution of snow leopards in areas surveyed.

3. General description of habitat types within the surveyed area.

4. Black-and-white or color photographs of survey sites.

5. Map indicating sites surveyed and locations where snow leopard or sign was observed.

Identify Survey Areas

ISLT recommends that the first priority be given to unsurveyed protected areas, followed by surveys of habitat judged to be most important to the long-term conservation of snow leopards in the country at question. For more information on corridors and protected area conservation biology criteria, see the tables presented in the section on Habitat Assessment Surveys.

Once a survey location is identified, delineate possible *survey blocks* in which sign transects can be located (Figure 3-1). This task is best accomplished by reviewing topographic maps (preferably at scales of 1:50,000 or 1:100,000), and noting the location of areas below 5,000 to 4,500 m in elevation that are: (1) steep-sided gorges; (2) prominent bluffs abutting rivers, streams, low hills or valleys; (3) abundant cliffs (slopes steeper than 50E); (4) watersheds with well-defined boundaries (e.g., sharp ridges with intervening passes to allow for the movement

Form No. 2. Snow leopard sign transect – abundance surveys.

Observer(s): ______________________ Date: __________ Transect No.: _________ Total length: ___________ Page ___ of ___

Location/Block No: ________________________________ Administrative District: ______________________________

Snow leopard sign survey data form. Enter information into appropriate column, using codes from Table 4–1.										
1. Site No. and 2. Observation no.	3. Distance	4. Species	5. Elevation	6. Aspect of site	7. Slope of site	8. Rangeland use	9. Habitat/ vegetation type	10. Landform ruggedness	11. Dominant topographic feature	12. Feature marked

1. Site No. and 2. Observation No.	13. Site type	14. Type of sign	15. Sign age or visibility	16. Substrate type	17. Sign measurement	18. Slope/aspect of transect	19. Comments

of cats across a snowbound range); and (5) confluences of permanent rivers or streams, especially if ridgelines reach down in a narrow V-shape to the point of confluence. Outline such areas in pencil, and note which best meet the criteria described in Chapter 3.

These areas or polygons should offer the best place to search for sign, provided that the surrounding terrain is relatively representative of the survey area at large, and that these areas are not clumped into one small part or another of the study area. Large gaps (100 to 250 km^2 or more) in coverage might represent blocks of less favorable habitat and should also be surveyed. However, a final decision on which areas to survey is best made in the field, when local conditions are better known. Remember, surveying only the *best places* biases population estimates upwards.

Schedule and Prepare for the Survey

Same procedure as used in presence-absence surveys.

Conduct the Field Survey

Transect placement. This task involves locating specific areas, or *search sites* within each *survey block* for placing and running sign transects (see Figure 3-1). Transect sampling must be undertaken systematically and carefully. The sampling procedures employed determine the outcome and validity of the survey. It is important that representative sections of the study area are sampled by transects, which must all be placed along routes and *landform edges* most likely to be visited and marked by resident or transient snow leopards. It is a waste of time running transects in places avoided by cats or in situations where sign is extremely difficult to locate. This task, therefore, merits special attention.

Sampling strategy. On arrival in the survey area, interview local residents to determine which places are likely to contain the best snow leopard and prey numbers and where they are relatively scarce. Delineate these areas as possible survey blocks and give them a name and number. Run a few transects in representative parts of both high density and low density survey blocks to get an idea of terrain and sign abundance associated with each class. Review the topographic map again, and delineate additional representative areas for sampling.

Conduct many (15 to 40) *short* transects, 250 to 700 m in length, rather than a *few* (5 to 10) long transects, 2 or more kilometers in length. Short transects require less time, provided they have been well-sited, and studies have indicated the odds of finding sign declines markedly as transect length increases (Ahlborn and Jackson 1988). Long transects are more likely to cross habitat or landform boundaries, making the data more difficult to interpret and assign to a particular terrain type or relative density class. Increasing sample size usually permits statistical treatment and computation of confidence limits (Harris 1986), which are essential if population trends are being monitored over time. One is better able to assess sample variability, which aids in extrapolating results to areas not surveyed or other areas surveyed using transects.

Until more is known about sign patterns in snow leopard, strict rules for transect sampling density cannot be provided. In general (1) sample high and low density areas in approximate proportion to their occurrence, based on the topographic map; (2) ensure each transect is placed so that it samples the survey block in places *most likely* to be traveled and marked by snow leopard; (3) keep transects to 0.5 km or less in length; and (4) aim for an overall density of about 200 m of transect per square kilometer of sampled survey area. Each transect should be separated by 1 to 3 km and be spaced reasonably evenly throughout the area sampled. Figures 4-4 and 4-5 illustrate examples of good and poor transect layout.

Note on the map the location of each transect undertaken to enable repeat visits in the future.

Walk, locate, and record. Slowly walk along each designated transect and search for snow leopard sign within a 5 m wide strip on either side of the line of travel (Figure 4-6). Use Data Form No. 2 to record details of *each item of sign* encountered, using the codes keyed to the column numbers, provided in Table 4-1. Note that the alphabetic and numeric codes used in entering the data are designed to assist in computerized data analysis and evaluation. Use a separate form for each transect conducted. If more than one page is needed for a transect, indicate the total number of pages used to record information for that particular transect. Enter observer's name, date, survey block number or name, search site number or name, and the number allocated to the transect (numbered consecutively).

Specify the numbering system clearly so that SLIMS personnel can clearly differentiate among different surveys or transects repeated in subsequent years. Put the transect number, its total length, and the elevation at the beginning and end points at the head of the form. With the transect starting point set at zero meters, the observer walks along its course, tallying the distance while searching for sign within the 10-m-wide "belt" along its full length. All distances are cumulative. Each time an item of sign made by a carnivore is found, record the site number and item number(s) in Columns 1 and 2. Allocate a unique consecutive number to each site and record the cumulative distance along the transect to that point in meters (Column 3). Groups of scrapes and scats are assigned the *same site number* if they are located less than 5 m apart. All sign *within* a site is numbered consecutively, using the site number as a prefix. Each item of sign can be listed on a separate line to avoid confusion. Transect length and distance between separate sites and their accompanying sign items is determined by pacing at 1 m intervals using a tally meter. Therefore, the observer should take even-sized paces, tallying the counter for each meter moved forward.

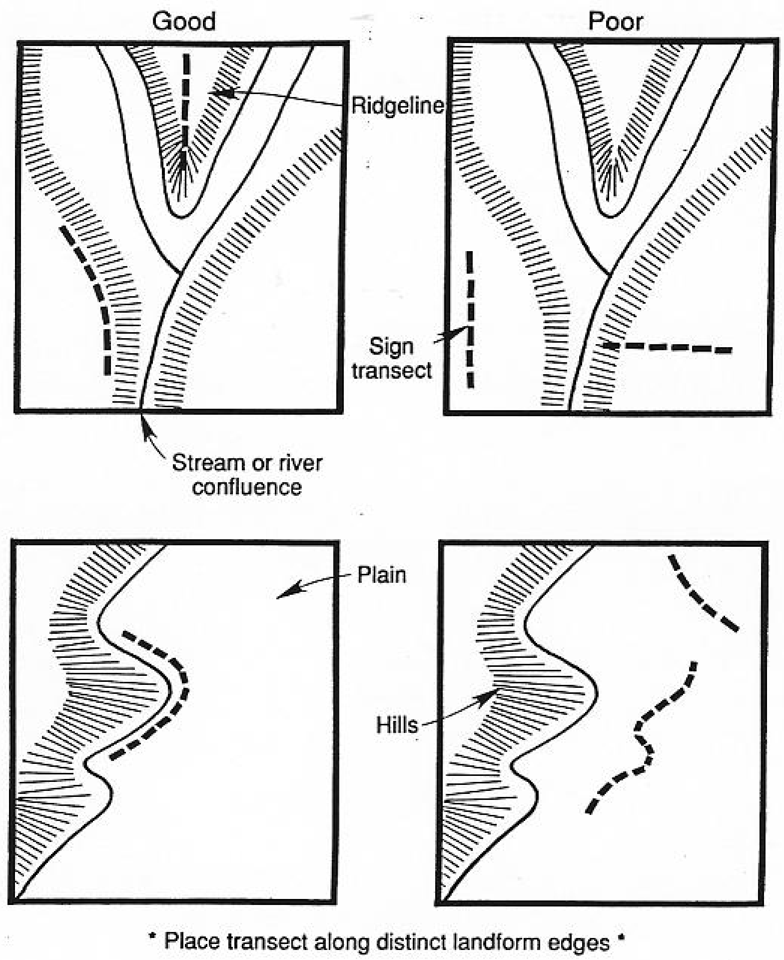

Figure 4-4. Examples of good and poor sign transect placement with respect to topography.

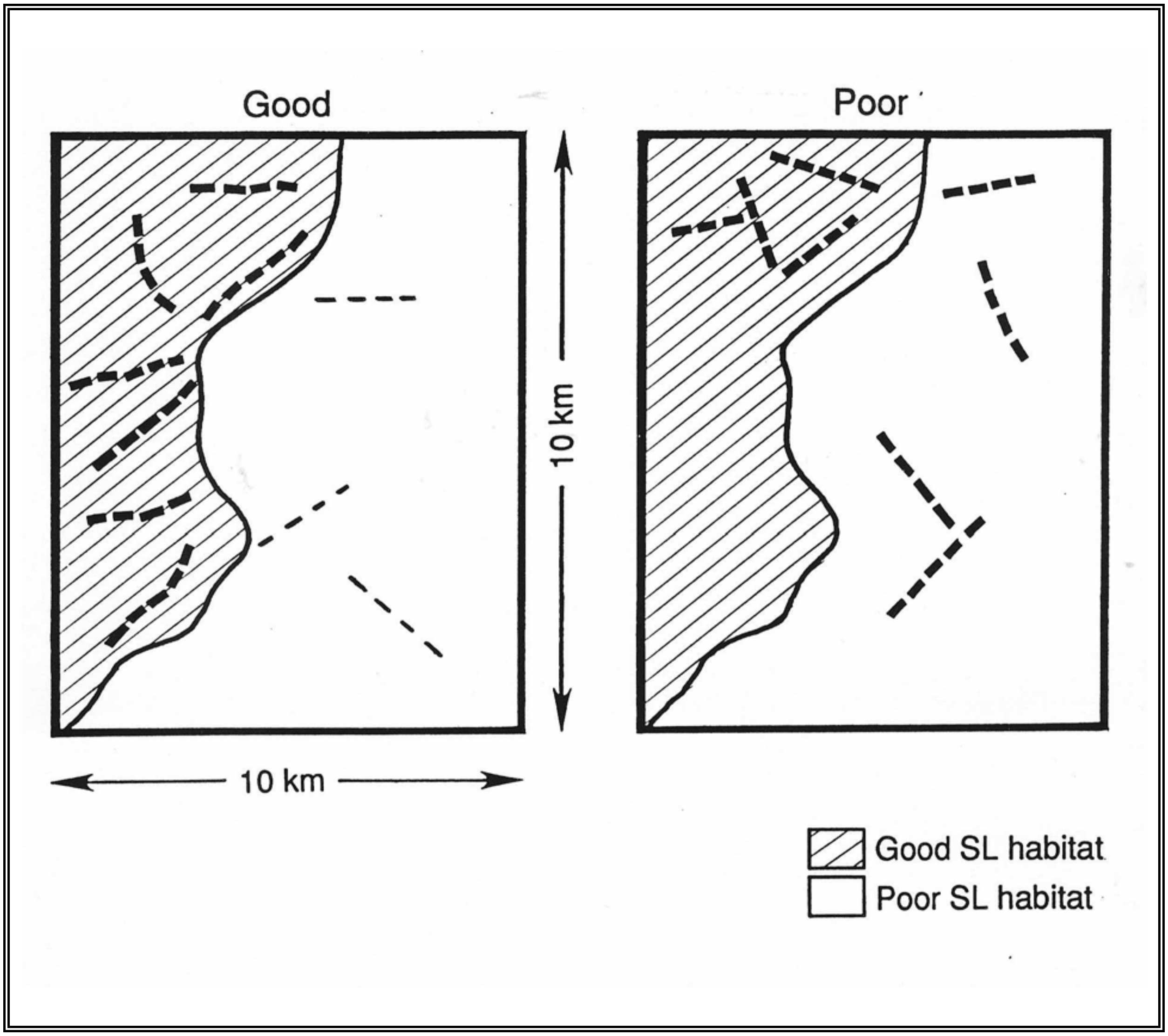

Figure 4-5. Another example of good and poor sign transect placement with respect to habitat distribution.

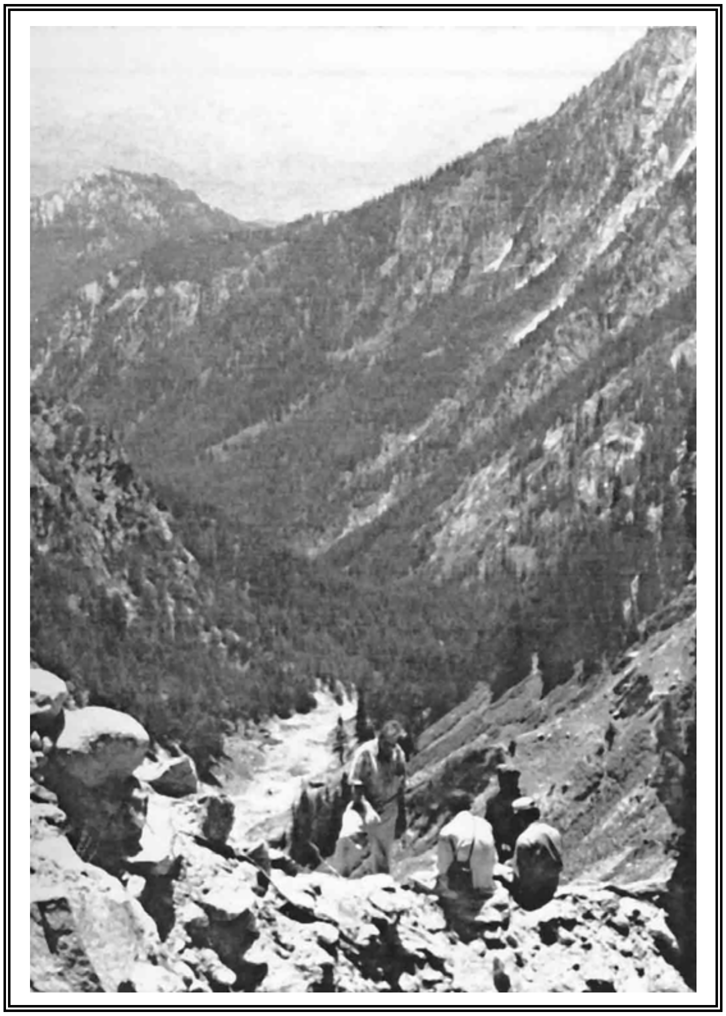

Figure 4-6. Walk transects, locate sign, and record observations (Photo: Don Hunter).

List the species responsible for leaving the sign in Column 4 using codes given in Table 4-1. Record a name only if the animal's identity is fairly certain, otherwise use a more general classification, such as "other felid". It is not a problem if some items of sign remain unidentified as to species.

For each site, record the following environmental parameters in Columns 5 through 12: elevation (meters), aspect (degrees), slope steepness (degrees), dominant rangeland use, habitat and vegetation types, landform ruggedness, dominant topographic feature, and name of topographic feature that has been marked. Use two lines if needed as both are recorded in degrees. Use an altimeter to measure site elevation, or refer to a reliable topographic map. Site aspect is the prevailing aspect of the terrain within a 5 m or less circle around the observation site measured with a magnetic compass. Slope is measured with a clinometer, or visually estimated to the nearest 5 to 10° for the same area as the aspect. Aspect is defined as the direction (0 to 360°) in which the site faces, while slope steepness is the gradient or incline of the marked site [i.e., within a distance of a few meters and not the whole mountain slope (Figure 4-7)]. Habitat features are based on the dominant condition within a distance of 50 m of the marked site. Landform ruggedness characterizes the "smoothness" of the earth's surface and the degree to which the surrounding terrain is broken by features such as cliffs, drainages, and rock outcrops. The notation "topographic feature" is defined as the dominant landscape feature present at the marked site, while the notation "feature marked" identifies the natural feature that appears to have attracted the attention of the marking snow leopard (e.g., base of cliff, boulder, or a tuft of grass). If terrain or vegetation at which marking has been directed cannot be clearly seen, enter "none".

Table 4-1. Codes to Form 2. Snow leopard sign transect.

Column number	Item	Code	Description
4	Species code		
	Uncia uncia	SLP	Sign known to be left by snow leopard.
	Panthera pardus	LEO	Sign known to be left by common leopard.
	Lynx lynx	LYN	Sign known to be left by lynx.
	Other felid	FEL	Sign known to be left by another cat species (specify if possible).
	Canis lupus	WOF	Sign known to be left by wolf.
	Vulpus vulpes and *V. ferrilata*	FOX	Sign known to be left by fox.
	Cuon alpinus	WDD	Sign known to be left by wild dog or dhole.
	Canis domesticus	DOG	Sign known to be left by domestic dog.
	Other canid	CAN	Sign known to be left by another dog species (specify if possible).
	Other species	OTH	Sign known to be left by another predator (specify if possible).
	Not known	UNK	
5	Elevation - Take from altimeter (in meters)		
6	Aspect of site - (degrees)		Record the direction of the site containing the sign. See Figure 4-7.
7	Slope - Take from clinometer (degrees)		See Figure 4-7.
8	Rangeland-use		
	None	NON	Area receives no human use
	Seasonal grazing	SGR	Area grazed seasonally by livestock
	Year-round grazing	YRG	Area grazed throughout the year by livestock
	Other	OTH	Other type of land-use (describe)
9	Habitat type		
	Barren	BAR	Less than 10% of the ground has vegetation cover
	Grassland	GRA	Dominant vegetation is grassland
	Shrubland	SHR	Dominant vegetation consists of shrubs
	Woodland	WOO	Dominated by open trees and savanna
	Forest	FOR	Tree cover exceeds 30%

Table 4-1. Continued.

Column number	Item	Code	Description
9 Habitat type (continued)			
	Other	OTH	Other habitat type such as field (describe).
	Vegetation type	in-country	Use standard classification developed by recognized expert and provide codes to SLIMS node.
10 Landform ruggedness			
	Cliff	CLF	Terrain at site is very precipitous (slope more than 50°).
	Very broken	VBR	Terrain heavily broken by cliffs, rocky outcrops, ravines, and gullies.
	Rolling	ROL	Terrain has a relatively smooth land surface (e.g., rolling hills or alluvial fan).
	Flat	FLA	Terrain forms a level surface (e.g., plain).
11 Dominant topographic feature			
	Cliff	CLF	Terrain at site is very precipitous (slope more than 50°).
	Ridgeline	RID	Narrow crest of land sloping down on either side
	Hill-slope	HIL	Side or slope of a hill.
	Valley floor	VAL	Valley floor or adjacent slope.
	Basin or bowl	BOW	Bowl-like depression.
	Stream bed or drainage	STR	Site with seasonal or permanent water flowing through it.
	Boulder field	BOU	Outcropping of large boulders.
	Talus or scree slope	TAL	Accumulation of rocks and pebbles at base of a steep slope.
	Rockfall or landslide	ROC	The mass of rocks at the base of a cliff.
	Bluff	BLU	Steep slope bordering a stream or river.
	Terrace	TER	Level raised area bordering a stream or river.
	Glacier	GLA	Permanent ice-field.
12 Feature marked			
	Cliff (base or crest)	CLIF (1)	Steep rock face.
	Boulder	BOUL (2)	Large rock.
	Promontory	PROM (3)	Peak of land that juts out over a hillside, offering a good view of the land below.

Table 4-1. Continued.

Column number	Item	Code	Description
12 Feature marked (continued)			
	Knoll	KNOL (4)	Hillock or rounded protuberance on a hillside or ridgeline.
	Pass	PASS (5)	A narrow passage across a mountain top.
	Bush or tree	BUSH (6)	Only obvious feature present is a large bush or tree.
	Grass	GRAS (7)	Most obvious feature is a tuft of grass.
	None	NONE (8)	No obvious feature is present.
	Saddle	SAD (9)	Saddle (a low spot along a ridgeline).

Numbers represent alternative coding to minimize possible confusion with other environmental parameters

Column number	Item	Code	Description
13 Site type			
	Scrape Site		
	Non-relic	0	Usually only one scrape is present at the site or all the scrapes (and feces) are about the same age. No evidence of repeated use.
	Relic	1	Usually there are numerous (3-10) scrapes present of various ages. Due to remarking, some or most scrapes have a sculptured appearance. Feces of many different ages may also be present.
14 Type of sign			
	Scrape	SC	Scrape made by a snow leopard or other felid.
	Scratch (canid only)	SR	Scratch made by a canid.
	Feces (scat)	FE	Scat or dropping.
	Urine	UR	Urination mark.
	Scent spray	RC	Scent mark.
	Claw rake	CL	Claw mark made on a tree trunk or rock face and left by a felid
	Pugmark	PU	Footprint impression or track

Table 4-1. Continued.

Column number	Item	Code	Description
15	Sign age or visibility		
	Scrape		
	Very old	0	Extensive weathering and disintegration, scrape features poorly defined, often with vegetation growth in the depression and on the pile (age = at least 3 to 6 months).
	Old	1	Moderate weathering and disintegration, with the scrape showing a rounded form, occasionally with vegetation in the depression or on the pile (age = several months or more).
	Fresh	2	Slight weathering. Scrape has a well-defined form with "sharp" edges, is easily recognizable, and has no new vegetation growing in the scrape depression or pile (age = 1 to 4 weeks).
	Very fresh	3	Little or no weathering has occurred, so that the scrape has a very sharp and "clean" form, is very easily recognizable, and has no vegetation in its depression or pile. Sand or gravelly material may cover some vegetation, causing it to "bend-down". Other ephemeral sign such as tracks or urine may be observed, while scats deposited at the same time are obviously still fresh or very fresh (age = less than 1 week).
	Pugmark		
	Old	0	Pugmark is very poorly defined, with an obviously "weathered" appearance (more than 2 weeks old).
	Fresh	1	Pugmark has sharply defined edges and shape (several days, but less than one week old).

Table 4-1. Continued.

Column number	Item	Code	Description
15 Sign age or visibility (continued)			
	Very fresh	2	Pugmark is very fresh, showing fine surface details and having a very sharp edge (made less than 24 hours previously).
	Feces		
	Old	0	Scat is mottled and cracked, with a hard, dull surface and dry interior (several weeks to several months of age).
	Fresh	1	Scat is odoriferous and "fresh-looking", with a glossy, sheen inside (more than 2 days but less than 10 days of age).
	Very fresh	2	Scat is still wet outside and moist inside (no older than 2 days).
	Scent-sprayed Rocks		
	None	0	No detectable odor (more than 3 months old).
	Slight	1	Odor is just detectable.
	Moderate	2	Odor is readily detectable.
	Strong	3	Odor is unmistakable.
	Very strong	4	Odor is very strong (can be detected from 25 cm or more away; less than several weeks old).
	Claw or Tree Rake (living tree only)		
	Very old	0	Bark has fully covered the claw scars, completely healing the wound.
	Old	1	Claw scars on bark present but the scar has clearly started to heal.

Table 4-1. Concluded.

Column number	Item	Code	Description
15	Sign age or visibility (continued)		
	Fresh	2	Claw marks still very evident and sap may still be exuding from the wound, with other sign such as mud on the bark or pugmarks nearby.
16	Substrate type		
	Rock	1	Ground surface consists largely of rock.
	Sandy soil	2	Sandy appearance with particles having a diameter of less than 2 mm.
	Gravelly soil	3	Mixture of small pebbles (particle diameter more than 2 mm) and soil.
	Fine or silty soil	4	Soil consists of fine or very fine particles (clay, silt, and dust).
	Snow	5	Snow dominates.
	Vegetation	6	Vegetation dominates.
17	Sign measurement (centimeters)		See Figures 4-8 to 4-10.
18	Slope/aspect of transect (degrees)		See Figure 4-7. The value should characterize the overall direction of the transect as opposed to the marked site.

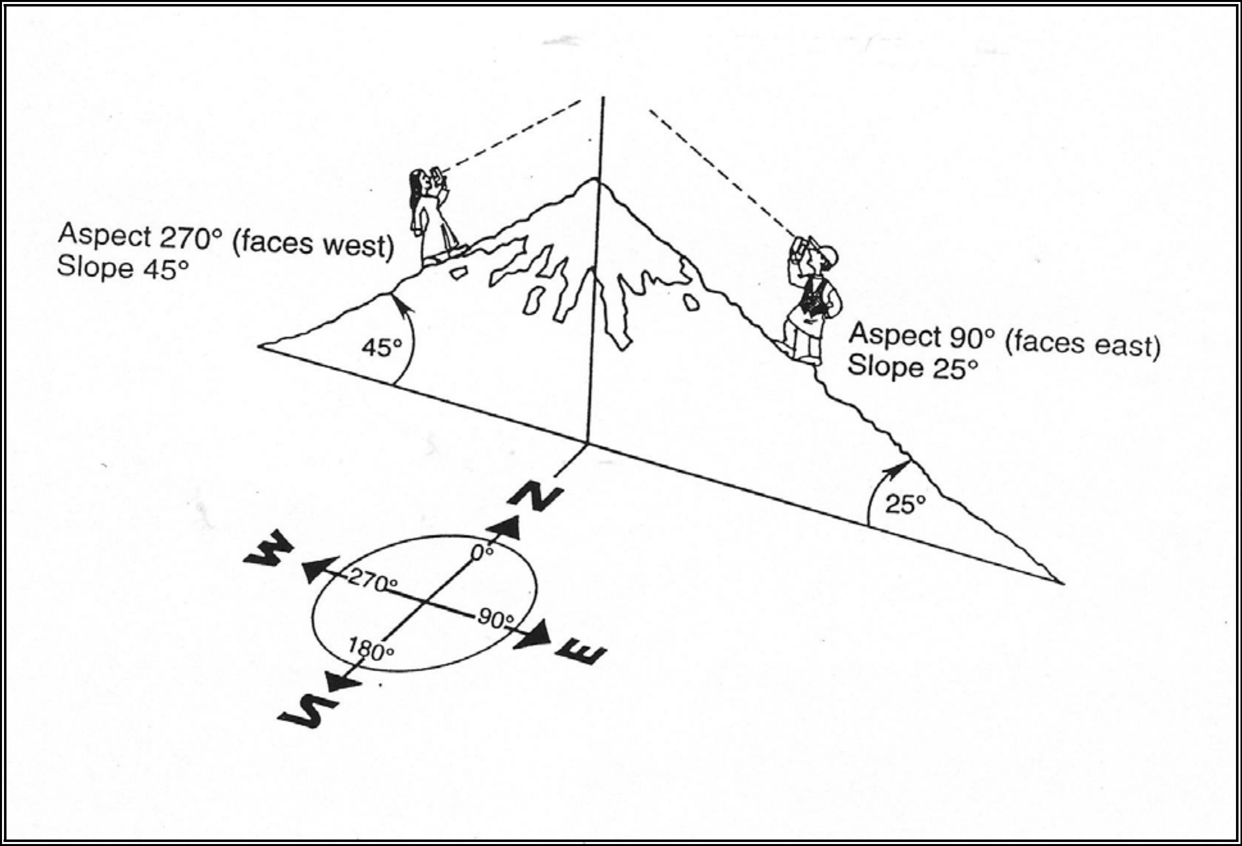

Figure 4-7. Measuring aspect and slope of observation or transect

Site type (Column 13) is used to identify sites used once and those visited repeatedly. Scrape groups or clusters are classified as being "relic" or "non-relic". Relic scrape groups are those that have been repeatedly used by snow leopards over a long period of time as opposed to non-relic scrape sites, which are not remarked and hence are transient in nature. Relic clusters are recognized by their obviously "sculptured" appearance, and the fact that vegetation touching scrapes grows on raised soil pedestals. Other clues include the presence of scrapes of many sizes and ages and feces ranging from fresh to very old and bleached.

Enter the kind and amount (number) of each sign present in Column 14, using a separate line for each individual item found at the site in question. Estimate the relative age of each item and enter a corresponding code into Column 15. A relative scale is used to age scrapes, as well as tracks, feces, rock scent, and tree rakes. For example, the age or visibility of scrapes is judged on a scale from 0 to 3 (old to fresh). Because scrapes are subject to wind or water erosion, their form becomes less well defined with time. The "pile" or mound loses its "sharpness" and plants start to grow on the scrape. Exact dating is possible only if there are clues from known weather events. For example, if it rained 15 days prior, and the substrate of one scrape shows pock-marks while the other does not, it can be safely deduced that the first scrape is more recent than the second, and that its age is no more than two weeks.

Record the type of substrate present in Column 16. Use Column 17 to record measurements such as the greatest length and width of representative scrapes or tracks, and
the vertical height above the ground surface of a scent-mark. Column 18 is for recording the slope and aspect of the transect. Figures 4-8 to 4-10 illustrate how to measure scrapes, rock scents and tracks. Scrapes are measured by noting the greatest length and width, while the diameter and length of feces are measured to the nearest 0.1 cm and its shape noted. Tracks are measured by recording their overall length and width, the length and width of the heelpad only, and noting whether it is a hind or forepaw impression. Record any obvious abnormality, such as a distinctly offset toe that might help identify an individual, as well as the number of individuals traveling together. Tracks are often easier to detect when the light angle is low and one is looking toward the light source.

Rock scents are often (but not always) detectable by their odor, although some are apparent by the dark stain present on the rock face. Record the height of a sprayed mark above ground level, as well as the feature marked (base of cliff or boulder) and its approximate dimensions (height, width, and length). Search for any hair that may have been caught on sharp edges of the marked rock face (indicating that a cheek-rub has occurred), look for claw-marks, and record other nearby sign such as scrapes, feces, and tracks. If a clinometer is available, measure the angle of the marked rock face, and note its aspect.

Assess habitat. Transect habitat characterization can be accomplished by noting the kind of habitat features present at random points along each sign transect walked. While not essential, characterizing the kind of habitat present (or "available") along a transect greatly aids in interpreting differences in sign frequencies among different transects or areas. It provides valuable baseline data on snow leopard marking behavior. Finally, characterization helps in classifying the transect and explaining the presence or absence of snow leopard sign.

Information can be recorded on a separate form or along with the sign data on Form No. 2 by using the letter "R" in Column 1 to differentiate between random and marked sites.

Using the attached Random Numbers Table (Appendix C), or a set of random numbers from another source, select four numbers for each transect up to 200 m in length, six numbers for each transect up to 500 m in length, and eight numbers for transects of greater length. Select the random numbers *before* walking the transect. Numbers can be selected with eyes closed and pointing with a pen or by randomly selecting a column and row (such as "3 rows across and 10 down" or "14 down and 4 across"). Reject values that are greater than the length of the transect or numbers that fall within 20 m of one another. Remember that numbers are cumulative from the beginning of the transect rather than additive.

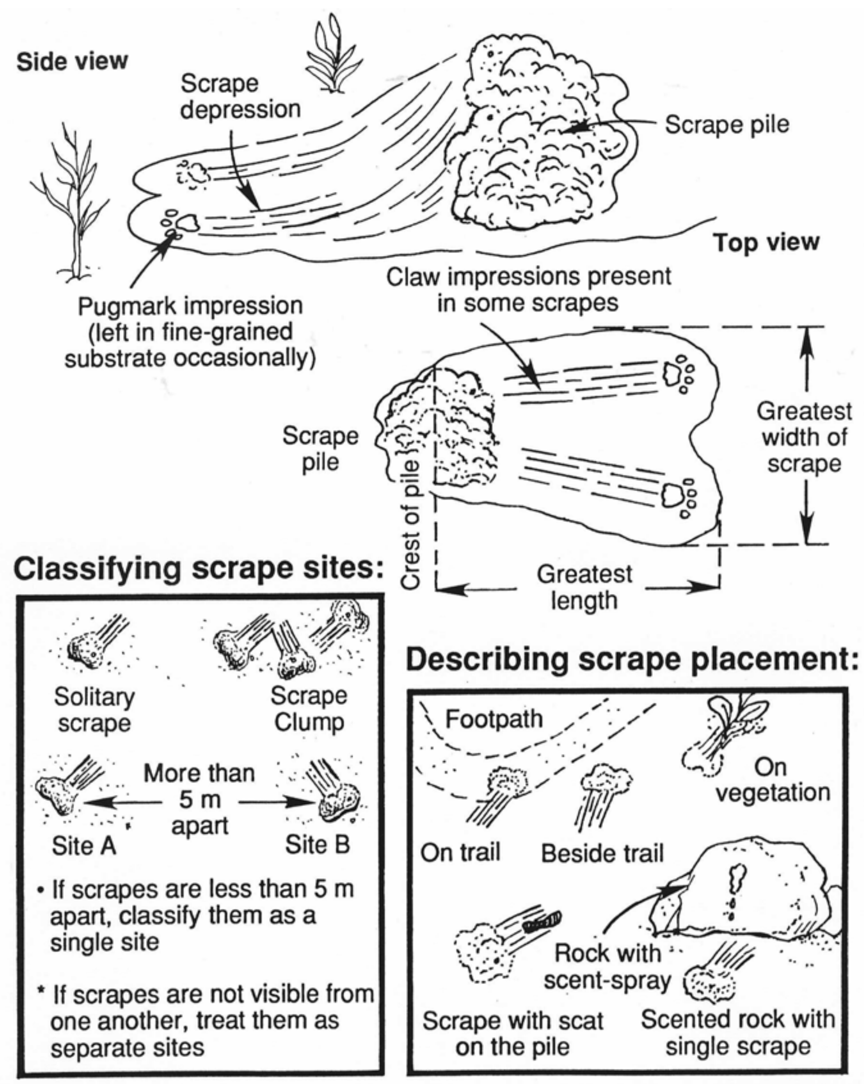

Figure 4-8. Measuring a snow leopard scrape and classifying scrape sites.

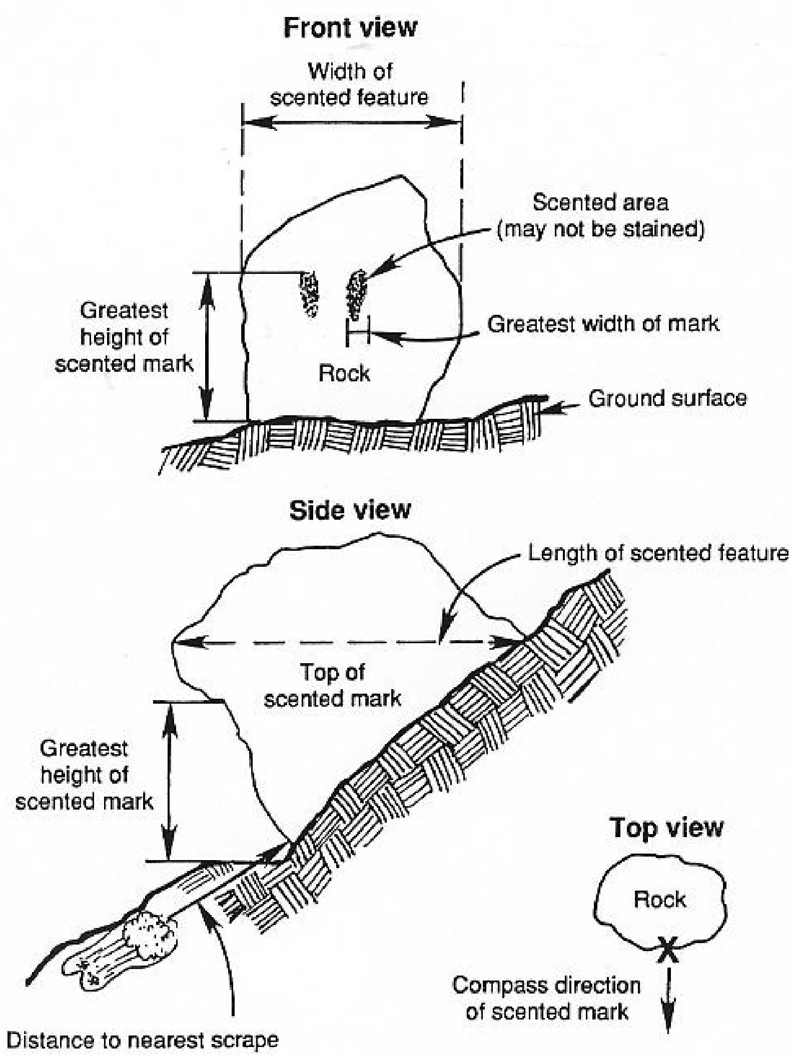

Figure 4-9. Measuring a scent-sprayed rock.

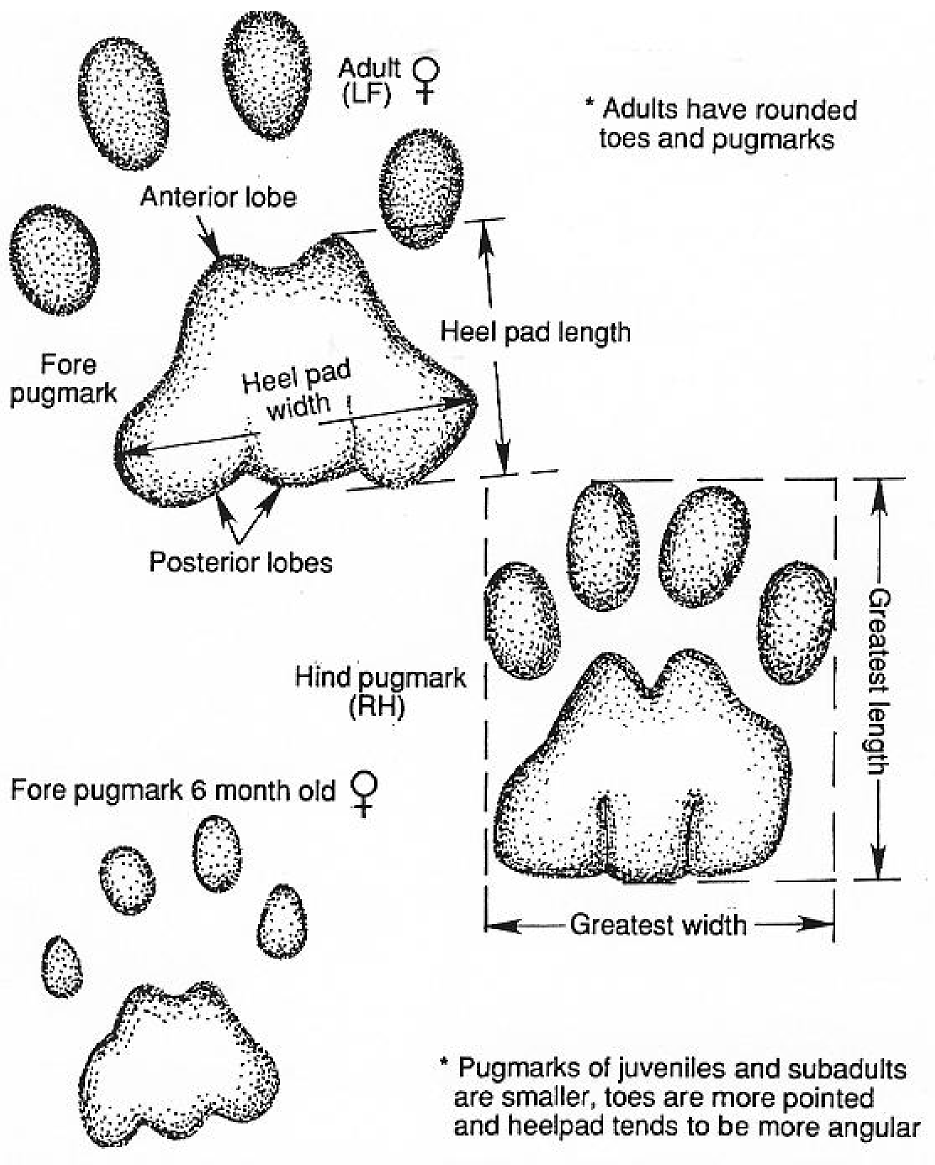

Figure 4-10. Measuring a snow leopard track.

Upon arrival at the random distance point, record the relevant environmental information listed above, including elevation, aspect, slope, rangeland-use, habitat type, landform ruggedness, topographic feature, and feature present for marking. In addition, information should be included on the presence or absence of ungulate species. For example, count the number of pellet groups in a circle with a 2 m diameter centered on the random site. Include only pellet groups that fall fully or more than 50% within the prescribed circle and note their relative age using criteria in Table 4-1.

Supplementary information. Each individual transect habitat characterization should be supplemented by notes on livestock grazing, loss of livestock to predators, hunting, and other information derived by questioning local people. Whenever possible, the observer should take black-and-white photographs that illustrate the terrain being sampled, as well as good examples of tracks, scrapes, and scats *in situ*.

Analyze Survey Data

This handbook assumes that the greater the density of sign, the greater the "relative abundance" of snow leopards within a particular area. However, sign frequency to actual cat density conversion figures are not provided because many factors must be considered, such as sample size, transect placement with respect to terrain, transect coverage, and observer skills. More information is needed on sign patterns within different terrain conditions across the cat's range to establish such conversion factors. This procedure may take time because the only reliable means of determining or estimating how many individuals are responsible for leaving the sign observed entails intensive radio-telemetry studies and tagging of individuals. As a starting point, we suggest the following procedure to "guesstimate" snow leopard numbers. Compute the average sign frequencies for each survey block, and classify these according to the following relative density classes:

High - more than 20 items per kilometer
Medium - 5 to 20 items per kilometer
Low - less than 5 items per kilometer

High density sign sites could be indicative of snow leopard densities as high as 10 or more cats per 100 km^2, while low density sites may have only one or two cats in the same area.

Report Survey Results

Box 4-1 suggests headings and an outline for the report.

Box 4-1. Final survey report outline and content.

Heading	Content
Title	Title, with the name, affiliation, and address of each author
Introduction	Background information
Objectives	Primary objectives of the survey
Study area	Description of location, physical features, human population, activities and land-uses, climate, and vegetation
Methods	Description of methods
Results	
Sign transects	Summary of sign located along sign transects
Habitat evaluation	Description of habitat(s) in the area
Major threats	Major threats to snow leopards and their prey
Management issues	Description of the major management issues, including information from interviews of local people
Recommendations	Recommendations for wildlife protection and management
References	Literature cited
Appendices	Persons contacted and interviewed for information, supporting tables, figures, and maps.

The following are specific items of information that should go into a final report.

For each transect:

(a) Length, starting and ending elevation, habitats present, dominant vegetation types, and landforms.

(b) Total number of scrapes, feces, tracks, and other snow leopard sign encountered.

(c) Frequency or percent of each age class observed by each kind of sign (e.g., number of scrapes classified as very fresh, fresh, old, or very old, and relic versus non-relic sites).

For all transects combined:

(a) Total length of transects surveyed, mean transect length, minimum and maximum transect lengths.

(b) Mean and total number of sites (per transect) with scrapes only, with feces only, or with scrapes and feces.

(c) Average number (density) of all sign encountered per kilometer (e.g., total all snow leopard sign seen and divide by the total distance of all transects run).

(d) Scrape frequency per kilometer.

(e) Density of sites with more than one scrape present per kilometer of transect.

Graphics:

Photographs of representative parts of the area surveyed showing the type of terrain, habitat, and vegetation present.

Map indicating the geographic location of the area surveyed, preferably accompanied by maps indicating transect placement with respect to the local topography.

Optional Data to Present:

Sign frequency of transects classified according to their topographic location and dominant topographic feature (for example, confluence transects = transects beginning or ending at a stream confluence, with no point further than 1 km from a stream; major ridge = transect not classified as above, but located along well-defined ridgelines dividing stream watersheds; ridge = all other ridge transects; and other = transects in all other locations (see Ahlborn and Jackson 1988).