CHAPTER 7

A FIELD SURVEY OF SNOW LEOPARD PRESENCE AND HABITAT USE IN NORTHWESTERN INDIA

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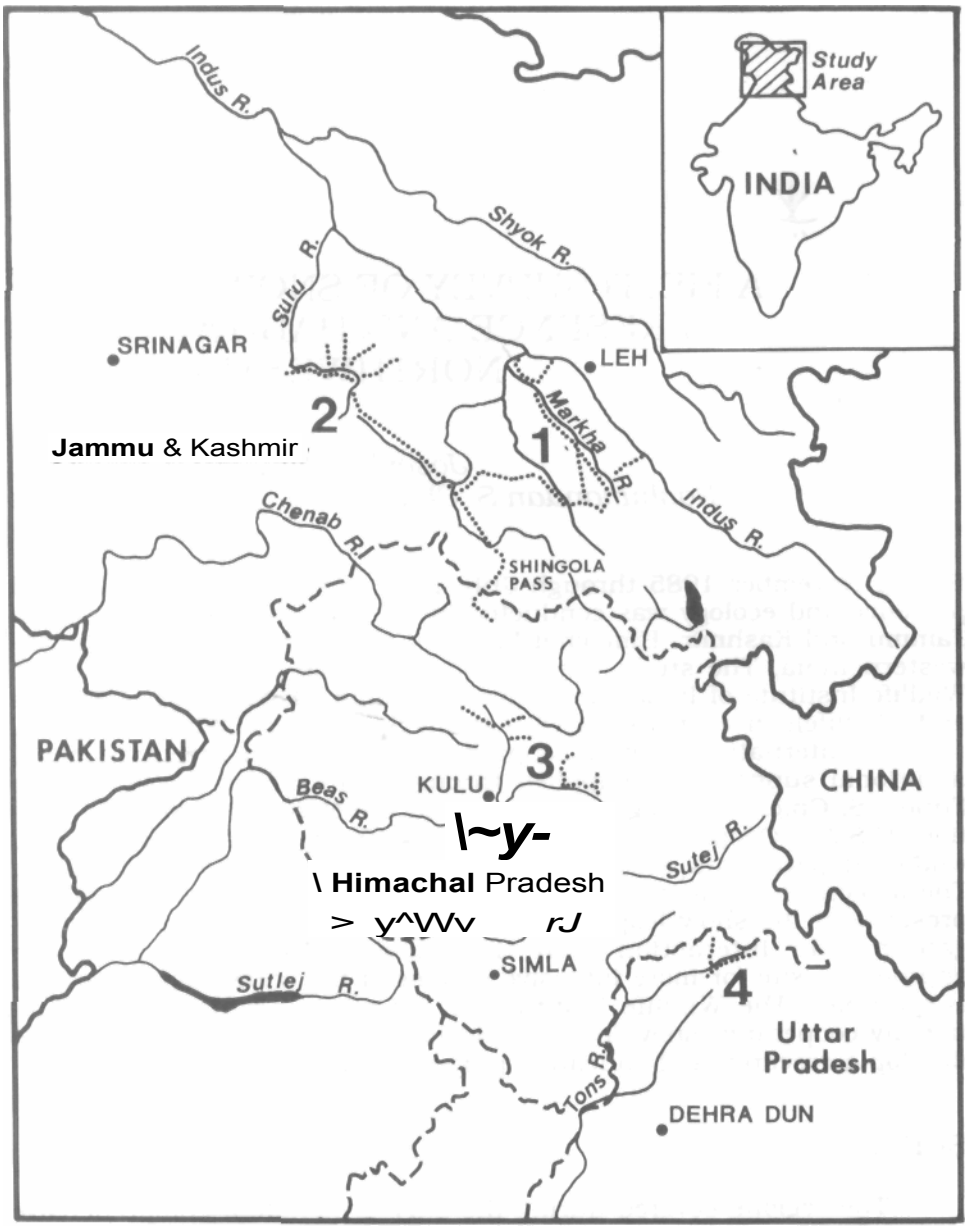
During November 1985 through July 1986. a survey of snow leopard presence and ecology was conducted in selected areas of the states of Jammu and Kashmir, HImachal Pradesh, and Uttar Pradesh in northwestern India. The study was carried out under the auspices of the Wildlife Institute of India (Government of India. Department of Forests and Wildlife), In cooperation with the U.S. Fish and Wildlife Service, and the International Snow Leopard Trust (Fox and Freeman 1984]. Additional support was supplied through grants from World Wildlife Fund-US, Chicago Zoological Society, and the National Wildlife Federation (U.S.A). Cooperation and logistical support was also provided by wildlife departments within the states where the surveys took place. The objectives of the survey were essentially to determine the relative presence of the snow leopard and its associated prey species, investigate human interaction with the snow leopard, and select an appropriate site for more intensive studies of the snow leopard and its ecosystem. The Wildlife Institute of India has begun this internationally cooperative snow leopard project as an initiation of its effort to develop a research and education program in high altitude ecology.

SURVEY AREA

The regions covered during the survey include a comprehensive array of representative snow leopard habitat throughout northwestern India. Survey sites were generally between 3.000m and 4,500m in elevation, and varied from the moist alpine meadows and timberline forest on the southern slopes of the Himalaya and Pir Panjal ranges, through the somewhat drier inner valleys and immediate northern side of the Himalayan crest region, to the high desert Trans-Himalayan mountains of Ladakh. The areas surveyed were: 1) the Zangla-Khurnak route and Markha valley region in the Trans-Himalayan



Flgure 1. Map of snow leopard survey areas in northwestern India: 1) Central Ladakh [J.&K.) - Markha and Khurnak regions, 2) Southern Ladakh (J.&K.) - Upper Suru and Zanskar Regions, 3) Kulu-Manali region (H.P.) - Upper Beas and Parbatl catchments, 4) Govind Pashu Vihar Wildlife Sanctuary (U.P.) - Upper Tons Valley. The main survey routes are shown with dotted lines.

Zanskar Range of central Ladakh (Jammu & Kashmir). 2) the upper Suru. Zanskar, and Lung Nag-Kurgiakh valleys on the north side of the Himalayan crest in southern Ladakh (Jammu & Kashmir), 3) the upper catchments of the Beas and Parbati valleys on the south side of the Pir Panjal Range In the Kulu-Manali region, and the inner Himalayan Jankar valley within the Lahul region, both of Himachal Pradesh (H.P.), and 4) the upper Supin and Beech Koopri valleys within the Govind Pashu Vihar Wildlife Sanctuary on the south side of the main Himalaya in Uttar Pradesh (U.P.) (Figure 1). Approximately 920 km of major and tributary

valleys were surveyed, 745 in Jammu & Kashmir (Ladakh). 95 km in Himachal Pradesh, and 80 km in Uttar Pradesh. The approximate areal extent of of the regions surveyed was 1.450 km^2 in central Ladakh. 2.150 km^2 in southern Ladakh. 265 km^2 in Lahul, 490 km^2 in the Kulu-Manali region, and 530 km^2 in Govind Pashu Vihar.

SIGN SURVEYS

Evidence of snow leopard presence in the form of scrape markings and tracks were tabulated along the 920 km of valley survey routes. Because of the long distances covered, continuous valley-bottom transects were used in searching for sign along the primary lines of travel. In small valleys there was random selection of valley-bottom transect routes, but in valleys with impassable rivers, transects were confined to the side of the valley with a trail. The transects were systematically sampled in 5 km sections, recording sign and habitat characteristics. There appears to be a definite trend toward increases in snow leopard sign as one moves from the moist southern slopes of the Pir Panjal and Himalaya ranges to the Trans-Himalayan mountains in the north (Table 1).

In Govind Pashu Vihar [U.P.) during April, two sets of leopard tracks were encountered in the 80 km of valley surveyed and the frequency of snow leopard scrape markings was 0.01 per km of valley bottom. During May-June in the areas of Kulu-Manali surveyed in H.P., two sets of leopard tracks were found in 95 km of Survey and no scrapes were found (Table I). In these survey areas on the southern slopes of the Pir Panjal in H.P. and the main Himalaya in U.P.. although the snow leopard is known to occur, common leopard Panthera *pardus* is also present and we could not distinguish these species on the basis of the tracks or scrape marks found. However, the limited number of scrapings found in locations characteristic of snow leopard marking sites (e.g., cliff-bases) suggests a relatively low occurrence of this species.

The upper Suru. Zanskar. and Lung Nag-Kurgiakh valleys in southern Ladakh had substantially greater amounts of sign than areas

TABLE I. Frequency of snow leopard sign along major valleys in four survey regions.

Survey location	Month	Km of survey	Frequency Km travelled per track found	of sign Scrapes per km
Govind Pashu Vihar*	April	80	40	0.01
Kulu-Manali	May	95	48	none
Southern Ladakh	June-July	255	64	0.2
	Nov.-Dec.	95	23	0.1
Central Ladakh	July Jan. -	130	14	2.6
	March	265	8	1.1

sign could be snow leopard or common leopard.

south of the Himalayan crest, and In these areas only the snow leopard is present. Seasonal differences in sign frequency are related in part to the presence of snow in winter which tends to conceal old scrapes and enhance track visibility, and the Ladakh results are accordingly separated by season. During winter surveys, the upper Suru valley in southern Ladakh and the Markha valley region in central Ladakh had respective track frequencies of 1 per 23 krn and 1 per 8 km. and scrape frequencies of O.I/km and 1.1/km. In summer, comparable areas In the upper Suru, Zanskar.and Lung Nag of southern Ladakh and the Khurnak valley of central Ladakh had respective track frequencies of 1 per 64 km and 1 per 44 km. and scrape frequencies of 0.2/km and 2.6/km (Table I),

Acknowledging a high degree of variability in the occurrence of snow leopard sign over the survey routes, the relatively high frequency shown for central Ladakh appears to reflect a real difference in snow leopard abundance. Factors such as time of year, which can affect both snow leopard behavior patterns (e.g., scraping frequency) and the availability of good tracking substrate (e.g., snow), and the intensity of search effort must be considered in evaluating the above frequencies of snow leopard sign. In addition, terrain geomorphics may also be important in determining whether valley bottoms are the most appropriate travel routes or marking sites for snow leopards (and thus for surveys) in a given area. Still, the order of magnitude differences in sign frequency suggest real differences in snow leopard presence among

the areas surveyed, with central Ladakh showing by far the greatest concentration of snow leopard sign.

HABITAT USE

On the basis of average habitat characteristics estimated over 5 km sections along the survey routes, the occurrence of snow leopard sign was associated with relatively steep and rugged terrain (Table II). Whereas ungulates were randomly distributed along the survey routes (except for wide valleys), snow leopard sign was more prevalent in relatively narrow and steep-sided valleys. The variability associated with the presence and abundance of snow leopard sign was high, due both to terrain and seasonal Influences (as mentioned above). For example, although snow leopard scrape abundance was clearly associated with the presence of valley-bottom cliffs (Figure 2). some survey sections with abundant cliffs of this type had few or no scrapes (due to ice or snow cover in winter, or frequent livestock traffic or high water in spring-summer) whereas others (e.g.. with major stream confluences) had numerous scrapes. Still, the association of snow leopard sign with rugged terrain remains clear.

TABLE II. Average 5 km section habitat characteristics associated with the occurrence of snow leopard sign and numbers of ungulates.

Category	Snow leopard scrapes	Snow leopard tracks	Ungulates	Survey habitat
	n=673	slope angle (degrees)		cliff	43
Elevation of valley bottom (m)	3800	Percent of valley bottom with		Percen	51
Valley side					

t of valley slopes with cliffs	45			n=184
Valley width (m)	66	n=45	n=1426	3750
Percent snow cover on valley sides	2	3850	3900	
		41	36	
6		48	29	
Snow depth on valley bottom (cm)	2	45	36	35
		76	161	225
		59	30	
		7	5	

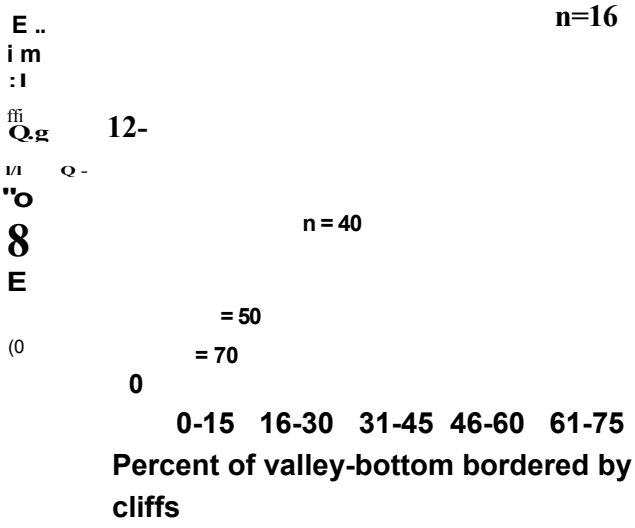


FIGURE 2. Distribution of snow leopard scrape frequency relative to the percent of valley-bottom survey routes that are bounded by cliffs.

More detailed information on snow leopard habitat use was derived from habitat sampling along their track routes. Snow leopard track routes were characterized with regard to habitat at 100m intervals for a total of 58 km. all during December-March in Ladakh, Twenty-six separate sets of tracks were followed, 12 of single individuals (27 km), nine sets of two individuals (21 km), four sets of three individuals (9 km), and one set of four individuals (1 km). The tracks were found at elevations between 3,300m and 4,725m, with a mean elevation of 4,040rn. Nine kilometers of tracks were along ridgetops, 20 km on mountain slopes, and 29 km on valley bottoms.

Slope aspects were not used randomly by snow leopards, but *a* greater use of westerly and avoidance of easterly aspects appears to be a reflection of the east-west trending Markha Valley where most data was collected. The mean slope angle on mountain slope travel routes was 36. on ridge top routes 28°. and on valley bottom routes 15". Along mountain slopes and ridgetops. snow leopard travel routes traversed broken terrain for 49% of the distance, whereas along valley bottoms 78% of the travel route was over smooth terrain. However, 50% of all track locations were within

5m of sharp breaks in terrain such as cliffs and river terrace bluffs and 75% were within 30m of such features. Habitat use by snow leopard, as compared to its .major ungulate prey blue sheep *Pseudois* nayaur and ibex Capra *ibex sibirica.*

is presented in Table III. Especially in terms of its travel routf;'s close association with cliffs, the snow leopard is using habitat frequented by blue sheep and ibex (Figure 3). The blue sheep and ibex use cliffs as escape habitat because they are more agile than the snow leopard in such terrain. However, they must leave the safety of the cliffs to find forage. The snow leopard's use of relatively gentle slopes, but In close association with cliffs suggests the use of cliff-open slope borders as cover when searching for ungulate prey.

The vegetation occurring along snow leopard travel routes is probably consequently related to a prior selection for the terrain characteristics outlined above. The most commonly traversed vegetation types were herbaceous communities. These commonly included *Stachys* sp. dominated communities on mountain slopes, and mixed herbaceous types on ridgetops and along valley-bottom river gravels. Vegetation along travel routes averaged 11% ground cover, which reflects the generally sparse vegetation cover in this region, especially during winter. A high percentage of snow cover along travel routes [snow depth was commonly only a few centimeters) was associated with the ease of following tracks in snow. Snow cover was 58% along snow leopard ridge top and mountain slope travel routes, and 89% on the valley bottom routes.

TABLE III. Habitat use characteristics and population composition based on track routes for snow leopard and visual observations for blue sheep and *Ibex.*

Category	Snow Leopard	Blue sheep	Ibex
Mean elevation (m)	4040	4200	4300
Mean slope angle	24	31	31
Mean distance from cliffs (m)	35	72	(12
Mean group size	1.6	11	13
Composition*		103m:100f: 39yr:97kid 23yr:78kid	91m:100f:

• m = male, f = female, yr = yearling

MARKING SITES

Sixty-eight fresh snow leopard scrape markings were found along the 58 km of tracks. 65 on valley bottom routes, three

on mountain slopes, and none on the ridgetop routes. Spray-marks (marking could not always be directly associated with the tracks being followed) were located at 29 sites, all along valley-bottom routes. Fresh scats were found at eight locations. The habitat associated with marking sites (scrapes, sprays, and scats) was characterized by areas of gentle terrain in close proximity to cliffs or other terrain breaks.

From the hundreds encountered. 80 snow leopard scrape markings were randomly selected for measurement of dimension and associated habitat characteristics. Sixty-four (80%) of the scrapes were found adjacent to cliffs, the remainder either near free boulders or slight breaks in terrain (e.g.. stream bank, trailside). The mean distance from cliff, boulder or other break in terrain was 45 cm. Substrates in which scrapes were found included snow and sandy and gravelly soil. Average dimensions of the scrape marks were: total length (pit and pile) 36 cm, length of pit 20 cm. width of pit 19 cm. depth of pit 5 cm, height of scraped-up pile 6 cm. Twenty percent of the scrape piles had noticeable urine deposits on them.

Seventy snow leopard spray sites were characterized. 53 occurring on rocky outcrops. 11 on free boulders, and six on trees. The spray mark was commonly located on the underside of a protruding outcrop or boulder. The mean height of the spray mark above ground level was 90 cm and mean distance out from the cliff surface or boulder-ground contact was 56 cm. The angle of the surface sprayed, relative to a level ground surface, averaged 166°. Forty-four percent of the spray sites were judged to have only light use, (one or two marks visible). 44% with moderate use (3-5 markings visible), and 12% with heavy use (>5 markings). Odor was discerned at 27% of the spray marks (20% light, 7% moderate odor).

INTERVIEWS WITH VILLAGERS

In the survey areas on the southern side of the Himalaya and Pir Panjar ranges In Uttar Pradesh and Hlmachal Pradesh, respectively. three of 36 villagers questioned had seen a snow leopard. Snow leopard kills of livestock were reported to occur, but were not common. Only a few people in the southern portion of Ladakh were interviewed: snow leopards were rarely seen and livestock was reported to be occasionally killed by snow leopards, although more concern was often voiced about predation by wolves and (in the Suru valley) brown bears. Within the Markha valley region of central Ladakh. nine of 38 persons interviewed had seen a snow leopard. Livestock kills by snow leopard and wolf were reported to be fairly Common. During the 12 month period from April 1985 to March 1986 about 130 sheep and goats and 10 yak and yak-cow hybrids were reported to have been killed by these predators (approximately equal predation by snow leopard and wolf).

EVALUATION OF SURVEY RESULTS

Sign Surveys

Evidence of snow leopard presence was found in each of the regions surveyed. However, the substantially greater amount of sign found in central Ladakh indicates that this is the best area for snow leopard in India that has been surveyed to date. It is consequently the area that has been selected for more intensive investigations of snow leopard ecology. However, several factors remain to be considered in

interpreting the concentrations of sign in central Ladakh. The surveys were conducted in large part during winter, the season of snow leopard breeding when production of sign (e.g., scrapes) appears to be greatest (Ahlborn and Jackson, this volume). The relatively low snow depths in central Ladakh allow an ease of winter travel for predators such as the snow leopard that is not found in the deep snowfall zones near the Himalayan crest. It is thus possible that there is some seasonal movement of snow leopards to regions of low snowfall during winter, with consequent greater accumulations of sign during the breeding season in these drier areas.

Furthermore, the valley bottoms of our surveys in central Ladakh provided travel corridors and ideal marking sites (cliffs along dry river gravels) not consistently found in similar-sized valleys in the other regions that were investigated. A larger percentage of wide valleys surveyed in southern as opposed to central Ladakh. probably also contributed to the differences in sign frequency between the two areas. Even so. alternate sites for snow leopard marking (e.g., ridgelines, bluffs, tributary valleys) in the crest region and southern side of the Himalaya did not have comparable amounts of sign relative to central Ladakh. Snow leopards undoubtedly do make some use of the heavy snowfall zones of the main Himalaya, but the period of this use is probably predominantly during summer when marking behavior (e.g.. the production of scrapes) is less prevalent. This would explain the lack of snow leopard interaction with local people in winter and the small amounts of sign (especially scrapes) that we found in Uttar Pradesh and Himachal Pradesh. That snow leopards with ranges along the Himalayan crest zone may move to regions of low snowfall during winter is an important characteristic that requires further investigation. If the moist Pir Panjal Range of H.P, and the Himalayan crest region of U.P. do not provide prime year-round habitat, then we would expect snow leopard densities to be somewhat lower than the drier Inner Himalayan valleys and Trans-Himalayan region.

Because snow leopard scrape markings have been found to be most prevalent adjacent to valley bottoms (Ahlborn and Jackson, this volume), sign surveys such as that reported here probably provide the best technique for initial determination of snow leopard presence and abundance in an area. However, as a follow-up to these long-distance valley-bottom surveys, more detailed measures of Sign frequency can be performed in areas where significant snow leopard abundance is indicated. And because sign (especially scrapes) appears to be closely associated with snow leopard density (Ahlbom and Jackson, this volume), scrape frequency may provide a useful measure of relative snow leopard abundance.

The more detailed sign surveys may be appropriate in areas where snow leopard sign scrape frequencies of greater than 20 per km are found on the long-distance valley-bottom surveys. Terrain where there Is sufficient sign to allow statistical measurements (e.g., valley bottoms and ridgelines in association with river confluences), will probably provide the best sites for comparisons between areas. Multiple short transects that tabulate scrapes should be used to provide an accurate measure of sign frequency. Perhaps 10 transects situated on valley bottoms, and another five along ridgelines would be appropriate. Transect lengths of 250-800m are recommended (Ahlborn and Jackson, this volume), and the shorter transects may be used in areas with abundant sign. Care must be taken to select transect locations that are comparable in terrain characteristics from one site to another.

The large ungulate prey species of the snow leopard (most commonly blue sheep and ibex in the present study) are still widely

distributed in the Himalayan and Trans-Himalayan regions surveyed. However, population densities appear to have been diminished around some of the administrative centers and along road corridors (e.g.. Kargil-Padum} in Ladakh. There is also a noticeable increase in these species' wariness toward humans along road access routes and in areas of western Ladakh and the southern side of the Himalaya where they are more commonly hunted. Better distribution and population data on these ungulate species is greatly needed in the Himalayan region. The smaller herbivore prey species such as hare, marmot, mouse hare and small rodents are unevenly distributed but locally abundant in suitable habitats in Ladakh, and probably provide important alternate prey for snow leopard, wolf, and brown bear. The interaction of these predators and prey is an important aspect of snow leopard ecology that needs to be addressed in terms of both competition and their relative impacts on predation of domestic livestock.

With regard to studies of snow leopard ecology in central Ladakh, it appears that there is currently a sufficient population density in accessible areas of the Hemis National Park to warrant an intensive research effort on this endangered species. Such work would provide a very useful comparision with spatial distribution and habitat use data that has recently been gathered in western Nepal

[Jackson and Alhborn, this volume). *The* research should be designed to answer basic conservation questions relating to the maintenance of snow leopard and their prey populations in a manner compatible with the socio-economic development of the region.

Human Interaction With Wildlife

In central Ladakh the snow leopard is tolerated as an occasional killer of livestock because in most cases the villagers (who are Buddhist and averse to killing animals themselves) are able to retrieve the carcass and utilize the meat. Thus, the interaction can often be positive as far as the villager is concerned. How beneficial it *Is* to the snow leopard depends on how often It is able to keep the kill for its own consumption. However, when a snow leopard gets into a household livestock pen and kills 30 or 40 sheep and goats at a time, such activity is not tolerated and under these circumstances snow leopards are often killed. Such killing appears to be an important mortality factor for snow leopards in the region. In this regard, an important question that must be addressed is whether the snow leopards that take livestock are in any way different (e.g.. injured, old) from the general population. Furthermore, both the importance of livestock as a food resource for snow leopard populations, and the economic losses to villagers associated with predation by snow leopard need to be investigated more thoroughly.

Central and southern Ladakh appear to be areas where there is substantial interaction between human resource use and the snow leopard. For example, although villagers contend that the wild ungulates do not deprive their domestic animals of food, there is undoubtedly some competition between blue sheep and domestic sheep and goats. The degree of this competition will determine the long term carrying capacity of the rangelands for wild ungulates and. hence, for snow leopards that subsist on wild prey. These are important concerns if, for example, efforts are to be made In developing pasture lands or increasing livestock populations in the region.

There is little doubt that the traditional levels of natural resource uses in Ladakh are compatible with snow leopard survival; they have been coexisting for centuries. However, rapid changes have been occurring In the social structure, resource use and availability, and access in the region; the effects of these on wildlife need to be documented. In the meantime, perhaps some immediate management programmes can be established to insure better snow leopard survival under both traditional and modern conditions. Such programmes could Include the provision of materials for securing household livestock pens against entry by snow leopards, and providing better protection from hunting (or a more even hunting distribution) for the ungulate species along road corridors. Also, the identification and establishment of areas for Intensive conservation management (parks and reserves) should continue to develop as more information becomes available.

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