CHAPTER 19

Snow leopards: conflict and conservation

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Adult male snow leopard photographed in February 2003 using a TrailMaster 1550 film camera trap at an elevation of nearly 13,000 feet in Hemis National Park, Ladakh, J&K State, India. © Snow Leopard Conservancy.

Introduction

The endangered snow leopard (*Panthera uncia*) is perhaps the world's most elusive and charismatic large felid. The wild population is roughly estimated at 4500–7500, spread across a range of 1.2–1.6 million km^2 in 12 or 13 countries of South and Central Asia, namely Afghanistan, Bhutan, China, India, Kyrgyzstan, Kazakhstan, Nepal, Mongolia, Pakistan, Russia, Tajikistan, Uzbekistan, and possibly also Myanmar (Fox 1994; Nowell and Jackson 1996; Fig. 19.1). Snow leopards suffer from similar conservation challenges as other large felids, namely persistence at naturally low densities, extensive home ranges, dependence upon prey whose populations are low and/or mostly declining, and high vulnerability to poaching and other anthropogenic threats. They inhabit mountainous rangelands at elevations of 3000 to over 5000 m in the Himalaya and Tibetan Plateau, but as low as 600 m in Russia and Mongolia (Sunquist and Sunquist 2002). Snow leopard habitat is among the least productive of the world's rangelands due to low temperatures, high aridity, and harsh climatic conditions, with an average peak graminoid biomass of 170 kg ha^{-1} (asymmetric 95% CI 128–228 kg ha^{-1}; Mishra 2001). Consequently, prey populations are also relatively low, ranging from 6.6–10.2 blue sheep (*Pseudois nayaur*) km^{-2} in productive habitat in Nepal (Oli 1994) to 0.9 ibex (*Capra ibex*) km^{-2}

Figure 19.1 Distributional range of snow leopards. (Adapted from Fox 1994.)

in marginal habitat of Mongolia (McCarthy *et al.* 2005).

Traditional pastoralism and agro-pastoralism are the predominant land uses and sources of local livelihood in snow leopard habitat, with seven range countries having over 25% of land area under permanent pasture, >50% of their human population involved in agro-pastoralism, >40% living below national poverty levels, and average per capita annual incomes of US $250–400 (Mishra *et al.* 2003a). Although relatively few humans live in snow leopard habitat, their use of the land is pervasive, resulting in ever-increasing human–wildlife conflict, even within protected areas. Snow leopards, and other sympatric wildlife range across the larger landscape beyond protected areas, albeit at low densities. Since few (if any) protected areas are free of human influence, the snow leopards' survival hinges upon an uneasy coexistence with subsistence pastoralists and farmers eking out their living from the same harsh environment.

In this chapter, we review pertinent aspects of snow leopard behaviour and ecology, followed by an assessment of threats arising from the above-mentioned livestock–predator–wild prey paradigm. We conclude with a discussion of alternative conservation measures currently being applied in efforts to reverse this species' declining population trend.

Snow leopard: an overview of adaptation for mountain living

The snow leopard is a large felid, with males weighing 45–55 kg and females 35–40 kg, a shoulder height *c.* 60 cm and head-body length of 1.8–2.3 m (Hemmer 1972). With its smoky-grey pelage tinged with yellow and patterned with dark grey, open rosettes and black spots, the snow leopard is especially well camouflaged for life among bare rocks or patchy snow (Figure 19.2). It has a well-developed chest, short forelimbs

Figure 19.2 Snow leopard investigating a scent-sprayed rock situated on a corridor frequently used by a other individuals. © Snow Leopard Conservancy.

with sizable paws, long hind-limbs, and a noticeably long tail (75–90% of its head and body length), giving it an amazing agility for negotiating steep terrain or narrow cliff ledges (Sunquist and Sunquist 2002). Adaptations for cold include an enlarged nasal cavity, long body hair with dense, woolly underfur (belly fur up to 12 cm in length), and a thick tail that can be wrapped around the body for added warmth while at rest. Mating occurs between January and mid-March, a period of intensified social marking and vocalization (Ahlborn and Jackson 1988). In captivity, oestrous lasts 2–12 days, with a cycle of 15–39 days (Nowell and Jackson 1996). Age at sexual maturity is 2–3 years (Sunquist and Sunquist 2002). There is no information on longevity in the wild. Litter size is usually two to three and exceptionally as large as seven. Dispersal is said to occur at 18–22 months of age, and sibling groups may remain together briefly at independence (Jackson 1996). This may explain reported sightings of as many as five snow leopards in a group (Hemmer 1972).

Snow leopards favour steep, rugged terrain well broken by cliffs, ridges, gullies, and rocky outcrops (Jackson and Ahlborn 1989; Sunquist and Sunquist 2002); however, in Mongolia and Tibet, they occupy relatively flat or rolling terrain when sufficient cover is available (Schaller 1998; McCarthy 2000). Home range size varies from 12 to 39 km^2 in productive habitat in Nepal (Jackson and Ahlborn 1989) to 500 km^2 or more in Mongolia with its open terrain and lower ungulate density (McCarthy *et al.* 2005). Densities range from <0.1 to 10 or more individuals per 100 km^2, but current knowledge is insufficient for generating a reliable range-wide population estimate.

The four telemetry studies to date reveal largely overlapping male and female home ranges, but with use of a particular area usually separated temporally. In Nepal, 42–60% of home range locations for four cats occurred within 14–23% of their respective home areas: these commonly used core areas intersected the most favourable local topography, habitat, and prey base (Jackson and Ahlborn 1989). Solitary and typically crepuscular, snow leopards remain within a small area for a week before shifting to another part of their home area. Mountain ridges, cliff edges, and well-defined drainage lines serve as common travel routes and sites for the deposition of signs, including scrapes, scats, and scent marks (Ahlborn and Jackson 1988). Core areas are often used by more than one snow leopard and are marked significantly more frequently than non-core sites, suggesting that such marking may help space individuals and thereby facilitate more efficient use of sparse resources (Jackson and Ahlborn 1989). In Nepal's

rugged habitat, leopards moved up to 7 km daily (straight-line distances), but averaged *c.* 1 km (Jackson and Ahlborn 1989); whereas in Mongolia, their daily movements were considerably greater at 12 km, with one female covering 28 km within a single day (McCarthy *et al.* 2005).

Ultimately such differences may reflect variation in prey availability. An opportunistic predator, the snow leopard is capable of killing prey up to three times its own weight, so that only adult camel (*Camelus bactrianus*), kiang (*Equus* spp.), and wild yak (*Bos grunniens*) are excluded as potential prey (Schaller 1998). The snow leopard's distribution coincides closely with its principal prey, the bharal (blue sheep) and ibex, ungulates with mean body weights of 55 and 76 kg, respectively (Mishra *et al.* 2002). These caprids reportedly contribute more than 45% and up to 66% of the snow leopard's diet, with livestock providing as much as 40–58%, though generally more on the order of 15–30% (Schaller *et al.* 1988; Oli *et al.* 1993; Chundawat and Rawat 1994; Jackson 1996; Bagchi and Mishra 2006). Important supplementary prey items (approximately 12–25% of diet) are marmot (*Marmota* spp.), pika (*Ochotona* spp.), hares (*Lepus* spp.), small rodents, and game birds. Annual prey requirements are estimated at 20–30 adult bharal, with radio-tracking indicating a large kill every 10–15 days (Jackson and Ahlborn 1984; Jackson 1996). Unless disturbed, a snow leopard may remain on its kill for up to a week (Fox and Chundawat 1988).

Status and threats to snow leopards

Snow leopards were first listed as endangered under the 1972 IUCN red list data. The 1975 enactment of the Convention on International Trade in Endangered Species (CITES) of Wild Flora and Fauna prohibited all international commercial trade of Appendix 1 species (which includes snow leopards). All snow leopard range states except Tajikistan are party to CITES, with Bhutan and Kyrgyzstan joining recently. The snow leopard has been designated as a 'concerted action' species under the Convention on Conservation of Migratory Species of Wild Animals, to which five range states are party (India, Mongolia, Pakistan, Tajikistan, and Uzbekistan) and thus obliged to conserve and restore its habitat.

Although officially fully protected in all 12 range countries, such protection is rarely enforced because of lack of awareness, insufficient political will to uphold regulations, shortage of funds and trained personnel, and the low priority some governments afford to biodiversity conservation (McCarthy and Chapron 2003; Theile 2003). Five countries (India, Mongolia, Nepal, Pakistan, and Russia) have developed National Snow Leopard Action Plans. However, their implementation has been often hindered by insufficient awareness amongst decision-makers, inadequate enabling legislation, and, most importantly, scarce funding.

With subsistence agro-pastoralism extensively practiced across snow leopard range, the widespread conflict over livestock depredation attributed to this felid (as well as the wolf, *Canis lupus*) comes as little surprise (Nowell and Jackson 1996; Mishra *et al.* 2003a). Depredation rates vary widely from under 1% in parts of Mongolia or western China (Schaller *et al.* 1987, 1994) to over 12% of livestock holdings in hot spots in Nepal (Jackson *et al.* 1996) and India (Mishra 1997; Bhatnagar *et al.* 1999), but they typically average 1–3% (Oli *et al.* 1994; Namgail *et al.* 2007b). These and other studies confirm depredation to be highly site-specific, with losses varying greatly between successive years and even between nearby settlements. Herders are especially angered by events of surplus killing when a snow leopard enters a corral and up to 50 or more of the confined sheep and goats are killed in a single instance (Jackson and Wangchuk 2001); in the Hemis National Park, India, such events (14% of all incidents) accounted for 38% of all livestock lost (Bhatnagar *et al.* 1999) and probably led to most retributive action against snow leopards.

Annual economic losses associated with depredation events range from about US$50 to nearly US $300 per household, a significant sum given per capita annual incomes of US$250–400 (Oli *et al.* 1994; Jackson *et al.* 1996; Mishra 1997; Bhatnagar *et al.* 1999; Ikeda 2004; Namgail *et al.* 2007b). Typically <10% of households suffer disproportionate loss, usually from corralled sheep and goats kills, or when unguarded, but high-valued yaks and horses are killed on the open range (Jackson *et al.* 1996; Ikeda 2004). Complacent guarding, poorly

constructed night-time pens, favourable stalking cover, and insufficient wild prey are cited as the primary factors contributing to livestock depredation.

Snow leopards are capable of killing nearly all types of domestic animals, and while herders take measures to reduce the risk of depredation (Mishra *et al.* 2003b), these are often insufficient. Livestock numbers and biomass may be an order of magnitude higher than wild ungulates. In Nepal, for example, livestock biomass may reach 1700 kg km^{-2} (Jackson *et al.* 1996) compared to 330 kg km^{-2} for bharal in the same season (Oli 1994), so the probability of encountering domestic animals is typically higher. Bagchi and Mishra (2006) reported higher livestock (58%) in snow leopard diet in an area with more livestock (29.7 heads km^{-2}) and fewer wild ungulates (2.1–3.1 bharal km^{-2}) in comparison to an adjoining area with less livestock (13.9 km^{-2}) but more wild ungulates (4.5–7.8 ibex km^{-2}), where livestock formed 40% of its diet. These data highlight the importance of livestock as prey for some snow leopard populations, and the potential role that local communities may unintentionally play in sustaining them. Superstition can also be a powerful force, for some Buddhist herders believe depredation results from deities they or the community angered.

The relative abundance of livestock and wild ungulate prey is considered a reasonable predictor of livestock depredation risk (Bagchi and Mishra 2006). Other indicators include the distance to snow leopard travel lanes (e.g. ridges and cliffs) and broken terrain ('depredation hot spots'), along with lax guarding by herders, in part resulting from insufficient manpower or funds for hiring communal shepherds (Jackson *et al.* 1996). Although livestock losses that herders attribute to wild predators tend to be higher than actual carnivore-caused mortality, it is the 'perceived' level of depredation that most defines people's negative attitudes and subsequent reaction towards wild predators (Mishra 1997; Woodroffe *et al.* 2005). As shown by Bagchi and Mishra (2006), negative attitudes may have a strong economic basis even in culturally similar areas: thus, communities with more access to alternative income displayed greater tolerance towards snow leopards, despite losing on average 1.1 livestock per family annually. A nearby community heavily dependent upon animal husbandry, however, held more negative feelings despite losing fewer livestock (0.6 animals).

The snow leopard's habitat is frequently overstocked with livestock, in some cases with herd densities compromising animal production itself (Mishra *et al.* 2001). The resultant competition for forage, along with human disturbance, is cited as causes for natural prey population declines (Mishra *et al.* 2002, 2004). As livestock numbers increase, so natural prey populations tend to decrease, as illustrated in a study where bharal density was 63% lower (2.6 bharal km^{-2}) in a rangeland supporting 30% more livestock than an otherwise comparable area sustaining 7.1 bharal km^{-2} (Mishra *et al.* 2004). Declining prey populations are a serious and often chronic threat to snow leopards, along with the cascading effect of escalating livestock depredation rates leading to intensified herder retribution.

Wild ungulates present protein sources for some impoverished local communities, thereby encouraging further prey depletion (Mishra and Fitzherbert 2004; Mishra *et al.* 2006). Similarly, excessive sport hunting has resulted in a decline of argali (*Ovis ammon*) in Mongolia (Fox 1994; Theile 2003). By contrast, Pakistan's community-based ungulate trophy-hunting programme has generated substantial economic benefit, with 80% of the >US$ 25,000 trophy fee being distributed to the local community, where it constituted US$150 per household for one settlement. Concurrently, the number of markhor (*Capra falconeri*) increased due to stringent community-imposed curb on poaching. However, one negative outcome is that some beneficiary communities have demanded monetary compensation when snow leopards prey upon this rare ungulate (Hussain 2003b).

Poaching and trading in the snow leopard's exquisite fur and highly valued bones or body parts (used in traditional Asian medicine) is another significant threat, fuelled by illegal international markets that operate in many range countries (Theile 2003). Koshkarev (1994) and Koshkarev and Vyrypaev (2000) estimated a three- to fourfold decrease in the snow leopard population of Kyrgyzstan and Tajikistan during the 1990s, with poachers taking up to 120 animals in a single year. With its emerging economic power and high demand for rare wildlife, China is judged a key catalyst for the recent poaching surge in neighbouring Mongolia (Wingard and Zahler 2006).

The primary trade centres for snow leopard pelts and body parts are thought to be Afghanistan, Pakistan, China, and the border towns of Mongolia (Theile 2003). The fur trade that thrived in Afghanistan during the 1970s (Rodenburg 1977) re-emerged following the fall of the Taliban government and influx of international aid workers and soldiers (Mishra 2003; Mishra and Fitzherbert 2004).

As human populations expand and new roads penetrate into previously inaccessible mountains, so snow leopard populations become increasingly subjected to poaching and retaliation for livestock depredation (Hussain 2003b; Theile 2003; Mishra *et al.* 2006). Up to a third of the snow leopard's range falls along politically sensitive international borders (Fig. 19.1) complicating trans-boundary conservation initiatives. In fact, over the past 50 years there have been several wars, along with low-intensity factional or international conflicts that continue in countries like Afghanistan.

Conserving the snow leopard: the needs

As highlighted above, extant populations of snow leopards face a multitude of conservation challenges. These include direct internal threats from local people, external threats like wars or lack of international cooperation, and indirect threats related to underdeveloped economies, illegal markets for fur and bones, or lack of public awareness. The importance of each factor varies across landscapes and between countries, thus necessitating locally appropriate conservation action (McCarthy and Chapron 2003). In Fig. 19.3, we present a general conceptual threat-based model (Salafsky and Margoluis 1999) for snow leopard conservation that summarizes these threats, identifies desirable conditions, and highlights the necessary interventions for achieving conservation targets.

Clearly, managing human–snow leopard conflict is critical, requiring reduction of livestock depredation levels through better animal husbandry and wild prey restoration, as well as devising sustainable means for offsetting or sharing economic losses. Incentive programmes for garnering local community support for snow leopard conservation are imperative; it is largely when tangible economic returns are realized that communities are willing, indeed able, to assume their role as conservation partners and become effective stewards of their surrounding environment (Western *et al.* 1994; Jackson and Wangchuk 2001; Mishra *et al.* 2003a). Additionally, effective snow leopard conservation hinges upon better, more inclusive national conservation policies, developing greater awareness through conservation education programmes targeting local and national levels, and by fostering international cooperation and financial assistance.

The establishment of protected areas is obviously important. Even by the mid-1990s there were 109 protected areas encompassing 276,000 km^2 within snow leopard range (Green and Zhimbiev 1997), although most are too small to support more than a few resident or breeding individuals. The total area under protected status has since increased substantially, especially with additions in China (which supports some 60% of snow leopard range) and Mongolia, but mega-reserves like the vast Changtang complex of Tibet harbour few cats (G.B. Schaller, personal communication). The Global Environment Facility and other multilateral organizations have funded trans-boundary protected area conservation projects, like the Trans-Altai project along the borders of Russia, Mongolia, Kazakhstan, and China, or the World Bank initiative involving Uzbekistan, Kyrgyzstan, and Tajikistan. Nonetheless, most protected areas still function as paper parks, with poorly regulated resource management. Barren rock and ice landscapes constitute a high proportion of land types present (Allnutt *et al.* 2005), with important wildlife populations, including snow leopard populations, lying outside the network (Jackson and Ahlborn 1991; Mishra *et al.* 2010). One notable exception is the Sagarmatha National Park in Nepal, where snow leopards were extirpated in the 1970s, but have recently recolonized the area following the recovery of wild ungulate populations (Ale *et al.* 2007).

Over the past 15 years, conservation organizations have set up small-scale, threat-based snow leopard conservation initiatives, working directly with local communities and governments. These serve as useful pointers for designing more effective range-wide programmes. In the following section, we review and synthesize some of these initiatives within context of the threat-based conservation model presented above.

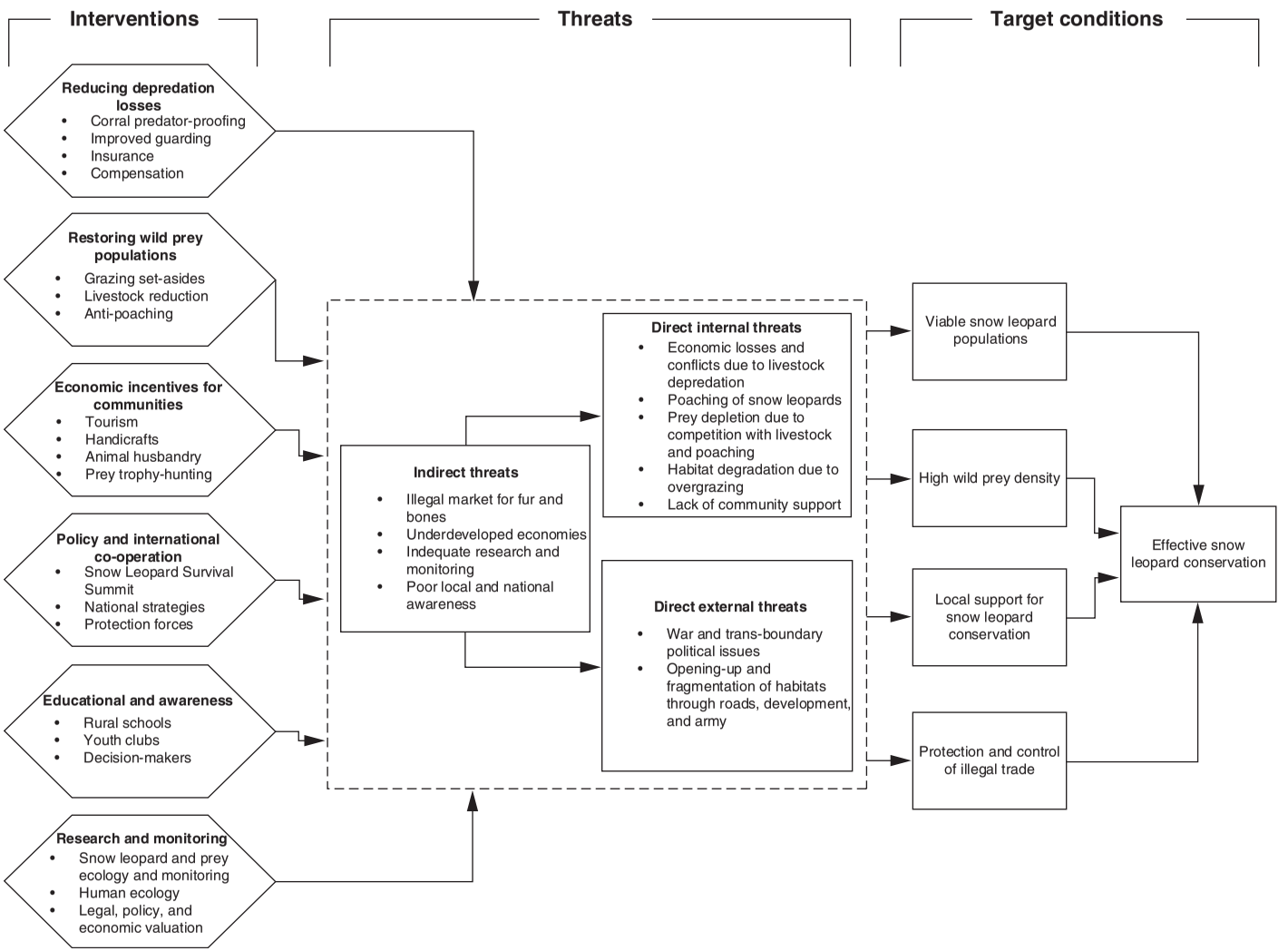

Figure 19.3 A conceptual threat-based model for snow leopard conservation. Bulleted sub-points under interventions represent examples of conservation interventions discussed in this chapter.

Threat-based interventions for snow leopard conservation

Addressing human–snow leopard conflicts

Addressing human–snow leopard conflict requires reducing livestock depredation and offsetting costs (real or perceived) of resulting losses. Better anti-predator livestock management is an important means of reducing livestock depredation by wild carnivores. In Ladakh, India, this has been achieved using predator-proof corrals, significantly reducing livestock losses to snow leopards (Jackson and Wangchuk 2001). This simple and effective conservation partnership provides predator-proofing material such as wooden doors, poles, and chain-link fences to local communities for construction and improvement of traditional livestock corrals. Such improvements ($n = 16$) have virtually eliminated multiple killing of sheep and goats in Hemis National Park, thereby removing long-held animosity towards the species. Livestock has declined from over 30% of the snow leopard's diet (Chundawat and Rawat 1994) to around 11% currently (U.R. Sharma, unpublished data). In India's Spiti Valley, where village livestock are herded communally by a few herders, vigilant herding to reduce depredation losses has been encouraged through an incentive system which provides cash rewards to herders for better shepherding and fewer depredation losses in the pastures (Mishra *et al.* 2003a).

Relatively low wild ungulate and high livestock abundance lead to increased livestock depredation by snow leopards and sympatric carnivores. In one high-conflict area in India, wild ungulate recovery has been facilitated by creating grazing set-asides on village land through a community-based conservation incentives programme (Mishra *et al.* 2003a). These livestock-controlled areas or village wildlife reserves, where grazing and resource extraction are curtailed, allowed intensified use by snow leopards in response to wild prey recovery from *c.* 4 blue sheep km^{-2} to more than 9 km^{-2} (C. Mishra, unpublished data). Together with improved herding practices, livestock depredation losses have been reduced from 12% to 4% of holdings annually (Mishra 1997), although the contribution of livestock to the snow leopard's diet declined less drastically from 58% to 40%. Within a few years following the natural recolonization of snow leopards to the Sagarmatha National Park, the number of Himalayan tahr (*Hemitragus jemlahicus*) declined by nearly 70%, which researchers attribute to heavy predation of kids by this carnivore (S. Lovari, personal communication). This suggests that a possible outcome of better nature protection and more wild prey could lead to increased snow leopard numbers or use of an area, intensified predation upon wild prey, and possibly also greater livestock depredation losses over the long-run. This underscores the need for multi-pronged conflict management programmes; in this case, wild prey recovery must be accompanied by better livestock protection.

Livestock are inherently vulnerable to depredation as they possess reduced anti-predatory abilities, so loss will continue to occur even under vigilant herding practices or high wild prey densities (Madhusudan and Mishra 2003). Therefore, addressing human–carnivore conflict by offsetting or sharing depredation-related economic impacts is necessary (Woodroffe *et al.* 2005; Treves *et al.* 2006). Compensation, an accepted predator conservation strategy in the Western United States, has been extended to Asian species like snow leopard and tiger (*Panthera tigris*). Although effective in some instances (Nyhus *et al.* 2003), compensation programmes in developing countries face numerous challenges (Loveridge *et al.*, Chapter 6, this volume). For instance, low compensation amounts (offsetting only 3–35% of the financial losses), false claims, corrupt disbursement officials, difficulty in authenticating claims, and bureaucratic apathy often associated with state-run programmes (Mishra 1997; Jackson and Wangchuk 2004) have resulted in increased resentment towards protected areas harbouring snow leopard populations.

Given these difficulties with compensation programmes, conservationists have helped communities establish locally managed insurance programmes for snow leopard depredation. In Pakistan's Baltistan region, Hussain (2000) established a community-managed insurance programme, which currently covers 3 settlements and 151 families, and is supported through premiums contributed by participating families along with contributions from local tourism. A similar programme, started in the Kibber village of

Spiti Valley in India (Mishra *et al.* 2003a), was supported with conservation funds (60% over 5 years) in addition to premiums contributed by the participating families (remaining 40%) and became financially self-sustaining within 5 years. This programme currently insures livestock worth US$60,000, with an average contribution of US$20 per year by each participating household (C. Mishra, unpublished data). It has been expanded to cover nine villages (*c.* 200 herding families) in Spiti and Ladakh. Such programmes have led to greater tolerance of snow leopards amongst local communities. With local management by village-level committees and family-paid premiums, local ownership is strengthened, as is internal peer pressure against corruption or false claims.

Incentive programmes for snow leopard conservation

Until local people have a meaningful stake in conservation, the long-term outlook for snow leopards will not be encouraging. Hence, conservationists often employ economic incentive programmes to gain local community support and involvement in snow leopard conservation. One such programme, Snow Leopard Enterprises, generates income for herder–artisans in Mongolia through handicraft development and sales, in exchange for community support of snow leopard conservation (Mishra *et al.* 2003a). Artisans receive training and simple tools to develop culturally appropriate woollen products which are marketable in the west. In exchange, communities sign conservation contracts stipulating a moratorium on snow leopard and wild ungulate poaching. Contract compliance brings herders a 20% bonus over the agreed price of their products. The bonus is split between artisans and a community conservation fund. A single contract violation loses the entire community's bonus. Resultant peer pressure results in collaboration to stop poaching by locals or outsiders. Compliance is monitored by nearby protected area rangers and law enforcement agencies. Currently 29 communities and over 400 herder families benefit from increased household incomes of nearly 40%. Until recently, there had been no known cases of snow leopards being killed at any project site, while pre-1997 poaching levels were as high as 0.5 cats per year per site (Snow Leopard Trust, unpublished data). The bonus had only been withheld twice and both resulted for poaching of ibex. In the beginning of 2009, however, there was a tragic loss of a snow leopard radio-collared a few months earlier by the Snow Leopard Trust in the Tost Mountains, after it got trapped in a snare set up for wolves and was shot by a herder. Wolf trapping is legally permitted in Mongolia. This incident resulted in a loss of bonus, as well as ongoing prosecution of the herder by the local administration. Over US $90,000 worth of Mongolian handicrafts was sold in 2007 and further growth is expected. Proceeds from sales now cover all programme costs, freeing donor funds for expansion. Success of this project in Mongolia has led to expansion in five Kyrgyzstan and three Pakistan villages.

The largely self-sustaining, 'Himalayan Homestays' incentive programme in India builds upon existing tourism and trekking to enhance livelihoods for local people and garner support for snow leopard conservation (Jackson and Wangchuk 2004). This UNESCO-supported initiative provides villagers training in running homestays and nature guiding, with bookings facilitated by local travel agents. Individual households operate through women's groups and revenue accrues from 'bed and breakfast' stays in village homes (rotated among households), catering and handicraft sales at tented cafes on trekking routes, and nature guiding. The first traditional homestays were established in Hemis National Park, India's premier snow leopard protected area. Now >100 families in 20 communities in Ladakh, Zanskar, and Spiti participate. Homestay operators (*c.* 40) in prime snow leopard habitat earn US$100–650 (average US$230) during the 4-month tourist season (Snow Leopard Conservancy, unpublished data). Tourist visitation increased from 37 in 2001 to >700 by 2006. Client satisfaction exceeds 85% and tourists welcome the cultural interaction. Another *c.* US$400 in sales from cafes is shared among 4–8 families. Approximately 10–15% of homestay profits go into a village conservation fund which has supported tree planting, garbage management, and recently the establishment of a village wildlife reserve for the threatened Tibetan argali (*Ovis ammon hodgsonii*). One community constructed predator-proof corrals, another paid a full-time herder to guard

livestock in high summer pastures, and a third insured large-bodied, high-valued livestock like yak through a national livestock insurance programme.

Livestock losses to disease (>50% of many herds) far exceed losses to snow leopards (<0.5% of average herd) in Chitral, Pakistan (Snow Leopard Trust, unpublished data). In response, a pilot livestock vaccination programme was established in a single village in 2003, and in exchange for tolerating depredation, 1452 village livestock were vaccinated against common diseases. Disease losses then declined by *c*. 90%. Participants agreed to cease snow leopard persecution, reduce their livestock holdings, and improve fodder handling methods to increase forage availability for wild herbivores. The programme creates economic incentives by increasing livestock survival and productivity, with sales of excess animals bringing each family *c*. US$400 per annum. The programme was expanded to eight villages in early 2008, with the goal of being self-sustaining and free of donor support within 5 years.

International cooperation, policy, and law enforcement

Given its widespread occurrence along international borders, the snow leopard is a species acutely in need of concerted international conservation efforts and cooperation, especially as funds are difficult to generate within most range countries. The establishment of the International Snow Leopard Trust 25 years ago represented an early step towards catalysing international cooperation among conservation partners in the range states, thus stimulating awareness, information exchange, on-the-ground research, and the establishment of pilot conservation projects. The Snow Leopard Trust and the more recently established Snow Leopard Conservancy represent two international organizations wholly dedicated to range-wide conservation of snow leopards and their habitat.

The Snow Leopard Trust played a key role in organizing international symposia, generally convened in range countries. Jackson and Fox (1997) reviewed the role these meetings played in setting research and conservation priorities. In 2002, the Snow Leopard Survival Summit brought together knowledgeable individuals from around the world to discuss and prioritize emerging threats to the snow leopard on a regional basis, and to identify and recommend 'best-practice' conservation, research, and policy actions appropriate to alleviating such threats. In addition to developing the Snow Leopard Survival Strategy (McCarthy and Chapron 2003), this summit led to the establishment of the Snow Leopard Network (SLN), a global alliance of institutions and individuals involved in snow leopard conservation. The SLN facilitates information sharing, supports advocacy through position papers and statements, and operates a small grants programme for snow leopard research and conservation.

The top-down 'fences and guns' approach to conservation is especially prone to failure in snow leopard habitat, given its remoteness, harshness, and subsistence livelihoods of local people, along with the fact that most habitat is located outside of protected areas. Governments are increasingly realizing the importance of more participatory approaches, and are thus developing more inclusive national snow leopard conservation strategies which identify a central role for local communities, as well as encouraging sound science, in underpinning the species' conservation.

Government agencies are primarily responsible for patrolling and preventing poaching, although an independent collaborative effort between a conservation organization Naturschutzbund Deutschland (NABU) and government to stop leopard poaching, called the Gruppe Bars, was launched in Kyrgyzstan in 1999. The specially equipped team, recruited in part from Ministry of Environment law enforcement officers, sought to halt illegal trade in snow leopards and other endangered species through a country-wide network of informants, undercover operations, and awareness programmes. Within 3 years, this effort led to the confiscation of a live snow leopard, 14 pelts, 162 firearms, numerous traps (including 79 snares specifically designed for snow leopards), numerous other wildlife trophies, and the arrest of 110 poachers (Dexel 2003).

Recently, following renewed use of real felid furs for lining their traditional ceremonial cloaks, and at the behest of His Holiness the XIV Dalai Lama, some Tibetans publicly burned skins and reverted back to using imitation fur products. There is unfortunately no easy solution to the problem of illegal national

and international wildlife trade. Since users of traditional Chinese medicine value bones from tigers, as well as other large felids used as substitutes, efforts at law enforcement and the strengthening of surveillance networks should target these species concurrently (Theile 2003; Nowell 2007).

Education and awareness

Conservationists have also undertaken educational initiatives to promote awareness of the precarious status of snow leopard populations and the need to conserve them, especially by local communities. For example, in Spiti Valley, this is being achieved through classroom and outdoor activities aimed at sensitizing school children to conservation issues (Trivedi *et al.* 2006). Appropriate educational tool kits for teachers and products for children and others, such as books and posters, have been developed and are being used to promote awareness in 10 rural schools under the pilot phase.

Youth clubs have been formed in several villages to help teachers implement educational and awareness activities, including those aimed at conflict resolution. In Ladakh and Zanskar, locally relevant educational materials and a teachers' handbook have been developed based on the region's wild biodiversity, threats, and conservation actions. Classroom workshops are led by conservationists, while the State Education Department is making these materials available to teachers throughout the district (Snow Leopard Conservancy, unpublished data). Similarly, in Nepal, a series of reading booklets about snow leopards and their role in the environment were produced in Nepali and English, with one booklet being translated into three other languages, including Tibetan Braille. These books have been used in 33 schools in Dolpo, Mugu, Mustang, and Manang, all important snow leopard areas.

Research and monitoring

The first ground-based very-high frequency (VHF) radio-tracking study was launched in relatively productive habitat in Nepal in the 1980s (Jackson 1996), followed in the 1990s by research in low-productivity habitats in Mongolia using a combination of VHF and satellite tracking (McCarthy 2000). These seminal studies have contributed much of our current understanding of snow leopards. They brought to light the high variation in home range size, highlighting the need to be cautious when extrapolating data to larger areas (McCarthy *et al.* 2005). Studies by Chundawat (1992) and Oli (1991) further contributed to understanding this felid's prey and dietary requirements. This was followed by applied research on wildlife and human ecology, which helped understand the direct and cascading effects of livestock grazing on human–snow leopard conflicts (Mishra 2001). Further applied research focused on human–snow leopard conflict (Oli *et al.* 1994; Mishra 1997; Bhatnagar *et al.* 1999; Hussain 2003b; Namgail *et al.* 2007b), human ecology (Mishra 2000; Mishra *et al.* 2003b; Namgail *et al.* 2007a), and the relationships between livestock, wild prey, and the snow leopard (Mishra *et al.* 2002, 2004; Bagchi *et al.* 2004; Bagchi and Mishra 2006). More recently, a snow leopard satellite-tracking study was launched in Pakistan (McCarthy *et al.* 2007). The realization that snow leopards must be conserved in a landscape with pervasive human use has encouraged multidisciplinary research with high emphasis on human ecology, as well as the use of social science tools (Jackson and Wangchuk 2004).

Development of techniques to monitor snow leopards (or their prey populations) has remained a challenge given the combination of harsh topography, severe climate, and the felid's cryptic nature. Until recently, snow leopard monitoring focused on quantifying indirect signs such as scats, scrapes, and other social markings that the cat leaves in relatively predictable micro-habitats (Jackson and Hunter 1996). More recently, camera-trapping and the use of capture–recapture statistical frameworks for estimating snow leopard populations has been found effective (Jackson *et al.* 2006; McCarthy *et al.*, 2008). Population surveys incorporating non-invasive genetic sampling have been successfully used for examining population status in diverse species (Schwartz *et al.* 2007). Preliminary work suggests molecular tools may be useful for monitoring snow leopards through species and individual identification of field-collected scats (Conradi 2006; Waits *et al.* 2007; Janečka *et al.* 2008).

Table 19.1 Show leopard conservation interventions: guidelines and comparisons.

Conservation action	Key activities	Cost, technical, and logistical factors	Potential pitfalls	Monitoring needs
Grazing management	Promote grazing practices that reduce impacts on wildlife	Low cost (excluding set-aside payments); moderate technical requirement	▪ Determining existing grazing patterns or land tenure disputes ▪ Grazing plans designed without input from community likely to fail	▪ Pasture quality and indicators developed by local herders ▪ Numbers and productivity of wild and domestic ungulates for grazing plan compliance
Wildlife-based ecotourism	Establish tourism that provides financial benefits to local people and creates incentives to protect natural resources	Moderate to high (may require substantial skills training and infrastructure development; marketing critical)	▪ Political instability, security, and health issues of importance to clientele ▪ Viewable wildlife often wary of humans ▪ Short season and leakage of revenue ▪ Financial benefits not equitably distributed ▪ Maintenance of prices and servicing standards may be difficult to achieve	▪ Numbers and trends of wildlife ▪ Quality of tourist attractions ▪ Level of economic benefit of ecotourism to local people ▪ Local attitudes towards wildlife and tourists ▪ Strong incentives for compliance
Cottage industry	Provide income to residents of snow leopard habitat through handicraft sales linked with wildlife conservation	Moderate to high cost (getting products to high-value markets, skills training, maintaining standards and marketing outreach)	▪ Semi-skilled artisans (products may not consistently meet market standards) ▪ Strong international competition ▪ Inconsistent participation after training investment ▪ Market saturation requires continued new or unique product development	▪ Numbers and trends of wildlife for anti-poaching compliance ▪ Other indicators determined collaboratively by community (compliance incentives) ▪ Number of participants benefiting ▪ Financial impact at household and community levels ▪ Public attitudes to snow leopards
Community-managed prey species trophy-hunting	Establish sustainable trophy hunting to provide return to local people as an incentive to protect ungulates and snow leopards	Moderate (externally driven planning and decision-making; high technical demands)	▪ Corruption at national and local level ▪ Lack of awareness of law among foreign outfitters/clientele ▪ Insufficient hunting fee revenues reach local level (lack of incentive to protect) ▪ Poor monitoring of trophy species ▪ Perverse incentive to persecute snow leopards	▪ Numbers and trends of wildlife ▪ Harvest statistics (hunting effort, trophy size, etc.) ▪ Numbers of local people or communities gaining benefit ▪ Financial impact at household/ community levels

Animal husbandry	Provide training in animal husbandry and veterinary care to improve monetary return at lower stock levels or to offset depredation costs	Low to moderate (linked with government veterinary extension capacity)	▪ Long-term commitment of community, government, or NGO may be difficult to maintain ▪ Low skill level for effective veterinary training program ▪ Limited acceptance of fewer high-quality animals versus large unproductive herds	▪ Numbers of livestock and financial returns ▪ Livestock health, incidences of disease, and other mortality ▪ Stocking density and carrying capacity of pastures ▪ Attitudes towards depredation/ predators
Livestock insurance	Establish locally managed subscription-based insurance scheme to offset depredation economic losses	Moderate over long term but potential high start-up costs	▪ Initial investment into capital fund can be high ▪ Validation of claims can be difficult and contentious ▪ Fails to address root cause of depredation	▪ Numbers of livestock and financial returns ▪ Livestock health and incidences of depredation ▪ Attitudes towards depredation and targeted predator species
Education outreach	Raise public awareness for snow leopard conservation	Low to moderate (hinges on collaboration with local school teachers and education departments)	▪ Low levels of education and literacy ▪ Linguistic, cultural, or ethnicity barriers ▪ Limited capacity of education system ▪ Dissemination in remote areas difficult	▪ Baseline surveys to determine current levels of awareness ▪ Monitoring to evaluate program effectiveness
Applied research	Investigate snow leopard and prey ecology, behavior, etc., including ecosystem and landscape dynamics	Moderate to high (dependent upon outside researchers and institutions)	▪ Research topics often not of interest to protected area managers ▪ Tendency to exclude communities from research (i.e. information ‘mining’ only)	▪ Ensure project targets priority topics and management issues ▪ Dissemination to general public and decision-makers

Conclusions

Conserving snow leopards is largely contingent upon the cooperation and goodwill of stakeholders, starting with local communities and extending to the international conservation community. Trade in snow leopard pelts and body parts are best arrested in tandem with actions addressing the tiger trade. Snow leopard conservation hinges on the equitable involvement and decision-making of local communities: there is no substitute to community-based incentive programmes, despite the challenges and costs involved (see Table 19.1 for a summary of conservation actions, costs, and some considerations for implementation). However, robust connections must exist between the rationale for providing such incentives, benefits they bring, and the community's vested responsibility for protecting snow leopards, its prey, and habitat. These include clearly articulating each stakeholder's conservation responsibilities, arrangements for reciprocal financing or in-kind contributions, and providing the project with efficient tools to enable participatory planning and action along with supporting collaborative compliance monitoring and project evaluation (Jackson and Wangchuk 2001). Substantial local support can be secured by valuing traditional ecological knowledge while building institutional capacity for adaptive management (Berkes *et al.* 2000).

Incentive programmes tend to be heavily subsidized, limited to relatively small areas or supported only over the short-term as part of larger Integrated Conservation Development Programs (Sanjayan *et al.* 1997; Mishra *et al.* 2003a; Wells and McShane 2004). Project transaction costs and human resources are high, since developing the necessary skills for undertaking relatively complex, competitive market-based enterprises like handicrafts production, traditional homestays, and nature guiding is time-consuming. Creating a self-sustaining market for such goods or services and implementing monitoring activities for ensuring compliance with species or general biodiversity conservation goals add to costs. Many donors fail to appreciate that significant returns on community-based programmes may not be forthcoming for 5–10 years, while implementing agencies are hard-pressed to demonstrate tangible results within the typical 2–5-year time frame expected by donors.

Central and South Asia's mountain areas are renowned for their varied climates, geography, biodiversity, and cultures that change dramatically over relatively short horizontal or vertical distances. Consequently, even closely spaced valleys typically exhibit different ecosystems, economies, and ethnic groups whose values, livelihood strategies, and influences have evolved to address a specific set of environmental, social, and political factors (Bishop 1990; Mishra *et al.* 2003b). Generally, each conservation initiative must address a different set of threats and conditions, along with the particular aspirations of the targeted community. The small community-based conservation and conflict management efforts described above were effective largely because of their well-informed and participatory focus. A critical, though often overlooked, element enabling successful conservation models involves site-specific scientific knowledge of wildlife and human ecology. This calls for both biological and social science expertise. Monitoring human socio-economy and land use, as well as the responses of snow leopards and prey species to conservation efforts, allows for adaptive management. While more experimental conservation models need to be assessed, conservationists must also work with national governments to formulate appropriate policy so that these inclusive, science-based conservation approaches can be scaled up and included in national conservation frameworks.

The real long-term challenge lies with moving communities beyond their harsh and insecure subsistence livelihood into more economically viable and environmentally friendly activities. Ultimately, local people must be encouraged to perceive snow leopards and other large carnivores as being worth 'more alive than dead'. They must also assume greater responsibility for protecting their herds from predators. This will enable an enduring coexistence between predators and humans across snow leopard range.