REDUCING LIVESTOCK DEPREDATION LOSSES IN THE NEPALESE HIMALAYA

By: **RODNEY M. JACKSON**, The Mountain Institute, Main and Dogwood Streets, Franklin, WV 26807 and International Snow Leopard Trust, 4649 Sunnyside Ave, Seattle, WA 98103.

GARY G. AHLBORN, 17145 Park Avenue, Sonoma, CA 95476.

MAHESH GURUNG and **SOM ALE**, Annapurna Conservation Area, King Mahendra Trust for Nature Conservation, P.O. Box 3712, Kathmandu, Nepal

ABSTRACT: In the Nepalese Himalaya, conflict with rural communities due to livestock predation to large carnivores like snow leopard, common leopard, wolf and wild dog has risen sharply in recent years. This increase is attributed to a number of factors, including implementation and enforcement of wildlife protection laws (which have permitted a recovery in carnivore numbers), the creation of protected areas (which serve as refuges from which predators can populate the surrounding area), the depletion of natural prey due to poaching and loss of habitat, and lax livestock herding practices. However, little information is presently available upon which to design remedial programs. U.S. AID provided research funding for an in-depth assessment of snow leopard predation in the Annapurna Conservation Area (ACAP), an new innovative approach to nature conservation. Baseline information on livestock numbers and mortality were gathered during household interviews, followed by field surveys to assess animal husbandry systems, map pastures, establish periods of use and estimate stocking rates, and to characterize habitat using randomly located plots. Data substantiate the existence of depredation "hotspots", where high loss occurs, in some cases exceeding 14% to 20% of the livestock population over a short period. Losses varied seasonally, and from year to year. Small-bodied stock like goat and sheep were more vulnerable than large-bodied stock like yak, although horses were especially vulnerable. Factors most closely associated with predation included lack of guarding (or very lax supervision), especially during the daytime, and repeated use of pastures where livestock depredators were known to be actively hunting. Herders usually reacted to repeated depredation incidents by attempting to trap or shoot the suspected culprit until losses declined to an acceptable level. As large carnivore populations become increasingly fragmented and genetically isolated, new management strategies are urgently needed, especially within the buffer zones and intervening corridors between separated parks and reserves. People reside within nearly all Himalayan protected areas, and such issues as loss of livestock and competition between wildlife and livestock cannot be avoided. A plan is offered for alleviating livestock loss in the Annapurna Conservation Area that involves local institutions in decision-making, rewards sound husbandry practices, strengthens indigenous institutions, without further eroding ACAP's unique biological diversity and diverse carnivore population. The authors believe these measures and ideas could be fruitfully extended to other parts of the Himalaya.

KEY WORDS: snow leopard, predation, control strategies, damage assessment, Himalaya, Nepal

In: Proc. 17th Vertebr. Pest Conf. (R.M. Timm & A.C. Crabb, Eds)
Published at Univ. of Calif., Davis. 1996. Pages 241-247.

INTRODUCTION

Although the livestock sector contributed only 15 % to Nepal's Gross Domestic Product for 1986/87, it constitutes an essential element of the country's subsistence farming systems, both in the mountains and the plains. Pastoralism is often the dominant livelihood of the diverse human communities occupying the Himalayan zone. High-altitude pastures are critical to local and tranhumant herders, and many alpine pastures are located largely or entirely within Nepal's protected areas network. Examples include the Sagarmatha (Mt. Everest), Langtang and Shey-Phoksundo National Parks, as well as the renown Annapurna Conservation Area. Known in short as ACAP, the latter is an innovative approach to nature conservation and resource management involving local people (Gurung 1989). Increases in livestock predation are attributed to several factors, including the implementation and enforcement of wildlife protection laws (which have permitted a recovery in carnivore numbers), creation of protected areas (which serve as refuges from which predators can populate surrounding areas), the depletion of natural prey due to poaching or loss of habitat, and lax livestock herding practices. However, little information is presently available upon which to design remedial programs.

The role of protected areas like the Annapurna Conservation Area in sustaining local communities while protecting and enhancing natural values and biological diversity is widely acknowledged (IUCN 1993). There is also widespread agreement that conservation initiatives must have the political, social and economic support of local people if they are to succeed (Wells et al. 1992). Crop and livestock damage incidents have increased dramatically in the ACAP area in recent years, and people are voicing legitimate concerns. Even when loss is shown to be due to negligence on the part of a villager, the local community may still view wildlife negatively, holding the government responsible for ensuring that the protected area offers them benefits as well.

As large carnivore populations become increasingly fragmented and genetically isolated, new management strategies are urgently needed, especially within the buffer zones and intervening corridors between separated parks and reserves. People reside within nearly all Himalayan protected areas, and such issues as loss of livestock and competition between wildlife and livestock cannot be avoided. Conservation agencies have typically espoused policies and regulations which restricted people's rights and engendered substantial animosity toward the regulatory agencies. Clearly, new models for protecting large carnivores both in and outside of protected areas are urgently needed. This paper reports on depredation patterns due to snow leopard (*Uncia uncia*) along the northern slopes of the Himalayan in the Manang Valley near the villages of Manang and Khangshar. Since the snow leopard is an endangered species, special emphasis is devoted to alternative options for resolving people-wildlife conflicts through means other than direct predator control or population reduction. We offer a plan for alleviating livestock loss in the Annapurna Conservation Area that involves local institutions in decision-making, rewards sound husbandry practices, strengthens indigenous institutions, without further eroding ACAP's unique biological diversity and diverse carnivore population. The authors believe these measures and ideas could be fruitfully extended to other parts of the Himalaya.

STUDY AREA AND METHODS

Study Area

The Annapurna Conservation Area Project (ACAP) was established in 1986 by the King Mahendra Trust for Nature Conservation, Nepal's largest non-governmental organization devoted to nature conservation and sustainable rural development (Gurung 1989). Encompassing over 2,600 km^2, it has been described as the most geographically and culturally diverse conservation area in the world (Wells et al. 1992). About 40,000 people of diverse ethnic backgrounds inhabit the Annapurna area, where agriculture and trade have flourished for hundreds of years in the steep-sided Himalayan valleys. Most residents are farmers, but income from tourism is becoming increasingly important. Each year over 30,000 visitors trek in the area, primarily into the spectacular Annapurna Base Camp area or along a circular route through Manang into the Kali Ghandaki Valley, one of the deepest gorges in the world. Expanding cultivation, grazing, water pollution, poor sanitation and littering along trekking routes have accelerated, compounded by a rapid growth in the human population. This deterioration led to a royal directive in 1985 to improve tourist development while safeguarding the environment, leading to the formation of the conservation area.

Relief is dominated by the Annapurna Range, with elevations ranging from 3,000 to over 7,000 m. The climate is cold and dry, with less than 500 mm of precipitation annually (Dobremez 1976). Because of a strong rain-shadow effect, the study area supports dry alpine or semi-steppe vegetation types (Stainton 1972). These consist of blue pine (*Pinus wallichiana*) and West Himalayan fir (*Abies spectabilis*) forests at lower elevations, juniper

(*Juniperus indica*) woodland or scrub at mid elevations, and alpine meadows or barren snowfields, ice and rock at higher elevations. A wide band of alpine grassland occurs between 3,800 and about 4,300 m. Moist north-facing slopes support a narrow band of birch (*Betula utilis*) forest, but plant cover varies widely, depending upon slope steepness, soil or moisture conditions. Level areas near the eight settlements are cultivated, with large areas now abandoned due to the declining agricultural economy and a severe lack of labor. A single crop, mostly buckwheat, barley and potatoes, is grown annually, with fields under production between May and late September. Aridity, cool temperatures and poor soils limit agricultural potential, and people are more dependent upon animal husbandry, trade and tourism for their income. Human density is placed at three persons per square kilometer (Pohle 1986).

Methods

All Khangshar households were interviewed for information on herd size, composition, mortality, and herding or guarding patterns. The reliability of information accruing was assessed through triangulation and other widely accepted social science techniques (for example, Casely and Kumar 1988). Special effort was made to validate predation incidents by examining fresh kills. Known or suspected kill sites were visited, characterized and compared to randomly selected sites with respect to over 30 habitat and topographic features (Jackson et al. 1994). The hypothesis that kill sites are utilized in proportion to their occurrence was tested using the methods of Neu et al. (1974), as modified by Byers et al. (1984). Finally, pastures were mapped using GIS and depredation "hotspots" identified using a variety of techniques.

RESULTS

Livestock Ownership, Management and Herding Pattern

Eighty-one percent of the 69 families residing in Khangshar own livestock. According to interviews the village owns about 1,500 animals, with yak and chauri comprising 16.0 %, cattle 19.6 %, goats and sheep 61.3 %, and horses 4.0 %. Because of the large area grazed and its well-broken terrain, herd size was not easily verified. However, actual herd size is probably greater, especially with respect to goat and sheep. Ownership varied widely: for example, over half of the households had fewer than 20 animals, while 7 % own more than 50. Only the wealthiest families kept horses or yaks. The largest herd consisted of 31 yaks/chauris (a cattle-yak cross-breed), 11 cattle, 40 goats and sheep and several horses. The smallest family unit consisted of two goats.

The herding pattern varied according to season, type of livestock, and agricultural activities, but followed long-established, traditional patterns that demand a high degree of cooperation among community members. Women and children spend summer months in the main village tending crops, while men take on the task of animal husbandry. A village committee monitors livestock movements and imposes fines on villagers transgressing traditional rules. Animals are tended from two distinct settlements, the permanent village (Khangshar) and a summer settlement located higher. During winter, fallow barley, potato and wheat fields are fertilized by livestock grazing upon the stubble and by dispersing barn manure. Livestock is then moved to temporary shelters (known as goths) in the nearby forest. In spring, after fields have been sown with a crop, livestock is moved to summer settlement to graze in open pasture, thus ensuring they are kept away from any crop-field. A series of tented goths are used to better distribute grazing and permit summer use of high elevation pastures located far from the village.

Yak and horses are largely free-roaming, but cattle are driven out each morning to forage nearby, to return of their own accord in late afternoon to spend the night in stables below the living quarters. During winter, sheep and goats often graze unattended, while in summer several hired shepherds tend to the village's flock but their guarding is lax. The flock, comprising some 800 individuals is grazed in 10 distinct pastures, with the only guard dogs being those stationed near their nighttime corral. During daytime hours, all lambs, kids and young calves are kept within sight of the goth, being corralled with their mothers at night. Female yak, subadults and calves are mostly herded out of the summer settlement or temporary goths located in four distinct pastures. They may or may not be corralled at night.

All manure and bedding material from stalls or corrals are collected, stored and distributed on the fields in late fall or early winter. Spring snowmelt helps to distribute nutrients. Natural pastures are heavily utilized, hay is not cultivated, and hardly surprisingly, forage resources are scarce, especially during winter and early spring, when morality is high among all classes of livestock. Animals are stall-fed during periods of sustained snow-fall. During parturition, animals are stall-fed and closely guarded for the first few weeks after delivering. Most goats and sheep are born in late winter or early spring.

Predation Losses

Villagers reported predation accounted for 63 % of all mortality over the 18-24 month study period (Table 1). Predators, mostly snow leopard, were blamed for most losses, even if pugmarks near the carcass were the only evidence to substantiate predation. Kill remains were rarely properly examined in order to verify predation as the cause of death. Although the degree of error could not be quantified, there was little doubt that villagers perceived predators as the major threat to their livestock. Using data from interviews, the village predation rates were estimated at 21.1 % for yak-chauri, 0.8 % for cattle, 7.1 % for sheep and goats, and 19.6 % for horses. This suggests that cattle are relatively immune to predation by snow leopard compared to high vulnerability of horses.

Adult yak-chauri were significantly under-represented in predation cohort, while subadult yak are significantly over-represented (χ^2 = 49.625, 2 df, Bonferroni confidence interval P < 0.001). The number of sheep and goats killed did not differ significantly from overall herd age composition. Cell size limitations precluded tests for cattle and horses, although they are likely taken in rough proportion to their availability. Although differences with regard to the sex of yak or chauri (χ^2 = 37.491, 1 df, P < 0.000), and sheep and goats (χ^2 = 10.920, 1 df, P < 0.002) killed by predation were detected, respective Bonferroni confidence intervals were not significant at the 95 % level. Female horses were significantly more likely to be killed by predators than males (χ^2 = 82.160, 1 df, P < 0.001).

Losses were not evenly distributed among household. Twenty-one households (37.5 %) suffered 50 % of the total loss due to disease and depredation. Loss due to disease was under-reported (especially among sheep and goat), but 22 of the 56 households owning livestock lost no animals to predators, while six households reported losing one animal and seven claimed they lost two animals. Nine families reported losing five or more animals, but only two families reported 10 or more of their stock were killed by predators. Generally, households reporting depredation loss owned larger herds than households reporting no such losses. Thus, the average herd size among affected households (N=34) was 27.8 ± 16.9 animals, compared to herds of 14.5 ± 10.2 among households (N=22) with no losses. By contrast, disease rates of predated and non-predated herds were similar.

Depredation loss occurred throughout the year, but peaked in spring and early summer (April - June), with secondary peaks in late October through mid-December, after livestock arrives in the village area from the high summer pastures, and in early winter (mid-February through mid-April). Most goat predation coincided with the peak lambing period. Most loss of chauri occurred between February and May, while horses and chauri were killed throughout the year. All horse and cattle, virtually all yak-chauri (93%), and 78% of the goat and sheep kills reported to us were being poorly guarded at the time, especially during daylight hours. Predation also resulted after one or a few individuals had become separated from the flock and were forced to spend the night outside of a secure shelter.

Despite knowing several snow leopards (including a female snow leopard with two cubs) were active within the immediate area, villagers allowed their livestock to continue grazing unattended, even after several had been killed and although alternative, "predator-free" pastures were available. Over a 24-day period in November 1991, the loss of 17 goats and 6 yak cross-breeds to snow leopard were documented . Clearly, presence of people in the vicinity is not sufficient deterrent. Virtually all of these incidents occurred in cover-rich areas and the affected livestock was either unguarded or poorly tended. Many of the kills occurred during daylight. Despite substantial loss, villagers made no attempt to guard their animals better or to attempt to drive snow leopard from the vicinity of the village where most incidents occurred. Field checks validated predation as the probable cause of death in at least 40 % of these incidents; evidence for the remaining accrued from villager reports and kill site remains, but scavenging as a cause of death could not be ruled out.

<u>Kill Site Characteristics</u>

Fifty-five known or suspected kill sites were characterized and compared to the same features at 134 randomly selected sites in the same general area. No kill sites were detected on cliffs or in very broken terrain, although these landform features often occurred nearby. Sites with moderately broken terrain were significantly over-represented or "over-utilized" as kill sites, while sites with smooth-surfaced, rolling or level terrain were significantly represented in the data-set (χ^2 = 13.404, 2 df, P < 0.001). Macro-topographic features, such as major hill slopes, ridges and valleys occurred in approximate proportion to their availability, but there were distinct differences in use at a micro-topographical level (χ^2 = 25.513, 1 df, P < 0.000). Bonferroni confidence intervals indicated that basins and bowls (P < 0.001) and gullies (P < 0.05) were significantly over-utilized, suggesting that livestock is more vulnerable to predation when grazing in or near such a topographic feature. Open hill-slopes were significantly under-represented ($P < 0.001$) among the kill sample.

Kill sites were significantly closer ($\bar{X} = 132.9 \pm$ SE 11.9 m) to cliffs than random sites ($\bar{X} = 245.4 \pm 17.1$ m) ($t = 4.593$, 200 df, $P < 0.000$) (Table 2). Very broken sites were also significantly closer at kill sites ($t = 3.4$, 146 df, $P < 0.001$; $\bar{X} = 175.5 \pm$ SE 15.2 m versus $365.0 \pm$ SE 27.2 m), as were moderately broken sites ($t = 4.7$, 195 df, $P < 0.000$; $\bar{X} = 78.8 \pm$ SE 12.8 m versus $223.7 \pm$ SE 23.3 m). Samples differed significantly with respect to distance to the nearest cliff ($\chi^2 = 19.825$, 2 df, $P < 0.001$). Thus, sites within 100 m of a cliff were significantly over-utilized ($P < 0.001$), while sites farther than 250 m were significantly under-utilized ($P < 0.001$). Similarly, sites more than 250 m from very broken terrain were significantly under-represented ($P < 0.05$) in the sample. By contrast, no differences were detected in terms of distance to smooth terrain.

Kill sites were more likely to be located in shrubland than grassland areas. Random ($\bar{X} = 298.3 \pm$ SE 22.3 m) and depredation sites ($\bar{X} = 85.3 \pm$ SE 8.2 m) differed significantly in mean distance to the nearest vegetation edge ($t = 8.1$, 201 df, $P < 0.000$). Sites less than 100 m from a vegetation edge were significantly over-utilized ($P < 0.001$), while sites farther away were significantly under-represented ($P < 0.001$). Kill sites 50 m or closer to a water source were significantly under-utilized ($\chi^2 = 12.958$, 3 df, $P < 0.005$). No difference was found with respect to distance to a well used trail. Violation of rules regarding Chi-square goodness of fit tests precluded statistical comparisons between kill and random sites with regard to the distance to large areas of heavily broken terrain. Forty-four percent of kill sites were located within 250 m of a heavily-broken area, compared to less than 8.7 % of sites using 184 randomly generated geographic information system points. Areas more than 2 km from the summer settlement were significantly under-represented in the kill sample ($\chi^2 = 8.796$, 3 df, $P < 0.032$).

DISCUSSION

Loss Rates and Causative Factors

Snow leopard are capable of killing all livestock but for a fully-grown male yak. Horses, by far the most valuable of livestock kept by Khangshar herders, also appeared to be most vulnerable to attack, assuming the reported depredation rate of 19.6 % is valid. A similar pattern was noted by Schaller et al. (1994) from Mongolia. Goats and sheep are predated upon most frequently, hardly surprising given their overall abundance, small body size and associated vulnerability. In an independent study in the Manang area, Oli (1991) estimated that four communities (including Khangshar) lost 72 animals out of a total herd of 2,737 in 1989/1990, for an overall depredation rate of 2.6 %. This compares with our estimate of 2.8 % for the same village for the period 1990-1992. Scat analysis indicated livestock contributed about a third of the snow leopard's diet Oli et al. (1993), but this does not rule out scavenging.

While the loss rates provided by the villagers cannot be fully documented, these are similar to independent predation reports from other high density snow leopard areas. Thus, Schaller et al. (1987) determined that 7.6 % of sheep and goats were taken in one area in western China, while the same investigator (Schaller et al. 1994) placed losses in Mongolia as high as 9.6 % (although rates of 0.34 to 0.38 % were considered to be more typical). In the more remote parts of southern Tibet, herders claimed to lose up to 9.5 % of their herd to predators wolf, snow leopard, lynx and golden eagle (Jackson 1991). Fox et al. (1991) placed sheep and goat predation at 2.3 % in India's Hemis National Park, due largely to snow leopard. In the Khunjerab National Park of northern Pakistan, Wegge (1989) reported that about 10 % of the domestic stock (mostly sheep and goats) were killed annually by snow leopard and wolf, with most of the loss occurring in winter and early spring. Finally, in the eastern Nepal, Braun et al. (1991) noted goat and sheep losses averaged 10.6 % among sedentary herds, but ranged from 2.9% to 4.7 % for migratory flocks in the western part of the country.

None of these investigators attempted explicitly to determine which factor or set of factors contributed most to the observed predation. Our study suggests that a combination of lax guarding practices, favorable cover and habitat conditions, and high snow leopard density are primarily responsible for the high depredation rates observed in ACAP. Oli (1994) placed snow leopard density at 4.8-6.7 adults per 100 km^2 in the Khangshar study site. Although it supports good numbers of blue sheep (*Pseudois nayaur*), livestock are the most abundant prey, at least in terms of overall biomass. Our surveys indicated that some pastures supported a livestock biomass as high as 1,700 kg per km^2 during the winter, compared to only 330 kg per km^2 for blue sheep, the snow leopard's principal large natural prey item (Oli 1994). Presumably snow leopards are more likely to encounter domestic stock, while taking advantage of the excellent cover available to them in the form of vegetation, steep slopes, rocky areas and broken terrain. Several depredation incidents were associated with a female and her two young cubs, but a determination whether old or injured predators caused more damage than healthy ones was not possible (Fox and Chundawat 1988). By chasing a predator away to retrieve meat for their own use, herders force the predator to replace the loss by killing again.

Local residents are reluctant to hunt snow leopard for fear of being reported or fined by the government. Yet few appear willing to improve their obviously inadequate guarding practices, at least of their own accord. As the snow leopard population rebounds, the herders' feeling of anger and frustration at not being able to hunt or control large predators will only increase. With tourism rising in the area, attempts by the authorities to shoot or trap problem snow leopards (an endangered species under both international and Nepalese law) would be viewed extremely negatively. The resulting "bad press" would tarnish Nepal's excellent and hard-fought reputation for nature conservation. Given such constraints in the Himalaya, what are the best alternatives to predator control?

Remedial Measures

Most herders consider total eradication of snow leopard as the only remedy worth considering (Oli et al. 1994), reflecting their traditional pattern of using professional hunters or shikaris to remove problem animals. Individuals displaying the carcass of a habitual livestock killer used to be given special gifts and lauded for their service to community, even among Buddhist communities who impose strong sanction upon the taking of life. All such hunting is now banned under the wildlife protection laws implemented by Nepal. While Tibetan mastiffs and other dogs are considered a deterrent to predator attack, the quality of local guard dogs is actually poor. The predator control measure currently favored, but highly illegal, involves the use of insecticides like dieldrin which are placed in kill remains and other items left as bait.

In an effort to pacify the villager while also protecting wildlife, government officials and protected area managers are increasingly resorting to non-lethal measures for reducing livestock loss. Within the context of a protected area like the Annapurna Conservation Area, the best long-term strategy lies in a combination of preventative and remedial measures which may include:

- Improved guarding of livestock, especially during winter, lambing or calving seasons, and when livestock is being grazed in pastures with broken, cover-rich terrain and at elevations in excess of 4,000 m

- Encouraging communities to hire skilled shepherds, by developing a special fund to help pay for more experienced herders and by offering subsidized veterinary care for families demonstrating reduction in depredation

- Promoting the use of improved breeds of guard dog and livestock showing a greater inclination for warding off or avoiding predators

- Creating core areas for snow leopard and blue sheep which are largely or entirely livestock free

- Establishing a village-based snow leopard conservation committee with preferential membership opportunities for herders, but operated under the overall supervision of ACAP

- Offering incentives for community development projects in exchange for predator and wildlife protection and conservation action by the community

- Developing safeguards against herders or communities making fraudulent claims, killing snow leopards or illegally poaching wildlife

Since lack of guarding or poor supervision of herds contributed most significantly to livestock loss, herder education must be given a high priority. Some depredation could be avoided by ensuring that livestock are securely housed in predator-proof pens at night; this is especially a problem in Khangshar during summer months when animals are kept on the open range day and night, often bedding without any protection other than the presence of the shepherd's tent. Limiting the use of open rangeland by calves, subadults and lactating females, by stall-feeding removes vulnerable livestock from predator access. The use of guard dogs to protect sheep from predators has been extensively researched in the United States, but it has not been attempted in the Himalaya where people are poor and may lack adequate facilities for housing or taking care of imported sheep dogs. An alternative involves using of traditional breeds of goat, sheep and cattle which are better adapted to local climate conditions and more predator wary like sheep and goats from Mongolia which "bunch-up" closely at any sign of danger. Programs to provide or improve forage could help to reduce the need to graze livestock in known depredation hot spots, such as areas of very broken terrain, places with an abundance of cliffs and stalking cover, and pastures located in wilderness areas.

In addition to an herder education program, Oli et al. (1994) recommended financial compensation for households suffering loss of livestock. However, limited financial resources, administrative constraints and a high potential for fraudulent claims augur against simple cash compensation or indemnity programs (Saberwal et al. 1993). An alternative approach, currently being attempted by ACAP, involves the provision of grants for community development work in exchange for community-wide agreements to better guard their animals while also protecting wildlife, including snow leopard and blue sheep. Such funds would be used to improve drinking water supplies, establish a health post, provide much-needed school materials, assist in hiring better-trained herders, or improve veterinary services, rangeland and fodder supplies. Progress has already been made with the establishment of a special “Snow Leopard Conservation Committee” with significant representation by herders. A long-term goal is the establishment of core wildlife areas and increasing tourism infrastructure so that local residents will have a more diversified set of income sources. While the realization of income from “eco-tourism” for local people is by no means clear, properly managed ventures can be profitable if the export of profits to distant cities can be reduced. Nature viewing tours could be promoted, with local residents serving as guides once they have been trained.

CONCLUSIONS

Although governments bear the cost of establishing a national park or protected area, it is the local people who must live with the consequences. Managers are increasingly relying upon community knowledge and traditional management systems, recognizing that traditional rights and practices must be balanced with other needs like protection of wildlife. This requires that specific management issues, such as grazing, wildlife protection or the control of livestock depredation, are effectively integrated into the broader socio-economic and ecological context of the area concerned. Compromises produced by participatory conflict resolution are usually preferable to forced decisions respected by no one, provided such agreements are consistent with important constraints, including those environmental factors governing resource availability and sustainability. In reaching conservation or resource management agreements with a local community, explicit linkages should be established between development components and conservation objectives, in this case the protection of predators and other wildlife. The nature of the exchange must be fully understood. Experience has indicated that “give-a-ways” must be avoided; commitment grows in relation to the time, energy and materials invested. Programs need to be monitored regularly to ensure goals and objectives are being achieved, with penalties or disincentives applied in the case of infringements.

ACKNOWLEDGEMENTS

This research was supported through a grant awarded to BioSystems Analysis, Inc. by U.S. Agency for International Development, to whom we express our gratitude. The study was co-sponsored by King Mahendra Trust for Nature Conservation and Tribhuvan University, Kathmandu, Nepal. We are indebted to the staff of the Annapurna Conservation Area for supporting our work.

LITERATURE CITED

BRAUN, A., B. LANDWEHR and U. IDE. 1991. The present situation of small ruminant production in Nepal with special emphasis on the Koshi Hills and Jumla District. Unpub. Thesis, Faculty of International Agriculture, University of Kassel and Promotion of Livestock Breeding Project, Kathmandu. 120 pages + Annexes.

BYERS, R.C., R.K. STEINHORST, and P.R. KRAUSMAN. 1984. Clarification of a technique for analysis of utilization-availability data. J. Wildlife Manage. 48:1050-1053.

CASELY, D.J. and K. KUMAR. 1988. The collection, analysis and use of monitoring and evaluation data. John Hopkins University and World Bank Publications, Baltimore, Maryland, and Washington D.C. 174 pages.

DOBREMEZ, J.F. 1976. Le Nepal: ecologie et biogeographie. Editions du Centre National de la Recherche Scientifique, Paris. 356 pages.

FOX, J.L. and R.S. CHUNDAWAT. 1988. Observations of snow leopard stalking, killing and feeding behavior. Mammalia 52 (1):137-140.

GURUNG, C.P. 1989. Conservation and Sustainable Development: a case from Annapurna Conservation Area Project in western Nepal. Pages

7-16 in B. Goodman, Bell (ed.). Proceedings of International Workshop on the Management of Khunjerab National Park, June 7-16, 1989. U.S. National Park Service, Government of Pakistan and IUCN, Islamabad. 154 pages.

IUCN. 1993. Parks for Life: Report of the IVth World Congress on National Parks and protected Areas. IUCN, Gland, Switzerland. 260 pages.

JACKSON, R., G. AHLBORN, S. ALE, D. GURUNG, M. GURUNG and U.R. YADAV. 1994. Reducing livestock depredation in the Nepalese Himalaya: case of the Annapurna Conservation Area. Unpub. report prepared for U.S. Agency of International Development by BioSystems Analysis, Inc., Tiburon California.

NEU, C.W., C.R. BYERS, and J.M. PEEK. 1974. A technique for analysis of utilization - availability data. J. Wildl. Manage. 38:541-545.

Oli, M.K. 1991. The ecology and conservation of snow leopard (*Panthera uncia*) in the Annapurna Conservation Area, Nepal. M.Phil. Thesis, University of Edinburgh. 155 pages.

OLI, M.K., I.R. TAYLOR, and M.E. ROGERS. 1993. Diet of the snow leopard (*Panthera uncia*) in the Annapurna Conservation Area, Nepal. J. Zool. (London) 231:365-370.

OLI, M.K., I.R. TAYLOR, and M.E. ROGERS. 1994. Snow leopard *Panthera uncia* predation of livestock - an assessment of local perceptions in the Annapurna Conservation Area, Nepal. Biol. Conserv. 68(1):63-68.

Oli, M.K. 1994. Snow leopards and blue sheep in Nepal: densities and predator-prey ratio. J. Mammal. 75(4):998-1004.

POHLE, P. 1986. High altitude populations of the remote Nepal-Himalaya: environmental knowledge and adaptive mechanisms. pages 113-147 In: K. Seeland (ed). 1986. Recent Research on Nepal. Proc. Conference held at Universitat Konstanz. Schriftenreihe Intern. Asienforum Vol 3, Munich.

SABERWAL, V.K., J.P. GIBSS, R. CHELLAM and A.J.T. JOHNSINGH. 1994. Lion-human conflict in the Gir Forest, India. Conserv. Biol. 8:501-507.

SCHALLER, G.B., LI HONG, LU HUA, REN JUNRANG, QIU MINGJIANG, and WANG HAIBIN. 1987. Status of large mammals in the Taxkorgan Reserve, Xinjiang, China. Biol. Conserv. 42:53-71.

SCHALLER, G.B., J. TSERENDELEG, and G. AMARSANAA. 1994. Observations on snow leopards in Mongolia. Proc. Int. Snow Leopard Symp. 7:33-42.

STAINTON, J.D.A. 1972. Forests of Nepal. John Murray, London. 174 pages.

WEGGE, P. 1989. Khunjerab National Park in Pakistan: a case study of constraints to proper conservation management. In P. Wegge, and J. Thornback (eds.). Conservation of Mammals in Developing Countries. Proceedings of a Workshop in association with 5th International Theriological Congress, Rome.

WELLS, M., K. BRANDON and L. HANNAH. 1992. People and Parks: Linking Protected Area Management with Local Communities. World Bank, 112 pages.

Table 1. Livestock mortality reported by Herders from Khangshar village, Annapurna Conservation Area

Type of Livestock	Number of Animals Lost	Number and Cause of Mortality (percentages in parentheses)			
		Predator	Disease	Accident	Missing
Yak-chauri	48	43 (89.6)	4 (8.3)	1 (2.1)	0
Cattle	16	2 (12.5)	12 (75.0)	1 (6.2)	1 (6.2)
Sheep/Goat	123	71 (57.7)	42 (34.2)	1 (0.8)	9 (7.3)
Horses	13	10 (76.9)	1 (7.7)	2 (15.4)	0
Totals	200	126 (63.0)	59 (29.5)	5 (2.5)	10 (5.0)

Table 2. Mean, maximum, and minimum distances (meters) to selected terrain features from pasture and depredation sites at Khangshar.

Terrain Feature	Sample Size	Minimum	Maximum	Mean	Std. Dev.
Cliff					
Pasture	133	15	1,000	245.4	197.5
Depredation	69	2	500	132.9	98.7
Very Broken Terrain					
Pasture	116	25	1,500	365.0	293.3
Depredation	32	60	350	175.6	85.7
Moderately Broken Terrain					
Pasture	129	0	1,500	223.7	264.3
Depredation	68	0	400	78.8	105.4
Smooth Terrain					
Pasture	133	0	500	101.4	112.2
Depredation	70	0	400	92.5	109.2