

WILDLIFE CONSERVATION AND LAND-USE CHANGES IN THE TRANSHIMALAYAN REGION OF LADAKH, INDIA

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ABSTRACT Changes in economy and land use are under way in the Indian Transhimalayan region of Ladakh, creating both negative and positive prospects for wildlife conservation in this sparsely populated and previously remote area. New livestock breeds, irrigation developments, farming practices, foreign tourists, and a large military presence are changing the way people view and use the mountainous land that surrounds them. With only 0.3% of the land currently arable, changes in wildlife and natural resource conservation are most apparent on Ladakh's extensive rangelands which are apparently undergoing a redistribution of use associated with social changes and recently introduced animal husbandry and farming practices. Internationally endangered species such as the snow leopard, several wild ungulates, and the black-necked crane provide special incentive for conservation efforts in what are some of the best remaining natural areas in the mountainous regions to the north of the Himalayan crest. The success of newly created protected areas for wildlife conservation in Ladakh rests on an understanding of the effects of various development directions, a commitment to environmentally sensitive development amid the many competing demands on Ladakh's natural resources, conservation laws appropriate to human needs, and a clear recognition that solutions can be neither directly adaptable from other mountainous areas nor even widely applicable across the Himalayan region.

fc Conservation de la Jaunt et ckangementi d'utiliatiion des trrres dam la region trtmshimalayeiinf du Ladakh, Inile. Des changements dans l'economic et l'utilisation des terres sont en train de se produire dans le region transhimalayenne du Ladakh en Inde, entrainant des expectatives negatives aussi bien que positives pour la conservation de la faune dans cete zone faiblement peulee et jusque dans ces derniers temps isolee. Les nouvelles especes de bestiaux, les projets d'irrigation, les pratiques agricoles, les touristes etrangers et la presence d'in stall aliens militaires imponantes ont modifie la maniere dont la population percoit et utilise le milieu momagnard qui les entoure. Si l'on considere qifa present seulement 0,3 pour cent des terres sont arables, les changements dans la conservation de la faune et des ressources naturelles sont plus apparents dans les grands paturages du Ladakh; ces paturages semhient subir line redistribution de leur utilisation associee aux changements sociatix et aux pratiques d'elcvage du bctail et de culture qui ont ete introduces recemment. Les especes menacees a l'echelle Internationale, comme le leopard des neiges, plusieurs ongules sauvages et la gnie a col noir, fournissent une forte justification pour les projets de conservation dans ces zones naturelles qui comptent parmi les meilleures encore preservers dans les regions montagneuses situees au nord de la crete himalayenne. Le succes des zones protegees qui ont etc recemment creecs pour la conservation de la faune du Ladakh est base sur une comprehension des effets de diverses approches vis-a-vis du developpement, un engagement total envers un developpement respectant l'environnement dans le cadre des demandes multiples sur les ressources naturelles du Ladakh, des lois sur la conservation appropries aux besoins de la population, et une admission claire que les solutions ne peuvent ni etre directement adaptees a partir d'autres zones montagneuses, ni elre applicables a la totalite de la region himalayenne.

ZUSAMMENFASSUNG Artenschutz und Landnutzungsänderungen im Transhimalaya Gfbiet von Ladakh, Indien. Im indischen Transhimalaya Gbict von Ladakh verändern sich die Ökonomie und die Landnutzung— was in diesem spärlich besiedelten und frtther abgeschiedenen Gebiet Vor- und Nachteile für den Artenschutz mit sich bringL Neue Arten bei der Viehzucht, Bewässerungsprojekte, neue Landwirtschaftsmethoden, ausländische Touristen und ein großes militarisches Kontingent verändern die Art und Weise, in der die Revolkerung das sie umgebende Land sieht und nutzt. Da nur 0,3% des Gebietes anbaufähig sind, werden Veränderungen beim Artenschutz und bei der Erhaltung der Naturressourcen auf den ausgedehnten Flächen Ladakh's besonders auffällig. Diese Gebiete unterliegen einer Nutzungsordnung, die sich aus sozialen Veränderungen und kürzlich neu eingeführten Ackerbau- und Viehzuchtmethoden ergibt. Tiere, die global geschützt sind, wie der Schneeleopard, verschiedene wilde Huftiere und die schwarz-halsigen Kranich geben Erhaltungsbestrebungen besondere Motivation, denn die bergigen Regionen nördlich des Himalaya Kammes gehören zu den besterhaltenen unter den verbliebenen Naturlandschaften. Der Bestand der neuerlich geschaffenen Schutzgebiete in Ladakh hängt voin Verständnis der Auswirkungen verschiedener Entwicklungsprojekte ab, ebenso von der Verpflichtung für umweltgerechte Entwicklung innerhalb der vielen konkurrierenden Anforderungen an Ladakh's Naturressourcen. Gesetzgebung auf dem Gebiet des Artenschutzes muß den menschlichen Bedürfnissen angepaßt sein, und es muß erkannt werden, daß Lösungen von anderen Bergregionen nicht unbedingt übernommen werden können und oftmals für das Himalayagebiet unzutreffend sind.

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Introduction

India's northernmost district of Ladakh, within the state of Jammu and Kashmir, encompasses a thinly populated region of dry, high-elevation mountains and plains north of the main Himalaya. Physically and culturally the area can be roughly divided into the jumbled mountains and gorges of the Muslim-inhabited western end of the Himalaya bordering Pakistan, and the more open Trans-himalayan mountains and high plains of the eastern portion which is predominantly Buddhist-inhabited and more closely linked to Tibet. Triggered by a rapid opening of the region from the south, Ladakh has recently been undergoing a substantial change from the patterns of traditional farming, pastoralism, and caravan-based trade that was present prior to the 1950s, and conservation of the region's natural resources is becoming of increasing concern.

The strategic importance of Ladakh, lying at the juncture of several major cultural influences, has led to frequent military conflicts, the most recent being between India and both Pakistan and China since India's independence in 1947 (Osmaston, 1990). International trade through Ladakh effectively ended during the hostilities between the 1950s and the early 1960s, but as road and commercial air links have subsequently become established via peninsular India, the region has experienced an ever increasing flow of traders and visitors. Today, a largely monetized economy strongly influenced by a large military presence, rapid growth of civil administrative structures, and the recent introduction of tourism have greatly influenced the people in the major valleys and are having ever greater effects on those in the remote mountain areas. The changes have undoubtedly increased the material welfare of people in many of the larger towns and villages, and instituted a generally increasing standard of living in even the most remote villages. There have even been suggestions that Ladakh may have already shifted from a subsistence agricultural economy and leapt "into post-industrial development that would make most of the developed world green with envy" (Ives *et al.*, 1987). Although such a conclusion is somewhat exaggerated, the changes resulting from the decline of the caravan trade and subsistence agriculture and pastoralism are dramatic and undeniable, especially along the new transportation corridors.

Economic and social consequences of the changes are varied, and include the abandonment of traditional polyandrous practices, decreasing entry into religious life, increasing reliance on salaried government positions for livelihood, a migration of young people to the towns and to areas outside Ladakh, and some realignment of wealth and political power within the region (Goldstein, 1981; Rizvi, 1983; Chatterji, 1987). Concomitant changes in the association of people with their surrounding landscape (e.g., patterns of livestock grazing, fuel collection, hunting) are important consequences of the economic and social changes and directly affect natural resource conservation, including wildlife, in the region. Many known and other potential social consequences of the direction of development in Ladakh have been discussed extensively (Crook, 1980; Goldstein, 1981; Norberg-Hodge, 1981, 1991; Rizvi, 1983; Chatterji, 1987), and an international conference was held recently in Ladakh's main town of Leh to highlight a perceived need to call for development along sustainable lines (Ladakh Project, 1986). Emphasis, however, has concentrated on the growth of urban areas and transportation corridors; the effect of development activities on natural resource use in rural areas (and its relationship to wildlife conservation) has so far received little attention. The impacts on the conservation of Ladakh's extensive pasture resources are discussed below, and these may both benefit and hinder wildlife conservation in the region. The process of establishing a system of national parks and reserves in Ladakh is currently occurring in tandem (though not necessarily in coordination) with increased public and private interest in the general effects of development on conservation of natural resources in the region. However, limited cooperation and communication among various development agencies has so far precluded any large-scale realization of conservation objectives.

Ladakh currently harbors a few of the best preserved natural areas in the more rugged and mountainous portions of the Transhimalayan regions found in India, Nepal, and the Tibetan Autonomous Region of China. The recently established Hemis National Park in central Ladakh, for example, encompasses a core area of unique and relatively undisturbed natural habitat of the endangered snow leopard (*Uncia uncia*) and many associated species (Fox and Nurbu, 1990). Throughout much of Ladakh, wildlife was not threatened in historical time due to a generally benign association with a sparsely distributed population whose traditional land use and religious practices have permitted long-term coexistence (Fox and Nurbu, 1990). Within the past 50 years, however, some native wildlife species in the relatively accessible high plains and major valleys have suffered dramatically due to human impacts such as military conflict and hunting, and populations of several large mammal species have been so much reduced that they are in danger of extinction in India (Fox *et al.*, 1991a).

Western techniques for enhancing farming and livestock production have been introduced, and government sponsored programs are attempting to change livestock breeds, pastoral patterns, and farming practices; these will have long-term consequences on utilization of natural pasture, fuel resource availability, and wildlife conservation that are not yet fully recognized or appreciated. Furthermore, a significant military presence and the increasing numbers of tourists in remote areas have impacts on land and wildlife conservation. The consequences of such developments need not necessarily be highly detrimental to rural natural resources (and are in fact beneficial to wildlife in some instances), but their effects must be noted and integrated into resource planning. In view of some apparent negative consequences of recent changes in those inhabited areas that are identified as requiring conservation, a re-evaluation of development priorities and the retention or adaptation

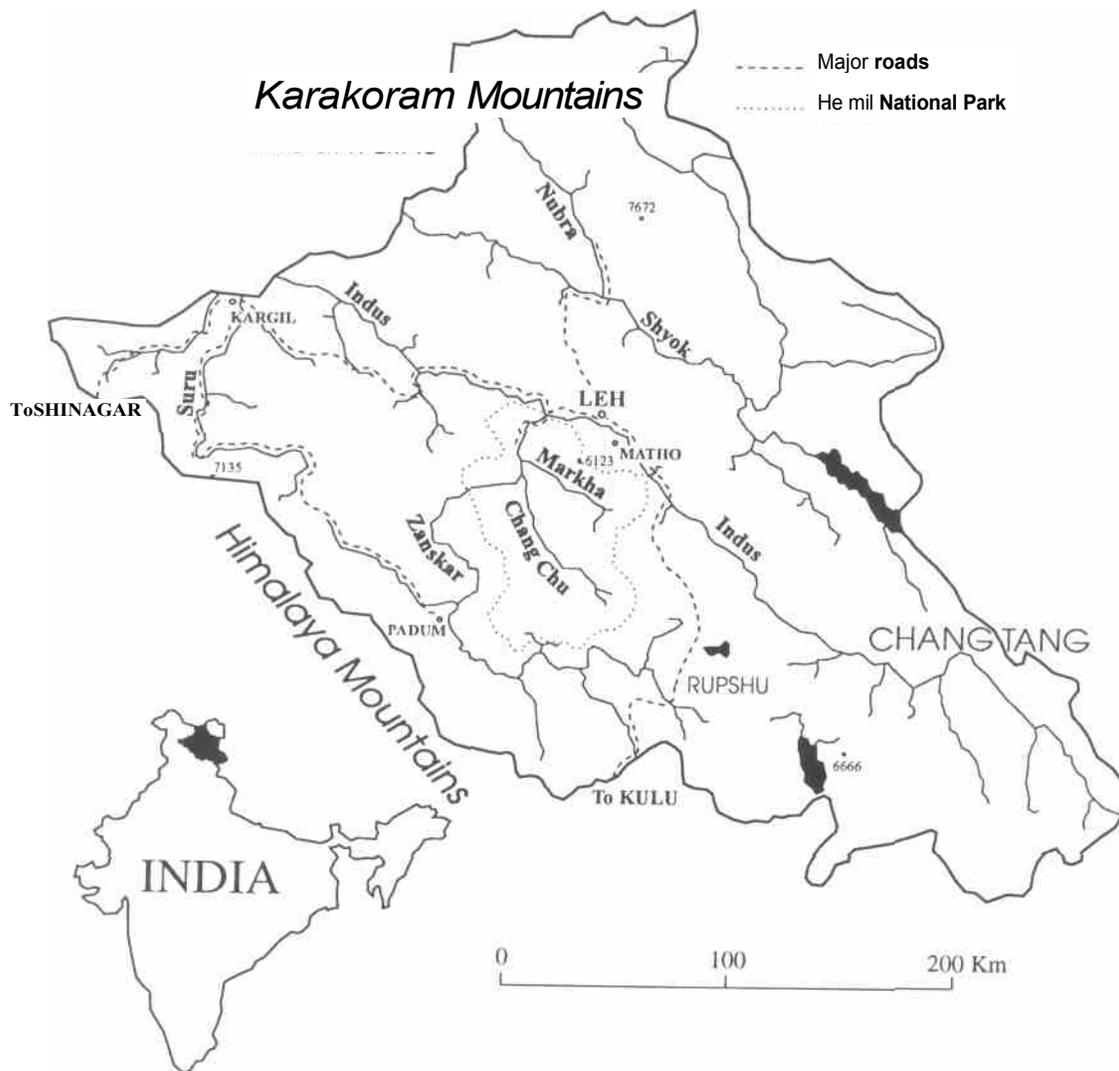


FIGURE 1. The districts of Leh and Kargil, encompassing the Indian administered region of Ladakh within the state of Jammu and Kashmir.

of traditional land conservation practices (Messerschmidt, 1985; Brower, 1990) may be appropriate. Certainly, a better understanding and recognition of the richness

of Ladakh's wildlife resources and the consequences of modern development activities on the conservation of its land and wildlife is long overdue.

THE NATURAL ENVIRONMENT

Ladakh is bounded to the north by the eastern Karakoram Mountains, to the south by the western extreme of the main Himalaya, and its interior is dominated by the somewhat tower and drier Transhimalayan ranges that form a transition zone to the high plains of Tibet in the east (Figure 1). Elevations range from 2,800 m where the Indus river leaves the region to peaks above 7,000 m in the Himalayan and Karakoram ranges, with Transhimalayan summits rising to over 6,000 m, and the eastern plains lying at about 5,000 m. Annual precipitation decreases to the north and east, ranging from 500-1,000 mm in valleys just north of the main Himalaya to

approximately 100 mm in the central Transhimalayan valleys such as the upper Indus near Leh (Hartmann, 1983), with substantial altitudinal variation throughout. Vegetation in Ladakh changes gradually from primarily alpine meadow (*Kobresia*, *Carex*, *Potentilla*, *Nepeta*) on the north side of the Himalayan crest to steppe vegetation (*Caragana*, *Artemisia*, *Stachys*, *Ephedra*, *Stipa*) to the north and east, with shrubland (*Hippophae*, *Salix*, *Myricaria*) along the river courses (Kachroo *et al.*, 1977; Hartmann, 1983, 1987, 1990). The region is virtually treeless, except for isolated patches of juniper *Juniperus macropoda*, *J. iridica* and birch *Betula utilis* in some valleys, and mostly cultivated (but a few wild) varieties of poplar *Populus* spp. and willow *Salix* spp. along the major water courses. Apparently juniper and birch have disappeared from many areas within historical times and only a few relict stands still survive in some of the more remote river gorges.

Ladakh is of primary concern in terms of wildlife conservation. It is the stronghold of the endangered snow leopard in India, and of two species of endangered wild sheep, the Ladakh urial (*Ovis vignei vignei*) and the Tibetan argali (*Ovis ammon hodgsoni*) (Fox *et al.*, 1991a, 1991b). In addition, it is the habitat of limited numbers, and the only populations in India, of the Tibetan antelope (*Pantholops hodgsoni*). Tibetan gazelle (*Pantholops picticaudata*), and the wild yak (*Bos grunniens*) (Fox *et al.*, 1991 a). A small population of the endangered Himalayan brown bear (*Ursus arctos*) still exists in southern Ladakh, the threatened dhole or wild dog (*Cuon alpinus*) and the threatened Pallas's cat (*Otocolobus manul*) are still occasionally met throughout the region, and the endangered Tibetan wild ass or kiang (*Equus kiang*) survives in far eastern Ladakh. Other large mammals include the blue sheep (*Pseudais nayaur*), Asiatic ibex (*Capra ibex sibirica*), wolf (*Canis lupus*), and lynx (*Lynx lynx*). Common smaller

mammals include the fox (*Vulpes vulpes*), marten (*Martes* spp.), otter (*Lutra lutra*), weasel (*Mustela altaica*), hare (*Lepus oiostolus*), marmots (*Marmota bobak*, *M. caudata*), and several species of mouse hare or pika (*Ochotona* spp.) (Fox *et al.*, 1986; Mallon, 1991). Larger birds include the endangered black-necked crane (*Grus nigricollis*), the golden eagle (*Aquila chrysaetos*), lammergeier (*Gypaetus barbatus*), griffon vulture (*Gyps fulvus*), Himalayan and Tibetan snowcocks (*Tetmogallus himalayensis* and *T. tibetanus*), and the chukor partridge (*Akrotis chukar*).

Despite the paucity of vegetation, the substantial numbers of domestic livestock, and the very dry climate, the diversity and abundance of wild large mammals, even today, is impressive. Furthermore, several spectacular and nearly impassable river gorges with relict juniper woodlands, streamside shrublands, and undisturbed slopes represent nearly pristine wildlife habitats rarely seen in Asia. Urban Ladakhis, as well as the many immigrant development officials, military personnel, and others involved in the rapidly changing face of Ladakh, are often ignorant of these myriad natural resources, that are well known to many of the 80 percent of Ladakhi people who live in rural areas.

RECENT HISTORY AND DEVELOPMENT

For several centuries Ladakh has been a semi-independent region of minor kingdoms with strong economic ties to both Kashmir and Tibet and somewhat stronger political ties to Kashmir, especially during the nineteenth century. One of the economic ties that continues to bind Kashmir to Ladakh is the lucrative monopoly that Kashmiri merchants maintain on the production of "cashmere" wool from the domestic goats of the high eastern plains. From the political and military standpoint, the consequences of a Sikh incursion from Kashmir in the late 1830s and early 1840s can still be seen today in the continued army use of a garrison fort built at that time just outside Leh. The British rulers of India agreed to Kashmiri administration of Ladakh, but stationed their own trade (political) representatives in Leh from the mid-1800s; with independence from Great Britain in 1947 Ladakh became part of the Indian state of Jammu and Kashmir. India and Pakistan fought over Kashmir and Ladakh in 1948-49, 1965, and 1971, and many of Muslim parts of Ladakh claimed by India came under Pakistani control in the early part of this period. India lost control over additional areas of their claimed territory in eastern Ladakh to the Chinese during a brief war in 1962. Ladakh remains a strategic and disputed juncture between India, Pakistan, and China (Figure 1 reflects the area currently under India's control), and will continue to harbor a large military presence for the foreseeable future.

The economic outcome of the wars with Pakistan and China was to effectively isolate Indian Ladakh from its traditional international trade and other contacts. As a major arm of the Silk Route to China, the upper Indus valley and the town of Leh had prospered as a cosmopolitan trade center with major links to Lhasa, Yarkand, and Baltistan. Ladakh thus became completely dependent on trade and supplies from Kashmir and peninsular India to the south. The introduction of a large military presence associated with the wars, the opening of road and air transport, plus the installation from Kashmir of a civil administrative infrastructure, have more than compensated for revenue losses associated with the decline of

international trade, but there have also been some significant changes in the pattern of trade and the distribution of wealth and social hierarchy (Rizvi, 1983). The introduction of tourism in 1974 also boosted the economy of a few towns and villages in Ladakh, predominantly Leh and Kargil.

Because of its strategic importance, Ladakh has received substantial development funding from both the central and state governments. The first major roads opened in the early 1960s; today at least dirt vehicle tracks lead to the majority of the villages in Ladakh, and there is regular bus service in most areas. In part to foster public support in the region, the prices of many food, fuel, farming, and animal husbandry requirements (or "improvements") are substantially subsidized, and the standard of living in Ladakh is relatively high compared with many areas in India. This is evident in the ubiquitous presence of itinerant laborers from as far as Bihar state and Nepal who perform most of the abundant construction work in the region.

Although the population has recently begun to increase relatively rapidly, Ladakh today remains the least densely populated area in India, with close to 150,000 inhabitants living primarily in rural villages within the approximately 60,000 km² region (Rizvi, 1983; Darokhan, 1986). Nevertheless, military personnel apparently several times this number (Ives and Messerli, 1989) maintain a presence in both urban and remote areas, substantially affecting the economy. Within the Leh district of northern and eastern Ladakh (approximately 45,000 km², and population about 70,000) livestock populations include about 345,000 domestic sheep and goats, some 58,000 cattle (including yak-cow hybrids), about 5,500 horses, 7,500 donkeys, and 50 camels (Darokhan, 1986, Jammu and Kashmir Department of Statistics, unpubl. data).

Only about 0.3% of land area in Ladakh is currently cultivated (Rizvi, 1983), and agriculture is based on irrigation of alluvial outwashes or raised river terraces along the major valleys. The very limited area of cultivation, coupled with average livestock densities in Leh

district of about 6/km² for sheep and goats and 1/km² for cattle and other large herbivores, reflects the very marginal quality of grazing and agricultural lands throughout much of Ladakh.

TRADITIONAL LAND USE AND WILDLIFE ABUNDANCE

People have been living in the high mountains and plains north of the Himalaya for several thousand years (Snellgrove *et al*, 1980). Although undoubtedly there were substantial reductions in populations of wild ungulates (wild species of sheep, goat, catde, etc.) with the introduction of domestic livestock, the marginal grazing habitats in many parts of Ladakh precluded full pastoralist exploitation, and apparently substantial numbers of wild ungulates and other wild herbivores remained. It is unlikely that wildlife habitats have remained unchanged by the influx of people and their livestock; the introduction of domestic animal grazing altered the original steppe communities to some extent, but this probably resulted in proportional differences in species composition rather than complete community change from the vegetation that had evolved with the foraging of similar wild ungulates. One must remember that the largest component of domestic livestock grazing, from yaks and yak-cow hybrids, is the result of domestication of a wild ungulate that evolved on the Tibetan highlands and the grazing effects are consequently similar to those in prehuman times. Populations of large predators were probably also reduced with the arrival of humans, but the impact was buffered because populations of wild prey were replaced by domestic livestock and human means of hunting the predators were relatively ineffective. Prins (1992) equates pastoralism with wildlife decimation in East Africa and Gadgil and Guha (1992) accurately note that, in contrast to hunter-gatherer societies, pastoralists are "proliferate exploiters of natural resources"; however, the seasonal restrictions on livestock use in the high Himalaya lessens competition with wild grazers and makes this region more amenable than tropical savannas to coexistence of pastoralism and wildlife. As Brown (1971) indicated, coexistence between pastoralists and wildlife requires the maintenance of very low density livestock and human populations, a situation characteristic of the traditional patterns in Ladakh. Whereas exploitation of fuelwood in Ladakh probably exacerbated the effects of a drying climate in eliminating native juniper woodlands from some of the lower mountain areas, alteration of the limited but important streamside shrubland habitats, although substantial, was mitigated by human cultivation of willow and poplar. Lastly, the collection of woody subshrubs for fuel and herbaceous and grassy plants for winter fodder has probably been important in altering some plant communities within the vicinity of villages and summer herding camps.

The high open plains of the Changtang region of eastern Ladakh (4,500-5,500 m) have long supported a pastoral nomadic system similar to that of the inhabitants of nearby areas in western Tibet (Goldstein and Beall, 1989, 1990). These herders lived off their livestock (e.g., domesticated yak and goats) and depended on barter





FIGURK 2. The village of Rumching within Hemis National Park, illustrating how arable land is severely restricted by the availability of water and level land throughout much of Ladakh.

with farmers for some foodstuffs, and with traders for getting their highly prized "cashmere" wool to Kashmir. Their primarily pastoral livelihood led to a relatively extensive exploitation of available grazing resources, usually involving substantial seasonal migrations. Still, the continued presence until quite recently of large herds of wild grazing competitors such as antelope, gazelle, sheep, and yak indicates a coexistence of the wildlife and pastoral practices; this is also apparent in areas of continuing traditional lifestyle within the Changtang region of western Tibet (Goldstein and Beall, 1990).

In contrast to a stricdy pastoral exploitation of the eastern plains, in the rugged mountain areas of central and western Ladakh and in the lower and warmer valleys (3,000-4,000 m), the combination of farming and pastoral activities sustained a permanent and relatively sedentary population. Traditional land-use patterns in these mountainous parts of the Transhimalayan region consist of cultivation (primarily barley) coupled with short seasonal migrations with livestock to mountain pastures (trans-humance) and limited trade with nomads or other outsiders for salt and other essential commodities (Osmaston, 1985). This is similar to that described in other areas of the High Himalaya and Tibet (Fiirer-Haimendorf, 1975; Bj0nness, 1983; Brower, 1987; Zhang, 1989). Within this system livestock provided food (meat and milk), fiber and skins for clothing, and also power for plowing. Equally important for traditional farming, livestock converted the nutrients and cellulose of sparsely distributed mountain vegetation into a more concentrated form (dung), used as fertilizer and organic soil for the cropfields and as fuel for cooking and heating. The small villages, severely restricted in size and location by availability of die irrigable land (Figure 2), obtained sufficient fertilizer, fuel, fiber, and milk products from relatively few livestock, and so there was limited incentive to attempt to graze the mountain pastures to capacity. This system left sufficient forage resources for the native wild sheep and goats and other grazers such as marmots to thrive in the mountains. Furthermore, the mountain pastures were even more marginal than the high eastern plains due to greater and longer-lasting snowfall and thus more limited seasonal accessibility to herders. Especially in the Buddhist regions where aversion to hunting is strong, die environmental limits to domestic livestock grazing have allowed the continued presence of viable populations of wild grazing mammals and their predators in the surrounding mountains (Fox *et al*, 1991a).

Such wildlife abundance was graphically documented throughout Ladakh (including the high eastern plains) in die late 1800s by European explorers and sportsmen who extolled the hunting opportunities in the region (Kinloch, 1885; Macintyre, 1891; Darrah, 1898). Subsequent dramatic decreases in many wildlife populations in increasingly accessible areas of Ladakh were described by later sport hunters and Indian conservationists (Bur-rard, 1925; Stockley, 1936; Ganhar, 1979; Ranjitsinh, 1981), and the current status of many large mammal species strongly reflects the effects of overhuning in the-recent past (Fox *et al*, 1991a). Still, thousands of blue

sheep (Figure 3) and ibex remain in the relatively inaccessible mountainous areas of Ladakh (Fox *et al.*, 1991 a) and the snow leopard and wolf appear to be more prevalent here than elsewhere in the Indian Himalaya (Fox *et al.*, 1986, 1991b).

Hunting has been a traditional practice throughout Ladakh and includes the snaring, and more recently shooting, of both large ungulates and smaller animals such as hare and chukor, and the trapping of nuisance predators such as wolf and snow leopard (Figure 4). However, in the Buddhist areas religious tenets that discourage the taking of life have traditionally limited the numbers of hunters and restricted general hunting to periods of famine, in a similar fashion to that described for the nomads of western Tibet (Goldstein and Beall, 1990), and any effects on wildlife populations have probably been negligible. Within the Muslim-dominated western parts of Ladakh hunting continues to be more prevalent, although the traditional relatively inefficient hunting techniques and weapons, together with the rugged country, have probably kept its impact on wildlife populations small. More recently, however, the introduction of modern firearms, especially among government workers and present and former army and paramilitary personnel, has affected populations of some species in accessible areas such as along roads, and the decimation of some wildlife populations in the eastern plains region can be directly attributed to the influx of well-armed and mobile outsiders (Fox *et al.*, 1991a).

Culturally and spiritually wildlife has an important place in the lives of many Ladakhis. The ibex, for example, is a symbol of good luck and prosperity and small statues of this wild goat are commonly prepared for ceremonies associated with renewal such as birth, marriage, and the new year. Throughout rural Ladakh there are stone cairns piled high with horns of wild ungulates, and such horns are often prominently displayed on or near village houses. In general, such displays are associated with offerings to various spirits or deities that will help to maintain good crops and grazing conditions, prevent floods or other disasters, and maintain good relations with the natural world in general—beliefs that predate both Buddhism and Islam. There are also numerous rock carvings of ibex and other wildlife, usually relating to pre-Buddhist hunting spiritualism, but also indicating a close association with the natural world. As in other cultures, there are many proverbs, folk stories, and songs that extol wild animals in the context of human interactions, and thus instill a sense of benign association with these creatures. The prime exception to this general goodwill toward wildlife is the natural dislike of predators that take livestock, and substantial efforts are sometimes made to rid an area of a destructive-predator. However, within traditional Buddhist society the sanctity of life and the bad "karma" associated with killing are strong incentives to leave wildlife alone, while Islamic teaching strongly maintains that it is man's responsibility to prevent overexploitation of nature (Mekouar, 1981; Davies, 1987).

MATHO VILLAGE: SOME EXAMPLES OF NATURAL RESOURCE USE

Matho (Figure 7) is a relatively large and accessible village along the upper Indus valley, at 3,600 m on an alluvial fan emanating from the Zaskar mountains on the south side of the valley, about 25 km up-valley from Leh (Figure 1). It lies within the main corridor of development in Ladakh, although its distance (10 km) and location across the Indus river from the main road has kept it somewhat isolated from the most obvious effects of development. The Matho stream is perennial as it emerges from its 80 km² catchment in the mountains, although during especially dry and/or cold periods there is only intermittent surface flow, and only during very warm spring snowmelt or rainy periods does surface flow reach the Indus. The population of the village is about 1,000 divided into some 150 families with separate dwellings. There are approximately 390 ha of irrigated cropfields within the 840 ha village grounds, and livestock number about 2,900 sheep and goats, 1,350 cows and yak-cow hybrids, 150 donkeys, and 60 horses. The village has had limited electricity since 1988 and a paved road with twice-daily bus service to Leh since about 1985.

The Buddhist monastery in Matho is currently one of the lesser attractions on the tourist circuit in the upper Indus valley, but its status as the only representative in the region of the Saliva sect of Tibetan Buddhism, its now easy access by road, and its fine view over the upper Indus valley, will guarantee a steady stream of visitors. Although no tourist amenities exist in Matho today, a relatively high-class tourist hotel is currently planned. The Matho valley does not lie along major tourist trekking routes, many of which go through parts of the nearby Hemis National Park, but its proximity to Leh makes it a logical location for short treks that can be arranged easily in the town.

Although a few persons commute daily or weekly to jobs in Leh or the main valley, Matho remains primarily a farming-pastoral village. Cultivation is in walled plots that are irrigated by means of small man-made channels derived from the Matho stream; a detailed village council-approved scheme allocates water. Crops are planted as

early as late May and harvested in late August and early September. The principal crop is barley, with smaller amounts of mustard seed and peas, and a few other vegetables and herbs are grown in kitchen gardens. Occasionally fields are planted in legumes to produce livestock fodder and replenish nitrogen in the soil. The village is too high and cool for productive orchards of mulberry or apricot (common in the lower villages), although a few apricot trees are present. Traditionally, animal and human waste material has provided the primary soil-building and nutrient input. However, the recent introduction of cheap (subsidized) commercial fertilizers is beginning to alter cultivation practices here and in other areas along the Indus (Norberg-Hodge *et al.*, 1989), and lessen the need for animal dung, previously the essential link between livestock grazing and farming. Animal dung will undoubtedly continue to be used to add organic matter to the soil, but its importance as a nutrient additive has been lessened, consequently

decreasing the need for livestock and the collection of dung.

Milk cows (including a few recently introduced Jerseys) are kept year-round in the village by most families, fed predominantly with fodder grown on the farm plots, but also frequently let out to graze on field edges or just outside the village. The other livestock (primarily sheep, goats, and yak-cow hybrids) are stall-fed to a limited extent from September to May but are mostly herded to feeding areas, either within a day's grazing journey from the village or at one of several seasonal grazing bases a few hours' walk either up the Matho Valley or along the Zaskar Range foothills. Families may herd livestock on a communal basis and in some cases hire non-family members as herders. During summer (June-August) the livestock are taken on a long one-day journey to a *jmlu* or summer camping area at 4,000-4,500 m where small stone huts are used as shelters for the herders and stone-walled enclosures for the livestock (Figure 8). The sheep and goats are herded out to different parts of the high mountains each day, often up to several kilometers from the *pulu*, but usually in relatively open habitats to avoid cliff terrain. They are returned to the stone-walled enclosures each night where dogs of various breeds are left out to warn of disturbances such as predators. Yak-cow hybrids and local breeds of cow are herded near the camps and returned within the stone walls. The larger yak-cow hybrids (mostly males) and the few yaks, however, are left to graze on their own in the mountains and are commonly found in relatively rugged habitats among the cliffs. Horses are also left on their own and generally graze in relatively open areas; along with donkeys and some of the yak-cow hybrids, they are also commonly used as pack animals to transport goods between village and *pulu*. Some villagers own several horses which they hire out to tourist groups and others as pack animals.

Vegetation cover on the Matho pastures, typical of the central Ladakh steppe, is characteristically sparse although it generally increases in density with elevation and soil moisture and, with the exception of areas near the village and *pulus*, obvious signs of excessive overgrazing or trampling are not common. In the Matho catchment mid-summer vegetation cover was measured and found to be approximately 10-20% in *Stachys*, *Tanacetum*, and *Artemisia*-dominated communities at sites on northerly slopes of 30-40° between 3,600 and 4,500 m. Such low coverage is typical of arid rangelands, reflecting the extremely dry and cold climate. On similar northerly sites in Ladakh between 4,500 and 4,800 m, but where soils are moistened by snowmelt from above, some locations had 50-70% cover in *Oxytropis*-dominated communities; Hartmann (1987) presented data on *Elymus*, *tbentilla*, and *Carex*-dominated communities in the Matho and adjacent drainages with similar measures of plant cover, representing some of the densest vegetation in the high mountains. Above 5,000 m plant cover becomes extremely sparse. Except on the heavily trampled areas around the seasonal *pulus*, vegetation cover of less than 1% was typical only of the alluvial fan of the Indus plain

(3,500 m) adjacent to Matho, which reflects both the very dry conditions in the valley and the impact of livestock grazing from Matho and nearby villages. Virtually all the mountain vegetation shows signs of grazing, but both the lush growth in more inaccessible areas and the presence of abundant flowering in many pastures indicate that the summer exploitation of forage resources in the mountain pastures is not excessive. Nevertheless, substantially greater grazing pressure is clearly apparent as one nears

the spring, autumn, and winter herding areas, especially those in the vicinity of the village.

Traditional pasture land allocation systems similar to that in the Matho Valley have been described for other areas of the high Himalaya (Brower, 1987, 1990) and Tibet (Goldstein and Beall, 1990). The allocation of grazing areas is made according to a long-standing traditional subdivision of all parts of the Matho catchment, with families maintaining rights to specific grazing areas year after year, although exact allocations can be changed over the years by village council agreement according to the number of livestock owned. This system has apparently maintained sustainable grazing resources in the relatively heavily exploited pastoral land of the Changtang highlands (Goldstein and Beall, 1990), and there seems little doubt that it has also done so in the less heavily exploited farming-pastoral systems of central Ladakh, such as Matho.

In July 1989 there were six summer camps in the high Matho mountains, with about 15 different family groups represented and a total of about 25 people, mostly middle-aged adults and children. Some 3,500 sheep and

goats, 350 yak and yak-cow hybrids, 15 horses, and 20 donkeys were in die high mountain pastures at that time. These totals include livestock owned by residents of Matho, plus additional animals belonging to people (primarily relatives) from die village of Chushot, below Matho on the Indus. Also, about 350 merino sheep owned by the government animal husbandry station in Madio (see below) were herded in die mountain pastures by station employees between mid-June and mid-August.

In addition to animal dung, woody subshrubs (*Caragena*, *Artemisia*, *AcanthoUmon*) were collected for use as fuel in the *pulus*. Butter, cheese, and some dried mountain plants (*Urlica* sp.) were brought down from the mountain pastures for use as winter foodstuffs, but the primary reason for constant travel between *pulu* and

village during summer was die transport down of animal dung. Plant material, eidier from dead shrubs in me main canyon or small subshrubs (primarily *Artemisia*) from the hillsides, was also collected and carried to Matho for fuel but during summer this was small compared to die transport of dung. Yak-cow hybrid dung (good for fuel) was collected from all over the mountainsides, whereas die sheep and goat droppings (used for both fertilizer and fuel) were brought only from the concentrated sources in the stone-walled livestock enclosures. In the fall grasses (*Stipci*) and herbs (*Acmogonum*, *Stathys*) are gathered from mountains near the village for use as winter livestock forage, and there is some additional collection of woody plant materials for fuel.

RECENT LAND-USE DEVELOPMENTS IN MATHO VILLAGE

CROSSBREEDING PROGRAM

In the 1960s at the lower edge of Matho village, die Jammu and Kashmir government established a livestock breeding station where they introduced merino sheep and have recently initiated an aggressive program to encourage crossbreeding the merino with locally owned sheep to improve die wool and meat production of the stock. A subsidiary office in the main part of the village offers help with introduction of the Jersey cow and cultivates a small plot to demonstrate introduced fodder species. The station has also used die intermittent surface flow at die end of the Matho stream to irrigate a limited amount of fodder production for its sheep. Because it lies along the new Indus irrigation canal, fodder production and livestock population should increase once the canal becomes operational. The local station is run by Kashmri officers, aldiough the sheep herders employed are often from Matho or surrounding villages.

According to officers of the livestock breeding station, the merino sheep require at least 1.5 times more feed and protein than the local sheep. Therefore, they are grazed only in the more productive summer pastures in the mountains and for two mondis only; although diey are also occasionally grazed on the Indus alluvial plain, they must be primarily stall-fed the rest of the year. Many livestock owners have taken advantage of the low purchase price of die merino sheep offered for crossbreeding, and with the initial increases in wool production by crossbred sheep, the proportion of merino-crosses in village livestock herds and total wool production are increasing somewhat. Moreover, station personnel trained in veterinary techniques now provide services in tending to sick animals. Nevertheless, die inability of die crossbred sheep to utilize very marginal grazing areas is becoming evident and is of great concern to herders and owners. Some village herders complain about the station's use of prime grazing areas in die mountains, and in the summer of 1991 the village livestock owners refused to give access to summer pasture to the government station and demanded that grazing fees be paid. The villagers eventually backed down in the face of government pressure but conflict remains over use of the best grazing areas.

DECLINE OF SUMMER HERDING

Although not yet a severe problem in Matho, there is increasing difficulty in getting able-bodied family members to spend the summer as herders in the mountains. There are much more attractive job alternatives in Leh and vicinity, which often provide cash payment and a much

higher social status than does herding. The only teenagers engaged in herding during our visit in the

Matho mountains, for example, were those employed by the government sheep breeding station. As standards of living and education among Ladakhis increase, and the social acceptability associated widi herding decreases, fewer local people will undertake such work. Outsiders could be hired to do the herding and in fact the government began a test program in 1991 to hire herders to take village livestock to summer grazing areas. However, the real question is how important it will be for Ladakhi farmers to maintain large herds of livestock. Already, some currently available pasture lands that arc not used to capacity are being appropriated by odier users.

TIBETAN REFUGEE HERDERS

A Tibetan refugee community has been established across the Indus valley from Matho. Many refugees were pastoralists from the Changtang region of Tibet and, although most have taken to a settled life in the refugee community, a few have recently acquired some livestock (mostly sheep and goats) and graze them in little-used areas between villages on the south side of the Indus valley. Although such areas were little-used for grazing by die Ladakhis and die pasture land was not used to its capacity, friction between local herders and the Tibetans has already occurred as the numbers of refugees' livestock have increased and compete with traditional grazing rights of the nearby villages. The main consequence, however, has been that, in combination with the grazing of government-owned livestock and the apparent decreasing use by villagers of high mountain pastures, the already relatively sparsely vegetated mountain pastures along the edge of the Indus valley are being subjected to greatly increasing livestock use.

We can summarize, then, a number of factors that appear to be influencing the intensity and location of livestock grazing pressure on the pasture resources of Matho village:

in grazing pressure

1. desire to keep or increase numbers of livestock to maintain rights to allocated grazing areas.
2. crossbreeds eat more, so greater grazing impact of a given number of animals.
3. introduction of non-traditional herding (e.g., government, Tibetan refugees).
4. greater pressure on near-village grazing areas with animals kept in the village.

5. greater demand and high prices for meat in nearby Leh. *Decrease in grazing*

pressure

1. fewer people are willing to perform the low status job of herding in the more remote areas.
2. fewer crossbreeds are needed to produce a given amount of wool or milk.
3. crossbreeds cannot utilize the more marginal grazing pastures.
4. new farming techniques have lower requirements for animal dung.
5. livestock are increasingly stall-fed.

during the summer of 1989, attitudes toward wildlife were shown to be generally positive (S. Bhatt, unpubl. data). The principal exception was the wolf which was well known as a killer of livestock around the village. Although virtually everyone interviewed knew of the common large mammals in the area, less than half indicated that they had seen blue sheep or urial, whereas almost all had seen wolf and fox; none had actually seen a snow leopard. Villagers indicated that urial and blue sheep had been hunted in the past but that both the religious influence from the monastery and the current illegal status of hunting expressed by the Leh wildlife ranger have precluded such activities today. Several villagers indicated that if a wolf were killed, it was paraded around the village for the "hero" to collect small rewards from livestock owners. A stone-walled pit-trap for wolves (Figure 4) still stands on the lower outskirts of Matho village, and is sometimes baited with a live animal when predation losses or a particular wolf becomes a special problem for the village.

Villagers who accompany livestock to the summer grazing areas are more closely acquainted with wildlife found in the mountains, and a few had even seen snow leopards. Herders interviewed in the summer grazing areas repeatedly indicated that, in their view, there was no competition for food between their livestock and the wild herbivores such as blue sheep, and their livestock grazing activities were not disturbed. In fact, one woman volunteered that if their activities were to pose a threat for the blue sheep, herders would try to prevent it. If villagers were vigilant in their herding duties, losses to predators could be kept to a minimum. Special efforts are made to secure and guard (with dogs) the nighttime enclosures for livestock and occasionally a snow leopard or wolf is killed if it gets inside.

The Matho stream flows from the high open pastures down through a steep and narrow gorge before emerging onto the alluvial fan on the Indus plain. Within the steepest part of the canyon dense natural thickets of willow, buckthorn, rose, and other tall shrubs cover the valley floor, presenting a marked contrast to the dry sparsely vegetated hillsides. It is said that two powerful

spirits, who came from Tibet in the fifteenth century with the founder of the monastery in Matho, reside in a small shrine within the thickets because they are too powerful to be allowed close to the village itself. These powerful resident spirits protect the shrub thickets in Matho canyon so they have not been exploited as much as those in similar adjacent canyons. The shrine site itself is marked by the presence on nearby cliffs of the only two juniper trees left in the Matho and nearby catchments. In recent years there has been some increased cutting of the thickets by both villagers and outsiders from neighboring areas, for personal use and for sale as firewood. During the New Year festival at the Matho monastery several years ago, when the monk chosen as the "oracle" representing these spirits of the monastery went into the ritual trance, he severely castigated people in the crowd (both villagers and outsiders) for displeasing the resident deities by cutting the tall shrublands in the Matho gorge, and such activity diminished dramatically thereafter.

Perhaps institutions based on religion or, in the case of pasture use, village councils can be effectively utilized in promoting conservation initiatives today. In any event, it is clear that competing non-traditional demands for grazing resources, such as those introduced by Tibetan refugees and government livestock breeding stations, will require new institutions for regulation of pasture use, especially in areas of such high demand and environmental sensitivity as along the Indus valley.

Matho village represents a part of Ladakh experiencing relatively heavy development pressures, and as such is perhaps indicative of changes that will come to more remote villages in the near future. Because the Matho catchment lies adjacent to Hemis National Park, although separated by a 5,000-6,000 m ridgeline, the developments here and the implications for villages inside the park present important considerations for agencies responsible for protected area management. However, before we consider these implications a few additional types of land-use changes, not present in Matho but affecting other parts of Ladakh, will be briefly reviewed.

FURTHER EXAMPLES OF RESOURCE USE CHANGES IN LADAKH

EXPLOITATION OF WOODLAND AND SHRUBLANDS

The provision of road access to villages throughout Ladakh is strongly desired by the local inhabitants. Nevertheless, where routes pass through areas of high natural value, care should be taken to ensure that construction does not unnecessarily destroy valuable resources. Although the Matho Valley is too small and steep to support more than one year-round village, in similar but larger Indus tributaries nearby there are small villages that lie up to 4,100 m. Roads are currently planned that will pass for several kilometers through

canyons similar to the Matho canyon where limited areas of woodland and shrub thickets occur on the valley bottoms and provide habitats for myriad small wildlife species; these represent areas of substantial biological

diversity in the typically very sparsely vegetated region. More significantly, a 70-km road is also planned through the large and spectacular Zaskar River gorge from the Indus to the open valley of the upper Zaskar region centered around the village of Padum (Figure 1). In the Zaskar gorge there are extensive areas of little disturbed relict poplar, willow, and juniper woodlands which indicate that natural vegetation has been removed or altered in the past by human impact along other large river courses in the region. The gorge also includes prime habitat for snow leopard, blue sheep, and ibex within the core area of the recently expanded Hemis National Park (Figure 10).

As roads are constructed through the rugged mountain canyons, the effects on native woodlands can be of

The overall effect of these factors is a redistribution of pasture use. The increases in grazing pressure are almost all near the village and along the edge of the Indus valley, whereas the decreases are mostly restricted to the higher and more rugged mountain pastures. Any increases in pressure in the mountain pastures will probably be restricted to the best, less rugged pastures where the new crossbreeds can be safely and productively grazed.

As Darokhan (1986) has suggested for much of the upper Indus valley, livestock use of the more remote portions of Madio's mountain pasturelands is apparently decreasing. One of the first changes will be a decline in the transport of animal dung. For example, an estimated 100-200 kg of dry animal dung, primarily yak and yak-cow hybrid but also sheep and goat, was being transported daily from high mountain pastures down to Matho by the herders in mid-summer; this amounts to 10,000-20,000 kg of dry dung between June and August and it apparently represents only a small portion of the total dung collected also from the auxiliary seasonal grazing camps closer to the village and from in and around the village itself. Indeed, special trips are made to seasonal and some summer livestock enclosures after the animals have left to collect the sheep and goat dung, for use on the crop fields and as fuel. Whereas these large efforts reflect the importance of dung in the traditional subsistence economy, it is apparently already declining with the introduction of chemical fertilizers and alternative cooking fuel, such as kerosene. Whether the collection of plant fuels and fodder from the mountains diminishes will depend on the economies of alternative sources. In this regard, improvements in the use of the Matho stream for irrigation of fodder crops and shrubs and trees would probably reduce pressure on the mountain sources, as would such use of the large Indus irrigation canal. The net result of decreased dung collection from the mountains will be an increased return of nutrients to the soils and vegetation which will benefit the mountain plant communities and their wild herbivores.

Additional changes in livestock and pasture use associated with tourism, such as provision of fresh meat and milk products, may become important in and around Matho itself; in the more remote areas the increased numbers of pack horses used for trekking will also affect pasture use. Future developments in Madio will depend on many factors, primarily tourism, the degree of success for the Indus irrigation project, and the amount of continued subsidization for introduced livestock and farming innovations.

The higher elevations of the Matho catchment support some 80-100 blue sheep, as well as hundreds of smaller mammalian and avian herbivores including marmots, hares, snowcock and rodents—all prey of the snow leopard, wolf, and dhole which hunt in the area. Currently, domestic livestock are grazed only during a three-month period so that mountain pastures may be used by wild herbivores during the remaining snow-free or limited snow depth seasons, although the ungulates must move to lower, more heavily grazed elevations during midwinter when snowcover is deep. If livestock grazing decreases in the future, the high mountain herbivores will probably benefit from the improved pastures, and consequently larger populations of wild prey will be available for the large predators. Species such as blue sheep that are adapted to the more rugged areas will probably benefit most, because these areas will be more completely abandoned by graziers.

Whereas the blue sheep is a high mountain mammal characteristic of rugged terrain, the endangered Ladakh urial prefers more open terrain and rolling hills at lower elevations (Mallon, 1983; J. L. Fox, unpubl. data). Its prime habitat lies typically on the alluvial outwashes and open foothills along the edge of the Indus valley (Figure 9), and small groups of the 30-50 urial can occasionally be seen grazing near Matho on the upper village fields at the base of the first hills of the Zaskar range. The Matho monastery affords them some protection and they are not usually harassed unless grazing in the fields where crops are growing. Nevertheless, their prime grazing habitats are also those of domestic livestock. The appropriation by Tibetan refugees of traditionally little-used grazing areas near Matho, grazing by the government's merino sheep along the foothills, and increases in livestock around the village have greatly intensified both grazing pressure and disturbance within the urial's habitat, thus increasing the threats to its continued survival in the area.

As individual livestock, especially exotics and crossbreeds, become more valuable there will be increasing pressure to deal effectively with livestock losses to predators. Near villages such as Matho, predator control measures will affect primarily the wolf and dhole which commonly hunt along the Indus foothills, and to a lesser extent the snow leopard which is more closely associated with relatively steep and rugged mountain terrain. However, livestock owners and government officials will be under increasing pressure to control all predators and the availability of modern weapons, trapping devices, and poisons will make control easier than in the past. Currently, the main threat to endangered snow leopard populations in Ladakh is the retaliatory killing of individual animals that take livestock (Fox *et al.*, 1991b), and efforts to conserve this species, as well as wolf and dhole, must be able to accommodate the livelihood requirements of the pastoral community.

In terms of wildlife conservation values, the location of Matho village along the main development corridor of the Indus valley has precluded the desirability of any type of strict protected status for the area. The Matho Valley catchment, however, is bounded to the southwest and south by the recently established Hemis National Park (Figure 1), which encompasses more remote and less inhabited valleys in the Zaskar mountains. Although the establishment of the park will not entail changes in general land-use practices in Matho, it has been proposed

that the lower Matho Valley and its adjacent catchments along the edge of the Indus valley be given special management consideration because of the presence of the endangered urial (Fox and Nurbu, 1990). Already reduced in number by hunting in the recent past (Fox *et al.*, 1991 a), approximately 1,000 urial are left in Ladakh and their fate will be determined by the conservation measures that protect this species in its prime habitat (i.e., Indus valley). Other areas further from Matho may be better suited for strict protection measures, and several have been included in the Hemis park and proposed wildlife reserves. If livestock grazing pressure and disturbance are reduced in the upper Matho catchment, the government may want to restrict non-traditional uses so that the area may act as a buffer to the adjacent national park and conserve the habitats of mountain mammals such as the blue sheep.

VILLAGERS' ATTITUDES

In a limited survey of 30 residents in Matho village

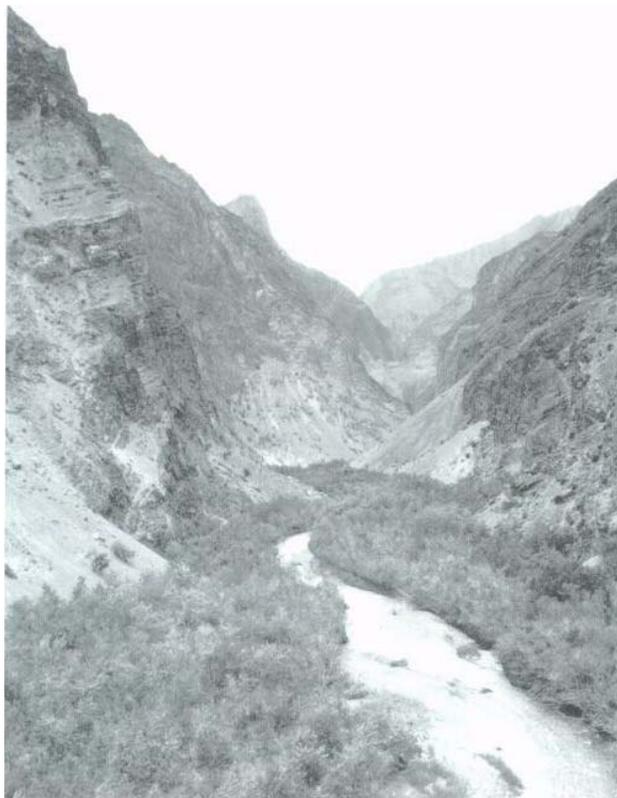


FIGURE 10. The densely forested valley bottom of the Chang Chu river within the uninhabited and little used core area of the Hemis National Park. The valley bottom is covered with *Satix*, *Hippophae*, and *Papulus*, with scattered small *Juniperus* trees present on the lower mountain slopes; both blue sheep and snow leopard are common throughout the canyon.



immense significance. As Burman (1990) points out, under normal conditions in the Himalaya, some 11 tonnes of wood per kilometer of road are typically used during the construction phase. Most comes from local sources and is used to provide cooking and heating fuel for all the migrant construction laborers who live on-site as well as for asphalt production used in paving the road. Although construction practices in Ladakh clearly cannot depend entirely on local wood and more efficient use of wood is necessary, it remains clear that most fuel resources used in road construction within Ladakh consist of local trees and shrubs. This is of special concern where construction takes place in areas of relict vegetation and high biodiversity, especially within designated or proposed protected areas (Fox and Nurbu, 1990). The state Department of Wildlife Protection argues that the difficulty of construction, limited commercial value, and location within the core area of a designated national park should lead to abandonment of road construction in the Zaskar gorge. However, if and when roads through such gorges are constructed, special efforts should be made to provide alternative sources of wood (or fuel) to protect the vulnerable natural woodlands.

Although the extremely limited extent of undisturbed natural woodlands and shrublands in Ladakh deserve explicit protection, the general question of forest and shrubland conservation must be viewed within the context of current trends in the region. The number of large trees and shrubs in the upper Indus valley including Leh has increased noticeably in the past fifty years (Chering Nurbu, pers. obs.). Perhaps this represents a long-term recovery from the massive destruction of woodlands associated with the Kashmiri occupation of Leh around 1840, exacerbated by the increased government and army demands soon after independence (1947) and before the Leh-Srinagar road opened in 1962. Nevertheless, it reflects the extensive efforts by Ladakhis and the Forest Department in planting and cultivating almost all the trees and large shrubs that are present in and around the major villages of the upper Indus valley. Numerous recent



FIGURE 11, The open plains and rolling mountains of the Changtang plateau in eastern Ladakh, here with domestic yak-cow hybrids grazing in the foreground. Photograph by Chering Nurbu.

government afforestation programs, mainly poplar and willow, have been effective in increasing the production of wood throughout Ladakh. In terms of species conservation, the increased planting and irrigation of trees and shrubs in and around villages tends to ameliorate the microclimate and provide habitats and cover for many species of birds, reptiles, small mammals, and other smaller organisms. Although the increased area of cultivated woodlands add substantially to the habitats for some wildlife species and may mitigate exploitation and offset losses in natural areas, some species of animals and plants are able to survive only in the relatively remote and relatively undisturbed native woods and shrublands. For example, a few areas along the bottom of the Nubra and Shyok valleys harbor some of the densest populations of lynx and hare in the Transhimalayan region (Chundawat, 1990). Concerted efforts will be required to prevent the loss of remaining natural woodlands and their relict species due to road construction and exploitation for fuel wood.

PAKTQALISM AND WILDLIFE IN CHANGTANG

On the Changtang plains of eastern Ladakh (Figure 11) recent high levels of mortality in livestock are believed to be a manifestation of deteriorating pasture quality (Darokhan, 1986); this is a major concern for both the livestock industry and wildlife conservation authorities in Ladakh. A combination of overstocking and bad weather reduced the productivity of the pastures, and livestock populations severely declined in the early 1980s (Darokhan, 1986), prompting government pasture management agencies to question their programs for increasing productivity of the livestock industry (Chakrabarti, 1986). Extensive efforts are being made to minimize neonatal mortality for all livestock. The government has not attempted to crossbreed the changra goats because of their value in producing the genuine "pashmina" or cashmere wool, but intensive breeding efforts are under way to improve the stock. The Kashmiri merchants' monopoly on Ladakh production of cashmere wool (about 30,000 kg/yr) kept prices artificially low (Rizvi, 1983), but recently international demands have led to higher prices and goat populations will probably increase substantially.

The overall effects of reduced livestock neonatal mortality, consequent increased stocking levels, and the influence of extreme weather are poorly understood and, although a severe deterioration of pasture quality is predicted and feared (Dardokhan, 1986), periodic incidence of high livestock mortality are natural occurrences within such strictly pastoral systems in marginal environments (Coughenour *et al.*, 1985; Mace, 1991).

Government pasture management agencies should be very cautious in attempting to devise pasture utilization schemes based on short-term assessments of pasture use capacity. In Ladakh, with a dry climate, short summers, and marked annual variation in precipitation, carrying capacity should be viewed as a very fluid concept; it can change dramatically from year to year. Dasmann and Poore (1979) recommend for mountain grazing lands, that "provision of forage reserves for drought years or arrangements for rapid reduction in stocking rates should be built into long-term planning for pastoral economies in such areas."

Moreover, the perennial grasses of Ladakh may be relatively susceptible to overgrazing (Mace, 1991) and trampling (Dasmann and Poore, 1979; Johnson, 1979). Because estimates of maximum stocking levels are fraught with uncertainty, efforts to keep livestock populations near a capacity level are often unrealistic; government or private efforts that attempt to greatly increase and maintain the productivity of such marginal rangelands as the Transhimalayan pastures, may inevitably fail. In fact, traditional pasture-use systems that experience periodic livestock losses and then a rapid rebuilding of herds may be the most efficient use of such grazing lands (Coughenour *et al.*, 1985; Goldstein and Bcall, 1990). More knowledge of the vegetation-grazing dynamics in the region is needed if traditional levels of exploitation are to be increased. As Tucker (1986) noted in reference to southern parts of India's Transhimalayan ecosystem, "no department of government has active responsibility for studying or managing these highlands," and this undertaking is only now beginning in Ladakh. For example, the government's initial efforts to decrease neonatal mortality of livestock will lead to increasing normal adult mortality which will occur during natural episodes of poor pasture quality.

Recently reported increases in populations of wild ass or kiang and demands for their control (Fox *et al.*, 1991a) suggest the possibility that factors other than grazing competition, such as continued hunting, may be preventing recovery of other plains species such as gazelle and argali. The recovery in kiang numbers implies that pastures have not greatly deteriorated, but rather have undergone an episode of low productivity as part of normal variation. The major areas of perceived conflict with kiang are in low elevation (4,500 m) winter grazing areas along valley bottoms, where grazing competition by kiang is exacerbated by a breakdown in traditional separation of grazing territories; many groups of nomadic herders are now using prime winter areas previously restricted to use by only a few family groups. These areas are also traditionally used by kiang in winter and wildlife has become the scapegoat for detrimental effects of changes in human land-use practices.

The major concerns of natural resource managers regarding future conservation of wild herbivore and large predator conservation in eastern Ladakh will be intimately associated with the development of the livestock industry. If the current problem is related to a long-term deterioration of grazing lands, resident wild ungulates will inevitably be affected, and endangered species will need protection. In any event, if the recently decimated populations of wild herbivores such as antelope, gazelle, wild yak, argali, and urial that use the relatively flat and open grazing lands (Fox *et al.*, 1991a) are to recover in population size, there must be a commitment to conservation and the establishment of protected areas where hunting is eliminated and competition from domestic livestock is restricted.

Widespread decimation of both ungulate and predator



FIGURE 12, The upper Sum valley (4,300 m) where intensifying conflicts over seasonal grazing rights threaten populations of ibex, snow leopard, and brown bear.

populations in western China has also occurred in recent years (Rowell, 1983; Schaller, 1990), and is probably similar to that accompanying the introduction of firearms, military presence, and railroads to similar habitats in western North America during the 1800s. The elimination of wildlife has been especially dramatic in the vicinity of major roads, such as the one skirting China's border with Transhimalayan India which was fought over in the 1962 war, and the prospects for maintenance of viable wildlife populations in conjunction with a large military presence here are uncertain, if a recovery of wild ungulate populations in the Changtang region is to be accomplished in the face of military presence and increasing domestic livestock production, then certain restrictions on livestock pasture use will be required in some areas where hunting is prohibited. Protection is also needed for other endangered wildlife species that are highly vulnerable to disturbance from human activities, such as the black-necked crane which nests in the lush vegetation surrounding high-altitude lakes in eastern Ladakh. With rising demand for meat and fiber products (such as cashmere wool) from these grazing lands, it will be increasingly difficult to maintain the same habitat for both wild and domestic animals. Nevertheless, if pasture management authorities are able to maintain conservative stocking levels and adapt traditional use-allocation princi-

ples in at least some of the public or private rangelands, then continued survival of the competing wild herbivores may be possible in habitats outside the few strictly protected areas.

HIMALAYAN GRAZIER CONFLICTS

In the upper Suru valley of southwestern Ladakh (Figure 12) an increasing conflict is developing over the use of pasture resources. Buddhist and Muslim farmer/pastoralists cooperatively share the valley on an amicable basis, with the Buddhist villages and grazing areas located in the highest part of the valley at 3,800 m. Since the 1960s a Kashmir government sheep breeding station in the lower valley has taken limited numbers of sheep into the upper valley for summer grazing. Within the past 10-15 years, however, the Kashmir government has supported a greatly increased movement of migratory herders from the south side of the Himalaya into the upper Suru valley for seasonal grazing. Recently, tensions have increased dramatically between the upper valley Ladakhis and these migratory "bakrwal" herders who in summer bring large numbers of goats and sheep to

areas important to the Ladakhis for autumn grazing and fodder collection (Fox *et al.*, 1986). Although the upper valley pasture resources were probably underexploited in the traditional Ladakhi pastoral system, current or increased levels of exploitation may have serious consequences for both the Ladakhis and the wildlife in the area. The political issues involved are complex and will not be easily resolved, but the probable effects on pasture and wildlife conservation are clear. The grazing resources will be fully exploited, the present populations of ibex will be reduced, and probably the last viable population of brown bear in Ladakh will disappear. The upper Suru valley was proposed as a wildlife reserve in about 1980 (Anon., no date), a possibility now very unlikely in view of both a major new road through the area and the increases in pasture exploitation described above.

WILDLIFE CONSERVATION AND DEVELOPMENT

Wildlife conservation and economic development are often viewed as mutually incompatible goals, and the history of modern conservation in developing nations commonly reflects an uneasy melding of the two (Tangley, 1988; McNeeley, 1989, 1990; Lewis, 1990). Such concerns are paramount within the context of the recent and continuing establishment of national parks and other conservation areas in the Himalaya, most of which include human populations and traditional agriculture, grazing, and other land-use rights. Similarly, a recent surge in information on indigenous traditional land-use conservation mechanisms in the Himalayan regions has prompted calls to incorporate these into current development and conservation programs (Messerschmidt, 1985, 1986, 1990; Brower, 1990; Stone, 1990). Fundamentally, this implies that local knowledge and participation are included in formulation of conservation actions which, although eminently logical and straightforward, have been largely ignored until quite recently in the central government dominated administration of national or international conservation objectives. Conservationists, therefore, are now attempting to target protected areas and their vicinity as key locations in the Himalaya for efforts to involve local participation in environmentally sustainable development programs (McNeeley 1985a, 1985b). As development officials in Ladakh become more cognizant of these issues, land-use managers will require more accurate assessments of the conservation implications of proposed actions in order to encourage programs for increasing human standards of living that incorporate conservation objectives. A few examples of conservation-related land-use changes from other areas of the Himalaya, such as the Mt. Everest region, may provide some useful comparisons to Ladakh.

LAND-USE TRENDS ELSEWHERE IN THE HIGH HIMALAYA The primarily pastoral use of Ladakh's steppe and alpine meadows is comparable with other predominantly alpine areas of the Himalaya. Livestock breeds, their abundance, and the use of pasture are changing throughout the region; although there is a wide variation in local circumstances, certain trends seem to be emerging that appear to be associated with an increasing desire to benefit from cash-producing enterprises and a concomitant disinclination toward spending long periods with livestock in isolated and remote pastures. Tucker (1986) and others (Phillimore, 1984; Noble, 1987) disagree

whether or not livestock (sheep and goat) populations are increasing in transhumant grazing systems in parts of the western Indian Himalaya, but they acknowledge that the use of remote higher pastures may be declining. Bishop (1989) has reported recent changes in yak and cow husbandry in a part of the Langtang National Park in Nepal that indicate increased near-village grazing pressure and undetermined effects on high elevation pastures, resulting from an increased desire to earn cash.

In the Khumbu area of Nepal, including Sagarmatha (Mt. Everest) National Park, sheep and goats, while never a large component of the resident livestock, increased in number between 1957 and 1971 and then decreased during the 1970s and 1980s, probably in response first to the cessation of wool trade from Tibet and later to the increase in availability of cloth from the south and increased buying power derived from tourism (Furer-Haimendorf, 1975; Björnness, 1983; Brower, 1990). There have been no significant changes in the numbers of cattle in Khumbu, but with more pack animals (yak hybrids) and milk-producing animals (cows) required near the villages for the tourist trade, and fewer people willing to herd yak, grazing no longer occurs on some of the higher pastures (Furer-Haimendorf, 1975; Björnness, 1980a, 1980b; Brower, 1990). Conservationists associated with the national park and local councils are currently attempting to redress problems stemming from the increased grazing at lower elevations through adaptation of traditional mechanisms for sustainable distribution of the common grazing resources (Brower, 1990). Wildlife species at higher elevations have increased in number since the park was established, but those species with habitats in the increasingly heavily used areas around the park's lower periphery may be suffering from the increased pressures (J. L. Fox, pers. obs.; L. Sherpa, Park Warden, pers. comm.). In all areas the introduction of oil-based cooking fuels has lessened demand for woody material and animal dung, but how much the impacts of increasing population and tourism overcompensate for this decrease and directly affect plant communities remains uncertain. Although the circumstances of change and effects on wildlife are site specific, general patterns of decreased use of remote pastures, increased use of near-village pastures, and preference for cash-earning enterprises are apparent across the Himalaya.

WILDLIFE AND FUTURE DEVELOPMENT IN LADAKH

The changes occurring in Ladakh, such as military

presence, medium-scale development projects, and tourism, are more substantial and varied than those in the Khumbu area around Mt Everest where trekking and tourism are predominant, although some of the effects on grazing patterns are rather similar. As long as the military remains, its infrastructure will continue to be a major influence on Ladakh's economy, providing jobs and supply systems in many remote areas. The livestock industry, including the production of cashmere wool, is a very important aspect of Ladakh's economy and its development will certainly have significant consequences for wildlife conservation. Ladakh is probably too dry and stark a land to develop as a major tourist destination. The future of its primary attraction—openly practiced Tibetan Buddhist culture—will depend to a large extent on the progress of political openness and religious revival in Tibet which could become a highly competitive alternative tourist attraction. The mountains and plains in Ladakh will never have the lure of a place such as Mt. Everest, but the ideal summer weather, unlike that in Nepal, may bring many visitors to experience the Himalaya and some parts of Ladakh will probably see tourism-based developments similar to those in Khumbu. In the long term, trekking tourism in Ladakh will unquestionably be closely tied to the success of conservation efforts in the region.

There is still widespread potential in Ladakh for additional and more efficient use of water storage and distribution (including pumping) in the irrigation of traditional crops, fodder, and wood, as has been described in areas of northern Pakistan (Dixon and Perry, 1986). There is considerable potential for the implementation of medium and small-scale hydroelectric generation; a high potential for development of solar power from the usually clear skies is just beginning to be tapped, primarily in passive solar ovens, heat boxes, walls, and water heating systems (Ladakh Project, 1989). Modern technological aids to development that provide alternative and appropriate sources of heat, cooking fuel,

fodder, and wood building material in Ladakh may relieve pressures on limited land-based natural resources, and can be used to advantage in and around areas of high conservation value.

Increased production from the rangelands, which depend on the natural rainfall and snowmelt rather than on irrigation, will be less assured and human exploitation will be largely limited by the natural environment. The future of the livestock industry will depend on well-crafted schemes for pasture use. As noted above, within the context of traditional land-use patterns in the marginal rangelands of Ladakh, wildlife populations have fared relatively well. Pasture management actions that simulate or uphold traditional practices are therefore likely to maintain this relatively benign association with wildlife. In general, very low human density ($2.5/\text{km}^2$) and limited prospects for large population increases will continue to minimize potential conflicts with conservation of native wildlife in Ladakh, and some general land management schemes that include a place for the wild animals may be practical.

The possible future reduction of domestic livestock grazing in remote and rugged mountain pasture lands may allow some wildlife populations such as blue sheep and ibex to increase in the future. Nevertheless, the apparent redistribution of grazing to near village sites and the introduction of new non-traditional graziers, such as the government station and Tibetan refugees, as well as

the possible further influx of traditional migratory graziers from the south side of the Himalaya, may cause overuse of some rangelands; pasture management authorities must take these factors into account. Where endangered wildlife species are affected by intensive livestock grazing, application of local knowledge of pasture use and traditional grazing allocation schemes will require intensive review and adaptation to the new circumstances.

Some current developments are being heavily subsidized in directions that may not necessarily coincide with conservation objectives. If increase in standard of living (quality of life) is acknowledged as the primary goal of rural development, and subsidization of development is used to foster this goal, then development should be oriented in directions that also support conservation goals as one aspect of sustainable development. Similar development innovations may affect wildlife species differently, so that they should be coordinated on a case by case basis with specific conservation goals. Measures that are appropriate in one region may be inappropriate elsewhere; for example, exotic livestock are inappropriate for Chantang but not for central Ladakh where fodder is grown with irrigation.

Potential development initiatives that may foster conservation goals in Ladakh include:

1. Efficient use of available water for fodder and fuelwood production.
2. Use of non-native wood (fuel) sources during road construction in areas of high conservation value.
3. Use of solar energy to minimize space and water heating and some cooking costs, traditionally provided by wood or dung.

4. A critical approach to "improvements" in traditional pastoralism methods, especially in recognizing the potentially large natural annual variation in pasture quality.
5. Restrictions on introduction of new types of pasture utilization in the limited areas of high conservation value.
6. Institution of tourism fees in protected areas with explicit direction that these monies be used to augment conservation-oriented sustainable development in and around such areas.
7. Recognition and application, when appropriate, of indigenous land-use conservation mechanisms.

natives (Rodgers, 1992). As several recent authors have discussed (Hurni *et al.*, 1987; McNeeley, 1990; Dyer and Holland, 1991), one possible solution to the issue of conservation and development in and around national parks is the use of UNESCO's designation of Biosphere Reserve, which incorporates different levels of protection to enable human uses in decreasing intensity around areas of strict protection. There are also other alternatives and Nepal, for example, is experimenting with several different approaches to conservation in its mountain regions. Efforts to establish conservation-oriented development programs in the relatively productive lower elevation zones will be absolutely essential for mountain

ESTABLISHMENT OF PROTECTED AREAS IN LADAKH

Following initial action by the British administration in the first half of this century, within the past decade the state of Jammu and Kashmir has renewed efforts at setting up a system of protected areas in Ladakh (Fox *et al.*, 1991a). The extremely low human population density in some parts of the region has permitted the inclusion of quite large areas in the proposed system, but much remains to be done to formalize and consolidate these efforts. The first national park in Ladakh, named Hemis after a prominent monastery, was initially designated in 1981 and recently extended to an area of approximately 4,800 km² (Fox and Nurbu, 1990). Whereas one small wildlife reserve has already been designated, another 10,000-20,000 km² are proposed within various protected area definitions. Were this, a substantial 25-42% of Ladakh would have protected area status but the realization of even a portion of these proposals will necessitate close cooperation between conservation and development authorities in the state. Because many proposed protected areas include significant areas of human habitation and are subject to extensive livestock grazing, site selection and management will need to incorporate and accommodate the development aspirations of the people involved.

The establishment of national parks and reserves within developing economies involves certain risks regarding local acceptance and local benefit (West and Brechin, 1991; McNeeley, 1985a, 1985b) and may encounter special challenges when situated in mountain regions (Bjenness, 1980a, 1980b; Jefferies, 1982; Pawson *et al.*, 1984; Hurni *et al.*, 1987; Brower, 1990). India's conservation laws are based on concepts of strict nature protection, and include legal definitions based on the most stringent of IUCN's protection categories (Government of India, 1982; McNeeley, 1990); thus, the established and proposed protected area designations in Ladakh imply severe restrictions on human use. It is no wonder that Ladakhi villagers who found their homes in the middle of Hemis National Park became fearful for their future and sent representatives to Leh to express their concerns about possible restrictions on their land-use rights, or even their continued presence. As there were no imminent plans for severe restrictions, these concerns were quickly mollified, but this again points to the need to change the typical top-down application of government objectives and to include the participation of local people early in the process of formulating conservation plans.

The effectiveness of management authorities in Ladakh and elsewhere in the Indian Himalaya is undermined because it is difficult to enforce restrictions in protected areas. Indian conservationists recognize the need to revamp or reinterpret the legal structure of conservation designations and to investigate new management alter-

protected areas, and should provide paradigms for conservation programs elsewhere in biologically rich areas of the Himalaya. Conservationists in India have begun to embrace the Biosphere Reserve concept, and very recent Himalayan examples include the designation of the Nanda Devi and the J.L.N. Great Himalayan National Parks as such reserves. Hemis National Park has been proposed several times as a prime candidate for designation as a Biosphere Reserve, and as both the largest designated

national park in India and the most critical in terms of snow leopard conservation (Fox and Nurbu, 1990), Hemis deserves special consideration within India's Himalayan protected area system. Its proximity to Leh provides an ideal situation for instituting and overseeing conservation-oriented development programs, the implementation and success of which will help determine the applicability of various sustainable development alternatives in conserving Ladakh's natural areas.

CONCLUSIONS

Current development directions in Ladakh may indirectly benefit wildlife species found in rugged mountainous regions yet be detrimental to those of the major valleys and high plains. Nevertheless, many factors influence these trends and an understanding of the interactions involved will be essential to the formulation of appropriate site-specific conservation actions that will preserve critical habitats and viable wildlife populations in Ladakh. There are low human population densities, limited arable land, and extensive areas with marginal pastoral potential, so that substantial areas remain open to natural ecosystem processes and long-term conservation of natural or near-natural systems may be possible.

Nevertheless, traditional land-use rights throughout all areas of Ladakh must be considered as programs for conservation and sustainable development are introduced.

Conservation of the large predators such as the snow leopard will be much more problematic than that of their ungulate prey, the black-necked crane, and other smaller animals. Careful selection of management approaches will be essential to ensure the maintenance of viable wildlife populations and their requisite habitats. The presence of prime wildlife habitats, such as Hemis National Park, within close proximity to the rapidly developing upper Indus valley underscores the importance of understanding the effects of development on Ladakh's natural resources. Success or failure to conserve the unique resources of places such as the Zaskar gorge and its surrounding areas in the Hemis National Park will strongly presage the outcome of India's conservation efforts in other parts of the Transhimalayan and Himalayan mountain regions.

POSTSCRIPT

Most of the field data for this paper were gathered prior to the recent upsurge of political violence centered in the Kashmir valley. This unrest has had a detrimental influence on day-to-day commerce and a decimating effect on the tourist industry in the state of Jammu and Kashmir; the primary access to Ladakh (the Srinagar-Leh road) had almost no tourist traffic during the summers of 1990 and 1991. In the meantime, however, the military authorities have allowed the opening of the road from the Kulu valley and Lahul in Himachal Pradesh through eastern Ladakh to Leh (Figure 1). This initiates a new route for both tourist and commercial traffic and, with continuation of the disruptive activities on the Kashmir side, will probably substantially alter the commercial trade connections and distribution of tourism in Ladakh. The previously remote and little-visited nomadic pasture areas of Rupshu, for example, will probably soon experience a greatly increased development of rest stops, camping areas, and trekking routes. Livestock composition and grazing patterns (as described above for Khumbu) may be adapted to cater to these new visitors, and this will foster changes in the lifestyle and economy of the nomads.

Lastly, the revival of Buddhist religious activities in Ladakh has recently been accompanied by an increase in political assertiveness that has railed against the growing Kashmiri Muslim domination of commerce in Leh, as well as claims of unequal education opportunities that have left few Ladakhis qualified for government administration and civil positions in the Leh district. As a result, civil unrest occurred in Ladakh during the summers of 1989 and 1990 and, although there were no major disruptions in 1991, tensions remain high. In general, although the activities in the Kashmir valley have far overshadowed disagreements within Ladakh, both have been disruptive of daily life and commerce, and future developments for conservation and other issues in Ladakh will depend significantly on the resolution of these disputes.

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