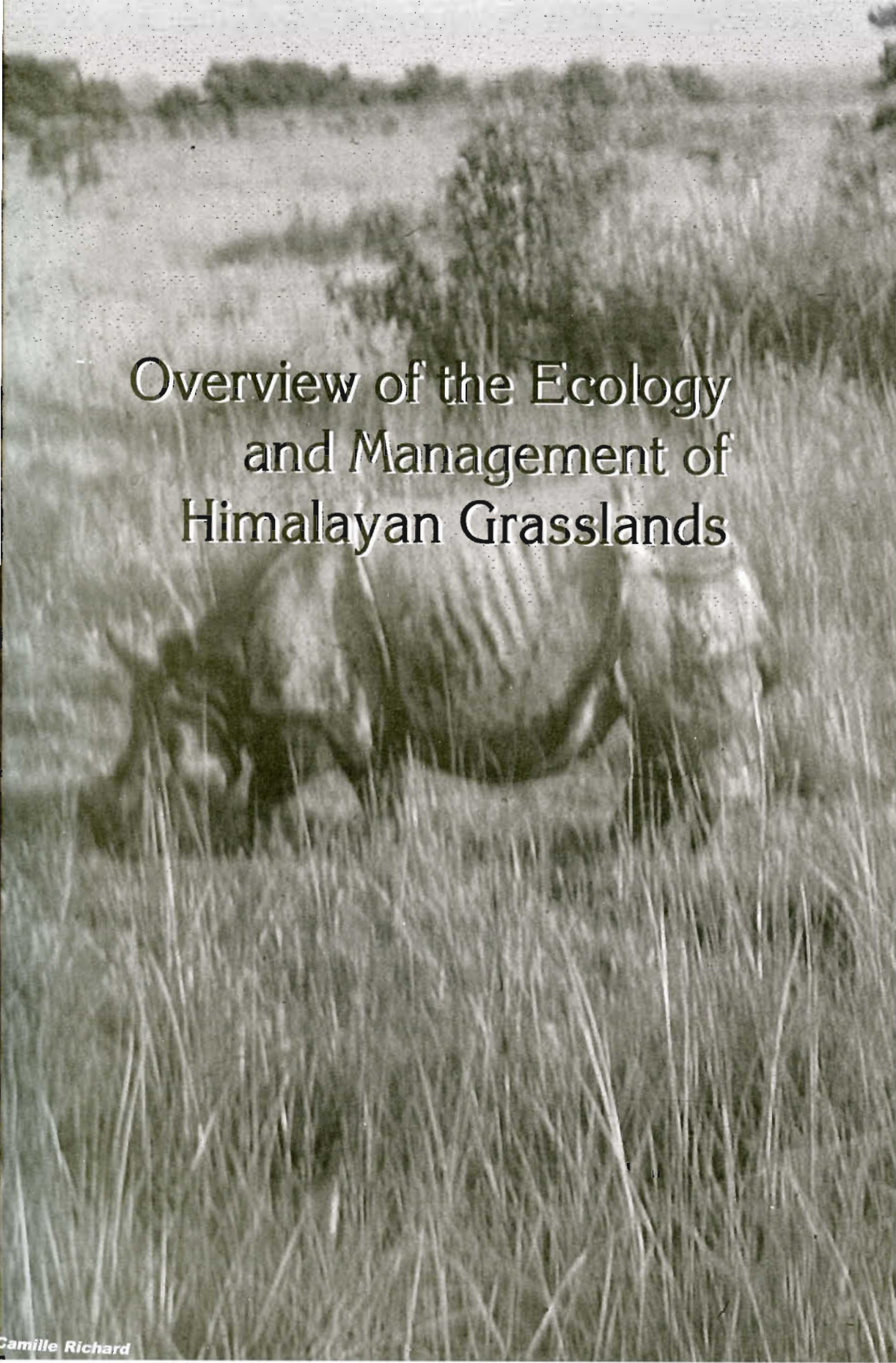
Overview of the Ecology and Management of Himalayan Grasslands



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Representation of Grassland Ecosystems in the Himalayan Ecoregions

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Natural grasslands are complex ecosystems. 'Grassland' means an area covered by herbaceous plants, mainly grasses and sedges, but is also used in the following to denote rangelands, which include tropical and sub-tropical alluvial grasslands, alpine meadows, shrublands, steppes, and deserts. Natural grasslands once occupied at least one-third of the land surface of the earth (Olson and Dinerstein 1998, WCMC 1992, Whitaker and Likens 1973). As a result of their extent, diversity, and use, grassland ecosystems have drawn the attention of rangeland, forest, and wildlife managers and conservationists for many decades (Lehmkuhl 1989, Peet *et al.* 1997, Tilman and Downing 1994). Understanding their biodiversity (species' composition and richness), regional distribution patterns, and ecosystem functioning, is important for their long-term management and conservation.

The main objectives of this overview are to:

- review the representation of grassland ecosystems in the Himalayan ecoregions, particularly in the Eastern Himalayan ecoregion of the Global 200 Ecoregions (Box 1) and Table 1;
- highlight grassland biodiversity and its importance for conservation; and
- examine the challenges and opportunities in managing the grasslands of Nepal.

The Himalayan Ecoregions and Grasslands

The Himalayas, the highest mountain chain on Earth, stretches about 3,200 km from Northern Pakistan in the west to the subtropical forests of Myanmar in the east (Figure 1). Parts of several countries like Bhutan, China (S.E. Tibet), India

Box 1: The Global 200 Ecoregions

An ecoregion is defined as a relatively large parcel of land or water that shares a large majority of its species, dynamics, and environmental conditions. It is a new and emerging concept in biodiversity conservation and is used as the unit for analysis, conservation planning, and action. WWF scientists have identified a list of more than 200 biological regions that are crucial to conservation of global biodiversity (Olson and Dinerstein 1998). The 'Global 200 Ecoregions' initiative identifies the most outstanding terrestrial, fresh water, and marine ecoregions on Earth. The concept of the Global 200 is based on the conservation of the broadest variety of the world's species and ecological and evolutionary processes by conserving the broadest variety of the world's habitats. The ultimate objective is to conserve the biodiversity linking specifically genes, species, communities, and ecological phenomenon within the ecoregion.

At present, there are 240 ecoregions on the list - more than 136 terrestrial, 36 fresh water, and 65 marine ecoregions. These ecoregions can be divided into 3 categories (Wikramanayake *et al.* 1998) depending upon their protection status (included or not included in the protected area network or PAN). They are: a) areas with extensive coverage by the PAN, b) areas with inadequate coverage by the PAN, c) areas with poor or no coverage by the PAN. Most of the Himalayan ecoregions are not/or poorly covered by the PAN system.

TABLE 1. COVERAGE OF THE HIMALAYAN ECOREGIONS BY THE PROTECTED AREA NETWORK (PAN)

No/poor coverage by PAN	Inadequate coverage by PAN	Extensive coverage by PAN
1. Western Himalayan Broadleaf Forests	1. Himalayan Subtropical Broadleaf Forests	1. Himalayan Subtropical Pine Forests
2. *Terai*-Duar Savannas and Grasslands	2. Eastern Himalayan Broadleaf Forests	2. Western Himalayan Alpine Shrub/ Meadow
3. Northern Triangle Subtropical	3. Western Himalayan Subtropical Conifer Forests	3. Eastern Himalayan Alpine Shrub/ Meadow
4. Northern Triangle Temperate Forests	4. Northern Himalayan Alpine Shrub/Meadow	4. Eastern Himalayan Subalpine Conifer Forests
5. Trans-Himalayan Alpine Shrub/ Meadow	5. The Tibetan Plateau	
6. Trans-Himalayan Subalpine Conifer Forests		
7. High Altitude Cold Steppe		

Source: Wikramanayake *et al.* 1998

(Sikkim and Arunachal Pradesh), Myanmar, Nepal, and Pakistan, belong to the range. The Eastern Himalayas, which cover Bhutan, S.E.Tibet (China), Sikkim and Arunachal Pradesh (India), the north-eastern part of Myanmar, and Nepal (east of Kaligandaki), are recognised globally as hotspots of biodiversity (Wikramanayake *et al.* 1998). WWF has identified 16 Himalayan ecoregions for the Global 200 which are the conservation targets in the Himalayas (Olson and Dinerstein 1998, Wikramanayake *et al.* 1998). They include:

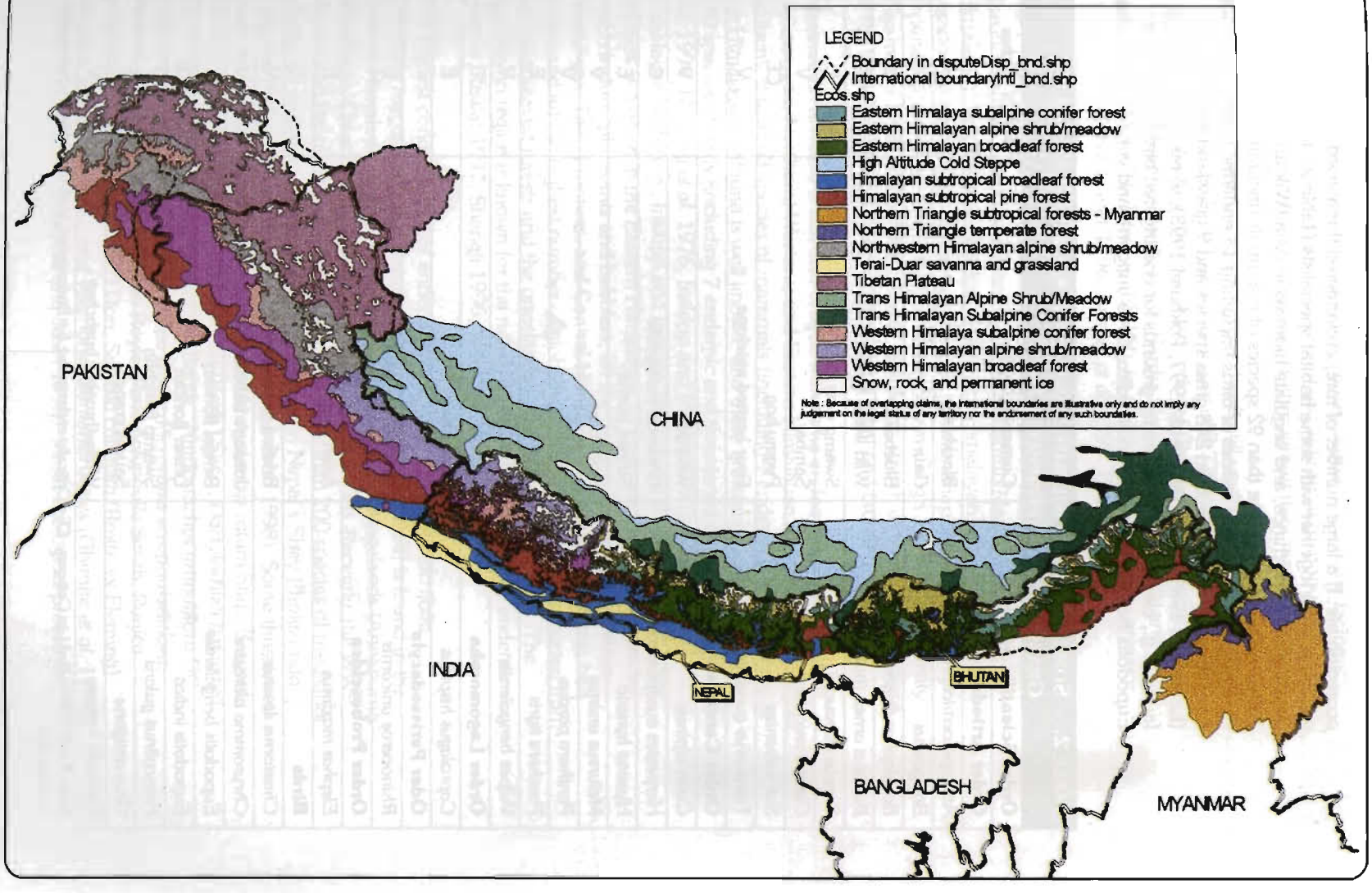
- distinct communities, habitats, and biological assemblages (e.g., *Terai*-Duar Savanna);
- large intact habitats and biotas (Northern Triangle Temperate Forests of Myanmar);
- keystone ecosystems and habitats (e.g., rivers and lakes/ponds like Ajingara tal); and
- distinct large-scale ecological phenomena (e.g., long-route migration of birds and elephants).

The Himalayan Ecoregions include two main types of grassland ecoregion: i) *Terai*-Duar Savannas and Grasslands (lowland alluvial grasslands); and ii) The Himalayan Alpine Shrub/Meadow and Trans-Himalayan Rangelands.

***Terai*-Duar Savanna and Grasslands**

The sub-tropical alluvial grasslands found in the lowlands of Nepal and Assam (India) are the last remnant of a once extensive ecosystem in southern Nepal and northern India (Lehmkuhl 1989, Peet *et al.*1997, Wikramanyake *et al.* 1998). These ecosystems (known as *charkose jhadi* in Nepal) are the tallest grasslands (up to 6-metre tall grasses) in the world and are confined mainly to protected areas (Bell and Oliver 1992; Figure 1). These grasslands are rich in biodiversity and contain complex ecological processes (Basnet 1996, Peet *et al.* 1997, Lehmkuhl 1989). Some of the distinguishing characteristics of the

Figure 1. Himalayan Ecoregions



ecoregion are: i) a large number of rare, endangered/threatened, and endemic wildlife species together with some habitat specialists (Table 2); ii) the highest densities of tigers, rhinos, and ungulate biomass in Asia (Wikramanyake *et al.* 1998); iii) records of more than 92 species of mammals (including 3 endemic species), and about 500 species of birds (including 18 endemic species); iv) high floral diversity with more than 248 grass species and 9 grassland assemblages (Lehmkuhl 1989, 1994, Peet *et al.* 1997, Pokharel 1993); v) migration of mega fauna (e.g., elephants); vi) breeding grounds for endangered bird species (e.g., *Eupodotis bengalensis, Eupodotis indica, Grus antigon*); and vii) a large number

TABLE 2. SOME IMPORTANT WILDLIFE SPECIES IN *TERAI* SAVANNAS AND GRASSLANDS AND PERIPHERAL AREAS

Order/Scientific name	Common name	IUCN status
Order Artiodactyla		
Antilope cervicapra	Blackbuck	V
Bos gaurus	Gaur	V
Boselaphus tragocamelus	Bluebull	S
Bubalus arnee (bubalis)	Wild water buffalo	E
Cervus duvauceli	Swamp deer	E
Cervus unicolor	Sambar	V
Sus salvanius	Pygmy hog	CE
Tetracerus quadricornis	Four-horned antelope	V
Order Carnivora		
Cuon alpinus	Wild dog	V
Herpestes auropunctatus	Common mongoose	C
Hyaena hyaena	Striped hyena	E
Melursus ursinus	Sloth bear	V
Panthera pardus	Leopard	V
Panthera tigris	Tiger	E
Vulpes bengalensis	Indian fox	V
Order Lagomorpha		
Caprolagus hispidus	Hispid hare	E
Oder Perissodacyla		
Rhinoceros unicornis	One horned rhino	E
Order Proboscidea		
Elephas maximus	Asian elephant	E
Birds		
Chaetornis striatus	Bristled grass-warbler	V
Chrysomma altirostre	Jordon's babbler	V
Eupodotis bengalensis	Bengal florican	E
Eupodotis indica	Lesser florican	CE
Francolinus gularis	Swamp francolin	V
Grus antigone	Saurus crane	E
Saxicola insignis	White-throated bushchat	V

Note: IUCN (1996) Red List Category: CE=Critically endangered; E=Endangered; V=Vulnerable; S=Susceptible or lower risk

of human settlements and disturbances. These unique habitats are facing several direct (e.g., clearing for agriculture) and indirect (e.g., population growth) threats and ecological degradation throughout their range (Table 4).

In Nepal, *Terai*-Duar Savannas and Grasslands still cover a significant portion of the *Terai* protected areas (>1,684 sq.km. out of 3,779 sq.km.), which include the Koshi Tappu Wildlife Reserve (KWR), Royal Chitwan National Park (RCNP), Parsa Wildlife Reserve (PWR), Royal Bardia National Park (RBNP), and Royal Shukla Phanta Wildlife Reserve (RSWR), in addition to their linkage areas or possible corridors (Basnet 1996, Basnet *et al.* 1998, BPP 1995).

The Himalayan Alpine Shrub/Meadow and Trans-Himalayan Rangelands
The Himalayan alpine grasslands are classified as: a) Trans Himalayan Alpine Shrub/Meadow, b) Northern Himalayan Alpine Shrub/Meadow, c) Western Himalayan Alpine Shrub/Meadow, d) Eastern Himalayan Alpine Shrub/Meadow, and e) High Altitude Cold Steppe (Wikramanayake *et al.*1998), depending upon their location, type of vegetation (Singh 1989), and diversity (Gyamtsho 1996, Miller 1998). These grasslands stretch along the high regions of the Himalayas and support an enormous floral and faunal diversity.

Mammalian diversity is rich and unique with some endemic species (Table 3). For example, Northern, Western, and Eastern Himalayan Alpine Shrub/Meadow contains at least 63 species of mammals (including 7 endemic). The diversity of the Himalayan avifauna is well known, and these grasslands support at least 180 species of birds (including 7 endemic and threatened e.g., *Grus nigricollis*) (Ali 1994, Fleming *et al.* 1976, Inskipp and Inskipp 1997). Studies of the Himalayan birds (e.g., Inskipp and Inskipp 1997) have shown that: i) species' richness is highest in the Eastern Himalayas; ii) there are 15 endemic species, which include pheasants and babblers; iii) the Eastern Himalayas, Western Himalayas, Tirap Frontiers, and Central Himalayas are the four endemic bird areas; and iv) the highest number of globally threatened species is reported from the broadleaved forests and the grasslands in the eastern Himalayas. The Himalayan region is known for the richest alpine flora, particularly endemic species (Rawat 1997, Shengji 1996, Shrestha and Joshi 1996).

The highest concentration of endemic plants (e.g., *Berberis mucrifolia*, *Corydalis megacalyx*, *Delphinium himalayai*, *Heracleum lallii*) is found in the Eastern Himalayan region, alpine shrub/meadows, and rangelands (Annapurna/Dhaulagiri, Chumbi Valley) (Wikramanayake *et al.* 1998). Recently, the WWF 'Plants and People Project' (PPP) identified more than 200 species of medicinal plants, 48 endemic, and 25 threatened species in Nepal's Shey Phoksumdo National Park only (Ghimire *et al.*1998 Shrestha *et al.* 1998). Some threatened plant species with economic value include: *Aconitum spicatum* Stap, *Bergenia ciliata* (Haw.) Sternb. *Cordyceps sinensis* (Berk.) Sacc., *Dactylorhiza hatagirea* (D.Don) Soo, *Megacarpaea polyandra* Benth., *Nardostachys grandiflora* DC, *Olea ferruginea* Royle, *Olea ferruginea* Royle, *Picrorhiza scrophulariiflora* Pennell, *Podophyllum hexandrum* Royle, *Paris polyphylla* Smith, *Punica granatum* L., *Rheum australe* D.Don, *Swertia chirayita* (Roxb. ex Fleming) Karsten, *Taxus baccata* L., and *Valeriana jatamansii* Jones (Ghimire *et al.* 1998), Shrestha *et al.* 1998, Shrestha and Joshi 1996). Major ecological processes

TABLE 3. SOME IMPORTANT WILDLIFE SPECIES OF ALPINE SHRUB/MEADOW AND PERIPHERAL AREAS

Order/Scientific name	Common name	IUCN status
Mammals: **Order Artiodactyla**		
Bos grunniens	Wild yak	S
Budorcas taxicolor	Takin	Rare
Capricornis sumatraensis	Serow	V
Hemitragus jemlahicus	Thar	S
Moschus chrysogaster	Musk deer	E
Moschus fuscus	Musk deer	E
Nemorhaedus goral	Goral	S
Ovis ammon	Great Tibetan sheep	V
Pantholops hodgsoni	Tibetan antelope	V
Pseudois nayaur	Blue sheep	S
Order Carnivora		
Canis lupus	Grey wolf	V
Cuon alpinus	Wild dog	V
Panthera pardus	Leopard	V
Uncia uncia	Snow leopard	E
Vulpes vulpes	Fox	S
Order Perissodactyla		
Equus kiang	Tibetan wild ass	E

Note: IUCN (1996) Red List Category:-E=Endangered; V=Vulnerable; S=Susceptible or lower risk

TABLE 4. MAJOR MANAGEMENT ISSUES ASSOCIATED WITH THE HIMALAYAN GRASSLAND ECOREGIONS

Major issues	Savanna	Alpine Meadow
Human population growth	High	Medium
Poverty and lack of opportunities	High	High
Lack of education and awareness	High	High
Clearing for agriculture	High	Low
Livestock grazing (and wildlife competition)	High	High
Encroachment and fragmentation	High	Low
Highways and development projects	High	Medium
Illegal hunting and poaching	High	High
Illegal collection of plants	High	High
Transboundary protection issues	High	High
Migration of wildlife populations	Medium	Medium
Annual burning	High	Medium
Hydropower and irrigation canals	High	Low
Increasing tourism	Medium	Medium
Park-people conflicts	High	High
Lack of research and adequate information	High	High

Note: Potential threats are indicated in terms of high, medium, and low.

include horizontal and vertical migration of wildlife (e.g., takin, migratory birds) and wildlife-livestock interaction (Basnet 1998).

The protected areas of the mountain region of Nepal are: the Kanchenjunga Conservation Area (KCA), Makalu-Barun National Park (MBNP), Sagarmatha National Park (SNP), Langtang National Park (LNP), Manaslu Conservation Area (MCA), Annapurna Conservation Area (ACA), Dhorpatan Hunting Reserve (DHR), Shey Phoksumdo National Park (SPNP), Rara National Park (RNP), and Khaptad National Park (KNP). Combined, they cover an area of about 21,241 sq.km. (16% of Nepal's land mass), which includes 2,954 sq.km. of alpine rangelands (BPP 1995).

Grassland Management Issues

Management of the Himalayan grasslands is essential for balanced biodiversity conservation and sustainable community development. However, these grasslands are largely neglected from a management point of view and are in a degraded condition in places (Peet *et al.* 1997, Wikramanayake *et al.* 1998). The Himalayan grasslands are challenging to manage because of: i) the diverse flora and fauna and associated habitats they possess (Shengji 1996, UNDP 1998; ii) high human population growth and associated disturbances such as forest clearing and grazing; and iii) the complex socioeconomic and political conditions of the region. The major management issues across the Himalayan grasslands include: i) human population growth and encroachment; ii) over-exploitation of resources; iii) poaching and hunting; iv) habitat degradation, fragmentation, and loss; v) loss of biodiversity; vi) transboundary problems and lack of coordination; and vii) lack of adequate information and a proper management plan (Table 4). However, the precise management issues are specific to the country, grassland type, and protected area, as has been highlighted in the working group sessions of this workshop.

Conclusion

Management priorities may differ considerably among different grasslands (see Basnet *et al.* 1996, DNPWC/WWF 1996, KMTNC 1998) because they are guided by different management issues. Considering the biodiversity of these areas, their protection status and the issues they face, priorities for the Himalayan Ecoregions, particularly for Nepal, should be to:

- identify research and management gaps and priorities;
- promote collaboration and cooperation at the local, national, and international level;
- include under-represented areas in the protected area network system;
- restore critical habitats; and
- develop effective research and monitoring strategies.

The Himalayan Ecoregions, particularly the Eastern Himalayas, are a focal point of the Global 200 Ecoregion Initiative (Olson and Dinerstein 1998). The grassland ecoregions discussed here are unique habitats harbouring endemic, rare, and endangered plant and wildlife species. But these important habitats are facing direct and indirect threats, including some spanning national borders, which can be addressed by the ecoregion-based conservation (ERBC) approach

that WWF is now promoting. Thus, an intergovernmental agreement among the Himalayan range states for the protection and conservation of the Himalayan grasslands is a high priority. WWF and UNDP (United Nations Development Programme), in collaboration with ICIMOD, have taken this initiative (UNDP 1998). Long-term research addressing questions using a holistic approach is essential for strong management prescriptions and sustainable management of these complex systems.

An Agro-ecological Perspective on Grassland Management in the *Terai* and Mountain Protected Areas

Camille Richard, ICIMOD

Grasslands of the Hindu Kush-Himalayan region are vast, ranging from the low-lying *Terai* savanna grasslands, to the forest grazing lands of the sub-tropical and temperate regions, to the high alpine and desert steppe rangelands of the Tibetan Plateau. They encompass approximately two million sq.km. or over 60 per cent of the region. These grasslands are important for a variety of reasons; they are the headwaters of the major river systems of Asia; they provide important habitat for many wildlife and plant species, thus much of the region is designated as protected areas; and they provide forage for grazing livestock, which make up a significant percentage of cash income in many areas (Miller 1995). The primary land use is livestock grazing on rangeland, forest, and anthropogenic shrubland and grassy pastures, which are managed as common property resources by millions of farmers and pastoralists reliant on their bounty.

Functional Definitions for Grasslands and Rangelands

When talking about protecting these ecosystems, it is important to realise that grasslands and their use do not exist in isolation from surrounding forest lands, agricultural lands, nor even distant urban centres, therefore our conservation goal should be to promote a 'biodiversity friendly' landscape beyond the PA. Protected area managers do not primarily manage biological resources, they manage people and their use of biological resources and should be concerned with the flows of goods and services derived from those resources. Therefore, when speaking of grasslands and rangelands, we must speak a common language and have functional definitions that focus on use of the resource. These distinctions in definition are important to make because of the management implications for maintaining particular types of vegetation communities.

The following definitions were put forth for use in this workshop.

Pasture – land used for grazing (synonymous with grazing land)

Forage – the portion of vegetation that is potential food for animals

Fodder – vegetation that is cut and carried to penned livestock (like tree leaves, grasses, and crop residues)

Grassland – a vegetation community in which the dominant component is comprised of herbaceous graminoid species such as grasses and sedges (generally but not always). Three types of grassland are distinguished.

> Artificial Grassland — Artificial grassland refers to artificial cultivation of annual or perennial grasses and forbs to meet the fodder needs of ruminant animals. These are generally cut and carry systems but also include improved pasture for grazing. *Semi-artificial* grassland means native vegetation communities that are over-sown with exotic fodder

species. Intensive pasture/hay meadow management requires high inputs such as: 1) species maintenance, 2) fertility and irrigation; and 3) protection. It is only practised where benefits in terms of livestock production exceed the cost of inputs, thus it is typically market driven.

Semi-natural Grassland — Semi-natural grasslands are composed of seral (successional) vegetation communities that are dominated by herbaceous species (usually native) resulting from anthropogenic disturbance in forest ecosystems, such as fire or grazing, or ploughing and subsequent abandonment of agricultural land. This definition would also include the *phantas* (previously cultivated and re-vegetated short grassland) of the *Terai* which, without grazing or fire, would convert to forest vegetation.

Natural Grassland — Natural grassland comprises a vegetation community dominated by graminoids as a result of some natural bio-physical limitation that precludes the growth of trees or shrubs. This would include native alpine grassland, maintained by a cold, high elevation climate, and alluvial tall grass communities of the *Terai*, maintained as grassland by natural hydrological processes.

Shrubland — Shrubland covers a vegetation community dominated by shrubs, such as a seral shrub community resulting from anthropogenic use of forests, or native shrubs in desert steppe and alpine environments.

Rangelands — Rangelands are "those areas of the world which, by reason of physical limitations, low and erratic precipitation, rough topography, poor drainage, or cold temperatures, are unsuitable for cultivation and which are a source of forage for free-ranging native and domestic animals, as well as a source of wood products, water, and forest wildlife" (Stoddart *et al.* 1975). Thus **rangeland** is an ecological definition. It denotes natural shrub or natural grassland and is not synonymous with *pasture* or grazing land, terms used to denote a use of rangeland, forest, or agricultural vegetation types.

Rangeland management — Rangeland management is "*the science and art of optimising the returns from rangelands in those combinations most desired by and suitable to society through the manipulation of the range ecosystem*" (Stoddart *et al.* 1975). These definitions for **rangelands** and **rangeland management** generally refer to areas characterised by cold temperatures, arid conditions, or some other bio-physical parameter that naturally precludes the growth of trees, and excludes forage resources from sub-tropical and temperate forest areas and cultivated lands. The term 'rangeland' covers a particular group of ecosystems in the Himalayas, principally alpine rangeland, Trans-Himalayan desert steppe rangeland, and *Terai* riverine/savanna grassland.

The focus of this workshop is primarily on the broad types of grasslands and pastures that are found in Nepal's protected areas. These include semi-natural grassland (seral grasslands found in the forest zones of the *Terai* and mountain areas), seral shrub and forest grazing lands, and native rangeland (native grassland or shrubland). Given the broad types of native and semi-natural grasslands prevalent in Nepal, we need a broader management definition for

these lands, beyond the classic definition for **rangeland management**. That is a functional definition that includes native rangeland as well as forest areas (often converted to shrubland, grassland, and cultivated fields). Considering that the primary use of 'grasslands' in Nepal is for grazing of domestic livestock and wild ungulates, we need a definition that focusses on sustained forage production. This leads to the concept of integrated forage management.

Integrated Forage Management - the sustainable use and maintenance of forage resources (native rangeland, forest, pasture, and agricultural lands), incorporating both scientific and indigenous systems of management,to meet the optimal needs and desires of households and the community (increased livestock and/or crop production, water availability, and forest products) without disrupting the integrity of the ecosystem (maintaining the ecological integrity of watersheds and biodiversity).

An Agro-ecosystem Perspective on Grassland and Rangeland Management in Protected Areas[1]

Given the inter-disciplinary nature of the above definitions, protected area managers should adopt an agro-ecosystem framework for analysis when addressing conservation issues in countries such as Nepal where humans reside within or use protected area resources. A well-designed assessment programme needs to shed insight into the complexities of indigenous land management systems and the manner in which outside intervention positively or negatively alters the ebb of village life, especially local institutional authority. Conflicts arise between local people and park authorities because protected area designations and policies are often formulated and implemented before the environmental and socioeconomic realities of the area are understood and appreciated. This information is vital to designate a protected area effectively, or devise realistic strategies for buffer zone management. This is because the environment first and foremost dictates production of plant biomass, and thus the potential for land-use intensification in associated farming systems (barring socioeconomic constraints for the sake of simplification in this discussion).

Farming systems are defined by the ecosystem in which they evolved. In this discussion, land-use systems of the Himalayan region are placed into three broad categories of agro-ecosystems, depending on the environment and their livestock use patterns, although it should be emphasised that these are generalisations

Agriculturalists — Agriculturalists are those communities who rely primarily on cultivation and in which livestock serve as an integral part of the mountain farming system. Animals are generally stall-fed, or grazed off the farm in localised grazing lands within neighbouring forest areas. Livestock usually provide negligible income and are kept mainly to promote crop fertility, but they also provide dairy products, meat, hides, and draught power. These cropping systems generally occur in sub-tropical and lower temperate mountain forests.

Agro-pastoralists — Agro-pastoralists are sedentary cultivators who graze

[1] Adapted from Richard (1999).

most of their livestock far from their homes (transhumance) in an effort to exploit micro-niches at different altitudes or latitudes to secure adequate forage throughout the year. This system is typically practised by communities who reside at higher altitude, where adequate precipitation or irrigation allows cultivation, but where crop production is generally insufficient to meet requirements. Consequently, these communities have developed elaborate herding and trading systems to procure the goods necessary for survival. In these systems, livestock are also kept for food, clothing, draught power, and crop fertility. In addition, they are used for transport in trading economies.

Pastoralists — Pastoralists reside in the most extreme environments of the Hindu Kush-Himalayan (HKH) region, in the high elevation, cold desert steppe rangelands of the Tibetan Plateau and the Hindu Kush mountains, areas which are too cold and dry to support agriculture. Livestock serve as their chief source of income as well as transport for traded goods. Surplus livestock products beyond subsistence needs are used as commodities in intricate trading systems, often with remote communities, to procure agricultural and other products that they can not otherwise acquire in their harsh environment. Grazing systems are very extensive in an effort to acquire the necessary forage.

Despite the diversity in the region, it is possible to view these broad land use systems and their associated landscapes along an ecological gradient in the Himalayas, for example a cross-section of Nepal from south to north. One moves from sub-tropical forests and riverine grasslands at low elevation in the Gangetic Plains up to the High Himalayas, characterised by alpine meadow, and on to the Tibetan Plateau, characterised by alpine desert steppes. Figure 2 illustrates a series of gradients that reflect the relationship between agro-ecosystems and their potential to produce biomass, and the ecological basis by which the gradients are designed. The potential to produce biomass is related to the potential for intensification, which is the basis for buffer zone management given the objective of reducing pressure on neighbouring protected areas. An ecosystem capable of producing a good amount of biomass is referred to as 'resource rich' in this discussion.

Grimes (1979) has provided plant ecologists with a simplistic but often applicable model to conceptualise plant species and their adaptability to various types of environments, termed **life history strategies**. These life history strategies, like the farming systems prevalent in each ecosystem, reflect the environmental conditions under which the plants evolved. In resource rich habitats characterised by low stress, like drought or nutrient stress, and low to moderate disturbance, such as fire or other activities that remove plant biomass, plant communities are dominated by highly productive **competitive** *(C)* species. When these habitats are highly disturbed, fast growing, weedy **ruderal** *(R)* species assume dominance. An example of this type of environment would be the sub-tropical forests or the riverine tall grasslands of the *Terai*. In resource poor environments, characterised by high stress such as aridity or cold temperatures, plant communities are dominated by **stress tolerant** *(S)* species that are naturally low in productivity. When these environments are subjected to high levels of disturbance, ruderal species cannot adapt well, and thus rarely come to dominate a large area (although they can dominate areas receiving

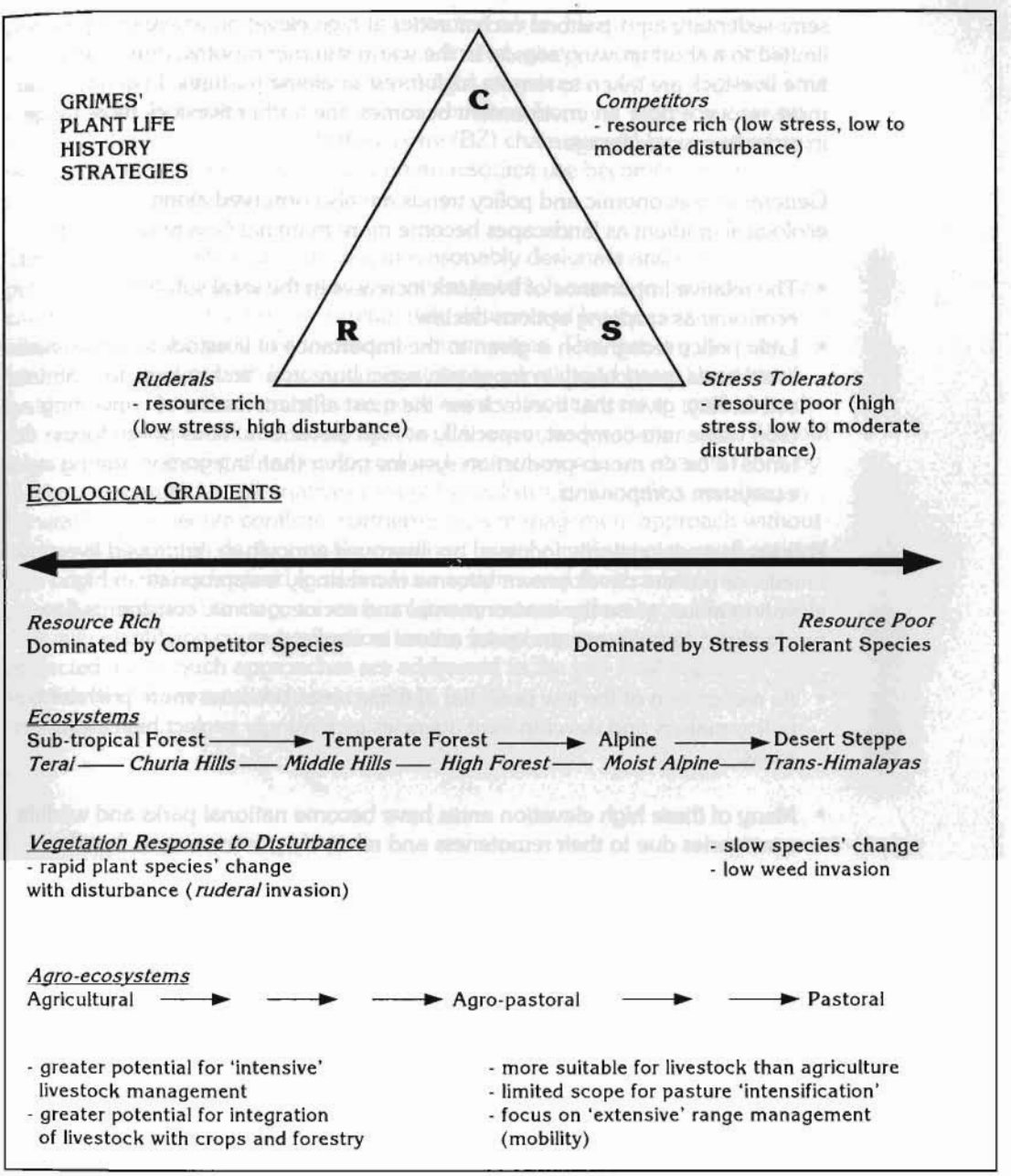


Figure 2. The relationship between agro-ecosystems and their potential for intensification along an ecological gradient in the Himalayas of Nepal

high nitrogen inputs such as grazing camps). Thus these areas can sustain higher grazing pressures without undergoing rapid species' change (although they are subject to erosion if highly disturbed). The Trans-Himalayan desert steppe is a prime example of this type of environment.

The associated farming systems change along the ecological gradient as well, from crop-based agricultural communities in sub-tropical climes to nomadic pastoral communities on the high elevation Tibetan Plateau. In between are

semi-sedentary agro-pastoral communities at high elevation where cropping is limited to a short growing season in the warm summer months, during which time livestock are taken to remote high forest or alpine pastures. In general, the more resource poor an environment becomes, the further livestock must range in order to procure forage.

General socioeconomic and policy trends are also observed along this ecological gradient as landscapes become more marginal (less resource rich).

- The relative importance of livestock increases in the local subsistence economy as cropping options decline.
- Little policy recognition is given to the importance of livestock in subsistence livelihoods, particularly in mountain agriculture as a 'technology' to maintain soil fertility, given that livestock are the most efficient means of converting crop waste into compost, especially at high elevations. Thus policy focus tends to be on mono-production systems rather than integration among agro-ecosystem components.

Policies that are primarily focussed on improved agriculture, improved livestock breeds, or pasture development become increasingly inappropriate in high elevation areas, given the environmental and socioeconomic constraints (low productivity, remoteness, and poor access to markets).

- As recognition of the low potential of these areas becomes more prevalent, policy-makers and development agencies increasingly neglect high elevation areas.

- Many of these high elevation areas have become national parks and wildlife sanctuaries due to their remoteness and relatively pristine nature, but the approach is often based on lower elevation models, where human access has been (and is capable of being) more restricted. Restricted access to resources has thus marginalised mountain communities who find themselves with few livelihood options, compared to lowland groups.

Implications for Buffer Zone Designation and Management

The primary goal in buffer zone management is to intensify land use in areas surrounding a core protected region, thereby reducing pressure on protected area resources, raising the living standards of local residents, and increasing local interest in conservation. However, the prevailing environment affects the potential to intensify livestock or agricultural output. This needs to be taken into consideration when developing plans for buffer zones, or even designating them in the first place. For example, in sub-tropical regions, the potential for intensified livestock management and its integration with cropping and forestry activities is greater than in high elevation areas, where the emphasis should be more on extensive livestock movements, thereby maintaining mobility of herds and quality of rangeland condition. Thus, at lower elevation (such as in the *Terai* protected areas), true core areas can be designated which exclude human use, with well-differentiated buffer or eco-development areas that effectively diversify land use options where access to markets and infrastructure is greater. At high elevation, livestock must be mobile and have access to remote

pasturage, which often occurs in core protected areas. Here the option to exclude human use of natural resources is limited, given the need for remote access in such marginal environments and the remoteness of these regions. This is exemplified in papers presented in this workshop from the Trans-Himalayan zones. Thus clearly defining a **buffer zone** (BZ) characterised by intensive use vs. a **core area** that ideally has no human resource use becomes a more difficult, if not impossible, task.

This raises the question of how we can reasonably designate and manage protected areas in the Himalayas. The extent to which access to protected areas can be restricted to human use is ultimately determined by the degree to which alternatives can be provided to resident communities. This rests on the potential for intensification of both land and industries as a livelihood base. Land use systems, especially those in resource poor areas without access to markets and infrastructure, will continue to rely on core PA resources for many years. Without a basic understanding of the ecological and socioeconomic constraints faced by resident communities, alternatives cannot be realistically identified, resulting in inevitable park-people conflicts. Furthermore, a management approach without local involvement in decision-making will not reveal a realistic picture of options. The best way to understand local land-use systems and their constraints is to adopt an 'inclusive' strategy to research, jointly assessing local conditions and mutually identifying courses of action for the future conservation of Nepal's protected areas. Such approaches are addressed in the two final papers in Volume III of these workshop proceedings.