Chapter 8
The Tibetan Steppe

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SUMMARY

The Tibet Plateau is a vast area to the north of the Himalaya between roughly 26°50′ and 39°11′N. The climate is severe continental, and most of the plateau is arid to semi-arid. Snow events in winter increase risk. Its high, cold grazing lands vary from cold deserts and semi-arid steppe and shrublands, to alpine steppe and moist alpine meadows. Much is above 4 000 m; some camps are as high as 5 100 m. It is traditionally an area of transhumant herding, but has undergone vast changes in the past half century – from feudalism, through a collective period, to privatized livestock and individual grazing rights that are circumscribing the mobility necessary for herding risk avoidance in such a climate. Yak, sheep and goats are kept, with yak more important in the wetter east and sheep in the west. The steppe contains the headwaters of many of the major rivers of Asia and has a very rich flora and fauna, with many endemic species, so grazing management is not only important for herders' livelihoods but also for catchment maintenance and *in situ* preservation of genetic resources and biodiversity.

INTRODUCTION

The Tibetan Steppe is one of the earth's important grazing ecosystems, encompassing about 1.65 million km² (Figure 8.1). The Tibetan Steppe ecosystem actually extends into northwestern Bhutan, northern Nepal and northwestern India, but this paper deals only with the land within the Tibet Autonomous Region of the People's Republic of China. Grazing lands vary from cold deserts to semi-arid steppe and shrublands, to alpine steppe and moist alpine meadows. It contains the highest grasslands in the world, much is above 4 000 m; some herders maintain permanent camps at elevations as high as 5 100 m, among the highest inhabited places in the world. With a severe continental climate, it is one of the world's harshest grazing environments, yet these pastures supply forage for an estimated 12 million yak and 30 million sheep and goats (Plate 8.1), and provide livelihoods for about 5 million pastoralists and agropastoralists.

The remote, northwestern Steppe, one of the last notable examples of a grazing ecosystem relatively undisturbed by man, is home to a unique assemblage of wildlife. Wild yaks are still found in large herds, great concentrations of Tibetan antelope continue to migrate between their winter pastures and sum-

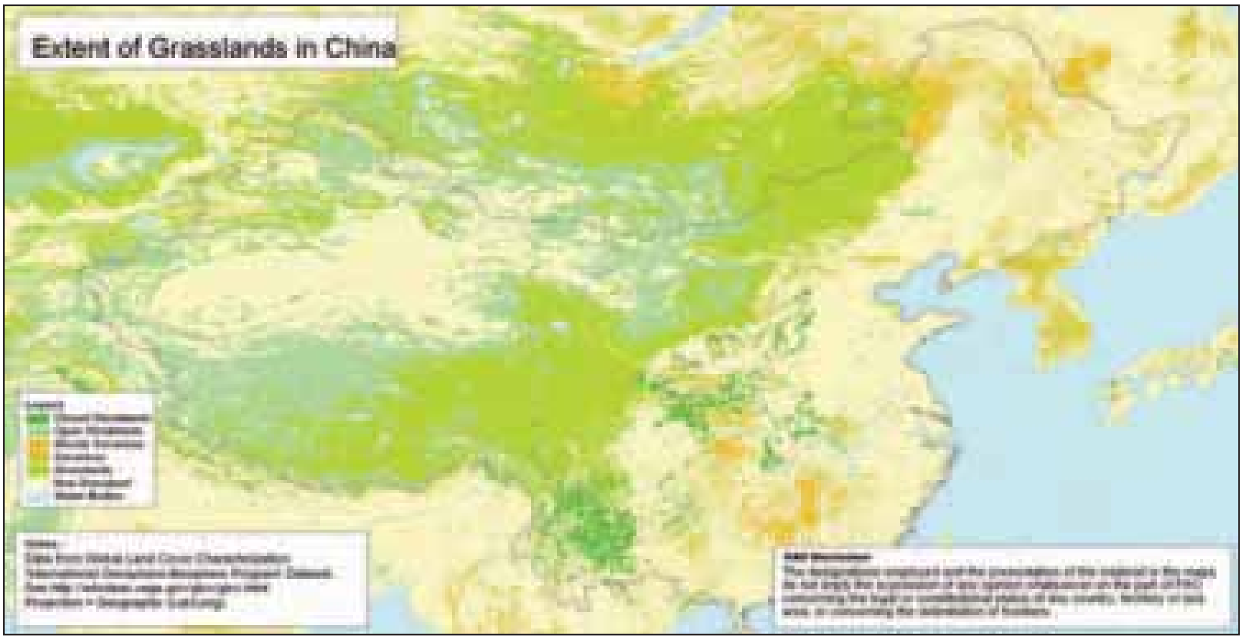

Figure 8.1
Location of the Tibetan Steppe and the extent of grasslands in the People's Republic of China.

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Plate 8.1
Sheep flock.

mer fawning grounds, and troops of wild ass (Plate 8.2) run across the steppes. Because of its highly distinctive species, ecological processes and evolutionary phenomena, the Tibetan Steppe is included in the World Wildlife Fund's list of Global 200 ecoregions that are priority biodiversity conservation areas (Olson and Dinerstein, 1997).

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Plate 8.2
*Wild ass (*Equus kiang*).*

Many major rivers originate in the Tibetan Steppe, including the Yellow, Yangtze, Mekong, Salween, Indus, Sutlej, Ganges and Brahmaputra. The preservation and management of these sources have global implications, as their waters will be of increasing importance in the future. The challenges facing the sustainable development of the steppe are considerable, but its pastures offer numerous opportunities for achieving the twin objectives of conservation and development of grassland resources. Properly managed, grazing lands can continue to be sources of water, provide wildlife habitat, feed for livestock and contribute to overall economic development of the region.

GENERAL DESCRIPTION

The Tibetan Steppe is on the Tibet-Qinghai plateau in the People's Republic of China and adjoining regions of Bhutan, Nepal and India. The Himalaya marks its southern boundary; the Kunlun, Arjin and Qilian Mountains delineate the northern boundary. The western limit is where the Himalaya, Karakoram, Kunlun and Pamir Mountains meet. In the east, the boundary extends along highlands in Qinghai, western Gansu and Sichuan and into northwestern Yunnan. Encompassing about a quarter of China's land, the plateau stretches for almost 1 500 km north to south and for about 3 000 km from east to west – the largest plateau on earth. Over 80 percent is above 3 000 m and about half over 4 500 m (Schaller, 1998). The vegetation is mainly grazing land, which is floristically distinctive, one of the largest of such ecosystems in the world (Schaller, 1998); at about 165 million hectares, it is 42 percent of China's grazing area (Miller, 1999a). This vast grassland is here termed the Tibetan Steppe; it

Plate 8.3
Harvested wheat in the Yarlung Tsangpo river valley.

includes all grassland in the Tibet Autonomous Region and Qinghai Province (118.4 million hectares), on the northern flanks of the Kunlun Mountains in southern Xinjiang (15 million hectares) and in western Sichuan (14 million hectares), northwestern Yunnan (5 million hectares) and western Gansu (12 million hectares). Less than one percent of the steppe is cultivated, although crops have expanded in recent decades, especially in the Qaidam Basin. In the east of the plateau, crop land is in the lower valleys; in western Tibet, along the valley and tributaries of the Yarlung Tsangpo (Brahmaputra River). The upper limit of cultivation, which is as low as 3 300 m in some eastern parts, can reach 4 400 m in the west. The major crops are barley, wheat (Plate 8.3), peas, rape and potatoes.

The Tibetan Steppe has several distinct topographic regions determined by drainage and the parallel mountain ranges that divide it (Schaller, 1998). Only the east and south have outlets to the ocean; rivers originating in the Kunlun Mountains flow north to the Taklimakan and Qaidam Deserts. Much of the Steppe consists of large lake basins with no outlets, ringed by mountains. Forests are limited to the eastern edge in western Sichuan, northwestern Yunnan, southeastern Qinghai and eastern Tibet, and in some valleys on the northern slopes of the Himalaya.

CLIMATE

The Tibetan Steppe has a severe continental climate and is affected by the southeastern monsoon in summer and western air circulation patterns and high Mongol-Siberian air pressures in winter (Huang, 1987). The Steppe slopes to the southeast, so moisture from the southwest monsoon comes up gorges from the east and south and precipitation in summer decreases in a gradient from east to west and from south to north. The east of the Steppe is humid, the south is semi-arid, and far western Tibet is arid. The central Steppe, in a broad band from Gansu and Qinghai west through Tibet, is sub-frigid, humid in the east and semi-arid in the west. The northern part Steppe is frigid and arid (Schaller, 1998).

In Lhasa, at 3 658 m, the average January temperature is -2°C, and in July it is 15°C; the absolute minimum is -16°C. Lhasa has about 130 frost-free days. In Naqu, at 4 507 m in northern Tibet, the average temperature in January is -14°C, and 9°C in July; there are only 20 frost-free days. Absolute minimum temperature in Naqu is -41°C. Temperature rises quickly during the day, but drops rapidly after sunset. The diurnal temperature range is 14 to 17°C (Huang, 1987), with an annual average of 2 500 to 3 000 sunshine hours.

Annual precipitation varies from about 600 mm in the east to under 60 mm in the west, most falls from June to September, often as wet snow and hail. Most of the pastoral area receives less than 400 mm per annum. Winters are generally dry, but periodical heavy snowfalls bury forage; low temperatures accompanying snowstorms put additional stress on livestock. Much of the steppe, especially in the west, has strong winds, with 100-150 days in a year with wind speeds over 17 m/s.

The eastern steppe receives enough precipitation (>400 mm) for the growth of forage, and the vegetation there probably exhibits characteristics of an equilibrium system (Schaller, 1998). Dry spells in late spring and early summer may delay growth, but rainfall is fairly reliable and many pastures have luxuriant vegetation. In the central and western Steppe, forage production is more variable from year to year due to fluctuating rainfall. There are even remarkable differences in grass growth within a small area due to local rainfall events. Here, non-equilibrium ecosystem dynamics may exert more influence on the landscape (Ellis and Swift, 1988; Laycock, 1991; Westoby, Walker and Noy-Meir, 1989a). Classical equilibrium theory may not be able to capture the uncertainty and variability in these environments, making such concepts as carrying capacity and stocking rate less effective in predicting ecosystem productivity and dynamics.

GRASSLAND BIODIVERSITY

Central Asia is normally divided into the Mongolian and Tibetan floristic provinces; the latter includes the entire Tibetan plateau with the exception of the Qaidam Basin, the Pamirs and southwestern Xinjiang. The Qaidam Basin is geographically part of Tibet, but its vegetation has more affinity with the Mongolian province (Walter and Box, 1983). The Tibetan floristic province is divided into four regions: (1) the Nan Shan and Chamdo in the northeast; (2) the deep river valleys in the southeast; (3) the deep longitudinal valley of the Yarlung Tsangpo in the south; and (4) the vast High Tibetan or Chang

Tang. The steppe is a meeting ground of several floras, including Central Asian desert species, East Asian temperate, and Himalayan. In Tibet, over 2 000 plant species have been identified (Gu, 2000), mainly in the families Compositae (330 species), Gramineae (277), Leguminosae (123), Rosaceae (102), Cyperaceae (102) and Polygonaceae (63). Over 1 720 species, accounting for 86 percent of forage plants, occur in the humid and subhumid pastures of eastern Tibet, and 540 species, or 27 percent of forages, occur in the arid and semi-arid grasslands of the northwest (Gu, 2000).

The vegetation of the Plateau and its floral elements differ strongly from the subtropical mountain forest vegetation of southeastern Tibet and adjoining regions (Chang, 1981). Plateau species have affinities with both Sino-Himalayan and Central Asiatic elements. Endemics comprise about 1 200, a quarter of all Tibetan species. Many dominants are endemics; *Stipa purpurea* is a dominant whose centre of importance is on the plateau. *Aristida triseta, Orinus thoroldii* and *Trikeraia hookeri* are also endemics in some of the drier valleys. Dominants of the steppe shrublands (*Sophora moorcroftiana, Caragana versicolar, Ceratostigma griffithii*) and some important companion species (*Artemisia wellbyi, Astragalus malcolmii*) are also endemics. The dominant in alpine desert vegetation, *Ceratoides compacta,* is considered to be a specialized species that was formed during the uplift of the Tibetan Plateau (Chang, 1981).

A number of plants found on the grasslands are valuable forage genetic resources. These include species such as *Brachypodium sylvaticum, Bromus himalaicus, Dactylis glomerata, Duthiea brachypodium, Elymus nutans, E. tangutorum, Festuca ovina, F. rubra, Phleum alpinum, Roegneria melanthera* and numerous species of *Medicago*. At least ten wild relatives of *Medicago sativa* are found there (Gu, 2000). Many forages from the steppe are of interest for resistance to cold, arid and saline or alkaline conditions. Collaborative collection expeditions have been carried out by the United States Department of Agriculture and the Chinese Ministry of Agriculture to identify and collect forage germplasm.

At the junction of the Palaearctic and Indo-Malayan biogeographic realms, the steppe supports diverse mammalian faunas. The northwest Steppe contains a unique assemblage of large mammals (Miller and Schaller, 1997). Ungulates, a number of which are endemic, are of special significance (Harris and Miller, 1995): species such as Tibetan wild ass (*Equus kiang*) (Plate 8.2), wild yak (*Bos grunniens*), Tibetan antelope *(Pantholops hodgsoni*) and Tibetan gazelle (*Procapra picticaudata*) are found. The mountains provide habitat for blue sheep (*Pseudois nayaur*) and Tibetan argali (*Ovis ammon hodgsoni*). In the mountains of the eastern Steppe, where forests mix with grasslands, musk deer (*Moschus sifanicus*), MacNeil's deer (*Cervus elaphus macneilli*), white-lipped deer (*Cervus albirostris*), roe deer (*Capreolus capreolus bedford*) and takin (*Budorcas taxicolor*) are found (Miller, 1998b). In southern Tibet there are still scattered populations of Tibet red deer (*Cervus elaphus wallichi)*. Around Qinghai Lake there are some Przewalski's gazelle (*Procapra przewalskii*). Goitered gazelle (*Gazella subgutturosa*) are found on the northern edge of the Plateau. Predators such as brown bear (*Ursus arctos*), wolf (*Canis lupus*), snow leopard (*Uncia uncia*), lynx (*Felis lynx*), Tibetan steppe fox (*Vulpes ferrilata*) and red fox (*Vulpes vulpes*) are found on the grasslands, and smaller mammals such as marmot (*Marmota bobak*) and pika (*Ochotona* spp.) are common (Miller and Jackson, 1994).

In Tibet alone, over 500 species of bird have been recorded (Vaurie, 1970), including large predators: steppe eagles (*Aquila nipalensis*), upland buzzards (*Buteo hemilasius*), saker falcons (*Falco cherrug*), goshawks (*Accipiter gentilis*), black kites (*Milvus migrans*) and little owls (*Athene noctua*), several species of snow finches (*Montifringilla* spp.), pheasants (*Crossoptilon* spp., *Tetraogallus* spp.), Tibetan sandgrouse (*Syrrhaptes tibetanus*), as well as waterfowl such as black-necked cranes (*Grus nigricollis*), bar-headed geese (*Anser indicus*) and ruddy shelduck (*Tadorna ferruginea*).

Dominant natural vegetation

Kingdom-Ward (1948) identified six subregions: (1) the interior plateau; (2) the outer plateau; (3) the rainy gorge region; (4) the arid gorge region; (5) the Qaidam Basin; and (6) Chinese Tibet, or the northeastern part of the plateau. Scientific investigation of grassland resources began in the 1960s, with surveys (Xizang Integrated Survey Team of Chinese Academy of Sciences, 1966, and Qinghai and Gansu Integrated Survey Team of Chinese Academy of Sciences, 1963). Chang (1981) divided vegetation on the Tibetan plateau into five major regions:

- the high-cold or alpine meadow of eastern Tibet;
- xeric shrubland and steppe along the valleys of the Yarlung Tsangpo and Indus River in southern Tibet;
- high-cold or alpine steppe in northern Tibet;
- high-cold desert in northwestern Tibet; and
- temperate desert in southwestern Tibet.

Schaller (1998) followed Chang's classification, but added a sixth region: the Qaidam Basin. Within each region, there is a diverse assortment of plant communities, varying in species composition and structure, and influenced by factors such as elevation, aspect, drainage and precipitation (Chang, 1983). For example, Chang and Gauch (1986) described 26 plant communities in western Tibet, and Achuff and Petocz (1988) identified 18 communities in the Arjin Shan region of Xinjiang on the northern edge of the Tibetan Steppe. The vegetation on the plains has a broad horizontal zonation and a relatively narrow vertical zonation on the mountain slopes, both reflecting precipitation and elevation.

The country's grassland resources were surveyed and mapped in the 1980s and classified into 17 types, based on climatic zonation, humidity index, veg-

TABLE 8.1
Grassland types of the Tibetan Steppe.

Type	Area ('000 ha)	As percentage of total area
Temperate meadow-steppe	210	0.16
Temperate steppe	3 833	2.92
Temperate desert-steppe	968	0.74
Alpine meadow-steppe	5 626	4.28
Alpine steppe	37 762	28.75
Alpine desert-steppe	8 679	6.61
Temperate steppe-desert	107	0.08
Temperate desert	2 084	1.59
Alpine desert	5 967	4.54
Tropical tussock	9	–
Tropical shrub tussock	28	0.02
Temperate tussock	1	–
Temperate shrub tussock	140	0.10
Lowland meadow	1 168	0.88
Temperate mountain meadow	6 067	4.61
Alpine meadow	58 652	44.64
Marsh	21	0.01
Total	131 322	99.93

SOURCE: Adapted from Chen and Fischer, 1998, and Ni, 2002.

etation type and importance to the livestock industry (CISNR, 1995, 1996). Within each type, a number of formations have been identified. Table 8.1 gives the seventeen types found in the steppe.

Alpine meadow

Alpine meadow, which makes up about 45 percent of the grassland is found on valley floors and mountain slopes from about 3 500 to 4 500 m with annual precipitation over 400 mm, mainly in the east. It is widespread in southwestern Gansu, western Sichuan and southeastern and southern Qinghai, and extends into Tibet to the longitude of Lhasa. Further west, alpine meadow is primarily riparian and in areas receiving melt water (Cincotta *et al.*, 1991; Schaller, 1998). The soil is an alpine meadow soil averaging 20–40 cm in depth, and rich in organic matter. The surface layer is a substantial, resilient sod (Huang, 1987). Ni (2002) concluded that high carbon storage in alpine meadows of China, as a result of the thick sod layer, could have a significant and long-term effect on global carbon cycles.

Alpine meadow is dominated by sedges of the genera *Kobresia* (Huang, 1987); dominant species are *Kobresia pygmaea*, *K. humilis, K. capillifolia, K. setschwanensis, K. schoenoides* and *K. littledalei*. *Carex atrofusca, Polygonum viviparum* and *P. macrophyllum* are the subdominant species in the alpine meadow, and numerous forbs are also found, including species in the genera *Leontopodium, Anemone, Anaphalis, Polygonum, Pedicularis, Rheum, Androsace, Gentiana, Ranunculus, Aconitum, Astragalus, Oxytropis, Primula* and *Potentilla*. Grasses include *Elymus nutans, Roegneria nutans, Koeleria*

Plate 8.4
Elymus nutans.

litwinowii, Helictotrichon tibeticum, Brachypodium sylvaticum, Stipa aliena, Festuca rubra, F. ovina and *Deschampsia cespitosa*. Large areas of productive pasture are dominated by *Elymus nutans* (Plate 8.4) in the alpine meadow, especially in northwestern Sichuan, southwestern Gansu and eastern Qinghai. In swampy depressions in the alpine meadow there is hummock vegetation dominated by *Kobresia* spp. (30-cm tall *K. royleana* and *K. schoenoides*). Shrub communities of plants such as *Salix* spp., *Caragana jubata, Potentilla fruticosa* and *Rhododendron* spp. are common on northern aspects in alpine meadow.

Most Tibetan pastoralists and their stock are found in the alpine meadow region. Livestock densities can be high; in eastern Qinghai, stocking rates are 28-70 animals/km^2, and heavy grazing and trampling, together with solifluction, have disturbed the sod layer, causing extensive rangeland degradation (Schaller, 1998).

Alpine steppe

The alpine steppe comprises almost 29 percent of the area and is found between 3 500 and 4 600 m in the central and western steppe. Unlike the alpine meadow, there is no sod layer, and the soil is often gravel and coarse sandy loam; it is a variant of the temperate steppe under the cold conditions of the Tibetan plateau (Huang, 1987). Grasses of the genus *Stipa* dominate, often accompanied by cushion plants, with *S. purpurea* and *S. subsessiliflora* as the dominant grasses. Associated species are mainly xeric and meso-xeric grasses: *Poa alpina* (Plate 8.5), *P. crymophila, P. dolichachyra*, *Roegneria nutans, R. thoroldiana, Agropyron cristatum, Stipa aliena, Orinus thoroldii, Calamagrostis* spp., *Festuca*

A. PEETERS

Plate 8.5
Poa alpina.

S.G. REYNOLDS

Plate 8.6
Stock grazing on stubble after harvest.

rubra, *Kobresia* spp. and *Carex moorcroftii*. Shrubs include *Potentilla fruticosa*, *Ajana* spp., *Artemisia* spp. and *Ceratoides compacta.* Forbs include *Potentilla bifurca*, *Dracocephalum heterophyllum, Heteropappus altaicus*, *Leontopodium* spp., *Pedicularis* spp., *Allium* spp., *Oxytropis* spp. and *Astragalus* spp., with the cushion plants *Androsace tapete, Arenaria musciformis* and *Oxytropis microphylla*.


S.G. REYNOLDS

Plate 8.7
Turnips are becoming a popular crop for winter feed.

Along the drainage of the Yarlung Tsangpo, in the rain-shadow of the Himalaya, between 3 500 to 4 000 m on valley floors and lower mountain slopes, the dominant vegetation consists of xeric grasses such as *Aristida triseta, Stipa bungeana, Pennisetum flaccidum, Elymus nutans* and *Orinus thoroldii*. Shrubs such as *Artemisia webbiana, Berberis* spp., *Sophora moorcroftiana, S. viciifolia, Lonicera spinosa, Leptodermis sauranja* and *Ceratostigma griffithii* are often mixed with grasses, or comprise distinct communities. On the upper slopes, *Juniperus* shrub communities are found. Since this central valley region is settled by farmers, most of the grasslands have been subjected to heavy, continual grazing for centuries, if not thousands of years, and are overgrazed and degraded (Meiners, 1991; Ryavec and Vergin, 1998). Desertification, with moving sand dunes, is a serious problem in many areas in the Yarlung Tsangpo valley.

Stock graze on stubble (Plate 8.6) and fodder crops like turnips (Plate 8.7) are grown for winter feed.

Many plants in the alpine steppe have distinctive adaptations to the harsh environment (Huang, 1987). Some have shiny hairs, possibly to retain humidity and reflect heat into the interior. Some have large taproots for nutrient storage, and cushion plants create their own micro-environment by accumulating windblown soil and snow. In the alpine steppe, plant canopy cover ranges from 10 to 30 percent and productivity is often low (<300 kg/DM/ha). Within the alpine steppe region, swampy depressions, fed by snow and glacial melt streams, are dominated by *Kobresia* spp. These areas are key grazing areas, since growth starts earlier than on the steppe, which depends on summer precipitation (Miller and Schaller, 1996). The alpine steppe is important for pastoral production (Miller and Bedunah, 1993). Most is still in quite good condition, although there are areas of overgrazing around settlements. Schaller (1998) estimated livestock density in the alpine steppe in northern Tibet at 8.7 animals/km^2 (comprising sheep, 5.71/km^2; goats, 2.60/km^2; yak, 0.36/km^2; and horses, 0.07/km^2).

Alpine desert steppe

The alpine desert steppe, which extends out of north Tibet into southern Xinjiang, is a bleak and arid landscape with large areas almost devoid of vegetation (Schaller, 1998). It makes up about 6 percent of the total grassland of the Steppe. Vegetation is similar to the alpine steppe, but plant cover is less. The dwarf shrub *Ceratoides compacta* and the sedge *Carex moorcroftii* are the dominant plants. There is little livestock in this cold, high desert, and even wild ungulates are limited in number (Miller and Schaller, 1998).

Temperate mountain meadow

The temperate mountain meadow is mainly in western Sichuan, southeastern Qinghai and east Tibet, and often found as meadows within forest between 3 330 and 4 200 m. It makes up 4.6 percent of the area. Forests are primarily of spruce (*Picea* spp.). Important grass genera include *Festuca, Ptilagrostis, Poa, Helictotrichon, Agrostis, Bromus, Elymus, Roegneria* and *Deyeuxia.* Common forbs are of the genera *Polygonum, Aconitum, Delphinium, Rheum* and *Ligularia.* Shrubs include *Rhododendron, Philadelphus, Sorbus, Salix, Spiraea, Prunus* and *Lonicera*.

Temperate desert

The temperate desert found in the Qaidam Basin is a transition zone between the Mongolian desert and the alpine steppe of the Tibetan plateau. It is orogenically part of Tibet, but belongs floristically to the Mongolian province (Walter and Box, 1983). The Qaidam basin is 100–200 km wide and 600 km long, once filled by a sea, with mean elevation around 3 000 m, about 1 500 m higher than the Mongolian Plateau and about the same below the Tibetan plateau. Shrubs of the genera *Calligonum, Haloxylon, Nitraria, Reaumuria, Salsola, Artemisia, Tamarix, Ephedra, Kalidium* and *Sympegma* dominate. There are large salt flats scattered across much of the Basin, and marshy areas support communities of *Phragmites*.

Classification of grassland types and plant communities

The rangelands of the Tibetan Autonomous Region have been classified into 12 different types (Mou, Deng and Gu, 1992; Deng, 1981; Gu, 2000). Table 8.2 lists these different types and the dominant groups within each type for the Tibetan Autonomous Region.

TABLE 8.2
Grassland types and plant communities in the Tibetan Autonomous Region.

Formation	Community
Alpine meadow	*Kobresia* spp.
Alpine shrub meadow	*Rhododendron – Kobresia*
Subalpine shrub meadow	*Sabina – Kobresia bellardii*
	Picea – Kobresia bellardii
	Quercus semicarpifolia – Kobresia bellardii
	Salix – Spiraea – Berberis
Mountain shrub steppe	*Sophora viciifolia – Pennisetum flaccidum*
	Sophora viciifolia – Orinus thoroldii
Mountain steppe	*Artemisia stracheyi – Kobresia bellardii*
	Artemisia stracheyi – Stipa sp.
	Artemisia stracheyi – Orinus thoroldii
	Orinus thoroldii
	Achnatherum hookeri
	Stipa bungeana – Pennisetum flaccidum
Alpine steppe	*Stipa purpurea*
	Stipa purpurea – Kobresia sp.
	Stipa purpurea – Caragana versicolar
	Stipa purpurea – Festuca ovina
Mountain desert steppe	*Stipa glareosa*
	Stipa glareosa – Ceratoides latens
	Caragana versicolar – Stipa glareosa
	Caragana versicolar – Ceratoides latens
	Ajania fruticulosa – Stipa glareosa
Mountain desert	*Ceratoides latens – Stipa* sp.
	Ceratoides latens
Alpine desert	*Carex moorcroftii*
	Ceratoides compacta – Carex moorcroftii
	Ceratoides compacta
Alpine cushion vegetation	
Lake basin and valley meadow grassland	
Woodland meadow	

Source: Adapted from Mou, Deng and Gu, 1992, and Gu, 2000.

Vegetational attributes

Vegetational attributes of the Tibetan Steppe vary greatly depending on the particular type, topography, soils, precipitation and grazing history. Some of the important vegetation characteristics that can help elucidate rangeland dynamics on the Steppe are botanical composition, productivity and nutritional content of rangeland herbage.

BOTANICAL COMPOSITION

Table 8.3 shows average botanical composition for alpine steppe and alpine desert in the Chang Tang Wildlife Reserve of northern Tibet, where the average elevation is 4 800 m and annual precipitation about 250 mm. Much of the grass is one species, *Stipa purpurea*. On mountain slopes in the alpine steppe, grasses decrease and forbs increase. In the alpine desert, sedges become more important, making up from 48 to almost 70 percent of vegetation; the primary sedge is *Carex moorcroftii*. Table 8.4 depicts average botanical composition

TABLE 8.3
Botanical composition in the Chang Tang Wildlife Reserve, northern Tibet (percentage basis).

	Alpine Steppe			Alpine Desert Steppe	
	plains	plains	mountain		
Grasses	61.9	58.8	29.8	42.7	17.5
Sedges	15.2	28.5	22.8	48.5	69.8
Forbs	17.5	10.6	35.2	6.2	9.3
Shrubs	5.4	2.1	12.2	2.6	3.4

SOURCE: Adapted from Miller and Schaller, 1997

TABLE 8.4
Botanical composition of rangeland in Hainan Prefecture, Qinghai (percentage basis).

	Alpine Meadow	Temperate Meadow-Steppe
Grasses	8.20	68.00
Sedges	40.70	3.87
Legumes	4.05	2.45
Edible forbs	29.33	18.68
Non-edible forbs	17.72	7.00
Total	100.00	100.00

SOURCE: Lang, Huang and Wang, 1997.

TABLE 8.5
Annual dry matter production and carrying capacity for different grassland types in Hainan Prefecture, Qinghai Province.

Pasture type	Dry matter (kg/ha)	Carrying capacity (ha/SU/yr)
Alpine meadow	934	0.78
Temperate meadow-steppe	623	1.17
Alpine steppe	594	1.23
Temperate desert steppe	345	2.11
Temperate desert	228	3.19
Lowland meadow	1 341	0.54

NOTES: SU = Stock Unit.
SOURCE: Lang, Huang and Wang, 1997.

in an alpine meadow and in temperate meadow-steppe in eastern Qinghai. In alpine meadow, grasses comprise only 8 percent of vegetation, while sedges comprise 40 percent, with the balance being forbs. In temperate meadow-steppe, a high proportion of vegetation (68 percent) is grasses.

GRASSLAND PRODUCTIVITY

The standing crop on the Steppe varies considerably. Alpine meadows are some of the most productive, as average annual dry matter (DM) production may reach 1 000 kg/ha. Productivity of desert pasture is low, averaging only 100–200 kg/DM/ha. Table 8.5 gives annual DM production and carrying capacity of different pasture types. Harris and Bedunah (2001), in Aksai County, Gansu Province, found average standing crop varied from 115 kg/DM/ha in desert shrub to 790 kg/DM/ha in desert sub-irrigated meadows (Table 8.6).

Nutrient content of herbage

On most of the steppe, natural forage is the only source of nutrients, except for small amounts of hay and purchased concentrates, so understanding

TABLE 8.6
Standing crop (kg/DM/ha) for different vegetation types in Aksai County, Gansu (3 100 to 4 400 m).

Vegetation type	Standing crop	Dominant species
Desert shrub	115	*Sympegma regelii, Reaumuria soongarica*
Desert steppe	167	*Oxytropis aciphylla, Leymus paboanus, Stipa glareosa*
Alpine desert shrub	141	*Ceratoides compacta, Stipa glareosa*
Alpine steppe	245	*Stipa purpurea, Poa* spp., *Festuca* spp., *Carex moorcroftii*
Desert sub-irrigated meadows	790	*Carex* spp., *Achnatherum splendens*
Meadows and sandy grasslands	423	*Carex* spp., *Leymus paboanus, Stipa* spp., *Kobresia* spp.

SOURCE: Harris and Bedunah, 2001.

TABLE 8.7
Crude Protein (CP) and Total Digestible Nutrients (TDN) of vegetation in Guoluo Prefecture, Qinghai Province (as percentage of dry matter).

Plant Form	Grasses		Forbs		Shrubs	
	CP	TDN	CP	TDN	CP	TDN
Late June	16.12	79.48	16.60	85.43	19.14	83.11
Late July	15.02	78.21	14.95	83.93	17.76	82.56
Mid-September	10.47	79.61	10.46	83.77	9.97	80.69

SOURCE: Sheehy, 2000.

the nutrient dynamics of forage in relation to animal needs is critical. Understanding temporal and spatial dynamics of forage is also important, with regard both to plant and animal needs and to demand functions in the livestock production system (Sheehy, 2000).

Investigations in an alpine meadow environment in Guoluo Prefecture, Qinghai, provide surprising information about the nutrient content of forages. Table 8.7 shows average crude protein (CP) content of three classes of forage and average percent total digestible nutrients (TDN) at three different times during the growing season. An important characteristic of the forage is the high protein and nutrient content of all growth forms at the end of the growing season. The total amount of nutrients available to livestock going into the autumn and winter is much higher than found in many other grazing ecosystems. This implies that: (1) sufficient nutrients remain available on the Tibetan Steppe to maintain livestock through normal periods when forage is not growing; (2) even degraded vegetation has relatively high nutrients; and (3) capacity of grasslands to support livestock needs to be evaluated in a nutrient context as well as a consumable biomass content (Sheehy, 2000).

Grassland degradation

About a third of the pasture of the Steppe is now considered moderately to severely degraded, calling into question its long-term sustainability under current use (Sheehy, 2001). In Tibet, the percent of degraded pasture increased from 18 to 30 percent of total area between 1980 and 1990. Degradation is a growing concern in Naqu, where degraded land makes up almost 40 percent of the total degraded rangeland in the whole of the Tibetan Autonomous Region (Ciwang, 2000).

Seriously degraded alpine meadow is often termed "black beach", since the *Kobresia*-dominated community has deteriorated to such a degree that most of the sedges and associated grasses have disappeared, leaving annuals and bare soil. The dynamics of this degradation are not well understood; it is usually blamed on overgrazing and the burrowing of pikas, but there is increasing evidence that climate change and desiccation may play a major role in vegetation changes (Miehe, 1988). Livestock may just accentuate natural ecological processes instead of being the underlying cause.

THE TIBETAN PASTORAL PRODUCTION SYSTEM

Tibetan pastoralism has evolved through long-term adaptation and persistence by herders (Ekvall, 1968; Goldstein, 1992; Goldstein and Beall, 1991; Miller, 1999b). Pastoralists kept a mix of livestock in terms of species and class and used a mosaic of grazing sites, exploiting seasonal and annual variability. Herders bartered products (Plate 8.8) for grain and supplies; quite elaborate trade linkages (Plate 8.9) developed between pastoral and agricultural areas; traditional pastoralism was more than subsistence oriented. Tibetan pastoralism is distinct ecologically from that of other semi-arid regions, except Mongolia (Ekvall, 1974), since it is separated from agricultural areas by temperature not aridity (Ekvall, 1968; Barfield, 1993; Goldstein and Beall, 1990; Miller, 1998a). The yak (Plate 8.10), which is superbly adapted to the cold Tibetan Steppe, also distinguishes Tibetan pastoralism (Cai and Wiener, 1995; Miller, 1997b).

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Plate 8.8
Yaks transporting wool.

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Plate 8.9
Yak pack train.

S.G. REYNOLDS

Plate 8.10
*The Yak (*Bos grunniens*).*

Historical and cultural aspects

Pastoralists have probably been raising stock on the Tibetan Steppe for 4 000 years (Barfield, 1989; Lattimore, 1940). As early as the Hsia dynasty (2205-1766 BC), nomadic Qiang were making fine woven woollen material in the Kunlun Mountains. In the Shang dynasty (1766-1027 BC) nomads in eastern Tibet were renowned for their horses. The development of Tibetan pastoralism was

Plate 8.11
Kokonor camp with the distinctive black yak-hair tents.

Plate 8.12
Amdo woman and tent.

shaped by nomads from Central Asia who brought sheep, goats and horses. The Tibetan black, yak-hair tent (Plates 8.11 and 8.12) is strikingly similar to the goat-hair tents of Afghanistan, Iran and Iraq (Manderscheid, 2001). The yak, domesticated on the Steppe (Miller *et al.*, 1994), enabled nomads to exploit the high grassland.

Most herders are Tibetan but there are small groups of Mongols and Kazakhs in Qinghai. Population density across much of the Steppe is less than two persons per square kilometre (Ryavec and Vergin, 1998). For a distance of almost 3 000 km, Tibetan is spoken and has been a written language for about 1 300 years. In recent decades, pastoralists across most of the Steppe have built houses and livestock shelters, on traditional winter-spring pastures where they spend up to 6–7 months of the year. The vast majority of herders have been "settled" for some time, but graze their livestock in a transhumant manner (Miller, 1998c).

Livestock management

Pastoral practices are similar across the Steppe, although the composition and size of herds differ. Herders keep milking (Plates 8.13 and 8.14) and dry herds of yak, yak-cattle crosses, sheep (Plate 8.15), goats and horses. The yak in many ways defines pastoralism across the plateau; they are preferred for riding in rough country, at extreme altitudes and in snow (Ekvall, 1974); their dung is an important fuel. The Tibetan term for yaks, *nor*, is also translated as "wealth". Sheep and goats are most important in the west where they suit the vegetation better than do yaks; there sheep and goats are milked; in the east, yaks supply all the nomads' milk needs. Mutton is the preferred meat. Goats yield cashmere, meat and milk; Tibetan cashmere is among the best in the world. Sheep, goats and camels (Plate 8.16) are also used as pack animals but, with expanding road access, their role for transport has diminished. Horses are used primarily for riding, but are also used as pack animals. Mares are not milked and Tibetans

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Plate 8.13
Milking yak.

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Plate 8.14
Milk collection.

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Plate 8.15
Sheep grazing on the high plateau.

do not eat horsemeat. Livestock belong to individual families since the communes were disbanded and the 'household responsibility system' introduced in the early 1980s. Each family is responsible for its livestock and the processing and marketing of livestock products.

The proportion of species and the size of herds differs according to grassland factors and the suitability of the landscape for different animals. Table 8.8

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Plate 8.16
Mongols and pack camels.

TABLE 8.8
Average livestock numbers per family in various Counties and Townships.

Administrative unit	Yak	Sheep	Goats	Horses
Shuanghu County, Tibet	18	282	107	4
Nyima County, Tibet	14	220	144	2
Amdo County, Tibet	45	189	25	4
Takring Township, Naqu County, Tibet	31	57	13	1.5
Tagmo Township, Naqu County, Tibet	30	54	11	1.5
Nyerong County, Tibet	27	46	8	1.4
Aba County, Sichuan	70	34	0	6
Hongyuan County, Sichuan	85	7	0	5
Maqu County, Gansu	46	48	0	6
Marma Twp, Maqu County, Gansu	51	71	0	6
Nyima Township, Maqu County, Gansu	46	81	0	1.8
Luqu County, Gansu	33	65	0	2

SOURCES: Interviews and Government Records.

shows herd composition for 16 counties and townships across a distance of 1 500 km from west to east. For example, in Shuanghu County of the Tibetan Autonomous Region, yaks make up only 4 percent of livestock; whereas in Hongyuan County of Sichuan, about 1 200 km to the east, yaks comprise 85 percent. Shuanghu is drier and the alpine steppe vegetation suits sheep and goats. Hongyuan is wetter and vegetation is dominated by alpine meadow. Herd compositions within a geographic area can also differ with the skills, preferences and availability of labour. Luqu County, in southwestern Gansu, is close to Aba and Hongyuan Counties in Sichuan and pastures are comparable, but in Luqu the government encouraged pastoralists to raise sheep, hence it has a much higher percentage of sheep than neighbouring counties.

The number of animals that herder households raise also varies considerably across the Steppe. In Shuanghu County in Tibet, an average-income family of five keeps about 280 sheep, 100 goats, 18 yaks and 4 horses. In Naqu County a family of five would have 60–80 sheep and goats, 30–35 yaks and two horses. A rich family in Naqu may have 200–300 sheep and goats and 100 yaks. In Hongyuan County in northwest Sichuan a typical family would have 80–100 yaks, five horses and no, or a few, sheep. Of the 80–100 yaks a family in Hongyuan has, only 30 to 40 are milking females. In Phala in northwest Shigatse Prefecture of Tibet, the richest herding family with six persons in the household had 286 sheep, 250 goats, 77 yaks and 8 horses.

Herd structure illustrates pastoralists' expertise in animal husbandry. In Phala, almost 60 percent of the adult sheep and goats are females. Adult males, at 30 percent of the flock, may seem high, but a significant portion of herders' income is from fibre from adult males and adult males for meat. In pastoral areas, livestock graze year-round. Some hay is cut for weak animals and horses in winter and spring. In recent years, however, some herders are sowing pastures for winter-spring grazing or hay.

Herds on the move

Traditional extensive grazing management was adapted to local conditions and stock were regularly moved between pastures to maintain grassland condition and animal productivity. Grazing lands were parcelled into seasonal pastures and grazed according to managerial and production objectives. Pastoralists' movements were well prescribed by complex social organizations and were highly regulated. Mobility is still vital for most herders (Plate 8.17), although

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Plate 8.17
Herders moving on the high plain.

with escalating settlement, livestock mobility is being curtailed. The system was designed around the seasonal movement of livestock; herds rotated between pastures to use forage in summer and reserve grass for autumn and early winter to prepare animals for the long winter. The survival today of numerous, prosperous groups of Tibetan pastoralists bears witness to their extraordinary indigenous knowledge, resourcefulness and animal husbandry skills. Much of the grazing ecosystem is intact and sustains a unique flora and wild fauna, despite centuries of grazing, indicating its remarkable resilience. Now, however, traditional, proven, yet often quite sophisticated livestock and grazing management systems are being altered as modern development sweeps across the Tibetan steppes.

Land tenure

Before 1949 there was a feudal "estate" system with land controlled by religious and aristocratic elites (Goldstein and Beall, 1990:54). Wealthy, powerful monasteries controlled huge fiefdoms with numerous pastoral estates and thousands of subjects. Herders were bound to an estate and not free to leave it, but owned their animals and managed them as they wished; they paid taxes and provided corvée labour to their lord.

Traditionally, pastoral estates were divided into numerous pastures, with borders recorded in a register book (Goldstein and Beall, 1990:69). Households received pastures according to the number of livestock owned, including multiple pastures for use at different seasons. Estate officials enforced pasture boundaries. Herding households were independent of each other regarding management of their pastures and animals and there was no "common" pasture open to all. On pastoral estates the system balanced grassland resources and livestock by reallocating pastures between families according to a census conducted every three years. Herders whose stock had increased were allocated more pasture and those whose herds had declined lost land, the aim being to maintain a specified number of livestock on each pasture (Goldstein and Beall, 1990:70).

In many areas herders were organized as a confederacy of separate kin-based groups which were of different sizes and each had customary rights to land of varying extent, used at different seasons. Groups were divided into 'encampments' of five to ten households and each encampment had rights to a set of seasonal grazing areas within the wider 'tribal' territory. Natural features like ridges and streams (Levine, 1998) marked boundaries. Herders had heritable grazing rights within a group territory (Clarke, 1998).

Traditionally, in areas outside the control of large pastoral estates, grazing rights were very insecure and depended on force (Levine, 1998). While the rights of tribes to certain tracts of land were fixed – unless and until other tribes took them by force – rights of encampments were more fluid. The camping sites and grazing grounds of the various groups could be changed from one part of the tribal territory to another at the discretion of tribal leaders and in response to changing needs of the encampment (Levine, 1998). In the Golog region of the northeastern Steppe winter camps had a sense of 'ownership' by specific encampment groups. Households in the encampment had 'individual and exclusive rights over certain hayfields' near winter sites (Ekvall, 1954).

Since 1949 the state has induced profound changes in land tenure and social organization of pastoral communities. In the 1950s, when land reform was being implemented throughout China, pasture was nationalized and aristocratic and monastic lords lost their estates. State ownership of grassland was not incorporated into law until 1982 (Ho, 2000). When communes were established in the late 1950s and 1960s, ownership was vested in the production teams, which came to regard the grassland as collective property. What emerged was a *de facto* situation of state and collectively owned pasture. All livestock was the property of the communes. Herders were transformed to holders of a share in the communes' livestock. In the commune era, however, mobile pastoralism continued and no attempt was made to reduce the geographic scope of livestock production.

Decollectivization of the agricultural sector in China was authorized in 1978. Institutional rural reforms began in agricultural areas of eastern China, where communes and state farms were dismantled and their lands redistributed under the family-based Household Contract Responsibility System (Ho, 1996). In agricultural areas farmers could lease land and land use rights could be subcontracted or inherited. The contract system became the orthodox form of land tenure for agriculture and was applied to grasslands with the promulgation of the Grassland Law in 1985 (Ho, 2000), which states that the user right of state or collective pasture may be leased to households for a 'long term', although in practice lease periods extend to 30 years and in special circumstances to 50 years. In much of the pastoral area of Qinghai, southwest Gansu and northwestern Sichuan, many herders have settled and have fenced pastures contracted to them. There is evidence that the allocation of rangeland is at the community and small group level, much as in the pre-commune era (Goldstein and Beall, 1991).

Transformation of the traditional pastoral production system

The profound changes of recent decades are transforming traditional land use, altering pasture conditions and disrupting the lives of pastoralists. Often these political, social, economic and ecological transformations have altered previously stable relationships between pastoralists and the grasslands.

In the mid-1980s winter grazing lands were allocated to households and winter pastures were fenced (Plate 8.18); this began in the Qinghai Lake region, but quickly spread to herding areas in Gansu and Sichuan. Exclusive usufruct rights to specific grazing lands for herding households, valid in most cases for 30 years, have now been established. These rights can be inherited, but not


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Plate 8.18
Fenced rangeland.

bought or sold. There is no mechanism yet in place for the readjustment of grazing land to individual families when livestock numbers fluctuate.

In the Tibetan Autonomous Region, however, grassland is not yet allocated to households, but is being allocated to groups of herders. One explanation for the difference in the privatization process in Tibet is that the grasslands are not as productive and the expense involved in fencing individual properties would be prohibitive. A new development is that summer grazing lands are also being privatized and fenced, except again in the Tibetan Autonomous Region where they are being allocated to groups instead of households. To complement the privatization a 'Four-Way Programme' is being implemented and consists of:

- fencing about 20 to 30 ha of productive winter pasture, reserved from grazing in summer and autumn, to provide grazing during the late winter and/or spring;
- construction of shelters for livestock;
- construction of homes for nomads in their winter pasture site; and
- planting small (0.5 to 2 ha) plots of oats for hay in the corrals around winter settlements (Plate 8.19).

In some areas, additional interventions include:

- fencing about 20 ha of degraded land which is rehabilitated by reseeding; and
- fencing of an additional 20 ha which is then improved with fertilizer, chemicals and improved management.

These activities are being undertaken on a large scale, with substantial government and donor investment, in almost all pastoral areas of Qinghai,

Plate 8.19
Oats for winter feed (as hay) being grown in a sheep pen, Qinghai, China.

Gansu and Sichuan. However, even in Tibet, great attention is being given to "scientific" animal husbandry and settling of herders.

The heavy livestock losses experienced on the plateau in recent years has convinced many authorities that transhumant pastoralism needs to be restructured. Programmes to settle herders, privatize and fence pasture and develop fodder for winter are seen as ways to prevent losses in severe winters and control what is perceived as widespread pasture degradation. While some of these interventions have merit, such as the growing of annual forage for hay, the long-term ecological implications of privatizing pasture and reducing the spatial movement of herds have received little analysis (Miller, 2000). The socio-economic and land-tenure ramifications of herders being settled on defined properties have also not been examined.

Foggin and Smith (2000) concluded that summer-autumn pastures may be unintentionally degraded further as artificially high winter populations of stock are forced to graze on summer-autumn pasture of reduced size. Official livestock-management views technology as having the ability to overcome resource limitations but fails to consider that a greater proportion of winter-spring pasture means a lesser proportion of summer-autumn pasture and overgrazing becomes increasingly likely as more livestock graze on a continuously decreasing area during a short growing season (Foggin and Smith, 2000). Considerable investment may be misdirected or inappropriately divided between winter-spring and summer-autumn zones and associated projects. For example, in Dari County of Qinghai, grassland condition has continued to deteriorate despite a decrease in livestock and considerable investment in "construction" projects.

The popular government development paradigm in the Tibetan Steppe, adopts a livestock rather than a grassland management perspective (Foggin and Smith, 2000); stock numbers are of primary importance and attention to vegetation secondary. As the human pastoral population increased there was a strong tendency to rely more heavily on winter-spring grazing, the condition of which decreased as human population density – and livestock density – increased. Since winter-spring is when most livestock die from poor nutrition, an increase in the area of winter-spring grazing land or the supply of feed in winter-spring is a rational response to ensure that more stock survive. This focus on maximizing livestock production detracts from promoting sustainable grassland management.

Snowstorms and pastoral system dynamics

Across much of the Tibetan Steppe, where there is sufficient rainfall and the pastoral system appears to operate in an equilibrium manner with regards to forage production, the continental climate and periodic weather perturbations in the form of sudden and brutal snowstorms add to the complexity and dynamic nature of the ecosystem (Goldstein, Beall and Cincotta, 1990; Miller, 2000). Snowstorms are a fundamental component of the Tibetan Steppe and probably serve as an important regulatory mechanism in the pastoral system. Serious losses occur as a result of heavy snowfalls and severe cold weather (Cincotta *et al.*, 1991; Clarke, 1998; Goldstein, Beall and Cincotta, 1990; Miller, 1998a; Schaller, 1998; Prejevalsky, 1876, in Schaller, 1998). From 1955 to 1990, six severe winters with heavy snow were reported, resulting in 20 to 30 percent losses in livestock each time. Schaller (1998) reported an unusually heavy snowfall of 30 cm in October 1985, followed by temperatures that dropped to -40°C, in southwestern Qinghai that resulted in large numbers of livestock and wildlife dying. Goldstein and Beall (1990) found that all lambs and kids died in the spring of 1988 in the Phala area of Tibet. The winter of 1989–1990 in Tibet resulted in the loss of 20 percent of livestock in affected areas. The winter of 1995–1996 was severe in many parts of the plateau, with 33 percent of livestock lost in Yushu Prefecture of Qinghai. Losses in summer are not uncommon; Goldstein and Beall (1990) found that after five days of snow in the summer of 1986, a herding area lost 30 percent of its stock. Ekvall (1974) mentions the effect of hail on Tibetan herds. Much of the Steppe probably functions as a non-equilibrium system with stock numbers frequently checked by climatic factors, such as snowstorms, rather than by increasing pressure of livestock on the pastures (Miller, 1997a).

Another severe winter was in 1997–98, when usually early and severe snowfalls in September was followed by cold weather, preventing the snow from melting. More snow followed and by November, the pasture was buried under deep snow. By April 1998, more than three million head had been lost. Thousands of families, many of which had lost all their livestock, suddenly faced poverty. In Naqu prefecture, 20 percent of the pastoral population of

340 000 lived in poverty prior to the severe 1997–98 winter; in the following year the percentage had increased to 40 percent.

Officials label heavy snowfalls and severe winters as “disasters”; however, pastoralists have been herding on the Tibetan Steppe for centuries and have dealt with snowstorms and cold weather – those of the winter of 1997–1998 are natural events of the pastoral system. Herding has always been a high-risk enterprise; pastoralists adopt strategies that minimize risk and make best use of the resources (Goldstein and Beall, 1990; Miller, 1998a). In contrast to severe droughts in semi-arid pastoral areas, heavy snowfalls do not affect the vegetation negatively. Unlike droughts, where the effects on livestock are more prolonged, severe snowstorms are sudden events, with a very short or no “warning” period, and often causing livestock deaths in days or weeks.

DILEMMA ON THE TIBETAN STEPPE

With attempts to transform pastoral livestock production towards a market economy the goal has been to increase off-take. This has been promoted through privatization of herds and land, settling herders, introduction of less mobile, intensive grazing management and of rainfed forage. Many of these interventions have been responses to political or economic objectives and while they have improved the delivery of social services, in many instances, they conflict with the goal of maintaining grassland health and stability since they limit the mobile nature of pastoralism (Miller, 1999a; Goldstein and Beall, 1989; Wu, 1997a). Movements between seasonal pastures are being reduced or eliminated; herd composition is being restructured along commercial lines; herders are being compelled to become livestock farmers. The environment and the pastoral cultures are under threat where mobility has been eliminated or substantially reduced (Humphrey and Sneath, 1999; Sneath and Humphrey, 1996).

A disproportionate amount of research is oriented to maximizing livestock productivity, rather than understanding how livestock fit into the ecological system in a socially sustainable way. There is also a problem regarding the effective privatization of pastoral land tenure. Transaction costs associated with the policy are high, including high private costs relative to the benefits and high public costs of monitoring and enforcing contractual provisions related to pasture management (World Bank, 2001). As Banks (1999) has outlined, privatization policy was based on the assumption that, through the better definition of property rights and introduction of individual land tenure, security would be improved and this would prevent a “tragedy of the commons” scenario which in turn would give herders the incentive to manage their pasture better and invest in improvement. It was asserted that private ownership, by combining interest in both land and livestock, would prevent overgrazing (Banks, 1997). This model has been widely rejected by most pastoral specialists, who have found it a very poor guide to understanding transhumant pastoralism and planning development of pastoral areas.

Privatization of land in semi-arid pastoral areas often leads to lower levels of production, decreasing numbers of people supported on equivalent land and in some cases unsustainable or even destructive use of natural resources (Galaty *et al.*, 1994). Individualization of tenure leads to loss of flexibility in grazing management and consequently, a means to manage environmental risk. In Inner Mongolia (Sneath, 1998) found that that the highest levels of grassland degradation were in areas with the lowest stock mobility; mobility indices were a better guide to degradation than densities of livestock. Williams (1996a, b) noted that grassland enclosures in Inner Mongolia compound grazing problems by intensifying stocking rates on highly vulnerable land, exacerbating wind and soil erosion across large areas only to protect small isolated fields dedicated to poorly financed fodder cultivation.

The fact that many prosperous pastoral groups still populate the Tibetan plateau is evidence of their extensive knowledge about grasslands and livestock. Multi-species grazing maximizes the use of forage but requires complex management. Multiple species minimizes the risk of total loss from disease or winter storms. As McIntire (1993) found for Africa, the central characteristics of traditional pastoralism – low productivity, high variability in forage and livestock production, low production density and high market transaction costs – mean that conventional markets in land, labour and capital have not become well developed. Tibetans, nevertheless, often develop quite sophisticated arrangements for meeting their labour requirements, for managing grassland without exclusive private property rights and for allocating their livestock as capital in the absence of financial markets.

There is increasing evidence that many of current policies for Tibetan pastoral areas may be based on flawed information about herd sizes and incorrect assumptions about the destructiveness of traditional pastoral systems. Political and donor-driven pressure to develop the hinterland of Western China and to alleviate poverty among pastoralists also means that many of the underlying ecological and socio-economic issues are not adequately addressed before development programmes are undertaken. As Goldstein, Beall and Cincotta (1990) pointed out, it would be tragic if the herding way of life was gradually undermined and destroyed by modern notions of conservation and development based on faulty evidence, negative stereotypes and untested assumptions.

Mobility

Throughout the Steppe, pastoralists who, until a few decades ago, lived in tents (Plate 8.20) year-round have built houses for themselves and shelters for their livestock and have fenced private winter pastures (Plate 8.18). Does a ‘home on the range’, however, have to signify the demise of mobile pastoralism? Or, is there still potential to engage in mobile herding and maintain some of the best aspects of traditional management?

Plate 8.20
Longri summer camp.

The emphasis on settling herders in Western-style, intensive ranching type of operations and a conservative approach to stocking and fencing has led to misguided policies and projects throughout the world. The mobility paradigm does not argue for the 'good, old days', nor try to maintain pastoralists in their current conditions (Niamir-Fuller, 1999); it seeks to put in place proper policies, legal frameworks and support systems to enable pastoralism to evolve towards an economically, socially and environmentally sustainable livelihood. It presents a framework for analysing pastoral issues related to their resources, the herders, their adaptive strategies and their common property regimes and not only gives mobile livestock production systems a raison d'être, but tries to redress the imbalance caused by emphasis on intensive production (Niamir-Fuller, 1999).

The mobility paradigm would advocate that livestock mobility is an essential ingredient for sustainable development in Tibetan grasslands and that houses, shelters and privately fenced enclosures for hay and winter-spring grazing could be compatible so long as livestock are allowed opportunistic mobility. It would acknowledge the importance of "key sites", or high-value grazing patches and the need for access to them. It would make the case for pooling of household livestock into larger herds to be herded on shared pastures and seek to revitalize common property regime institutions. The mobility paradigm would seek ways to manage uncertainty and risk better through risk minimizing and risk buffering. There would also have to be a commitment to decentralization and real participatory processes.

CONCLUSION

The economic viability and environmental sustainability of pastoral production on the Tibetan Steppe is under considerable scrutiny. The Tibetan Steppe has received little research attention from grassland ecologists and specialists in pastoralism. Lack of information limits proper management and sustainable grassland development. Pastoral ecosystem dynamics are poorly understood and data on ecological processes taking place are limited. Many questions concerning how vegetation functions and the effect of grazing on the pastoral system remain unanswered. There is a critical need for more in-depth studies of the relationship between herbivores and the vegetation resource, and the relationship between domestic livestock and wild herbivores.

For the Tibetan Steppe there is need for fresh perspectives and information on ecosystem dynamics and pastoral development. Theories of plant succession leading to a single equilibrium community have been found to be inadequate for understanding the complex successional pathways of semi-arid and arid rangeland ecosystems (Stringham, Krueger and Thomas, 2001; Westoby, Walker and Noy-Meir, 1989a). This recognition has generated a search for an alternative theory that more adequately reflects the dynamics of pasture ecosystems. Theories involving multiple successional pathways, multiple steady states and state-and-transition processes are gaining in acceptance. On Tibetan Steppe pastures therefore, traditional measures for condition and carrying capacities may not be effective gauges for management. New perspectives regarding non-equilibrium ecosystem dynamics and concepts about plant succession processes in semi-arid ecosystems provide interesting frameworks for analysing Tibetan Steppe pastures (Cincotta, Zhang and Zhou, 1992; Fernandez-Gimenez and Allen-Diaz, 1999; Westoby, Walker and Noy-Meir, 1989b).

Neither are the socio-economic dimensions of Tibetan pastoral production systems well known (Clarke, 1992; Goldstein and Beall, 1989; Levine, 1998); greater efforts need to be directed towards developing a better understanding of current systems and how they are changing and adapting to development influences. Practices vary considerably across the area and need to be analysed (Clarke, 1987). Why do herders in different areas maintain different herd compositions? What are current offtake rates and how do increasing demands for livestock products in the marketplace affect livestock sales? What constraints and opportunities for improving livestock productivity are recognized by the herders? What forms of social organization exist for managing livestock and grasslands? How have these practices changed in recent years and what are the implications of these transformations? Answers to these and related questions, will help unravel many of the complexities of Tibetan pastoralism. Analyses of the socio-economic processes at work are a key challenge for researchers. It will also be important to determine which aspects of indigenous knowledge systems and traditional pastoral strategies can be used in the design of new development interventions on the Tibetan Steppe (Miller, 2002; Wu, 1998).

There is growing appreciation of the complexity and ecological and economic efficacy of traditional pastoralism (Wu, 1997b) which provides hope that the knowledge that pastoralists possess will be used in designing development interventions. It also gives a prospect that the pastoralists will be listened to and involved in the planning and implementation of pastoral development. Herders must be involved in the initial design of interventions, their needs and desires must be heard and their knowledge put to use. An important message for policy-makers is the need for active participation by the herders in all aspects of the development process and for empowered herders to manage their own development.

Given the generally poor experience with settling herders in other pastoral areas of the world, it will be interesting to watch the attempts to foster more sedentary livestock production systems on Tibetan grasslands. What effects will the privatization of the grazing lands have on pasture condition? Will herders overgraze pastures which they now view as their own property? What kinds of monitoring programmes are needed to look after the privatized pastures? What effect will private land and fences have on traditional mechanisms for pooling livestock into group herds and group herding?

There is a need to re-orient policy objectives in terms of grassland management and livestock production, and in the management of rural development. Maximizing agricultural output is not relevant to current circumstances. The need in the twenty-first century is for ecologically and economically sustainable development of pastoral areas, neither of which is consistent with output maximization (World Bank, 2001). Policies and development strategies should be based on consideration of ecological constraints, the interests and aspirations of the pastoralists themselves and alternative methods of meeting social objectives. There is a general need to invest more in grassland and livestock research in the Tibetan Steppe to guide policies and to help herders develop appropriate technologies for the range of ecological and socio-economic conditions found. Research needs to be more participatory and herders need to play a larger role in setting priorities and in determining the merits of findings.

Opportunities do exist, however, for improving the management of pastoral resources, increasing livestock productivity and bettering the livelihoods of the population. Programmes stressing multiple use, participatory development, sustainability, economics and biodiversity could be realized through complementary activities in resource management, livestock production and wildlife conservation. Sustainable land use on the Tibetan Steppe depends heavily on the local-level users of the resources – the Tibetan herders. It is at this level that pastoral resource use decisions are made on a daily basis. It is also at this local level that awareness, incentives and institutional and infrastructure conditions must be appropriate in order to secure sustainable grassland management.

Sustainable grassland management and pastoral development on the Tibetan Steppe requires: (1) greater concern about the welfare of herders; (2) increased concern about grassland degradation and ecosystem processes; and (3) the political will to address the problems. Concern and political will are not enough: there also has to be improved human resource capability to design and implement policies and actions. Lack of capacity at the local level is one of the main constraints to more sustainable pastoral development and pasture management in the Tibetan Steppe. It is necessary, therefore, to foster an enabling environment for local-level capacity building. This must take into account the local variability and site-specific conditions related to climate, soils, ecology, livestock production and socio-economic factors.

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