Chapter Two

Fodder Resources and Their Management

Background information

Topography, geology and soils

George Bogle described Bhutan's topography as: "A succession of lofty and rugged mountains, separated by gorges and a few valleys somewhat wider than the generality of ravines" (Marakham 1876). The elevation ranges from about 200m in the south to almost 8,000m in the north. The physical features of the country are described in Karan (1967). Based on a comprehensive geological study of the Bhutan Himalayan chain, Ganser (1983) defined five geological zones: the Sub-Himalaya, the Lower Himalaya, the High Himalaya, the Tibetan Himalaya, and the Indus-Tsangpo zone. Geologically the larger part of Bhutan consists of crystalline sheets with large masses of tertiary granite intrusions towards the north.

Little information is available about Bhutan's soil. The FAO/UNESCO soil map (FAO/UNESCO, 1977) classified about 27% of the country as having either cambisol or fluvisol soils. Cambisols are most common at middle altitudes, while fluvisols mostly occur in the southern belt. Less fertile acrisols, ferrasols, and podzols are estimated to cover about 45% of the country. The same study claimed that 21% of the soil-covered area is only shallowly covered, mostly with lithosols on steep slopes.

Bhutan's forest soils have been classified by Sargent et al. (1985) and Okazaki (1987). Okazaki delineated five major soil groups (Figure 4) based on 69 samples collected from sites between 150m and 5,300m. Altitude and precipitation were the major factors used in this classification.

Soil analysis data are available for a range of sites and cultivation practices in Bhutan (Roder 1982a). There is a wide variation in the availability of macro- and micro-nutrients. In most areas in Bhutan's High Himalaya zone, soils are poor in phosphorous (P) but have sufficient reserves of potassium (K).

Climate and vegetation

Bhutan's climate is dominated by the Indian monsoon with high levels of precipitation between June and September. The winter season is generally dry. The wide range of topography and elevation leads to Bhutan having a wide variety of climatic conditions. A detailed review of the climatic data available for Bhutan's temperate regions has been given in a recent review by RNR-RC Jakar (Roset 1998). This review is of special interest because of the long span of

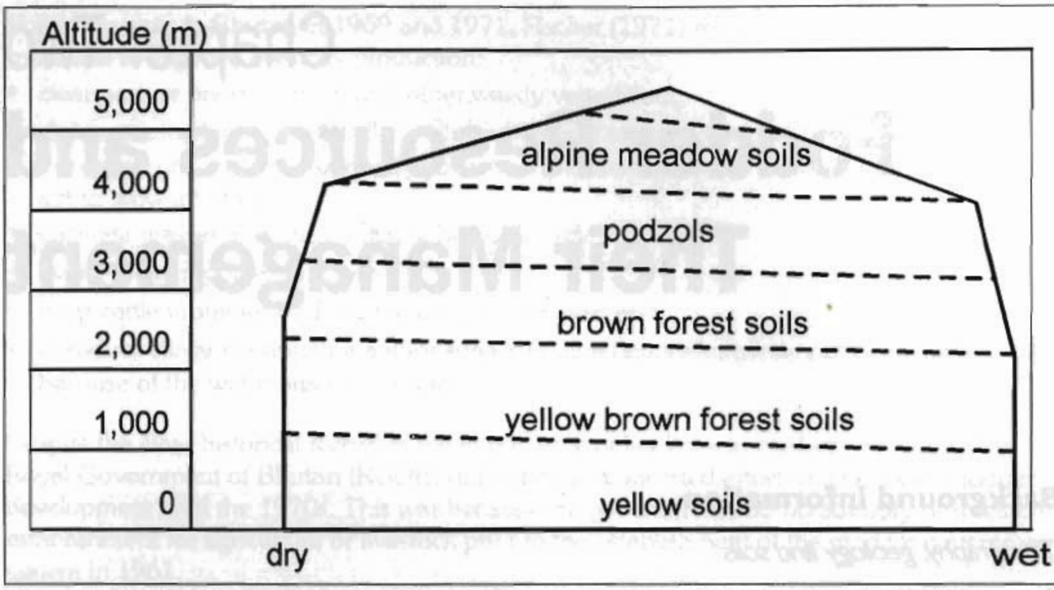

Figure 4: Vertical distribution of soils in the Bhutan Himalaya (Source: Okazaki, 1987)

the available measurements and the high density of meteorological stations sited in Bumthang dzongkhag. The data shows that in Bumthang a 100m increase in elevation gives an average decrease in temperature of 0.55°C, resulting in a decrease in the growing season of about 12 days.

Various attempts have been made to classify Bhutan into agroecological or vegetation zones (Grierson and Long 1983; Negi 1983; Oshawa 1987b; MOA/ISNAR 1992; Gyamtsho 1996). At present, the Ministry of Agriculture recognises the following six zones: wet subtropical (150-600m), humid subtropical (600-1,200m), dry subtropical (1,200-1,800m), warm temperate (1,800-2,600m), cool temperate (2,600-3,600m) and alpine (3,600-4,600m) (MOA/ISNAR 1992). This classification is only a crude simplification as the distinction between vegetation types and the demarcation along altitudinal and rainfall gradients is much more complex on the ground.

Table 3: Vegetation zones in Bhutan (after Grierson and Long 1983)

Dominant species	Altitude (m)	Rainfall (cm)
Subtropical forest	200-1,000	250-500
Warm broadleaf forest	1,000-2,000	230-400
Chir pine *(Pinus roxhburgii)* forest	900-1,800	100-130
Cool broad-leaf forest	2,000-2,900	250-500
Evergreen oak *(Quercus semecarpifolia)* forest	2,000-2,600	200-300
Blue pine *(Pinus wallichiana)* forest	2,100-3,000	70-120
Spruce *(Picea spinulosa)* forest	2,700-3,100	50-100
Hemlock *(Tsuga dumosa)* forest	2,800-3,100	130-200
Fir *(Abies densa)* forest	3,300-3,800	≥130
Juniper/rhododendron	3,700-4,200	-[1]
Dry alpine scrub	4,000-4,600	-[1]

[1] No rainfall estimate given

Grierson and Long (1983) classified Bhutan's vegetation into 11 zones and compared their classification to earlier published systems from neighbouring regions. Their classification is probably the best available to date (Table 3, Figures 5 and 6) (Grierson and Long 1983).

Figure 5: Fir forest above 3,300m

The botanical exploration of Bhutan by foreigners was also reviewed by Grierson and Long (1983). The authors list 17 plant collectors who collected over 10,000 specimens between 1838 and 1980. Only a few of these expeditions were aimed purely at botanical and floristic studies.

The first recorded collections were made by Griffith in 1838 (Griffith 1939). Griffith was the medical doctor as well as the botanist of an English Mission which travelled to Bhutan in 1837-38. This mission, headed by Major Pemberton, entered Bhutan in the east to travel to Punakha to meet with the Bhutanese Government. Their trek of 640 km took them from Deothang, through Lhuentse, to Bumthang, Wangdue, Punakha, Thimphu, and Chhapcha. Griffith's travelogue includes many vegetation diagrams.

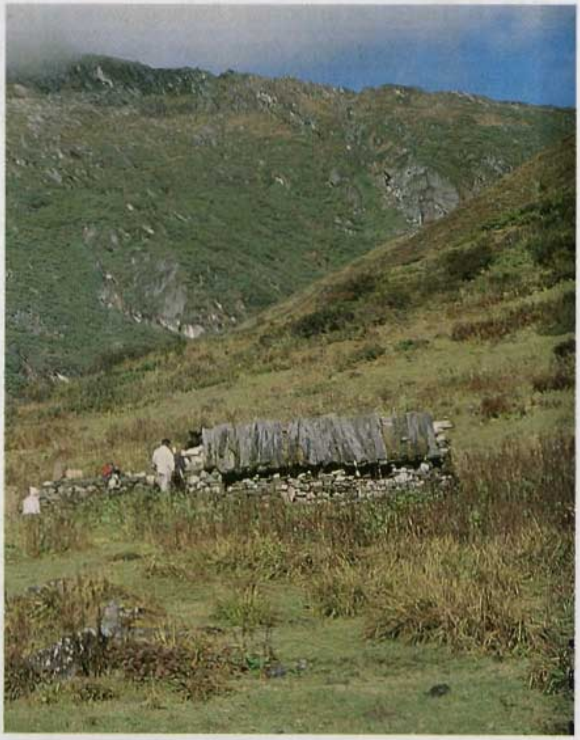

Figure 6: Alpine scrub

Descriptions of the vegetation in the Himalayas (Polunin and Stainton 1984; Stainton 1988; Stearn 1976) and in the Indian sub continent (Bor 1960) have been useful when studying Bhutanese vegetation. The collections of Ludlow and Sheriff (Stearn 1976) focused on primula and rhododendron species and are of special interest for studying the vegetation of alpine grazing lands in Bhutan.

A comprehensive description of the flora of Bhutan is being prepared by the Royal Botanical Gardens, Edinburgh and is well under way (Grierson and Long 1983, 1984, 1987, 1991; Noltie 1994, 2000, and additional volumes in progress). It provides an important base to describe grazing land plant communities and other fodder resources. The volumes containing the families *Cyperaceae* and *Juncaceae* (Noltie 1994), and *Poaceae* (Noltie 2000) are of particular importance.

Table 4: Contribution of different types of fodder resources to Bhutan's national fodder requirements		
Fodder source	**Relative contribution (%)**	
Forest grazing	22	23
Natural grassland	22	38
Improved pasture	1	9
Shifting cultivation and fallow land	15	-
Fodder trees	20	15
Crop residues	20	13
Other	-	2
Source:	Roder 1990a	RGOB 1994

Fodder resources

The fodder resources used by livestock vary with the climate, the farming system, and the seasons. No reliable nation-wide data is available on the relative contribution of individual fodder resources but estimates agree that natural grazing lands, including forests, provide the highest proportion (Table 4).

The relative importance of the various fodder resources has been assessed recently in a survey carried out in selected geogs (sub-units of a dzongkhag) of Paro, Wangdue, Trongsa, Zhemgang, and Bumthang dzongkhags. The results are summarised in Table 5. The most important findings were as follow.

- With a few exceptions, there were only minor differences between fodder used by milking and non-milking animals. The main differences across all regions were that milking animals were more likely to be given residues from ara (local distilled alcohol) and chang (local beer) making.
- Forest grazing (including grazing on natural grasslands) was overall the most important fodder resource. The grazing of post-harvest crop fields, pangshing (grass fallow shifting cultivation land) and tsheri (bush fallow shifting cultivation land) areas, and common pasture were the next most important fodder resources.
- Depending on elevation and cropping systems, the most important winter feed was paddy straw, buckwheat straw *(Fagopyrum esculentum)*, and turnip.
- The post-harvest grazing of crop fields received the highest overall ranking as a source of winter feed.
- Residues from ara and chang making were given very high ratings in Bumthang and Trongsa during the summer and winter periods. In the other dzongkhags the rating for this source of fodder was low. This probably does not indicate a higher alcohol consumption in Bumthang and Trongsa, rather it is due to these residues being fed to pigs in the other dzongkhags, where there is a higher pig population.
- Fodder trees are not as important as generally thought. This may partly be due to the characteristics of the geogs included in the study, but even in a subtropical geog such as Drakten (Trongsa) the main winter fodder sources were ranked as firstly rice straw, followed by ara and chang residues, and then post-harvest grazing of crop fields, grazing tsheri, forest grazing, and only finally tree fodder.
- Fodder from improved pasture received a surprisingly high ranking, especially in Wangdue, Trongsa, and Paro dzongkhags. Similarly, hay as a fodder resource for winter feeding received high rankings from the cooler regions of Paro, Wangdue, and Bumthang. Perhaps the contribution from improved fodder has been underestimated in the past.

Fodder from registered grazing land

Bhutan has over 400,000 ha of registered grazing land (Table 6). These areas are known as tsadrog. The area of tsadrog available for large ruminants (cattle and yak) is about 1.6 ha per

Table 5: Rating of fodder resources for milking cattle						
Area details/ Fodder source	**Paro**	**Wangdue**	**Trongsa**	**Zhemgang**	**Bumthang**	**Average**
Geog and altitude[1]	Dobjari 2,400-4,000m Narja 2,300-4,000m	Sephu 3,000-4,000m Phubjikha 2,800-4,000m	Tangsibi 1,500-4,000m Drakten 1,200-3,800m	Trong 800-2,600 Nangkhor 600-4,000m	Tang 2,600-4,000m Chumey 2,600-4,000m	
Altitude range, district	2,000-4,000	1,000-4,000	800-4,000	200-4,000	2,600-4,000	
No. of households interviewed	152	172	146	130	133	
Summer period	**Proportion (%) of respondents listing a particular fodder[2]**					
Forest/natural grassland	43	26	45	47	88	50
Crop fields	2	2	45	52	81	37
Ara/chang residues	1	15	70	6	86	37
Pangshing and tsheri	3	43	45	1	73	33
Common pastures	27	37	25	38	18	29
Improved pastures	30	42	44	13	18	29
Other crop by-products	4	4	41	2	48	20
Cut and carry/weeds	58	0	0	0	0	12
Hay	1	24	1	0	2	6
Turnip and radish	0	9	1	1	0	2
Maize straw	3	<1	2	0	0	1
Fodder trees	0	2	0	0	3	1
Buckwheat[3] straw	1	1	0	0	0	1
Winter period						
Crop fields	0	1	84	51	83	44
Forest/natural grassland	3	11	41	47	87	38
Ara/chang residues	0	15	71	11	86	37
Turnip/radish	38	87	15	4	24	34
Hay/silo	33	64	9	0	63	34
Pangshing and tsheri	1	7	46	2	78	27
Rice straw	30	3	80	2	1	23
Buckwheat straw	6	16	5	0	87	23
Other crop by-products	1	10	36	4	51	20
Common pastures	1	3	20	41	15	16
Improved pastures	1	5	20	5	39	14
Fodder trees	15	8	33	3	8	13
Wheat and barley straw	24	0	0	0	0	5
Maize straw	1	0	8	0	14	5

[1] There is a considerable bias in this data towards higher elevation areas; [2] Respondents were asked to list their fodder resources and then rank them in sequence of importance. This table shows the proportion of respondents listing a particular fodder as first or second most important. The same ranking could be given to more than one fodder category; [3] *Fagopyrum esculentum*

Source: Roder, 1998b

Table 6: Grassland resources for individual dzongkhags

Dzongkhag	Tsadrog[1] ('000 ha)	Natural grassland[2] ('000 ha)	Area of tsadrog per animal[3] (ha)
Ha	67.4	12.1	5.63
Gasa	10.0	23.3	3.25
Thimphu	55.2	33.4	2.48
Paro	32.6	8.2	2.20
Trongsa	22.9	6.5	1.89
Bumthang	26.8	21.4	1.86
Punakha	18.4	1.9	1.78
Wangdue	38.8	14.2	1.56
Zhemgang	23.3	1.0	1.39
Trashigang	40.2	10.9	1.04
Samtse	15.4	0.1	0.95
Chhukha	26.2	3.0	0.94
Dagana	8.0	1.6	0.76
Lhuentse	7.5	9.5	0.46
S.Jongkhar	10.2	0.8	0.43
Mongar	7.8	1.4	0.27
Tashiyangtse	1.7	4.7	0.12
Pemagatshel	0.9	0.0	0.11
Sarpang	0.2	1.2	0.02
Tsirang	0.0	0.1	0.00
Total	**413.6**	**155.3**	**1.36**

[1] Registered grazing; [2] grassland estimated from aerial photos or satellite imagery; [3] area of tsadrog per number of cattle and yak combined
Source: LUPP 1995

animal. The natural grassland area estimated from aerial photographs is considerably lower than the official area of tsadrog, however. This is probably because in aerial photograph estimates a large part of the registered tsadrog was classified as forest as a result of the substantial tree cover in some tsadrog areas.

The most extensive areas of natural grassland are the areas of natural alpine grassland and scrubland found above the tree line at altitudes between 4,000m and 5,000m in the northern dzongkhags of Ha, Paro, Thimphu, Gasa, Wangdue, and Bumthang. Tsadrog is distributed somewhat differently (LUPP 1995). Dzongkhags with large areas of tsadrog include those with winter grazing areas under forest cover such as Zhemgang, Trashigang, and Chhukha. Relatively large areas of natural grassland can also be found at elevations between 700m and 2,100m in dry sites that were originally covered by chir pine forest.

Bhutan's natural (non-forested) grassland types were first discussed by Singh (1978), who described five types of grass cover (Table 7). Soon after, Dunbar (1979) published the first list of species and genera occurring in high altitude natural grasslands in Bhutan.

Vegetation composition and production

The following sources provide lists of species common in Bhutan: Griffith 1839; Karan 1967; Dunbar 1981; Dunbar 1985; Harris 1987; Numata 1987b; Tsuchida 1987; and Tsuchida 1991. The most exhaustive list describes the vegetation along the 640 km transect walked by Griffith (1839).

Most authors have been subjective in their descriptions and their observations have been influenced by seasonal trends in vegetation cover. Griffith (1839) travelled during the dry season (January to May) and his observations focus mostly on tree and shrub species. Others have also focused mainly on either tree species (Karan 1967) or grasses (Miller 1987a,b). Legumes, although present at most locations, are never mentioned in Miller's descriptions of grassland vegetation (1987a,b).

Interestingly, most reports are concerned with observations on Bhutan's alpine environments; there are only a few references for temperate and subtropical areas. In all ecological zones, there is virtually no quantitative data on the relative importance of species, their value as fodder, and their actual and potential dry matter yield.

Table 7: Natural grassland types and their dry matter yields, after Singh

Grassland type	Altitude (m)	Yield (t/ha)
Saccharum reed dominant cover	800-2,000	1.5-2.0
Chrysopogon-Themeda cover	2,500-2,800	1.0-2.0
Thin and short bamboo dominant cover	2500-3,000	data not available
High altitude scrub cover	above 2,800	data not available
Alpine and sub-alpine cover	3,500-5,000	0.3-0.4

Source: Singh (1978)

Numata (1987a) compared the natural grassland vegetation of Bhutan to that found in south-western Japan. He described plant communities using the summed dominant ratio (SDR) of species based on the extent of their cover and height observed in quadrats. This method may, however, overestimate tall growing species. Tsuchida's 1987 and 1991 reports offer the most comprehensive descriptions of Bhutan's grassland communities, and the only source of information pertaining to Bhutan's subtropical areas; they are summarised in detail in Annex 1, Tables A1-A5. These tables provide average figures for between three and six sites from the data provided by Tsuchida. Based on his observations, Tsuchida delineated grassland types depending on elevation and precipitation (Table 8).

Table 8: Natural grassland types and dominant species in Central and Western Bhutan according to Tsuchida

Altitude (m)	Dry soils	Moist soils	Wet soils
1500–2,500	**Chrysopogon grassland** *Chrysopogon aciculatus* *Heteropogon contortus* *Eragrostis tenella* *Ischaemum rugosum*	**Cynodon grassland** *Cynodon dactylon* *Digitaria setigera* *Digitaria stricta* *Digitaria spp* *Chrysopogon aciculatus*	**Paspalum grassland** *Paspalum scrobiculatum* *Fimbristylis spp* *Pycreus spp* *Eleusine indica*
2,500–3,500	**Agrostis grassland** *Agrostis nervosa* *Eragrostis nigra* *Festuca sp*	**Arundinella grassland** *Arundinella hookeri* *Eragrostis nigra* *Agrostis pilosula*	**Carex grassland** *Carex nubigena* *Juncus sp* *Fimbristylis spp* *Eriocaulon sp* *Luzula* sp Kobresia duthiei
3,500–4,000	**Festuca grassland** *Festuca ovina* *Festuca spp* *Anaphalis triplinervis*	**Agrostis grassland** *Agrostis inaequiglumis* *Carex nubigena* *Agrostis pilosula* *Poa sp*	**Carex grassland** *Carex nubigena* *Juncus sp* *Kobresia duthiei*
4,000–5,000	**Festuca grassland** *Festuca sp*	**Kobresia grassland** *Kobresia duthiei* *Poa sp* *Potentilla microphylla* *Deyeuxia pulchella*	**Juncus grassland** *Juncus* sp

Source: Tsuchida 1991

Tables 9 and 10 provide summaries of the natural grassland communities that have been described by various authors. No information is available on the relative importance of these communities. At elevations below the tree line, grassland communities generally consist of secondary vegetation, strongly influenced by cultivation, fire, and grazing (Figures 7 and 8).

Figure 7: Sheep grazing on permanent grassland at 3,000m

Figure 8: Yak grazing bamboo (*Yushania microphylla*) dominated winter pasture (3,100m)

Dry sites ranging from 700 to 2,100m altitude are frequently dominated by *Cymbopogon* type grassland (Miller 1989a) (Figure 9, Table 9). Major grass species at these sites include *Cymbopogon khasianus, Cymbopogon gryllus, Cymbopogon* sp, *Apluda mutica, Arundinella nepalensis,* and *Heteropogon contortus.* Above these elevations *Themeda* sp, *Schizachyrium delavayi,* and *Eragrostis* spp become dominant (Roder 1983c; Roder et al. 1997b). At a typical grassland site evolving from shifting cultivation in Bumthang at 2,700m altitude, *Schizachyrium delavayi* was found to contribute over 60% of total dry matter yield (Figure 10, Table 11) (Roder 1983b and 1990a).

Figure 9: Grassland dominated by *Cymbopogon* species in the *Pinus roxhburgii* belt, Wangdue valley

Table 9: Natural grassland communities described by various authors				
Region	**Site description**	**Elevation**	**Reference**	**Genera/Species**
Humid/Dry Sub-tropical (< 1,000m) to Warm Temperate (1,000-2,400m)				
Chapcha	Grassy banks	2,400	Griffith 1839	*Agrostis, Bromus, Ervum, Aster, Rumex, Hieraciae, Lactuca, Astragalus, Vicia*
Eastern Bhutan	Dry sites	700-2,100	Miller 1989a	*Cymbopogon khasianus, Cymbopogon sp, Apluda mutica, Arundinella nepalensis, Chrysopogon gryllus, Heteropogon contortus*
Cool temperate (2,500–3,800m)				
Nikkachu	Pasture	2,530	Numata 1987a	*Senecio chrysanthemoides, Arthraxon sikkimensis, Paspalum commersoni, Pteridium aquilinum, Arundinaria sp, Elymus sikkimensis, Rosa sericea, Potentilla griffithii, Digitaria ciliaris, Persicaria nepalensis, Poa annua, Geranium nepalense, Commelina paludora, Anaphalis triplinervis, Amaranthus viridis, Artemisia indica, Eleocharis congesta, Bulbostylis densa, Plantago erosa*
Chapcha	Meadow	2,700	Griffith 1839	*Baptisia, Gnaphalium, Pedicularis, Rosa, Bistorta, Nepenthes, Cephalotus, Pteridium*
Bumthang	Evolved from shifting cultivation	2,650	Roder 1983b	*Schizachyrium delavayi, Eragrostis nigra, Potentilla* sp, *Agrimonia* sp, *Lespedeza sp, Desmodium sp*
Merak-Sakten	Dry south–facing slopes	2,500-3,000	Miller 1989a	*Schizachyrium delavay, Arundinella hookeri, Helictotrichon virescens, Themeda quadrivalvis, Bromus ramosus*
Merak-Sakten	Forest meadow (oak-rhododendron forest)	2,900-3,300	Miller 1989a	*Eragrostis nigra, Arundinella hookeri, Agrostis sp, Sedges, Geum elatum*
Merak-Sakten	Moist bamboo grassland sites	3,200-3,600	Miller 1989a	*Bambusa sp, Dactylis glomerata, Helictotrichon virescens, Agrostis sp, Bromus ramosus, Brachypodium sylvaticum*
Merak-Sakten	Drier south–facing slopes	3,000-3,800	Miller 1989a	*Danthonia cumminsii*

Table 10: Vegetation components listed for alpine regions[1]											
	Lingshi	Lunanana				Merak-Sakten		Kidiphu	Western Bhutan		
		Meadow	Dry scrub	Moist scrub	Scree slopes	Fir forest	Grassland	Grassland	Winter pasture	Spring pasture	Summer pasture
Altitude (m)	3,600-4,900	3,700-5,000	3,700-4,200	3,800-4,500	4,800-5,500	3,600-3,900	3,900-4,100	4,000-4,100	3,400-4,100	4,100-4,600	4,200-4,800
References[2]	1	2	2	2	2	3	3	4	5	5	5
Carex	X		x	x	x	x	x		x	x	x
Agrostis	X	x	x		x	x	x		x		x
Festuca	X	x	x			x	x	x			x
Poa	x	x		x	x	x	x	x			
Rhododendron	x		x	x				x	x	x	x
Potentilla	x		x	x				x		x	x
Primula	x	x	x	x				x			
Danthonia	x	x	x	x						x	
Stipa	x	x	x	x							
Junceacea			x						x	x	x
Bromus	x						x		x		
Gentiana		x			x						x
Cotoneaster	x		x							x	
Delphinium	x	x			x						
Rheum	x	x		x							
Salix				x				x	x		
Elymnus			x	x							
Koeleria	x							x			
Deyeuxia	x							x			
Trisetum	x					x					
Anemone			x						x		
Anaphalis										x	
Sausaria				x	x						
Geranium	x									x	
Berberis	x								x		
Juniperus	x		x								
Bryophyta									x		x
Polygonum			x					x			
Calthus			x	x							

[1] Genus only included if listed more than once in a reference; [2] references 1 = Dunbar 1979, 2 = Gyamtsho 1996, 3 = Miller 1989a, 4 = Roder 1983b, 5 = Harris 1987

Figure 10: *Schizachyrium delavayi* dominated grassland in Bumthang (2,800m)

The most important genera at higher elevations in Bhutan include *Carex, Agrostis, Festuca, Poa, Rhododendron, Potentilla, Primula,* and *Danthonia* (Figures 11 and 12, Table 10). The lower elevation grass species which other authors have noted as dominant, such as *Cymbopogon, Apluda* and *Themeda* species and *Schizachyrium delavayi* (Miller 1989a; Roder 1983b; Roder et al. 1997b) were not recorded by Tsuchida (1987, 1991).

Legume species with a wide distribution in natural grassland communities include *Astragalus leucocephalus, A. bothanensis,* other *Astragalus* spp, *Desmodium* spp *Gueldenstadtia himalaica, Hedysarum* spp, *Indigofera* spp, *Lespedeza* spp. *Parochetus communis,* and *Vicia tibetica* (Roder 1982c; Grierson and Long 1983; Grierson and Long 1984; Polunin and Stainton 1984; Gyamtsho 1996).

Table 11: Composition of grassland evolving after shifting cultivation (Bumthang, 2,700m)

Species	Botanical composition (%)[1]
Schizachyrium delavayi	64
Eragrostis nigra and other grasses	19
Potentilla sp	12
Lespedeza sp, *Desmodium* sp, and others	5

[1] Dry matter yield was 0.8 t ha^{-1} $year^{-1}$
Source: Roder 1990a

Natural grassland cover at higher elevations has been assessed by measuring plant cover (Dunbar 1979; Harris 1987). Cover provides an indirect indication of (1) the relative importance of individual species, (2) the relative and actual yield of individual species and plant communities, (3) grazing effects, (4) the health of plant cover, and (5)

Figure 11: Vegetation cover dominated by *Carex* species, Kidiphu (4,000m).

Figure 12: Sheep grazing on alpine pasture (4,000m)

the levels of soil and moisture conservation by different kinds of plant cover. Dunbar (1979) reported the cover on a south-facing slope as 41% plant cover, 13% litter cover, and 46% bare soil. Harris (1987) reported that the amount of bare ground was greater in heavily grazed areas.

No reliable data has been gathered on natural grassland production under herder or farmer management. Several observers have estimated production based on visual observations (Singh 1978; Harris 1987; Rumball 1988a; Miller 1989a; Gyamtsho 1996), whilst others have physically measured the dry matter production of areas from where grazing animals have been excluded (Dorji and Roder 1980; Roder 1983) (Figure 13, Table 12). In these estimates the dry matter yields ranged from 0.7 to 3.0t ha^{-1} for temperate grasslands at elevations of less than 3,000m and 0.3 to 3.5t ha^{-1} for alpine grasslands at elevations over 3,000m. Estimates based on actual measurements (Gyamtsho 1996; Roder 1983) are generally lower than those based solely on visual assessments (Harris 1987; Miller 1989a). Dorjee (1986) estimated an average carrying capacity of 0.5 livestock units per hectare for subtropical regions, 0.25 livestock units per hectare for temperate regions, and 0.10 livestock units per hectare in alpine regions. With a dry matter requirement of 8 kg per animal per day, this would correspond to annual dry matter yields of 1.5t ha^{-1} in subtropical regions, 0.73t ha^{-1} in temperate regions, and 0.29t ha^{-1} for alpine regions. If an average dry matter production of 0.7t ha^{-1} is assumed, then Bhutan's registered grasslands produce about 289,000 tonnes of dry matter every year, sufficient to

Table 12: Estimates of natural grassland production and quality

Source & method	Description, management	Elevation	Dry matter ($t\ ha^{-1}\ year^{-1}$)
Singh (1978), visual[1]	*Saccharum* and reed dominant	800–2,000	1.5–2.0
	Chrysopogon/Themeda cover	2,500–2,800	1.0–2.0
	Alpine pasture	3,500–5,000	0.3–0.4
Harris (1987), visual[1]	Winter yak pasture	3,400–4,100	1.5–3.5
	Spring/autumn yak pasture	4,100–4,600	2.5–3.5
	Summer yak pasture	4,200–4,800	0.5–1.8
Miller (1989a), visual[1]	Dry south–facing slopes	2,500–3,000	2.0–3.0
	Forest meadows	2,900–3,300	0.8–1.0
	Dry south–facing slopes	3,000–3,800	1.0–1.5
	Forest meadow in fir belt	3,600–3,900	1.0
	Bamboo grassland, moist	3,200–3,600	2.0–3.0
	Alpine rangeland	3,900–4,500	0.5–1.0
Gyamtsho (1996), disk method[1,2]	Natural grassland	<4,000	0.3
		4,000–4,500	0.4
		>4,500	0.5
Dorji and Roder (1980), clipping[3]	Bamboo	2,700	1.0
Roder (1983), clipping[4]	Natural grassland	3,900–4,000	0.4 (0.2–0.7)
Roder (1983), clipping[4]	Natural grassland	2,700	0.7

[1] Estimates/measurements made at one point in time, heavily biased by previous grazing treatment; [2] the herbage disk meter consists of a vertical graduated axis, a collar, and a linked aluminium disk that settles on the herbage, the disk height from the ground is used as an indicator of the standing dry matter (Gyamthso 1996); [3] grazing animals excluded and yield measured by repeated cutting over one season; [4] grazing animals excluded and yield measured by repeated cutting (simulating grazing animals) over three seasons.

feed about 99,000 livestock units (8 kg dry matter per day), or 30% of the livestock population.

Natural grassland management and herding systems

Traditional production systems take advantage of the variations in climate and vegetation as herders migrate with their animals according to the seasons. High altitude pastures are grazed during the summer, whilst lower elevations (usually in the south) are used for winter grazing (Table 13, Figure 14).

Figure 13: Cages used in measuring grassland production

Overgrazing is frequently mentioned as the main cause of low and deteriorating grassland yields (Fischer 1971; Miller 1986) and as a threat to the environment (NES 1992). No information is available on livestock numbers and grazing pressure prior to 1960. It is assumed that the periodic occurrence of epidemics would have reduced the human and livestock populations from time to time thus reducing the pressure on fodder resources (Fischer 1971). The last major outbreak of the cattle disease rinderpest in the late 1960s substantially reduced livestock numbers (Fischer 1971; Maurer 1985).

Table 13: Cattle migration from Bumthang (south during winter)

Geogs	Migration as proportion of the total	
	Households (%)	Animals (%)
Choekor	6	12
Tang	9	17
Chumey	41	51
Ura	59	67

Source: Baumgartner 1984

Herding systems are influenced by the natural environment and the socioeconomic setting (Gyamtsho 1996). Households with small herds often pool their animals. Transhumance yak herding systems have been described for Merak Sakteng (Gyamtsho 1996; Miller 1987b; Wangmo 1984), Soi Naro (Gibson 1991), and Laya (Gyamtsho 1996). Most herders have grazing rights to one or more areas of pasture either individually or as part of a community. In some regions large areas of grazing land are owned by absentee landlords (Gibson 1991; Gyamtsho 1992). While most herders and absentee owners treat their grasslands as their family's inheritance, the 1991 Land Act states that all grazing land belongs to the state and herders only have the grazing rights.

Figure 14: Yak herding family ready to move camp (Yutongla, 3,700m)

A system to allot communal pastures to herders has been described for Ha (Ura 1993). In other areas, it is reported that community pastures are grazed indiscriminately on a free-for-all basis (Dorjee 1993; Gyamtsho 1996).

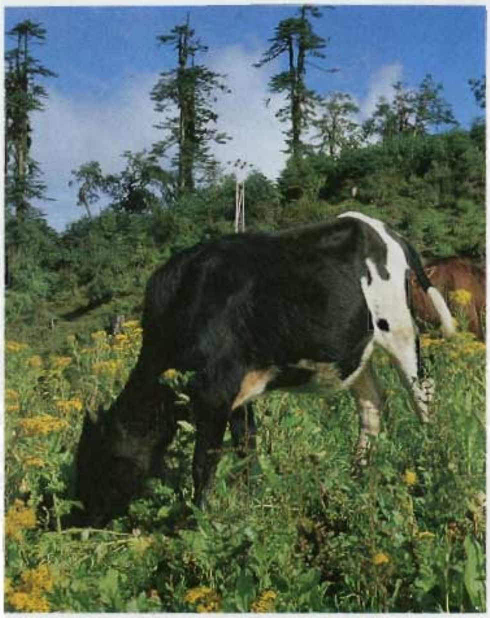

Figure 15: Cow grazing grassland dominated by *Senecio* sp

Pastures at elevations of between 2,000m and 3,000m are often used by cattle for summer grazing and by yak for winter grazing (Gyamtsho 1996). It is not uncommon for two parties, such as a transhumance yak herder and a family from a nearby settlement, to have the grazing rights over the same area. These situations inevitably put extra pressure on the grasslands.

Forest and natural grassland communities include poisonous plant species such as *Aconitum sp*, *Senecio* sp (Figure 15), *Euphorbia* sp, *Pteridium* sp, and *Eupatorium adenophorum* (Gierson and Long 1984; Gierson and Long 1987; Winter et al. 1992; Denzler et al. 1993; Winter et al. 1994a; Winter et al. 1994b; Gyamtsho 1996; RNR-RC Jakar 1997d). Livestock will not graze these species except under abnormal circumstances such as lack of other feed sources, exhaustion as a result of long travelling distances with heavy loads, or in other stress situations.

Wildlife interactions

Natural grassland resources support a wide range of wild animals of which the takin *(Budorcus taxicolor)*, the blue sheep (*Pseudovis nayaur*), the sambar (*Cervus unicolor*) and the musk deer *(Moschus chrysogaster)* are the most important. In recent years some of these species, especially the blue sheep, have increased, probably due to a decline in the population of its predators (Wangchuk 1994). Herders in the Laya region have claimed that the grazing resources have deteriorated due to an increase in the number of blue sheep (Gyamtsho 1996). This is likely, considering the erosion damage at grazing sites where yak are joined by flocks of blue sheep and marmots (Gyamtsho 1996).

Another wildlife species that has substantially increased its population is the wild boar. Wild boar damage is often cited as a major constraint to fodder development, due to its burrowing for roots (RNR-RC Jakar 1996c; Wangdi 1992).

Forest grazing

Herbaceous undergrowth in forested areas is an important direct source of ruminant fodder and indirectly of plant nutrients (manure). The majority of respondents in a recent survey (Roder et al. 1998b) considered forest grazing as the main source of ruminant feed, especially during the summer period (Table 5, Figure 16).

The earliest recorded observations of the impacts of forest grazing were made by White (1909), during a trek he made in the Ha and Paro valleys.

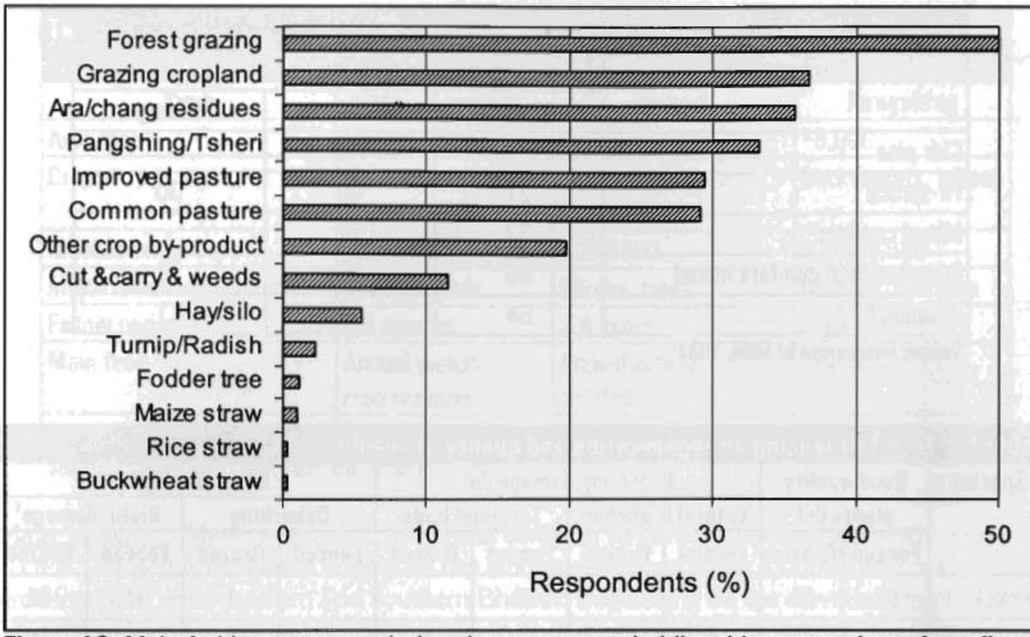

Figure 16: Main fodder resources during the summer period listed by respondents from five dzongkhags

> "On either side and at our back was a deep fringe of fine trees of every age, from the patriarch of the forest down to young seedlings. The Bhutanese seem to have acquired the secret of combining forest self-reproduction with unlimited grazing for, from the time we left Rinchengong (Ha dzongkhag), we passed through forests which, without exception, were self-reproducing."

Tegbaru (1991) has reviewed forest grazing in Bhutan. The assessment by forest specialists today is far less positive than that of White. The widespread grazing of animals in forest systems is frequently blamed for forest degradation or destruction. It has become routine to blame the practice of forest grazing for poor forest regeneration (Blower 1989; Tegbaru 1991; NES 1992; Sangay 1997) and poor forest condition. Yet, there is no quantitative information to prove that livestock grazing in forests prevents forest regeneration or harms forest health. The limited studies that have attempted to quantify livestock effects on forests have either concluded that livestock grazing is not a major problem for forest regeneration and health (Gibson 1991; RNR-RC Jakar 1997b; Tegbaru 1991), or that further studies are required to understand its impact (RGOB/ISDP 1995). A recent assessment of forest grazing in Zhemgang dzongkhag concluded that forest grazing can be an efficient use of available resources (RGOB/ISDP 1995).

Country-wide estimates in the 1970s indicate that grazing was either moderate or absent from most areas of southern Bhutan (Table 14). A recent study of coniferous forests in Bumthang concluded that browsing damage due to grazing animals is negligible for coniferous species, although broadleaved deciduous tree species exhibit more damage (Table 15) (RNR-RC Jakar 1997b).

While forest grazing may not have serious effects on the regeneration and health of well-managed forests, it is a serious problem in forest ecosystems that have been disturbed by mechanical logging or by poor silvicultural management. These effects may be especially harmful in subtropical broadleaf forests.

Table 14: Incidence of forest grazing reported in 1981			
Forest type	Grazing incidence (% of forest area)		
	Absent	Moderate	Heavy
Chir pine	-	100	-
Fir-spruce	21	49	30
Mixed conifers	33	67	-
Broadleaf and conifers mixed	55	30	15
Broadleaf	54	34	11

Source: Government of India, 1981

Table 15: Effect of fencing on regeneration and quality of seedlings										
Species	Good quality plants (%)		Browsing damage (%)				Other damage (%)			
			Lateral branches		Terminal buds		Debarking		Biotic damage[1]	
	Fenced	Grazed	Fenced	Grazed	Fenced	Grazed	Fenced	Grazed	Fenced	Grazed
Hemlock	82	68	0	0	0	1	7	1	11	30
Fir	91	85	0	0	0	0	0	0	9	15
Blue pine	77	91	0	0	0	0	8	0	15	9
Rhododendron	90	84	1	0	0	0	0	0	10	16
Birch	78	57	0	20	0	6	0	0	22	17
Other broadleaves	59	46	0	3	0	4	2	0	39	48

[1] Damage by rodents

Source: RNR-RC Jakar 1997b

Forest grazing and the use of forest litter leads to the constant transfer of nutrients from the forests to the cropped areas (Roder 1990b). Depending on the level of mineralisation of nutrients from the parent material this may lead to a gradual depletion of nutrients in some forest ecosystems.

Fallow land

As soon as crops are harvested, cattle are allowed to graze freely in the crop fields. The quantity and quality of available fodder will vary substantially depending on the crop, the weed flora, and the harvesting systems used (Table 16). The grazing period varies with the crop and the type of cropping system, but it is generally extensive during the dry winter season. During winter periods the grazing of fallow lying crop fields was the most frequently cited fodder resource in Roder's survey (Roder 1998b, Table 5).

Fallow systems which provide substantial quantities of fodder include the seasonal fallows in maize systems, which extend from two to eight months, and the long term fallows of two to twenty years in the pangshing and tsheri shifting cultivation systems. There are no quantitative data available on the dry matter production and quality of these systems. Table 16 shows a qualitative description of the most important systems.

Table 16: Fodder from fallow land and selected characteristics of the major crop and fallow systems			
Type	**Maize system**	**Tsheri**	**Pangshing**
Area (ha)	55,000	40,000	10,000
Crops	Maize	Maize, millets, rice, buckwheats	Buckwheats, wheat
Altitude range (m)	300-2,600	300-2500	2,500-4,000
Major fallow vegetation	Annual weeds	Shrubs, trees	Grasses, blue pine
Fallow period	4-8 months	2-8 years	6-20 years
Main feed	Annual weeds, crop residues	Annual weeds, shrubby species	Grasses
Dry matter (t/ha)	0.1-1.0	0.2-3.0	0.1-1.5

Source: Adapted from LUPP 1995 and Roder et al. 1992a

Maize systems – Maize is the most important cereal in terms of both area and production (LUPP 1995). It is cultivated mostly on dry land at elevations up to 3,000m. The main maize growing areas are in eastern and southern Bhutan. Depending on the elevation, rainfall and levels of soil fertility, maize is usually grown in combination with a variety of other crops in intercropping and sequential cropping systems (Table 17) (Roder and Gurung 1990). The length of the fallow period and the amount of fodder available are also dependant on the same factors and the associated other crops. Livestock are generally allowed to graze the fields immediately after the harvesting of maize cobs.

The maize stems are often harvested and stored for winter feed. The large extent of maize cultivation means that a substantial quantity of crop residue is available for fodder.

Table 17: Typical maize growing systems in Bhutan		
System	**Importance (% of total maize area)**	**Altitude (m)**
Maize-maize (often intercropped with beans, soybeans, or *Vigna* sp)	20	<1,000
Maize-paddy	<5	<1,000
Maize-wheat or barley	25	900-2,000
Maize-buckwheat	10	900-2,400
Maize (often intercropped with beans, soybeans, or *Vigna* sp)	30	1,500-3,000
Maize intercropped with potato	<5	1,500-,700

Source: Roder and Gurung 1990

Slash and burn bush fallow (tsheri) system – This system is found in many subtropical and tropical regions of Asia (Roder et al. 1992a). The vegetation - consisting of trees, shrubs, other perennials and annuals - is cut during the dry season, allowed to dry, and burned shortly before seeding the crop seed. Seeds are either dibbled or broadcast. The crops are mainly maize, millet, rice, and buckwheat (Figure 17).

Grass fallow (pangshing) system – This is a fallow vegetation type that evolves several years after abandonment of cropping and persists under grazing. It consists of short grasses, sedges, and forbes, and is often interspersed with blue pine trees (*Pinus wallichiana*) in the cool temperate zone. Prior to cultivation, the top soil layer is cut to about 5-7 cm depth with a hoe and left to dry for several months. The dry top soil is collected in conical mounds spaced 2 to 3m apart, with between 1,200 and 2,500 mounds per hectare (Figure 18). Small quantities of blue pine needles or dry manure are then added to each mound as fuel. This fuel is ignited and the organic material in the dry soil mounds burn slowly, eventually reaching temperatures of 500°C or higher (Roder et al. 1992a, 1993a). This burning lasts for several hours and results in significant losses of organic matter and nitrogen. As all the vegetation is burnt off, the soil is left fully exposed to the forces of erosion. Buckwheat seeds broadcast in April are sometimes incorporated into the soil using a traditional bullock drawn plough or manually with a rake. Labour inputs are high at between 150 and 400 person days per hectare. Most of the labour (65-85%) is required for land preparation. No weeding is necessary.

Figure 17: Different stages of fallow vegetation in the tsheri (Bush fallow) shifting cultivation system

Other cropping systems – Fallow land from other kinds of cropping systems, although locally important, contribute little to the overall production of fodder. Wheat and barley are only grown over a limited area in Bhutan and have short fallow periods. Fallow fields of wheat, barley, and buckwheat are important at higher elevations, while rice fallow provides some grazing at elevations below 2,500m.

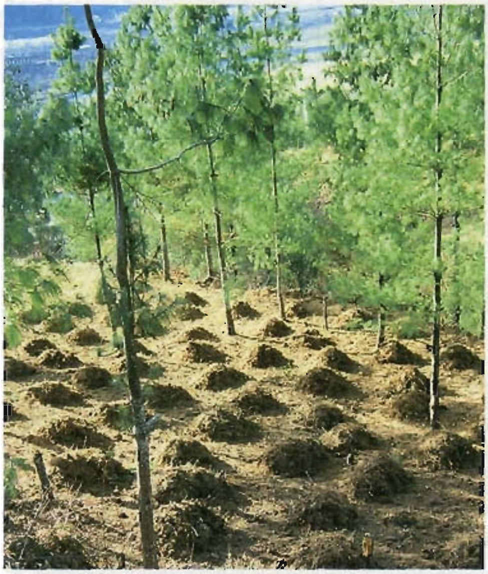

Figure 18: Mounds prepared with dry topsoil and ignited with additional fuel in the pangshing (grass fallow) shifting cultivation system

Crop residues

The contribution of crop residues to Bhutan's total livestock feed requirements has been estimated at 13% by RGOB (undated), 20% by Roder (1982c), and 43% by Verma (1984). The use of crop residues varies with the season, livestock type, and region. Verma (1984) estimated Bhutan's annual straw production at 378,000t of which 232,000t is used for livestock feed. This was probably an overestimation.

Rice, maize, and sweet buckwheat stems are an important source of winter feed in many areas (Figures 19 and 20). Rice straw is used as a winter livestock feed by almost all farmers who grow rice (Tables 5 and 18). Maize residues are the main winter feed in the major maize growing areas. Sweet buckwheat is mainly cultivated at higher elevations for the production of winter feed. In a survey of 206 households in Bumthang dzongkhag, 24% of households indicated production of winter feed from stems as the primary reason and 59% as the secondary reason for growing sweet buckwheat (RNR-RC Jakar 1996b). Other important crop residues include inferior and broken grain, husks and other chaff, residues from chang and ara making, and by-products from milling grain.

Arable fodder (annual species grown on cropland)

Throughout Bhutan, farmers traditionally produce small quantities of arable fodder for use during the dry season. These are mainly fed to draft animals whilst they undertake field preparation work at the beginning of the rainy season. With a gradual increase in the milk production potential of crossbred cows, these fodders are also becoming an important source of feed for lactating cows. The most important species are turnip, radish, pumpkin, maize, wheat, barley, and oats.

Figure 19: A store with maize husks for winter feed

Turnip, radish, and pumpkin are the most important arable fodders at elevations between 2,500m and 4,000m. They are fed to milking cows, growing animals, draught animals and pigs throughout the winter season, especially when the grasslands are covered with snow. At higher elevations individual households may cultivate up to 0.3 ha of turnip annually. In a survey of Sephu and Phubjikha geogs (Wangdue dzongkhag), 87% of households said that turnip was a major fodder resource during the winter (Table 5) (Roder 1998b). Turnips are traditionally important. Samuel Turner (1800) made the following observations:

> "The turnips peculiar to this country, deserve a decided preference over all those that I have ever seen. They are large, free from fibres, and remarkably sweet; and it is with justice, that the inhabitants pride themselves on their great superiority".

Figure 20: Buckwheat *(Fagopyrum esculentum)* straw stored for winter feed

Maize is cultivated to feed draught animals in May and June in lower areas such as Zhemgang and Sarpang. Wheat and barley are cultivated over a wide range of production systems including the rice systems of Paro and Thimphu and the wheat/barley systems found at higher

Table 18: The quantity and quality of major crop residues				
	Maize	Rice	Buckwheat	Wheat
Production (References 1 & 2)				
Area ('000 ha of particular crop)	55.5	45.1	7.3	9.6
DM produced ('000 t)	110	90	7	10
DM used as fodder ('000 t)	50	80	3	2
Relative importance in area of production[2]				
Households (%)	95	94	90	30
Reference[1]	2	3	3, 4	2
Quality of feed				
Crude protein	6.1	4.4	5.7	4.2
Crude fibre	29.1	39.2	42.8	41.1
Reference[1]	3	5	3	5

[1] References 1 – MOA 1997a (for area estimates); 2 – estimates by authors of review; 3 – RNR-RC Jakar 1996b; 4 – RNR-RC Jakar 1997a; 5 – Tamang 1987; [2] Proportion of households using the particular crop residue

elevations in Wangdue and Trongsa dzongkhags. Oats have partly replaced wheat and barley as winter fodder in the rice growing areas of Paro, Thimphu, Wangdue, and Trongsa.

Tree fodder

In many parts of Bhutan, tree fodders are an important source of feed for ruminant livestock during the dry winter season (Figures 21 and 22). The estimated contribution of 19-20% (RGOB undated; Roder 1982c) to the overall fodder needs of the ruminant population is probably an overestimate. A survey carried out in 1982 found that a large variety of tree species were used as fodder (Roder 1985). The species used, their relative importance, and the management practices vary according to the altitude, the availability of other types of fodder, and the prevalent land use practices.

A recent survey (Tshering et al. 1997a, Table 19) found that 100% of households in Chhukha, Trongsa, and Mongar dzongkhags, and the majority of households in Punakha, Wangdue,

Figure 21: Tree fodder species along the borders of paddy fields, Samchi (300m)

Figure 22: Calf feeding on leaves of tree fodder

Zhemgang, and Lhuentse dzongkhags, had fodder trees. The number of trees owned by individual households ranged from 1 to 1,015. The importance of tree fodder tends to increase with decreasing elevation. The highest numbers of fodder trees were found in Zhemgang and Chhukha dzongkhags. Most households said that they wanted to plant additional trees.

Table 19: The extent of fodder trees in seven dzongkhags

Dzongkhag	Altitude range	Sample (no of hhs)[1]	HHs with trees (%)	Species (no.) Per hh Av	Range	Per dzongkhag	Trees owned (no./hh) Av.	Range
Punakha	1,700-2,400	254	76	<2	1-3	14	5	1-94
Wangdue	1,220-2,000	248	79	2	1-6	5	6	1-56
Trongsa	800-4,400	48	100	2	1-4	4	12	2-35
Chhukha	320-1780	263	100	5	1-13	28	53	1-1015
Zhemgang	160-2,000	54	94	2	1-5	10	17	1-70
Lhuentse	2,000-5,000	21	95	2	1-3	2	8	2-22
Mongar	650-3,700	18	100	1	1	2	12	2-40

[1] hh - household

Source: Tshering et al. 1997

The number of species reported ranged from 28 in Chhukha to only 2 in Lhuentse and Mongar dzongkhags. The largest number of species used was also in Chhukha dzongkhag. *Ficus roxburghii* was the most important species in all dzongkhags with *Ficus cunia* as the second most important.

At elevations above 2,000m, the choice of tree fodder species is limited (Roder 1992). The most important higher elevation species are willow *(Salix babylonica)* and evergreen oak *(Quercus semecarpifolia)* (Roder 1992) (Figure 23). Willow, although an excellent fodder, has the disadvantage of shedding its leaves at the beginning of the dry winter season.

Fodder trees are mainly found near to houses, along fences, and along field boundaries (Table 20). Future plantings of trees will most likely be along cropland borders and in separate fields.

There are no area based yield data available for tree fodder in Bhutan. Yields for temperate species extrapolated from single tree measurements have been estimated at 4t ha^{-1} year^{1} for willow, 2t ha^{-1} year^{1} for evergreen oak, 4t ha^{-1} year^{1} *for Populus robusta*, and 12t ha^{-1} year^{1} for Chinese pear (Roder 1992).

Figure 23: Cow feeding on *Quercus semecarpifolia* leaves

Where planted?	Per cent of respondents						
	Punakha	Wangdue	Trongsa	Zhemgang	Chhukha	Lhuentse	Mongar
Near houses	47	62	35	43	41	33	50
Along fences	11	2	0	22	3	29	22
Crop field boundaries	7	9	56	20	43	52	28
Inside crop fields	1	6	4	11	27	0	0
Separate field	2	2	4	7	13	0	0

Table 20: Indigenous preference for fodder tree location: Response to the question "Where are the trees planted"

Source: Tshering et al. 1997

Most tree fodders are inferior in quality to herbaceous species (Tamang 1987). Willow is an exception as it has excellent nutritional qualities and high palatability (Roder 1992; Wangdi et al. 1997). All farmers viewed *Ficus roxburghii* as giving superior dry matter yield (Table 21) and being a comparatively good quality fodder (Tshering et al. 1997a). The nutritional qualities of tree fodder are discussed in detail in Chapter 3.

Table 21: Fodder tree yield estimate (in loads per tree)

Species	Sample size (household no.)	Yield[1] (no. of loads)	Standard deviation[2]
Ficus roxburghii	138	5	4.7
Artocarpus lakoocha	18	3	1.6
Gmelina arborea	52	2.8	1.6
Ficus cunia	83	2.7	1.4
Litsea monopetala	27	2.7	1.6
Sterosperum sp	56	2.4	1.4
Saurauia nepaulensis	37	2	1.2
Bauhinia purpurea	63	2	1.2
Brassaiopsis hainla	29	1.9	0.8
Ficus nemoralis	26	1.7	1.1

[1] Load of approximately 40 kg; [2]Variation in reported yield

Source: Tshering et al. 1997

Fodder conservation - winter feed

Fodder availability from permanent grasslands peaks in the wet summer months, with a deficit in the dry winter period (Roder 1998c). The post-harvest grazing of cropland, forest grazing, residues from alcohol production, hay, and root crops are the main sources of winter fodder (Figure 24, Table 5). Farmers and herders have developed a number of methods to extend the availability of fodder over the entire year. These include:

- deferred grazing of permanent grasslands (Harris 1987);
- use of tree fodder species which have green foliage during the dry season (Roder 1992, Tshering et al. 1997a; and
- seasonal migration to lower areas (Figure 25).

Deferred grazing of permanent grasslands and migration are suitable for large cattle herds but generally not feasible for smallholders. Tree fodders are mostly used by smallholders on their privately owned land, and by migrating cattle herds in the forests.

Except for the evergreen oak, neither evergreen nor deciduous tree fodders are available at elevations above 2,500m and so livestock owners in these regions have to find other alternatives. Hay made in small fenced-in areas (tsa dham) has been the traditional means of fodder

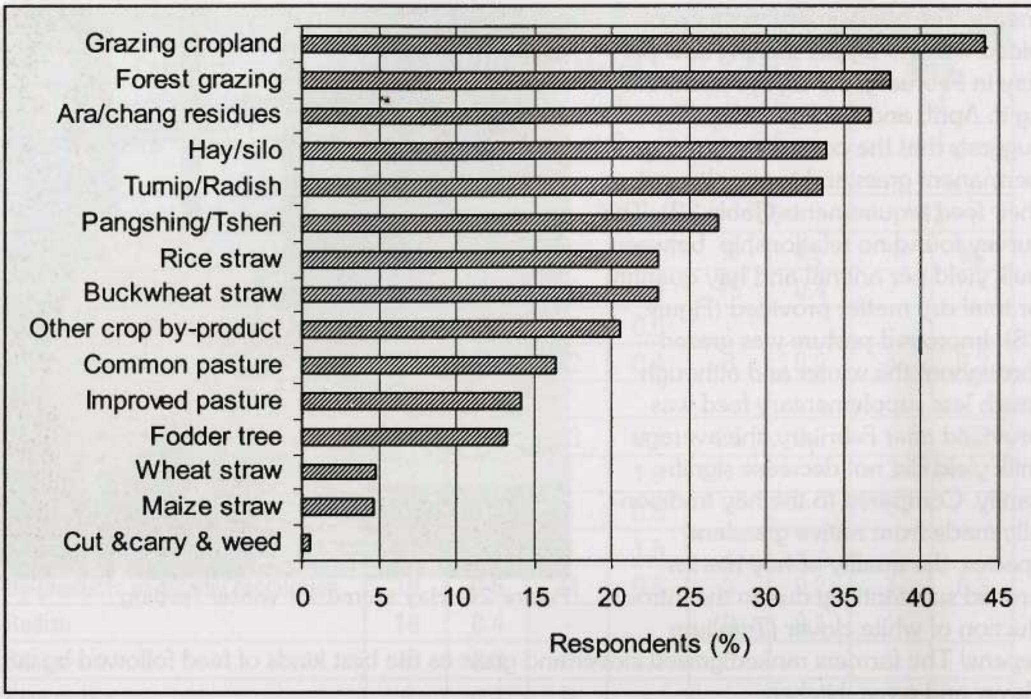

Figure 24: Main fodder resources during the winter period listed by respondents from five dzongkhags

conservation in Bumthang (Figure 26). Traditionally only one cut was taken from these areas which are dominated by *Schizachyrium delavayi, Eragrostis nigra* and *Potentilla* sp (Roder 1983c).

The need for fodder preservation in cold temperate areas such as Bumthang has increased with the reduction in cattle migration, the shift to smallholder livestock systems, and the improved milk production potential of crossbred animals (Figure 27). At the same time the options for fodder preservation and the types of winter feed available to farmers have increased due to the fodder extension programmes.

Figure 25: Herder migrating with animals to lower elevations in the south

A survey on the management of lactating cows in Bumthang in 1996 found that a wide variety of mostly traditional winter feeds were used (Tables 22 and 23) (RNR-RC Jakar 1997a). Hay and buckwheat straw were the most important feeds. Although not a traditional crop, maize residue was used in February and March. However, the total amount of fodder provided was far below livestock maintenance requirements. The average dry matter provided was 4.9 kg per milking cow per day in February, 1.9 kg in March, 0.5 kg in April, and 1.1 kg in May. This suggests that the cows were grazing permanent grassland to supplement their feed requirements (Table 22). The survey found no relationship between milk yield per animal and hay quantity or total dry matter provided (Figure 28). Improved pasture was grazed throughout the winter and although much less supplementary feed was provided after February, the average milk yield did not decrease significantly. Compared to the hay traditionally made from native grassland species, the quality of hay has improved substantially due to the introduction of white clover *(Trifolium repens)* The farmers ranked grazed clover and grass as the best kinds of feed followed by cut clover and grass, kitchen waste, wild oat *(Avena fatua)* plants (weeds in barley fields), hay, silage, maize residues, and lastly sweet buckwheat straw. These results are shown together with the results of chemical analysis of feed samples in Table 23.

Figure 26: Hay stored for winter feeding

Figure 27: Farmer feeding bull with kitchen waste after a snowfall

Table 22: Fodder resources and quantities used by households with milking cows (1996)

Category	February		March		April		May	
Average daily milk yield (litres/cow)	3.0		2.4		2.5		2.4	
Total dry matter of feed provided (kg/cow/day)	4.9		1.9		0.5		1.1	
Grazing improved pasture (%)	9		32		56		63	
Feed type[1]	%[2]	kg[3]	%	kg	%	kg	%	kg
Hay	91	2.4	71	1.3	15	0.4	-	
Sweet buckwheat straw	70	1.5	21	0.6	-		-	
Concentrate flour	55	0.4	32	0.4	6	0.2	4	0.2
Pumpkin	48	0.5	-		-		-	
Kitchen waste	39	0.6	53	0.5	35	0.5	8	0.3
Sweet buckwheat leaves	27	1.1	9	1.6	-		-	
Turnip	30	0.6	3	0.5	-		-	
Maize residues	21	1.1	6	1.5	-		-	
By-products of alcohol production	18	0.5	21	0.8	3	0.2	4	0.3
Radish	18	0.4	-		3	0.1	-	
Silage	9	2.3	6	0.4	0		-	
Rice husks	6	0.7	0		-		-	
Oats (from wheat/barley fields)	-	-	-		21	0.9	8	2.8
Cut clover and grass	-	-	-		3	1.0	29	2.8

[1] Other types of feed mentioned by one household each were mustard oil and fodder beet in February and willow leaves in March; [2] per cent of households using the particular feed; [3] kg provided per animal per day (averaged among those households using the feed)
Source: RNR-RC Jakar, 1997

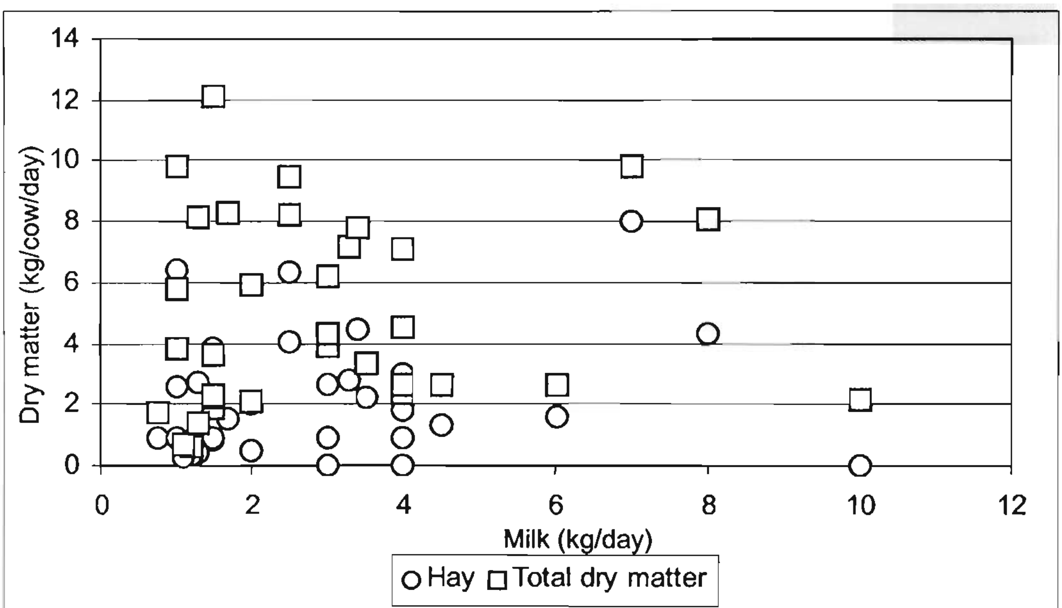

Figure 28: Daily milk yield, hay dry matter and total dry matter provided in February

Table 23: Chemical analysis of selected feed samples

	Rank[1]	No. of samples	CP[2] (%)	CF[2] (%)[3]	EE[2] (%)	NFE[2] (%)
Grazed pasture – March	8	4	30.6±1.92[3]	13.4±2.25	2.53±1.00	41.5±0.74
Grazed pasture – April	8	10	26.9±1.68	13.0±1.27	3.07±0.27	46.7±1.50
Clover/grass cut	7	1	25.8	16.8	2.53	45.0
Kitchen waste	6	9	19.8±2.58	14.3±1.38	3.50±0.63	53.6±4.11
Sweet buckwheat leaves	-	3	17.6±2.44	8.5±1.55	1.51±0.12	60.7±2.81
Oats (wheat/barley fields)	5	4	14.6±2.51	22.2±0.18	2.14±0.29	51.1±3.46
Hay	4	53	17.6±0.48	28.3±0.44	1.46±0.08	41.8±0.74
Silage	3	3	15.3±0.47	35.4±1.20	2.18±0.08	37.7±0.74
Maize residues	2	10	6.1±0.67	29.1±0.84	1.46±0.084	41.8±0.74
Sweet buckwheat straw	1	9	5.7±0.48	42.8±1.51	11.7±10.5	42.8±1.40
Rice husk	-	1	5.22	33.27	0.59	30.0

[1] Rank of fodder quality from the farmer survey described above (RNR-RC Jakar 1997a), a higher number means higher rank;
[2] CP – crude protein; CF – crude fibre, EE – ether extract; NFE – nitrogen free extract; [3] standard error
Source: RNR-RC Jakar 1997a