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Walter Roder, Georg Gratzer, and Kinzang Wangdi

Cattle Grazing in the Conifer Forests of Bhutan

Cattle grazing, although widely practiced in Himalayan conifer forests, is perceived to be harmful to the environment. The present article summarizes experiences in Bhutan where grazing in the forest remains the single, most important source of cattle fodder. The ongoing debate about the effect of cattle grazing is often based on speculation and driven by conflicting interests. With a few exceptions, descriptive observations consider grazing as harmful to the forest and the environment. Quantitative observations, however, do not support these assertions. Removal of herbaceous biomass by grazing enhances regeneration of conifer species and reduces damage done by small rodents. Grazing, however, diminishes the number and the density of broadleaved species. Through livestock grazing, plant nutrients are transferred from the forest to the agricultural systems. This may result in a gradual decline in the fertility of forest soils. The nutrients, especially P, are of utmost importance to agricultural production on marginal mountain soils. Silvopastoral systems combining dairy and timber production with coniferous species offer promising opportunities for many temperate regions of Bhutan. When assessing the opportunities and the problems of forest grazing, it will be important to consider sociocultural aspects and to include the opinions of farmers and herders in the debate.

Keywords: *Grazing; forest cover; conifers; nutrient transfer; phosphorus; regeneration; silvopastoral systems; Bhutan.*

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Introduction

Cattle grazing in traditional forest management systems or in plantations is practiced in many parts of the world. Yet, forest managers, livestock specialists, and ecologists remain divided regarding the advantages or disadvantages of such integrated systems (Brower 2000; Clason and Sharrow 2000). Many believe that cattle grazing and sound forest management or timber production are incompatible (Blower 1989; Carson 1992), whereas others believe that moderate grazing may help reduce competition from unwanted species (Allen and Bartolome 1989; Gratzer et al 1999; Norbu 2000) or bring substantial ecological, social, and economic benefits (Clason and Sharrow 2000). Negative effects on forest ecosystems attributed to forest grazing include loss of species diversity due to selective browsing, soil erosion, depletion of nutrients, soil acidification due to removal of biomass, compaction of topsoil and formation of hydromorphic humus, and damage to tree roots that facilitates root rot (Carson 1992; Glatzel 1999). Proponents of forest grazing and silvopastoral systems, however, emphasize that cattle generally do not browse conifer species (Clason and Sharrow 2000) and that the benefits of controlling competing vegetation may outweigh temporary grazing damage.

In the Himalayan countries, the prevailing opinion is that cattle are detrimental to forests (Blower 1989; Tegbaru 1991; Carson 1992). Forest grazing is frequently blamed for slow regeneration, poor forest conditions and, in extreme cases, for causing potential ecological disasters. In Bhutan, environmentalists and foresters routinely view cattle grazing as a serious threat to the environment and as a major constraint on good forest management (Roder et al 2001). Livestock producers may disagree, but their voices are rarely heard. Although science is often evoked, arguments on the issue are routinely made without any quantitative proof from either side.

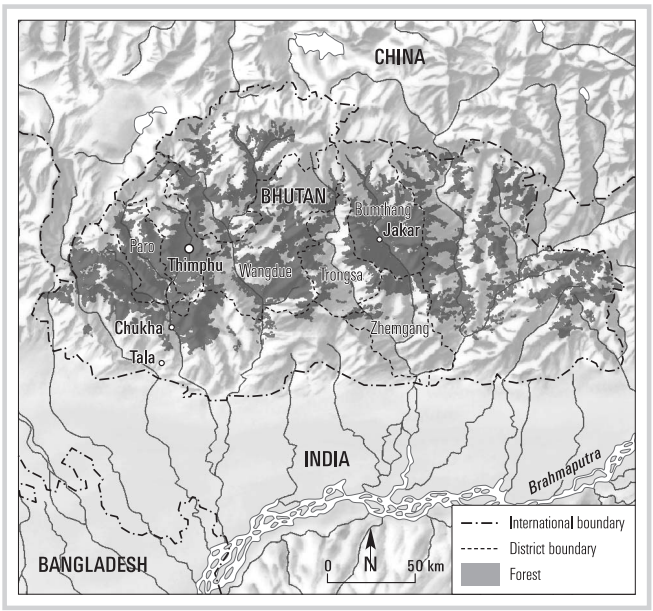
Pragmatic economic and ecological investigations may favor silvopastoral systems (Clason and Sharrow 2000). The productivity of systems combining livestock and timber production is generally higher than that of monofunctional systems, and trees in silvopastoral systems often grow faster than do trees under conventionally managed systems (Sharrow 1995; Clason and Sharrow 2000). Forest grazing is thus widely used as a forest management tool as well as for optimizing timber and livestock production (Lawrence and Hardesty 1992).

Methods

Forest grazing is widely practiced in Bhutan and is a source of continuous debates concerning its effect on forest ecosystems. Lack of quantitative data frequently leads to biased arguments. Quantitative information on the subject has been generated by various studies, but much of this information has not been published. Studies by the Renewable Natural Resources Research Centre, Jakar, and the Integrated Forestry Management Project Ura (both located in the Bumthang district and both represented by the authors), focusing on conifer forests, are of particular importance. Ongoing discussions show that there is a need to summarize these findings and to make the information available. The present article provides a synthesis of the information generated so far and compares findings based on quantitative results with conclusions based on descriptive observations.

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FIGURE 1 Areas of Bhutan covered by conifer forests, showing the districts from which most of the data referred to in the present article were obtained. (Map by Andreas Brodbeck)



The extent of forest grazing

The contribution of forest grazing to the total dry matter requirement of Bhutan's livestock was estimated by different authors to range from 20% to 24% (Roder et al 2001). Grazing is common in all forest types in the country. The forest is owned by the state. Herders have legal grazing rights (*Tsadrog*) in some of the forest areas, but grazing is not limited to these areas.

FIGURE 2 Cattle grazing on grassland mixed with blue pine. (Photo courtesy of the authors)



Approximately 72.5% of the area of Bhutan is classified as forest. About 27%, or 10,616 km^2 (Land Use Planning Project, unpublished data), of the area is conifer forests (Figure 1), which can be broadly grouped into 6 types (Grierson and Long 1983):

- Chir pine (*Pinus roxburghii*) forest (900–1800 m).
- Blue pine (*Pinus wallichiana*) forest (2100–3000 m).
- Spruce (*Picea spinulosa*) forest (2700–3100 m).
- Hemlock (*Tsuga dumosa*) forest (2800–3100 m).
- Fir (*Abies densa*) forest (3600–4100 m).
- Juniper (*Juniperus recurva*)–Rhododendron scrub (3700–4200 m).

The density of tree cover is generally highest for mixed coniferous forests and lowest for chir pine forests. Herbaceous undergrowth in all the above-mentioned forest types is an important source of ruminant fodder and plant nutrients (cycled through the grazing animal, see Figure 2). The results of a recent survey (Roder et al 2001) indicated that the majority of households interviewed considered forest grazing as the main source of ruminant feed, especially during the summer months (Figure 2). The survey did not differentiate between coniferous forest and broadleaf forest, but coniferous forests dominate a large proportion of the area covered by the survey. Summer grazing is generally concentrated at higher elevations in coniferous forests, whereas cattle herds migrating to lower elevations in the winter months largely depend on dry matter obtained in broadleaf forests. A large percentage of the dry matter used by these herds during the winter comes from broadleaf trees (Norbu 2000; Gyalthsen 2001).

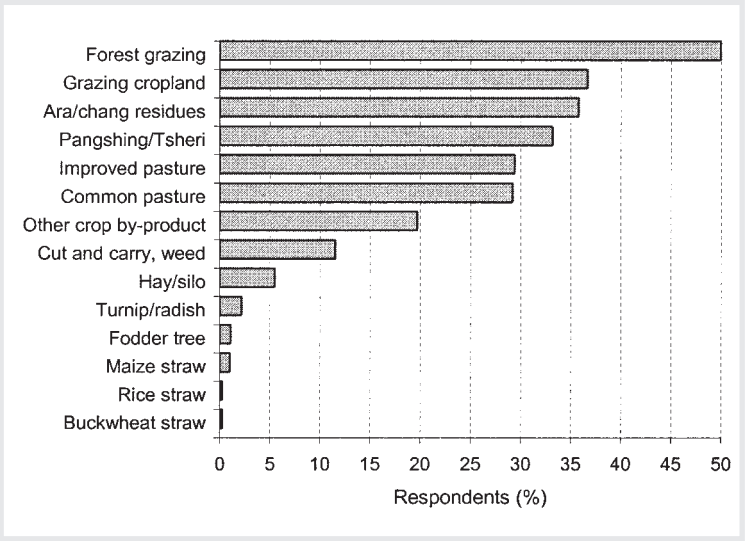
Results

The effects of forest grazing

Many writers discuss the effects of forest grazing on the basis of casual observations without providing supporting quantitative data. Observations made by White (1909), during a trek in Paro valley, may be among the earliest references available. White noted: "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 we passed through forests which, without exception, were self-reproducing." More recent assessments by forest specialists are generally less positive. It is now a routine to blame the practice of forest grazing for poor regeneration of forest vegetation (Blower 1989; Tegbaru 1991; Miehe G and Miehe S, unpublished data) or poor forest conditions, or both. Most authors, however, do not differentiate between the effects in coniferous and broadleaf forest systems.

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FIGURE 3 Main fodder resources during the summer period, listed by respondents (733 households) from 5 districts (Paro, Wangdue, Zhemgang, Trongsa, and Bumthang).



Miehe G and Miehe S (unpublished data) observed an increase in species richness in grazed fir forests through the invasion of alpine plants brought in by cattle. However, the authors classified these species as weeds and considered this influence as negative in terms of nature conservation.

A ban on the use of fire for grassland improvement introduced in the Forest Act (Ministry of Trade and Industry 1969; Rosset 1998) decreased the area and the quality of the traditional grassland used by herders (Gyamtsho 1996). Reduced fodder availability from traditionally used grasslands may have increased the pressure on forests. Another argument frequently made is that cattle populations have been increasing and thus grazing in forests has increased. Because no information is available on livestock numbers and grazing pressure before 1960, this argument has no basis. Some authors suggest that Bhutan may have had larger human and cattle populations in the past (Fischer 1976). It is assumed that periodic occurrence of epidemics may have reduced human and livestock populations temporarily (Fischer 1976), thus reducing the pressure on fodder resources.

Although some consider forest grazing as negative, others suggest opportunities for integrated use (Royal Government of Bhutan/Integrated Sustainable Development Program, unpublished data; Rosset 1998; Norbu 2000). A recent assessment in the Zhemgang district concluded that it can be an efficient use of available resources (Royal Government of Bhutan, Dzongkhag Administration Zhemgang Integrated Sustainable Development Program, 1995, unpublished data). Most authors, however, emphasize that grazing has to be conducted in a controlled manner.

Quantifying the effects of grazing

The earliest documented study of the effect of grazing on forests was done in the 1970s (Table 1). It included observations in coniferous and broadleaf forests and used different forest categories (types) than those mentioned above. These early observations indicated that the incidence of grazing was either moderate or absent for most of the forest areas in the country. In this study blue pine must have been included under mixed conifers. The highest proportion of heavy grazing was found in fir and spruce forests, confirming the high concentration of cattle in the higher temperate (2700–4000 m) zones.

Later studies used: (1) paired samples with applied treatments (fencing, no fencing) or (2) a comparison of forest regeneration or quality under a range of conditions with varying degrees of grazing pressure.

A recent study in mixed coniferous forest in Bumthang (central Bhutan) using 6 pairs of fenced and unfenced plots concluded that:

- Grazing increased the proportion of good-quality blue pine plants.
- Browsing damage due to grazing animals was negligible for conifer species.
- Grazing reduced damage (debarking) by small rodents.
- Grazing reduced the number and density of broadleaf species (Renewable Natural Resources Research Centre, Jakar, 1997, paper presented at the IUFRO Seminar in Chumney; Table 2).

The fact that grazing favors blue pine regeneration is painfully felt by many households that have lost large proportions of their cultivable land because of vigorous colonization of this species despite heavy grazing pressure. Grazing during the fallow period was an important component in the traditional grass–fallow shifting cultivation system widely used in Bumthang (Roder et al 2001). Yet, when fields have not been cultivated for 15–20 years, they revert to blue pine forest.

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

TABLE 1 Incidence of forest grazing reported in 1981. The forest type categories used in this table are not consistent with those commonly used today. (Source: Government of India 1981)

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Species	Good-quality plants (%)		Browsing damage (%)				Other damage (%)			
			Lateral branch		Terminal bud		Debarking		Biotic damage	
	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
Betula	78	57	0	20	0	6	0	0	22	17
Other broadleaf	59	46	0	3	0	4	2	0	39	48

TABLE 2 Effect of fencing on regeneration and quality of seedlings. Study with 6 pairs of fenced and unfenced plots. (Source: RNR-RC, Jakar, unpublished data)

Yushania microphylla, a spreading bamboo species common at elevations of 2300–3700 m, was often found to impede regeneration in coniferous forests disturbed by logging or by other interventions (MacKinnon 1995). The species is browsed by yak and cattle, and competition with regenerating conifer species can be greatly reduced by grazing. Gratzer et al (1999) found that the density of fir seedlings increased threefold when the height of bamboo (*Y. microphylla*) cover was reduced by grazing.

Nedomlel (unpublished data) studied the phytopathological situation in fir forests of central Bhutan. He found that wounds on the stems and roots of fir seedlings and saplings caused by cattle grazing facilitate infection by *Armillaria* species. A total of 12 decay-causing fungi were found in the study area, which caused rot in 52% of the live trees. Although the rot can be considered an integral factor of the ecosystem, external factors, such as trampling by grazing cattle, may increase the chance that pathogens reach and colonize the roots.

Nutrient transfer and alternative nutrient sources

Bhutanese farmers produce reasonably good crop yields with minimal inputs of chemical fertilizers. This is possible only because of the input of plant nutrients collected in the forest. The animals that are grazing in the forest during the day are confined to houses or to crop fields during the night. This practice results in a continuous export of plant nutrients from the forest. Soils in northern Bhutan are extremely poor in available phosphorus (P). Burning topsoil to increase availability of P (Roder et al 1993) and burning manure to reduce bulk and speed up the release of P (Roder 1990; Norbu et al 1996, poster presented at international congress in New Delhi) are ingenious practices devised by Bhutanese farmers to optimize the use of limited P pools.

Growing on low P soils, the plant material consumed in forest systems has a relatively low P content (Table 3). In spite of this deficiency, the P quantities transferred by the grazing animals from coniferous forest systems range from 2 to 5 kg per gazing animal per year (depending on the number of days and hours per day of grazing in the forest). With about 200,000 to 300,000 animals dependent on grazing in coniferous forests, the amount of P transferred from these forests to agriculture systems is in the range of 300–700 tons per year, which corresponds to 4000–10,000 tons of single superphosphate fertilizer. Unless this P is replaced through mineralization of parent material, the already poor P pools of coniferous forests will experience further decline. Nutrient loss from the system could thus be the most harmful effect of forest grazing.

In addition to the nutrients removed by grazing animals, there is a substantial flow of plant nutrient elements from forest systems to agricultural and horticultural lands through forest litter, which consists of leaves or needles in various stages of decomposition. This litter is collected from forest tracts specifically allotted for this purpose (*sogshing*). Although this practice is limited to small areas, it may lead to a faster depletion of P.

Although other plant nutrients, especially N, K, Ca, and Mg are similarly removed from the forest environment, their loss is less of a concern. Nitrogen is more easily replaced through biological N fixation or through rainfall. Potassium, Ca, and Mg do not generally limit plant growth under the given conditions. Removal of these cations ($NH4^+$, K, Ca, Mg), however, may gradually lead to soil acidification. Hager (Institute of Forest Ecology, UNI BOKU Vienna, personal communication) estimated that forest grazing in the Austrian Alps gradually increased soil acidity from 0.16 to 0.67 kmol ha^{-1} y^{-1}.

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TABLE 3 Phosphorus concentration in plant materials grazed in coniferous forests.

Plant material	Phosphorus content (%)	Reference
***Schizachyrium delavayi* (before flowering)**	0.11	Roder et al (2001)
***Lespedeza* sp (before flowering)**	0.16	Roder et al (2001)
Plant biomass from typical grassland fallow[a]	0.07	Roder et al (1993)
Blue pine biomass (needles)	0.05	Norbu et al (1996)
Fir biomass (needles)	0.11	Gratzer et al (1997)
***Stipa* sp**	0.10	Gyamtsho (1996)
***Carex* sp (before flowering)**	0.08	Gyamtsho (1996)
Bamboo leaves *(Yushania microphylla)*	0.15	Roder (unpublished data)
Manure with blue pine needles	0.33	Roder (1990)
White clover (at flowering)	0.29	Jucker (1969)

[a] Above-ground biomass and roots.

Discussion

The effect of forest grazing on coniferous forest ecosystems needs careful assessment and should not be subject to speculation driven in many cases by conflicting interests in resource use. Available quantitative observations do not support the assertion that moderate livestock grazing is harmful to coniferous forest communities. Although we cannot generalize across the various conifer communities, results indicate that removing herbaceous and bamboo biomass through grazing facilitates regeneration of coniferous trees. On the other hand, grazing damages saplings through trampling, browsing (especially of fir), and damage to the bark. Although not proven, it is conceivable that grazing can have negative effects in forest ecosystems that have been disturbed by mechanical logging or by poor silvicultural management in general. Overgrazing compacts soils, leading to increased bulk densities, decreased infiltration rates, increased surface runoff, and subsequently erosion (Schwab 1984; Broersma et al 2000). In Bhutan, however, erosion caused by trampling of cattle can generally only be found on some tracts frequently used for migration of cattle.

We can assume that today's forest systems have evolved under grazing by domestic livestock and wild animals. What may have changed are the logging interventions, which have become possible because of the establishment of a road system. Successful exclusion of grazing animals therefore could result in different species compositions and may, in the worst case, result in large areas with vegetation dominated by shrub or bamboo.

Sociocultural dimensions must also be considered. In the absence of fertilizer inputs, Bhutan's agricultural production would be impossible without forest grazing because of the necessity of the described nutrient transfer from forest to agricultural land. Hence, livestock was and still is the key factor that makes it possible for the people of Bhutan to prosper in a relatively infertile mountain environment. Moreover, livestock production systems have contributed substantially to shaping the contemporary landscape by creating a mosaic of pastures, cultivated fields, and forests, which is generally considered to be attractive for tourism and recreation (Figure 4). Removing the influence of livestock may change these characteristics. It would allow secondary succession and the eventual afforestation of the landscape, a result that would be less attractive for tourism. Trends such as these are seen in some regions of Switzerland and Austria. In spite of very heavy subsidies aimed at retaining livestock production systems in mountain areas, rural households are giving up livestock production and abandoning their grazing land.

Opponents of forest grazing often evoke the argument that grazing in the forest is an outmoded practice. This is a serious misconception. Forest grazing and silvopastoral systems are widely accepted as modern forest-management tools. Clason and Sharrow (2000) estimated that one-quarter of all forest land in the United States is grazed by livestock. Silvopastoral systems can be particularly appropriate for hilly environments, and they may offer the best economic and ecological options for many Bhutanese farmers who are finding it difficult to compete with lowland farmers in the production of agriculture crops. Dukpa et al (1997, poster presented at an international workshop in Bogor, Indonesia) estimated that silvopastoral systems

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FIGURE 4 Forest cover on the ridges above Jakar dzong (Bumthang district). A mosaic of pastures, cultivated fields, and forests (dominated by blue pine) is seen in the lower part (2700–3200 m). Spruce, hemlock, and fir are found at higher elevations. (Photo courtesy of the authors)

combining fast-growing blue pine with dairy production could generate cash returns (annual timber increment and milk value) of US$1000–2000 ha^{-1} y^{-1} from land presently used for shifting cultivation. Combining livestock with timber production will generate faster returns than when compared with systems limited to timber production only. Managing systems integrating timber and livestock production will be more demanding than systems focusing on a single output only. Bhutanese livestock producers, however, have convincingly demonstrated that they can manage complicated systems, provided they get the benefit from the outputs produced.

Despite this, it can be expected that forest grazing for dairy production, as it is practiced today, will gradually disappear for economic reasons. The dry matter produced in these systems will not be of sufficient quality to support animals with higher production levels. Forest grazing, however, may continue for unproductive animals (animals without any production in the form of milk, meat, or draft) if culling is not practiced. With increased emphasis given to organic farming, forest systems will continue to be an important source of plant nutrients. Grazing unproductive animals in the forest would continue to be the most efficient method of nutrient collection and transfer.

It must be emphasized that uncontrolled grazing with high animal densities is harmful to both forest and grassland ecosystems. This is largely the result of uncontrolled access to "common resources" and is certainly not limited to forest ecosystems in Bhutan (*The Ecologist* 1993). Experience in Bhutan and elsewhere has shown that the problems related to excessive use of these "free for all" resources can only be solved by involving the rural population in forest resource management, which would create a feeling of "ownership."

Challenges to making best use of grazing resources in the forest include: (1) the lack of representation of herders' interests in policy and decision-making bodies and (2) the priority given by the government to forest protection. Similarly, the possible positive benefits of cattle grazing in forest management have not been exploited. It will be important to include farmers and herders as equal partners in future discussions focusing on forest grazing. All parties concerned need to be made aware of cattle and timber combinations used successfully in other countries. Farmers, herders, forest managers, ecologists, and livestock specialists should work together to address the following issues:

- Long-term effects of nutrient transfer on forest production and health.
- Development of systems to optimize timber and livestock production.
- Integration of livestock grazing in forest management to optimize regeneration and biodiversity.
- Loss of cultivable land to invading tree species, especially blue pine and chir pine.

Through the introduction of the Social Forestry Act (Ministry of Agriculture 1995), farmers and herders will be given ownership of some of the forest resources. This dramatic change will certainly lead to a different assessment of forest resources and may lead to changes in herding practices, depending on the economic considerations of farmers and herders.

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