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Impacts of Recent Policy Changes on Rural Communities and Species Diversity in Government-Managed Forests of Western Bhutan

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Forest management plans in Bhutan are implemented under the premise that species diversity is not significantly altered while providing forest products and services to local communities. This study examines the impact on local communities of government-management logging operations in national forests near their villages and the impact of the single-tree selection system on species diversity in 4 forest management units with mixed conifer forests in western Bhutan. Household interviews were conducted using semistructured questionnaires to assess the availability of forest products and the accessibility of forests for grazing and identifying constraints and opportunities. Moreover, single-tree selection forests and old-growth uncut forests were sampled for comparing species diversity. Forest product availability and accessibility of forests to rural communities for grazing varies between forest management units (FMUs). Currently, at Chamgang and Gidakom FMUs, lesser quantities of timber and other wood products such as beams, planks, scaffoldings, poles, fuelwood, and leaf litter were available to rural communities compared with 10 years before the implementation of logging operations. At Chamgang and Gidakom FMUs, logging followed by plantation and fencing and retention of coarse woody debris constituted barriers to cattle herding. Notwithstanding, forest roads provided access to forest resources. The government-managed national forests, however, provide limited accessibility to rural communities for extracting timber and other wood products. The single-tree selection system did not alter species composition and was not detrimental to forest species diversity in national forests.

Keywords: *Forest management plan; forest products; forest grazing; species diversity; mixed conifer forests; Bhutan.*

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Introduction

The forests of Bhutan were nationalized in 1969, bringing all forests under government management. Forest management was timber oriented with little or no value attached to other forest products and services under the centralized system. This system continued through the 1970s and 1980s until the enactment of the Forest and Nature Conservation Act in 1995 (DoF 1995). This act marked a significant shift in policy, returning forest management and use rights in parts of forest management units (FMUs) and outside FMUs to rural communities under the framework of community forestry. Community forests are any part of national forests designated by the government for management by the local community, primarily to transfer to communities the management responsibilities of protection, utilization, and development of national forests near their villages (DoF 2004). Community forestry planning and implementation are jointly undertaken by the government and local communities. Though the act was promulgated in 1995, progress in implementing community forestry has been slow and cautious. By June 2009, only 0.9% of total forest cover was under community forests, the target to be achieved being 4% by 2013 (DoF 2009). Approximately 71% of national forests continue to be government property and fall in the category of a common pool resource, which may have had contributed to forest degradation because of the timber-oriented and centralized system of forest administration and management, with implications on forest governance and livelihoods (Rasul and Karki 2007).

FMUs are national forest management schemes that aim to sustain an annual yield, conserve forest biodiversity, and protect ecosystem services, while also addressing the forest product needs of urban and rural communities. FMU planning and implementation are driven by the government with little or no community participation. The management plans are implemented for a period of 10 years under the premise that species diversity and regenerative capability are not significantly altered (Palmetzhofer et al 2004) while providing socioeconomic benefits to rural communities from the use of forest resources.

The diversity of forest products is harnessed as timber, fuelwood, food, and medicinal products. Timber products are beams, planks, poles for scaffolding and fencing, and

religious flag poles. Nonwood forest products (NWFPs) such as leaf litter are collected for cattle bedding and fertilizing agricultural farms (Roder et al 2003), mushrooms are picked as vegetables (Namgyel 1996), fuelwood is collected for cooking and heating (Dick and Yonten 1995), and tree fodder is used for feeding domestic cattle (Roder et al 2003). The forested watersheds of Bhutan also provide vital ecosystem services: They regulate drinking water supply and provide water for irrigation and electricity generation, which contributed 38% of gross domestic product in 2008 (DoE 2009).

Timber harvesting, forest grazing, and construction of forestry roads are significant interventions in the mountain forests of Bhutan. Single-tree selection and group-tree selection are the 2 main silvicultural techniques used to manage old-growth forests. Within FMUs, the single-tree selection system is practiced for rural timber harvest, which forms an integral part of local forest use, whereas the group-tree selection system is practiced for commercial harvest of natural forests, followed by natural regeneration and/or plantation and fencing. Harvesting of timber is highly organized and visible, and in certain FMUs, harvesting of timber exceeds the capacity of forests to regenerate, leading to the loss of species diversity. For example, at Chamgang and Gidakom FMUs, the demand for timber exceeded the annual allowable cut, resulting in a change of species (Dhital and Wangchuk 1998). Forest roads are constructed for providing access to forest resources before commencement of logging operations in FMUs.

Forest grazing by domestic cattle is ubiquitous, and overgrazing due to high cattle densities deteriorates forest productivity (Dhital and Wangchuk 1998). Recent studies, however, have revealed that forest grazing by cattle transfers nutrients from forests to agricultural farms (Roder et al 2003) and facilitates regeneration of conifer forests where dense understory *Yushania microphylla* bamboo competes with tree regeneration (Darabant et al 2007).

Forest management plans are revised based on progress of implementation and feedback; however, to date no studies have documented the consequences of government-management logging operations on local communities and species diversity in national forests—a gap addressed by this paper. The specific objectives of the present study were to assess (1) the impacts of recent policy changes on rural communities in government-managed national forests near their villages and (2) the impact of single-tree selection on species diversity in 4 FMUs in western Bhutan.

Methods

Study area

The study area comprised Chamgang, Gidakom, Paro-Zonglela, and Haa-East FMUs, which are representative of mixed conifer forests in western Bhutan (Figure 1). These FMUs were operationalized to meet the timber demand of urban and rural communities in the districts of Thimphu, Paro, and Haa. The 4 FMUs are similar in terms of history of forest use, harvesting techniques, forest types, and FMU plan implementation. Blue pine (*Pinus wallichiana* A. B. Jackson), spruce (*Picea spinulosa* Griff.), hemlock (*Tsuga dumosa* D. Don), fir (*Abies densa* Griff.), and larch (*Larix griffithiana* Carriére) are the main timber tree species (Grierson and Long 1983).

Altitudes in the FMUs range between 2200–3800 m above sea level. Most climate stations are located in valleys. The valleys are drier than the forested slopes (Schweinfurth and Schweinfurth 1975) with annual precipitation on the forested slopes higher than in valleys. For example, at Bumthang in central Bhutan, the annual precipitation in the valley was 795 mm/year at 2600 m whereas it was 1164 mm/year at 2940 m (Chhetri and Dorji 2000). A similar valley slope gradient was assumed for the study area. Soil parent materials of Thimphu, Paro, and Haa consist of crystalline limestone, quartzitic, garnetiferous micaschist, and calc-silicate rocks (Gansser 1983). The annual precipitation in all FMUs falls mainly between June and September (Slavicky 1992).

Chamgang FMU is located between 89°43′ longitude and 27°24′ latitude and supplies forest products to 255 rural households. The mean annual temperature reaches a maximum of 24°C in July and minimum of −3.4°C in January at 2310 m, and the mean annual precipitation is 633 mm/y at 2310 m. Gidakom FMU is located between 89°30′ longitude and 27°23′ latitude and supplies forest products to 115 households (Dhital et al 1992). The mean annual temperature reaches a maximum of 25°C in July and minimum of 5°C in January at 2210 m (Stark 2002), and the mean annual precipitation is 561 mm/y at 2210 m. Paro-Zonglela FMU is located between 89°20′ longitude and 27°17′ latitude and supplies forest products to 3077 households (Moktan et al 2003). The mean annual temperature reaches a maximum of 26°C in August and minimum of −1°C in January, and the mean annual precipitation is 1037 mm/y at 2280 m. Haa-East FMU is located between 89°17′ longitude and 27°23′ latitude and supplies forest products to 1005 households. The mean annual temperature is −1°C in February and 20.3°C in June, and the mean annual precipitation is 731 mm/y at 2712 m (Rinchen and Pushparajah 1994).

Rapid rural appraisal

We solicited the information on forest product availability, accessibility for forest grazing, and constraints and opportunities on forest management using semistructured household survey questionnaires. The questionnaires were designed in such a way that each respondent could give only one answer for each question. The multidisciplinary team comprised researchers and subdistrict agriculture, livestock, and forest practitioners.

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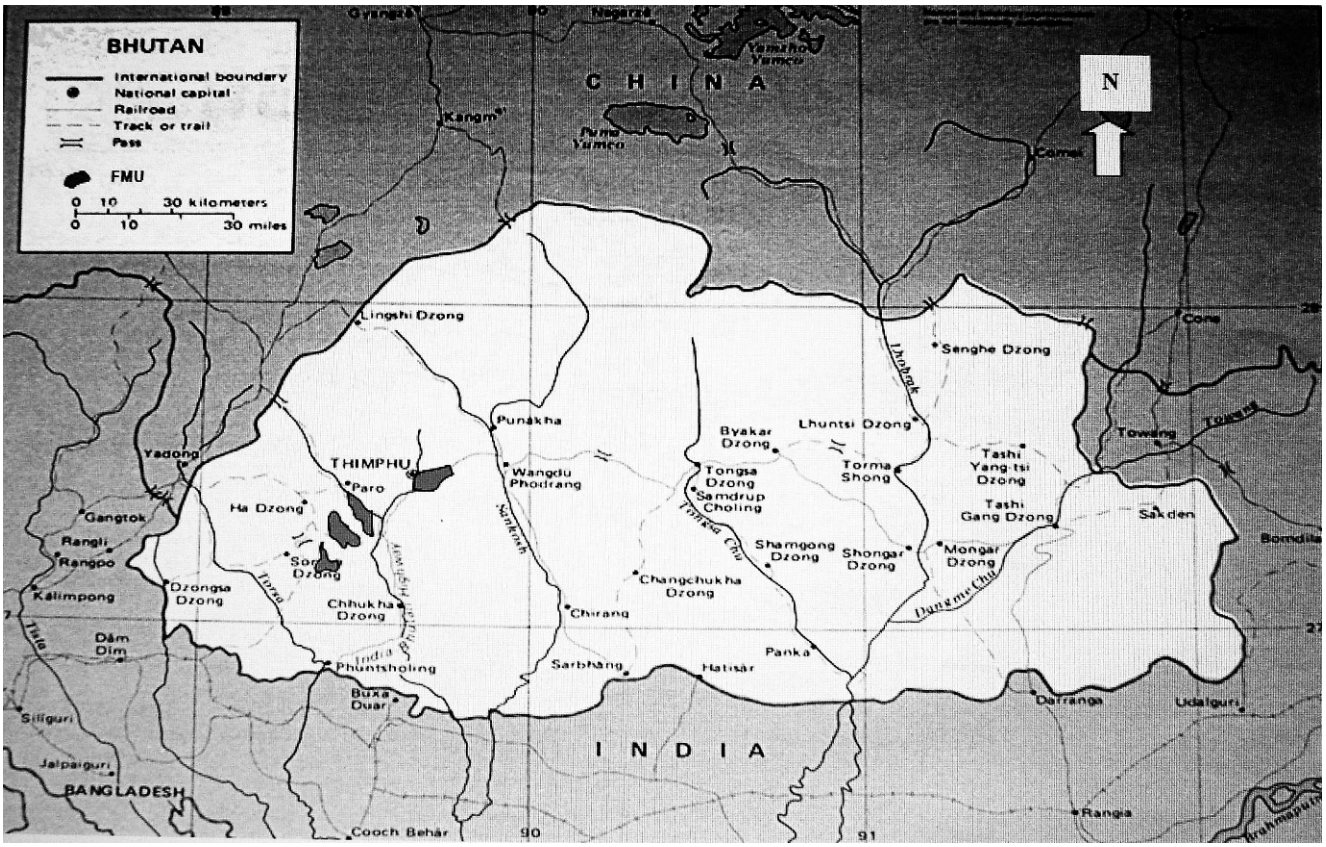
FIGURE 1 Location of the 4 FMUs in western Bhutan. (Map by Karma)



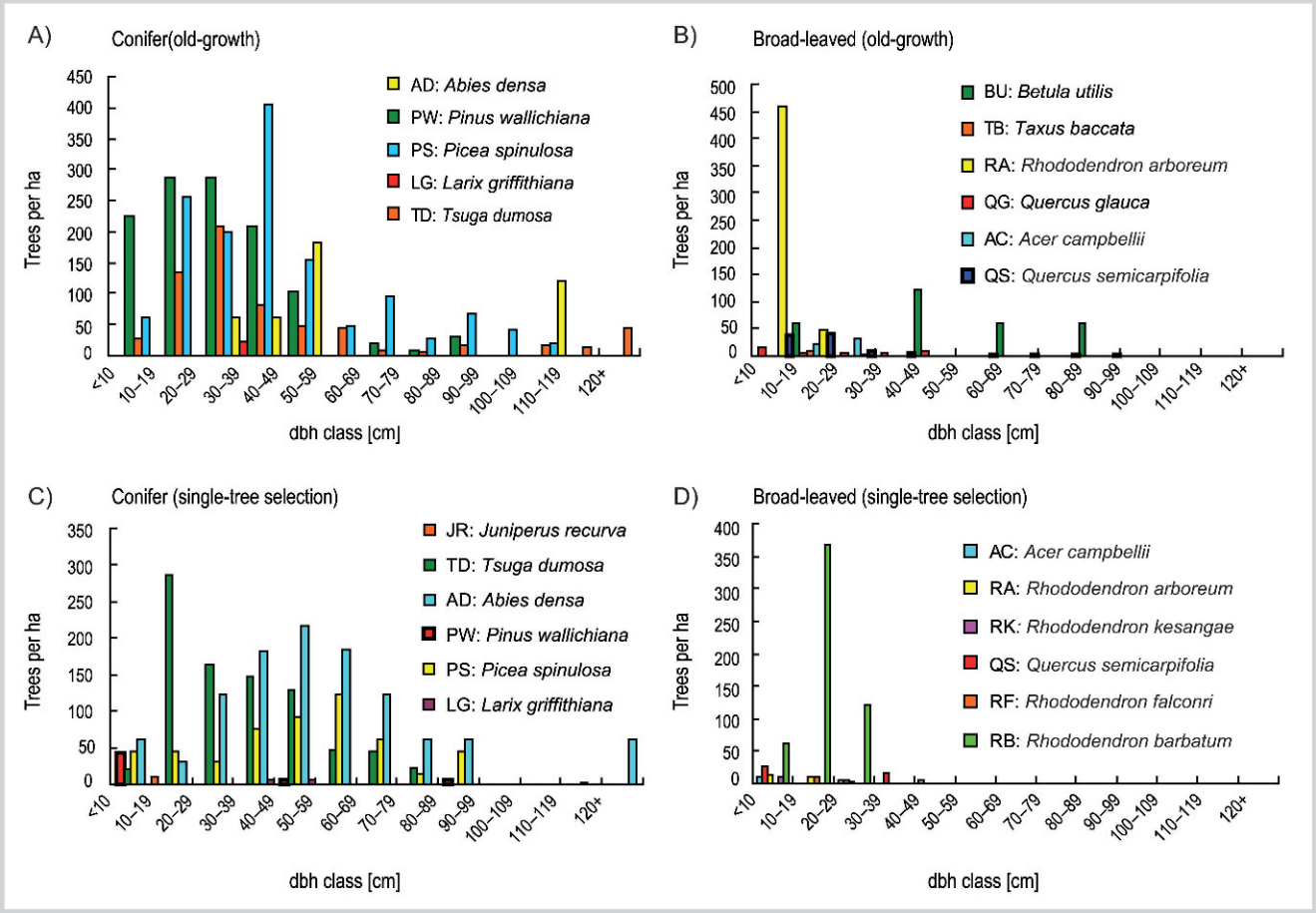
The respondents were selected from the household list and interviewed after consulting the local forest practitioners, elected village head, and representative of a village. We interviewed the household heads, who usually make decisions on behalf of the family. Informants comprised 74% male and 26% female, aged between 41 and 56 years (8 males from Chamgang, 6 from Gidakom, 5 from Paro-Zonglela, and 9 from Haa-East; and 1 female from Chamgang, 3 from Paro-Zonglela, and 6 from Haa-East FMU). Altogether, we interviewed 38 key informants.

Selection of plots and measurement

We identified single-tree selection and old-growth uncut forests on FMU topographical maps. During the field reconnaissance, forest stands and the location of plots were ascertained in consultation with forest practitioners. For this study, we define single-tree selection and old-growth stands as follows. Single-tree selection stands are stands where single-tree selection was practiced 2–3 years earlier (*Supplemental data*, Table S1; http://dx.doi.org/10.1659/MRD-JOURNAL-D-10-00015.S1). Before single-tree selection in this forest, local communities had customary rights for collection of firewood and grazing by domestic cattle. In contrast, old-growth stands are stands that are purposely retained within FMUs for ecological studies or protected by law and are part of old-growth forests characterized by mature and senescent trees (snags) and multicohort trees with minimum anthropogenic disturbances except grazing. Single-tree selection and old-growth stands, altitudes, aspects, soils, and stand parameters were comparable (*Supplemental data*, Table S1; http://dx.doi.org/10.1659/MRD-JOURNAL-D-10-00015.S1).

We conducted fieldwork from June to July 2006. In each FMU, 4 temporary plots—2 each in single-tree selection stands and old-growth stands of size 900 m^2 (30 m × 30 m)—were laid out to accommodate a sufficient number of large diameter breast height (Dbh)-class and spaced trees in selected forests. With the help of a compass and measuring tape, plots were established in single-tree selection stands and old-growth stands. All woody plants in the plots were enumerated by species (Grierson and Long 1983). We measured height and diameter at breast height 1.30 m above the ground for trees (≥10 cm Dbh), including dying or dead trees. A total of 16 plots were sampled from all the FMUs. We calculated species diversity using the Shannon index (1948).

FIGURE 2 (A–D) Dbh frequency distribution of tree species in old-growth and single-tree selection stands.



Results and discussion

Forest products availability

The rapid rural appraisal (RRA) results revealed that at Chamgang and Gidakom FMUs, fewer beams, planks, scaffoldings, poles, and firewood were available after the implementation of logging operations than earlier (*Supplemental data*, Table S2; http://dx.doi.org/10.1659/MRD-JOURNAL-D-10-00015.S1). This indicates a diminishing supply of forest products for rural communities after harvests and may have been caused by a higher proportion of timber and wood products supplied to the urban communities of Thimphu and Paro from the 2 FMUs. A similar study conducted by Moktan and Gyaltshen (2002) reported that quantities of forest products collected by rural households diminished after logging operations began in eastern Bhutan. In contrast, at Paro-Zonglela FMU, the RRA showed that greater quantities of beams, planks, grass fodder, and mushrooms were available after the logging operations but lesser quantities of scaffolding material, poles, firewood, and leaf litter.

The decrease in quantities of fuelwood available at Chamgang, Gidakom, and Paro-Zonglela FMUs is attributable to cooking and heating by rural and notably urban homes, when consumption peaked in the 1990s. According to a study conducted by Moktan et al (2003) urban firewood supplies from Chamgang and Gidakom FMUs were 6 times higher than rural supplies from 1995–2001. Firewood consumption was exacerbated by subsidies, limited energy substitutes, and the high calorific value of broad-leaved species, particularly *Quercus semicarpifolia* and *Q. glauca*. Accordingly, the plot results showed that broad-leaved tree densities were reduced to a minimum in the single-tree selection stands compared to old-growth uncut stands, followed by emergence of lesser-known firewood species such as *Rhododendron barbatum* (Figure 2). The high calorific value of oak trees makes them particularly suitable for cooking and heating, as in other parts of eastern Himalaya Garhwal, India (Awasthi et al 2003).

At Gidakom, Paro-Zonglela, and Haa-East FMUs, lesser quantities of leaf litter were available because of significant collection from forests for cattle bedding and subsequently fertilizing large agricultural farms (Roder et al 2003). A similar study conducted by Adhikari et al (2004) in Nepal points out that the quantity of forest

TABLE 1 (A) Constraints on forest management activities according to respondents, in percentage of respondents. (B) Suggestions regarding forest management activities according to respondents, in percentage of respondents. CWD: coarse woody debris; FMU: forest management unit.

A) Constraint	Chamgang	Gidakom	Paro-Zonglela	Haa-East
Harvesting, CWD retention, and plantation fencing disrupts cattle herding	56	33	–	27
Do not own or have fewer cattle	22	17	12	–
Foresters regulate activities	11	17	–	–
No comment and/or problem	11	17	52	53
Shortage of fodder trees in the forest	–	16	12	20
Forest activities coincide with farming	–	–	12	–
Forest and grazing land are not segregated	–	–	12	–
B) Suggestion				
Minimize harvest, fencing, and removing of CWD	45	–	–	40
Revert to selection cum improvement of felling	22	–	–	13
Restrict access to outside FMU users	11	–	–	–
Timber quota (reduce to 4 trees per household)	22	–	–	–
No comment and/or problem	–	67	100	40
Government should supply fodder seeds/seedlings	–	33	–	07

products collected by rural households depends on the socioeconomic significance of forest products and the existence of large private household assets such as land and cattle.

The RRA results showed that 56% and 33% of Chamgang and Gidakom FMU respondents, respectively, stated that timber harvesting, followed by plantation and fencing and retention of coarse woody debris (CWD), restricted cattle herding (Table 1A; see also Table 2). A similar study conducted by Moktan and Gyaltshen (2002) reported that harvesting, followed by plantation and fencing of clear-felled broad-leaved forests, offered barriers to grazing by domestic cattle in eastern Bhutan. To mitigate the problems, 45% and 40% of Chamgang

TABLE 2 Pros and cons of implementing forest management activities in FMUs according to respondents, in percentage of respondents.

Positive	Chamgang	Gidakom	Paro-Zonglela	Haa-East
Plantation benefits future generation	22	–	12	13
Forest management activities generates employment	33	–	–	13
No comments and/or no problem	45	–	63	10
Forest road provide access to forest resources	–	83	25	64
Forest protects watershed	–	17	–	–
Negative				
Reduction in cattle herding area	45	–	13	13
No comments and/or problem	33	50	12	60
Reduction of forest use by local	22	17	–	–
Mechanized harvest focus on good trees	–	33	75	–
Environmental degradation	–	–	–	27

TABLE 3 Overall changes after the implementation of forest management activities in FMUs according to respondents, in percentage of respondents.

Response	Chamgang	Gidakom	Paro-Zonglela	Haa-East	Overall
Good	89	100	37	27	63
Bad	–	–	13	27	10
No comment	11	–	37	33	20
Neither good nor bad	–	–	13	13	07

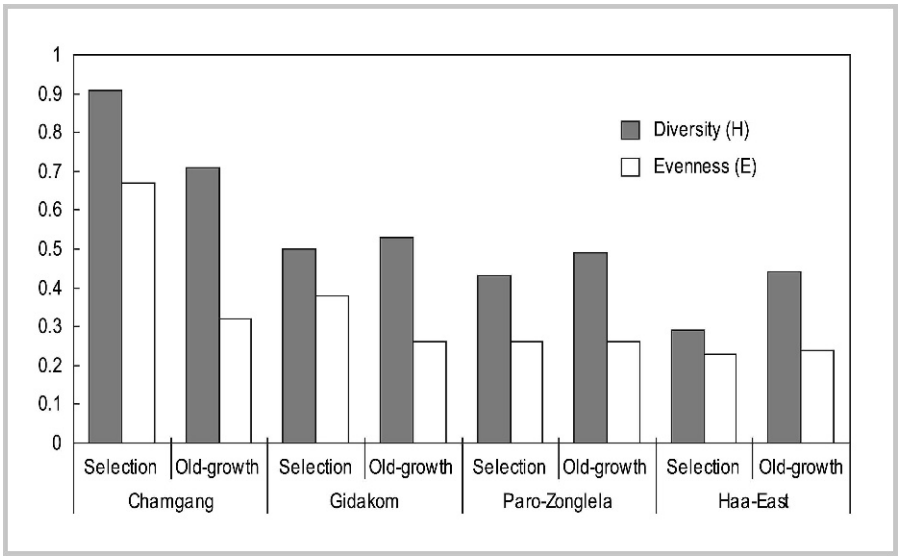
and Haa-East FMU respondents, respectively, suggested minimizing harvesting, fencing of plantations, and CWD (Table 1B). The results indicate that logging followed by plantation and fencing reduces cattle herding areas in FMUs.

Conversely, logging operations provide co-benefits to local communities. At Gidakom and Haa-East FMUs, 83% and 64% of respondents, respectively, stated that forest roads provided access to forest resources, whereas 33% of Chamgang FMU respondents stated that logging operations provided employment (Table 2). A similar study conducted by Gratzer (1998) in central Bhutan points out that forest roads provide access to forests that were inaccessible to the public. Across the FMUs, 63% of respondents stated that implementation of forest management activities were good (Table 3), indicating that overall changes in national forests near their villages had positive impacts.

From the above results and discussion, it appears that government-managed national forests have had fewer benefits for rural communities than intended. This is attributable to centralized planning and implementation of FMUs focusing on timber and wood products with minimum participation of rural communities in forest management issues that affect their livelihoods (Khan and Begum 1997; Ballabh et al 2002; Rasul and Karki 2007). The consequences are limitations in forest product availability, accessibility for forest grazing, and participation in national forest governance. The purpose of government-managed national forests, however, is also to provide timber and wood products to meet the national demand in urban and other regions of the country, rather than to serve only the local communities.

Current policy changes have taken this apparent incompatibility of purposes into account: community forestry in Bhutan has emerged as a viable model for managing pockets of national forests handed over to communities while addressing these unresolved issues. Recent studies have revealed that communities are capable of benefiting from improved accessibility to forest products, resolving the problem of cattle density in forest grazing, and maintaining species diversity in their forests (Tshering 2006; Buffum et al 2009). Community forestry, however, needs to increase its pace and magnitude to enable rural communities to reduce poverty and improve forest governance and livelihoods.

FIGURE 3 Diversity and evenness of old-growth and single-tree selection stands.



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Species composition and species diversity

Across the FMUs, single-tree selection stands have 23 woody species, and old-growth uncut stands have 22. The number of species thus did not significantly differ between the 2 stand categories. Accordingly, species diversity and evenness were not significantly different in single-tree selection stands (between 0.53 ± 0.29 and 0.38 ± 0.24) and in old-growth stands (0.54 ± 0.18 and 0.26 ± 0.07), respectively (Figure 3). Single-tree selection did not change the species composition because this system concentrates on the removal of elite trees; retention of young seed trees allows regeneration of the stands by means of natural regeneration. Dorji (2004) underscores that at Gidakom FMU retention of seed trees regenerates single-tree selection stands with desired species. The plot results, however, indicate that single-tree selection focuses on the cutting of higher proportions of large-Dbh-class blue pine trees compared to old-growth stands. Similarly, Davidson (2000) points out that a limited number of the best timber species are cut in Dbh class 65–115 cm in single-tree selection broad-leaved forests of eastern Bhutan.

Conclusion

From the results and discussion, it can be concluded that forest product availability and accessibility of forests to local communities for forest grazing vary among the 4 studied FMUs since implementation of logging operations in national forests near their villages. Forest logging, followed by plantation and fencing and retention of CWD, offered barriers to cattle herding. Nothwithstanding, forest roads provided access to forest resources. The government-managed national forests, however, provide limited accessibility to rural communities for collecting timber and other wood products. Single-tree selection did not change species composition and was not detrimental to species diversity in national forests.

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REFERENCES

Adhikari B, Falco SD, Lovett JC. 2004. Household characteristics and forest dependency: Evidence from common property forest management in Nepal. *Ecological Economics* 48:245–257.

Awasthi A, Uniyal SK, Rawat GS, Rajvanshi A. 2003. Forest resource availability and its use by the migratory villages of Uttarkashi, Garhwal Himalaya (India). *Forest Ecology and Management* 174:13–24.

Ballabh V, Balooni K, Dave S. 2002. Why local resources management institutions decline? A comparative analysis of van (forest) panchayats and forest protection committees in India. *World Development* 30: 2153–2167.

Buffum B, Gratzer G, Tenzin Y. 2009. Forest grazing and natural regeneration in a late successional broadleaved community forest in Bhutan. *Mountain Research and Development* 29(1):30–35.

Chhetri PB, Dorji K. 2000. *The Weather in Bumthang, Bhutan.* Annual report of the Renewable Natural Resource Research Centre. Bumthang, Bhutan: Renewable Natural Resource Research Centre.

Darabant A, Rai PB, Tenzin K, Roder W, Gratzer G. 2007. Cattle grazing facilitates tree regeneration in a conifer forests with palatable bamboo understory. *Forest Ecology and Management* 252:73–83.

Davidson J. 2000. *Ecology and Management of Broadleaved Forests of Eastern Bhutan*. Khangma, Trashigang: Third Forestry Development Project.

Dhital DB, Pushparajah M, Maatta M. 1992. *Forest Management Plan (1992–2002). Gidakom Forest Management Unit*. Thimphu, Bhutan: Forest Resources and Development Division.

Dhital DB, Wangchuk N. 1998. Analysis of fuelwood use in Thimphu Valley: A case study. *In:* FAO [Food and Agriculture Organization of the United Nations], editor. *Wood Production and Marketing National Workshop.* Regional Wood Energy Development Programme in Asia Proceeding. Bangkok, Thailand: FAO, pp 13–23.

Dick JH, Yonten DP. 1995. *A Preliminary Sectoral Environmental Assessment and a Framework for Environmental Monitoring*. Khangma, Bhutan: Third Forestry Development Project.

DoE [Department of Energy]. 2009. *Overview of Energy Policies of Bhutan*. Thimphu, Bhutan: Ministry of Economic Affairs.

DoF [Department of Forests]. 1995. *Forest and Nature Conservation Act 1995*. Department of Forests. Thimphu, Bhutan: Ministry of Agriculture.

DoF [Department of Forests]. 2004. *Community Forestry Manual for Bhutan. Part 1: Initiating Community Forestry*. Department of Forests. Thimphu, Bhutan: Ministry of Agriculture.

DoF [Department of Forests]. 2009. *National Forest Policy 2009.* Department of Forests. Thimphu, Bhutan: Ministry of Agriculture.

Dorji S. 2004. *Natural Regeneration in Cable Crane Logged Sites in the Mixed Conifer Belt of Gidakom Forest Management Unit* [Master's thesis]. Vienna, Austria: University of Natural Resources and Applied Life Sciences.

Gansser A. 1983. *Geology of the Bhutan Himalaya*. Basel, Switzerland: Birkhäuser.

Gratzer G. 1998. *Regeneration Ecology of Abies Densa Forests in Eastern Central Bhutan* [PhD dissertation]. Vienna, Austria: University of Natural Resources and Applied Life Sciences.

Grierson AJC, Long DC. 1983. *Flora of Bhutan Including a Record of Plants from Sikkim*. Vol 1, Part 1. Edinburgh, United Kingdom: Royal Botanic Garden.

Khan NA, Begum SA. 1997. Participation in social forestry re-examined: A case study from Bangladesh. *Development in Practice* 7:260–266.

Moktan MR, Gyaltshen J. 2002. *Socio-economic and Environmental Impact of Korila Forest Management Unit in Eastern Bhutan*. Trashigang, Bhutan: Renewable Natural Resources Research Centre.

Moktan MR, Norbu L, Rai TB, Gurung PB, Dukpa K, Dorji R. 2003. *Use of Oak as Firewood: Its Implication on Socio-economy and Environment*. Thimphu, Bhutan: Renewable Natural Resources Research Centre.

Namgyel P. 1996. *Beyond Timber—What Value of the Forest? A Rapid Rural Appraisal Study on Non-Timber Forest Products of Nahi Gewog*. Wangdi Phodrang, Bhutan: Forestry Research Centre and Bhutan and German Sustainable Renewable Natural Resources Development Project.

Palmetzhofer D, Lexer MJ, Vacik H, Stampfer K, Lilienau BL. 2004. A spatial decision support system for exploring stand management and harvesting scenarios in mountain forests. *In:* Ammer C, Weber M, Mosandl R, editors. *Regenerating Mountain Forests.* Proceedings. Kloster Seeon, Germany: Zentrum Wald-Forst-Holz Weihenstephan, pp 1–21.

Rasul G, Karki M. 2007. *Participatory Forest Management in South Asia. A Comparative Analysis of Policies, Institutions and Approaches*. Kathmandu, Nepal: International Centre for Integrated Mountain Development.

Rinchen D, Pushparajah M. 1994. *Management Plan for Haa-East Forest Management Unit*. Thimphu, Bhutan: Forest Resources Development Division.
Roder W, Gratzer G, Wangdi K. 2003. Cattle grazing in the conifer forests of Bhutan. *Mountain Research and Development* 22(1):1–7.
Schweinfurth U, Schweinfurth-Marby H. 1975. Exploration in the eastern Himalayas and the River Gorge Country of Southeastern Tibet: Francis (Frank) Kingdon Ward (1885–1958): An annotated bibliography with a map of the area of his expeditions. *Geoecological Research* 3:1–114.
Shannon CE. 1948. A mathematical theory of communication. *Bell System Technology Journal* 27:379–423.
Slavicky J. 1992. *Management Plan for Paro-Zonglela Forest Management Unit*. Thimphu, Bhutan: Department of Forestry.
Stark C. 2002. *Management Plan for Gidakom Forest Management Unit*. Thimphu, Bhutan: Forest Resources and Development Division.
Tshering C. 2006. Community forestry in Bhutan: Experiences and the way forward. *In:* Gyamtsho P, Singh BK, Rasul G, editors. *Capitalisation and Sharing of Experiences on the Interaction between Forest Policies and Land Use Patterns in Asia: Linking People with Resources.* ICIMOD (International Centre for Integrated Mountain Development) Proceedings. Kathmandu, Nepal: ICIMOD, pp 73–90.

Supplemental material

TABLE S1 Sample plots and site characteristics in 4 FMUs in western Bhutan.
TABLE S2 Availability of forest products before implementation of forest plan management and after 10 years of implementation, according to respondents in the 4 case study areas. Values given are in percentage of respondents who considered that there had been an increase or decrease.

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