Forest Dynamics in Nepal: Quantity, Quality, and Community Forestry Issues in Middle Mountain Watersheds

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Over the past 50 years the forest cover has changed significantly in the middle mountains of Nepal. A GIS analysis showed cycles of degradation followed by rehabilitation and then again degradation. Unfortunately, because of the intense population pressure, the rehabilitation periods have been insufficient to restore forests to a sustainable level. The changes in forest cover were investigated in one watershed in the middle mountains as an example. The overall changes were identified using maps and aerial photographs, the changes in forest quality were investigated over nine years using a plot study. The dilemma faced by user groups was investigated through a user group survey in another watershed. The results demonstrated that the forest quality in the study area is still declining, as shown by a loss of more than 50 per cent of individual trees. At the same time the tree biodiversity is limited to two major species, there is a lack of groundcover, and the soil fertility in the forest is declining as a result of massive removal of palatable material for animal fodder, litter to support agriculture, and firewood. Turning over the control of forest management to the communities has been claimed as a positive step towards obtaining better management of the forest resources. However, the poorest segments of the society, particularly the women with little access to forests on private land, suffer most because their workload is increasing, and fodder and fuelwood shortages are worse than five years ago. The introduction of native nitrogen-fixing fodder trees into the forest and a well planned collection calendar endorsed by the community is likely to be a better approach than simply restricting access to the forest in the hope of rapid natural regeneration.

Introduction

Much has been written about forest cover degradation in Nepal and the topic has always been controversial. Many authors have warned about the rapid decline in forest cover (World Bank 1979; Eckholm 1975), while others have written about forest improvements (Gilmour 1991). What became obvious in the 1990s was that if the pressure on forest resources continued to increase due to population growth, then it would be difficult to maintain the quantity and quality of forests without major changes in forest policies. Recent changes in national policy aimed at placing forest management control into the hands of communities have been greeted with much optimism in the hope that this will result in an improvement of the forest resources. However, since the demand for forest resources is high and the supply is limited, restrictive access and conservation measures might result in significant hardship, particularly for the poorer people in the mountains. The pressure on the forest resources is most evident in the middle mountain region of Nepal where the population is high and agricultural intensification has resulted in a significant flow of biomass and nutrients from the forest into agriculture. The Jhikhu Khola and Yarsha Khola watersheds are used here as examples to document the forest dynamics in this region. The aims of the paper are to:

- document recent changes in forest cover;
- identify changes in forest quality and biodiversity; and,
- identify interactions and constraints amongst forest user groups.

Historic maps, aerial photographs, and GIS techniques were used to document temporal changes in forest cover in the Jhikhu Khola watershed. Thirteen forest plots were inventoried in 1989 and have been monitored for nine years to document forest quality changes and growth. A user group survey was carried out in the Yarsha Khola watershed to describe the dilemma faced by the user groups in trying to find a balance between excessive use, degradation, and conservation.

Site Description and Methods

The Jhikhu Khola watershed covers 11,000 ha, is located 45 km east of Kathmandu, and is accessible via the Arniko highway. The watershed has a very high population density and due to market access, agricultural production is some of the most intensive in the middle mountains of Nepal. The average crop rotation intensity is 2.4 crops/year and forest resources play an important role in maintaining the agricultural production. Fodder from the forest plays a key role in the production of manure, which is the main source of organic matter input into agriculture, and the ashes from home-kitchen fires are returned into the cropping system. During the dry season, forest litter is collected in very large quantities for animal bedding and is then added to the agricultural soils as compost. The forest cover in the watershed was determined for 1947, 1972, 1981, 1990, and 1996 using historic maps and aerial photo interpretation techniques. All data sets were digitised and incorporated into a GIS system, and the changes in forest cover determined using a GIS overlay technique.

The forest quality and growth measurements were examined using a time series analysis of 13 forest plots of 20x20 m size. A baseline inventory was carried out in 1989 (Feigl 1989) during which every tree was identified, dbh and tree heights were measured, soils and foliar nutrients were analysed, corner trees in each plot were marked with red paint, and the x and y coordinates of each tree within the plot were determined and marked on a georeferenced plot map. Monitoring of tree removal took place every three years, and in 1998 the baseline inventory was repeated to determine overall tree losses, growth rates, and changes in soil nutrient content. The plots were selected to reflect the different forest ownership and forest types in the Jhikhu Khola watershed. A summary of the general site conditions is provided in Table 44. The chemical and physical conditions of the soils in 1989 and 1998 were determined using a composite sample consisting of 15 sub-samples collected randomly within each plot.

Table 44: **Forest Plot Site Conditions**			
Plot No.	Elevation (m)	Protection	Dominant Trees
1	800	no	chir pine
2	820	no	chir pine
3	890	yes	chir pine
4	880	yes	sal + chir pine
5	870	yes	Sal
6	930	no	chir pine
7	840	no	chir pine
8	880	yes	chir pine
9	950	no	sal + chir pine
10	910	no	Sal
11	880	no	Sal
12	880	yes	chir pine
13	870	yes	Sal

The dynamics in forest use were examined in the Yarsha Khola watershed, located 190 km east of Kathmandu along the Lamasang-Jiri Highway. The watershed covers an elevation range of 1000-3000 masl and extends over 5500 ha. The changes in the use of the forests were examined in a participatory manner with the Department of Forestry and local user groups. Four types of management were identified: formal FUGs (forest user groups), informal FUGs, national forests, and private forests. In the Yarsha Khola watershed, 12 formal forest user groups manage 29 per cent of the forests, and much of the remainder is claimed by informal FUGs. Information for each user group was obtained from the Department of Forestry (DFO) and from participatory surveys with the user groups. In each case information on the size of the forest, the number of participants in the group, the user rules, and the penalty system were recorded. The actual forest cover classification was derived from 1:25,000 scale aerial photographs and subsequent GIS analysis.

Results

Changes in Forest Cover in the Jhikhu Khola Watershed, Nepal

The forest cover dynamics in the Jhikhu Khola were examined by Schreier *et al.* (1994), and Shrestha and Brown (1995) and revealed that between 1947 and 1981 some 24 per cent of the cover had been removed as a result of deforestation. Activities by the Nepal-Australia Forestry Programme (NAFP) in the early 1980s resulted in a significant increase in forest cover, which resulted in a 10 per cent gain in forest cover between 1972 and 1990. In 1990 and 1996, new 1:25,000 scale aerial photographs were acquired which enabled a more detailed assessment to be made of the forest cover dynamics in the watershed. The results showed a small decrease in forest cover, which was attributed to conflicts during the introduction of democracy in Nepal. Overall the two most dominant forest types were chir pine (*pinus roxburgii*) dominated forests, and sal (*shorea robusta*) dominated forests. Between 1972 and 1996 the forests dominated by pine increased by 680 ha—largely as a result of afforestation, while the sal forests remained relatively constant until 1990 and subsequently increased by 300 ha as a result of natural regeneration. These findings were converted into a historic cover change graph (Figure 31) which shows evidence of a cycle of

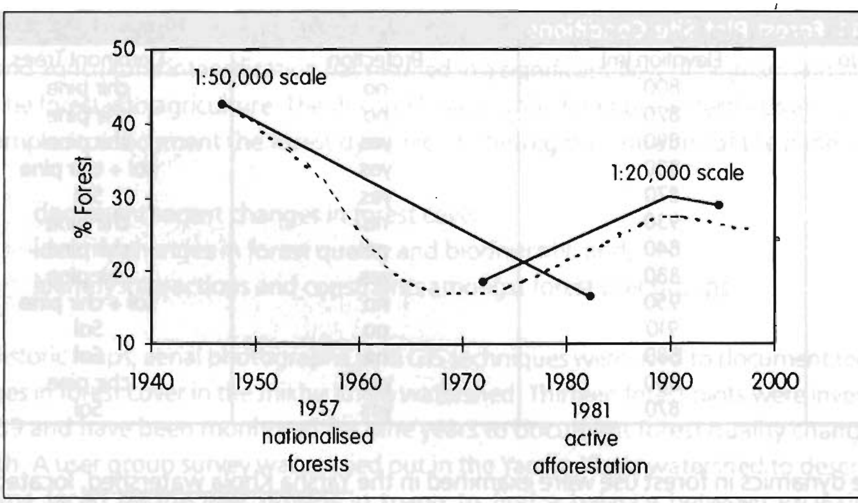

Figure 31: **Historic Changes in Forest Cover**

deforestation followed by afforestation, followed by renewed deforestation. While the most recent rates of deforestation are small, they are nevertheless significant because the afforestation period is usually too short to recover what was lost over the previous period. This results in a downward spiral, which is of significant concern. Community forestry was initiated in 1978, but the programme of transferring national forests to community user groups only accelerated in the mid 1990s. It is hoped that once the management control of the forests is in the hands of community groups, self-imposed restrictions will result in an improvement in forest cover. However, the pressure on the forests is severe and a recent farmers' survey showed that fodder and fuelwood deficits increased between 1990 and 1996. The forest cover analysis only provides information on tree cover, not on tree biomass growth, tree quality, and understorey cover. Changes in these cannot be measured via remote sensing, and forest plot studies have to be undertaken to record these factors.

Changes in Forest Quality in the Jhikhu Khola Watershed, Nepal

The 1989 survey showed that chir pine dominated eight of the thirteen plots and sal forests five. Overall there was a significant loss of trees between 1989 and 1998, but the losses were sporadic. All sal trees were removed from three plots between 1989 and 1994. In two of these plots the removal occurred during the process of introduction of democracy in Nepal in 1993, while the trees in the third plot were removed more gradually over a five-year period.

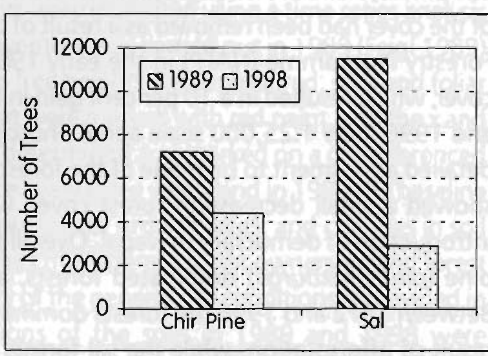

Figure 32: **Change in the Number of Trees in Forest Plots 1989-98**

Sal trees were removed at a much higher rate than pine trees (Figure 32) because sal wood is a much more desirable fuelwood for brick making than is pine. The demand for fuelwood increased significantly between 1989 and 1998 because of rapid population growth (both internal growth and immigration of labourers working in the intensive agricultural system, Brown 1999). This spurred a building boom resulting in a high demand for sal wood to produce local brick.

Of the nine pine-dominated sites (Figure 33) seven showed major losses and only two minor losses of trees over the nine year period. All trees were removed from two of the four sal-dominated plots, while the other two plots experienced large losses (Figure 34). Overall 40 per cent of all chir pine trees and 75 per cent of all sal trees were removed from the 13 sites over the 9-year cycle. These trends clearly show that the forests in the Jhikhu Khola watershed are under intense pressure.

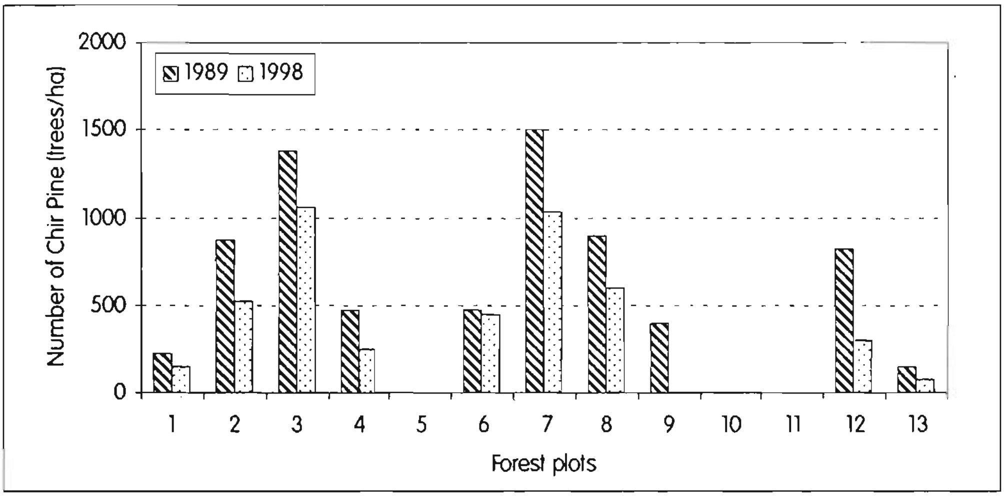

Figure 33: **Losses of Chir Pine Trees in Forest Plots 1989-1998**

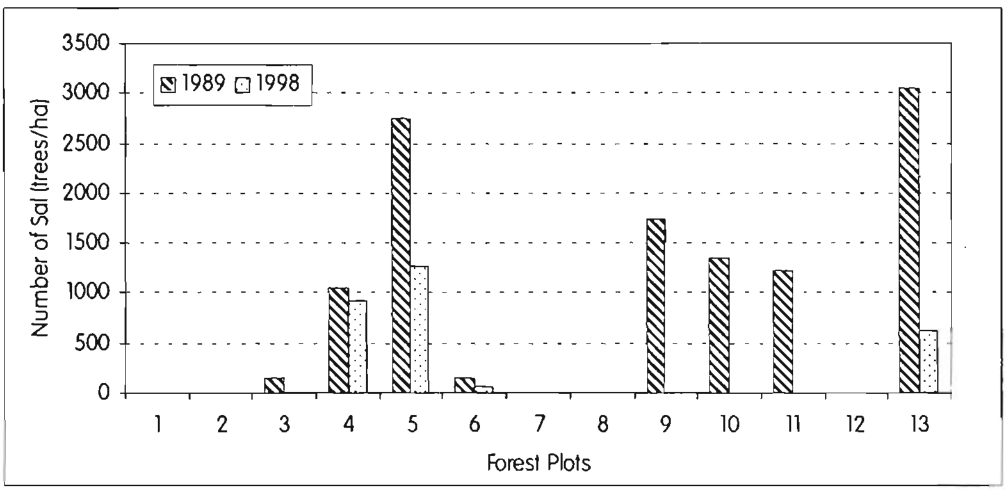

Figure 34: **Losses of Sal Trees in Forest Plots 1989-1998**

In 1998, 98 per cent of all remaining trees in the 13 sites were either chir pine or sal trees. During the nine-year observation period no introduction or regeneration of any other species was observed, and the understorey became degraded.

On the positive side it can be argued that removal of trees is a necessary management practice. As Figures 35 and 36 show, the growth rate of the remaining trees was significant with an average stem diameter (dbh) change from 10 to 40 cm for pine and from 5 to 25 cm for sal. However, the increase in biomass and growth in crown cover could have been significantly higher without the loss of more than 40 per cent of the trees over a nine-year period, since tree spacing was appropriate and no thinning was needed. In addition the biodiversity also decreased because no new trees or species were introduced or regenerated in these plots.

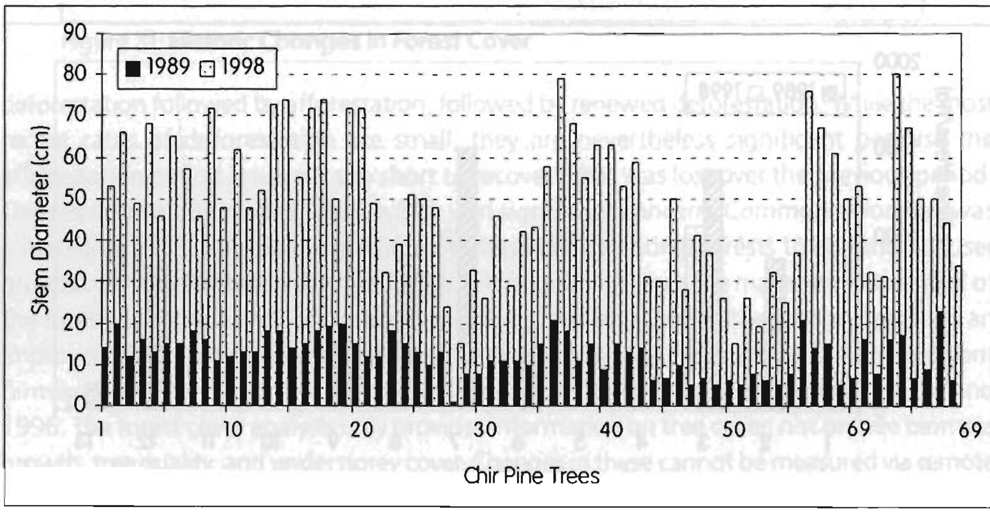

Figure 35: **Changes in Chir Pine Diameter 1989-1998**

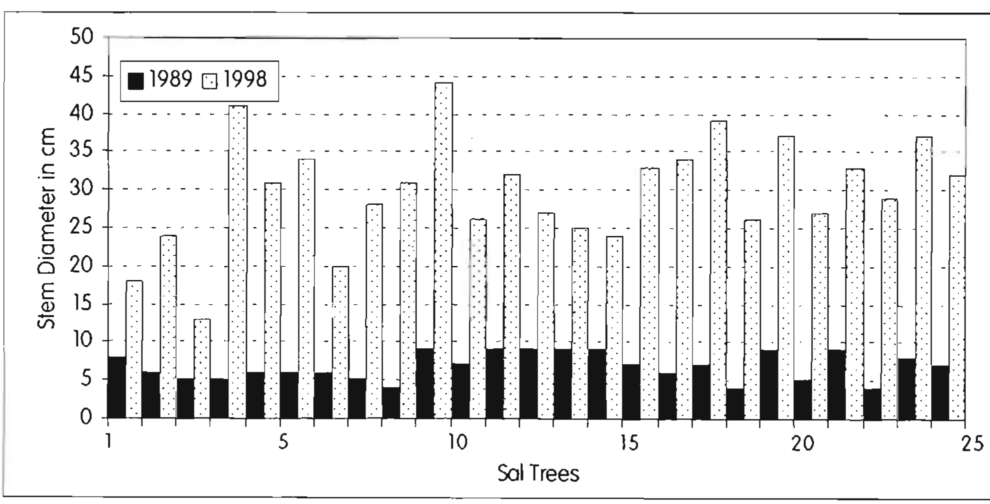

Figure 36: **Changes in Sal Diameter 1989-1998**

Trees were mainly removed for fuelwood and timber. At the same time the demand for forest litter also increased significantly because of agricultural intensification. This removal of biomass resulted in an increased flow of nutrients out of the forest. This is shown by a comparison of the carbon and available phosphorus content in the soils. Overall the percentage carbon content in the soils declined from 0.4 to 0.15, and the available P content from 0.4-0.1 mg/kg of soil (Figures 37 and 38).

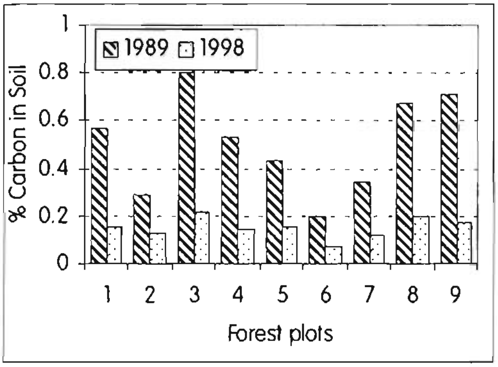

Figure 37: **Decline in Soil Carbon (%) 1989-1998**

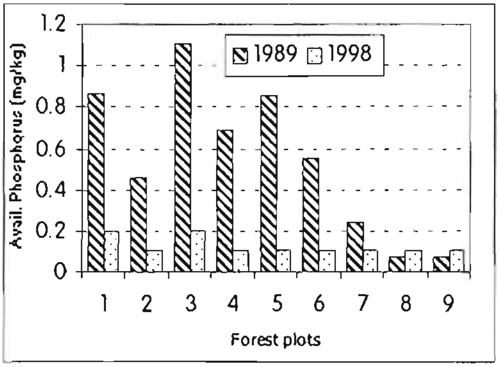

Figure 38: **Decline in Soil Phosphorus (mg/kg)**

Detailed analysis of the tree survival and growth rates indicate that while the overall forest cover increased in the watershed, there were significantly fewer standing trees and no evidence of vegetation diversity or recovery of the understorey. This suggests that the fodder, fuelwood, and litter demand from the forest exceed the growth capacity and sustainability of the forest system, as was evident from the loss of trees, biodiversity, soil quality, and soil nutrient pools. The decline in tree numbers and soil nutrients raises the question of how to sustain forests under the increasing population pressure in the middle mountains of Nepal. Many suggestions have been made that externally managed forests (under the control of the national government) will not be managed as effectively as those where forest management is under the control of community user groups. Since the introduction of democracy in Nepal, many forests have been turned over to community groups; the management difficulties faced by these user groups are discussed in the following paragraphs.

Constraints Faced by Forest User Groups in the Yarsha Khola Watershed, Nepal

The critical problems of sustainability faced by forest user groups (FUGs) were investigated in the Yarsha Khola watershed (Brown 1999). Twelve formal user groups were identified in the watershed. Forest access is typically restricted when a new FUG is formed. Collection of fodder (green leaves) is not currently permitted by 11 of the 12 formal FUGs, and fuelwood collection is not permitted by 8 of the 12 groups. Informal FUGs also restrict access, with many forests closed for five years. When forest access is permitted, collection periods are typically restricted to 1-2 weeks per year for fuelwood, and less than one month for fodder. This shows that local residents are aware of the potential degradation problems and that they take active steps to protect the remaining resources.

However, evidence from the Yarsha Khola watershed indicates that restricted access to community managed forests as a result of establishing user group rules results in fuelwood and fodder shortages that extend over 40 weeks of the year. These shortages are most prevalent at mid to low elevations where forests are limited in extent and consist largely of pine plantations (not useful for animal fodder). The restricted access to government-owned forests shifts the pressure to private lands. The majority of animal fodder and bedding material (litter) is collected from terrace risers, crop residues, and shrubs and fodder trees on private land. Government forests (formal, informal, and national management) are an important source of fuelwood, but access has been limited through the establishment of community forestry. The majority of women (86-91%) indicated that the collection of fuelwood, fodder, and litter is now more difficult than five years ago when the forests were primarily under the control of the national Forestry Department (Table 45).

Table 45: **Forest Access Restrictions**

Management Regime	Fuelwood		Fodder		Litter	
	No. closed	Average Access (days/year)	No. Closed	Average Access (days/year)	No. Closed	Average Access (days/year)
Formal FUGs (n=12)	8 of 12	7	11 of 12	2	5 of 12	45
Informal FUGs (n=11)	9 of 11	32	9 of 11	3	6 of 11	44

The collection of forest products is largely the responsibility of women and girls. In over 90 per cent of the households females are involved in the collection of animal fodder, litter, and fuelwood, while males are typically involved in fuelwood collection only. Women and girls typically make one trip per day to collect fodder and litter, and one trip per week to collect fuelwood. Community forestry initiatives have restricted the access of women to forest products. The new restrictions are quite severe, as shown in Table 46, with fodder access limited to 2-3 days per year and fuelwood to 7-32 days per year. Only litter collection is somewhat more open. Closures have created additional workloads for women who are forced to collect fodder, litter, and fuelwood from alternative sources, and households with limited land are severely affected.

Table 46: **Women's Perception of Forest Product Collection**

Compared to Five Years Ago	% Households Reporting		
	Fuelwood	Fodder	Litter
More difficult now	91	86	90
Same	7	8	4
Easier now	2	6	6

The survey showed that almost all households that have access to private lands rely on these for fodder, litter, and fuelwood (Table 47). As a result of the creation of community forestry, it is now evident that some 45 per cent of households do not have access to formal or informal forests as a result of either forest closure or exclusion from the FUGs.

Table 47: **Collection of Forest Products by Source**

Source	% Households Using		
	Fuelwood	Fodder	Litter
Private land	87	98	97
Formal FUGs	25	29	19
Informal FUGs	32	2	10
National forest	1	2	0
Buy	3	3	0

These results clearly show the dilemma of Nepal: how to protect the forest without increasing the hardship of the poorer fraction of Nepalese society, the female farmers with no access to private land who are now restricted from using the community forests. There are no easy solutions to this dilemma, but creative afforestation with nitrogen fixing fodder trees is one of the options. As shown by Schreier *et al.* 1999, rehabilitation of degraded land offers some limited possibilities, but such activities are not easy, require external inputs, and certainly will not improve the fodder and fuelwood shortages in the short term. Active afforestation of existing community forests using native nitrogen fixing fodder trees and nitrogen fixing grasses, rather than extensive forest closures, is an alternative that should be considered.

Summary and Conclusions

The research described in this paper clearly shows the dilemma faced by Nepali people in the middle mountains. Excessive use of forests leads to degradation, loss of biodiversity, shortages of fodder and fuelwood, a decline in the nutrient pool, and a long-term decline in forest productivity. Protection of the forest by community groups will help in re-establishing the forests, but such processes are long term and create significant hardship for the poorest fraction of society. The analysis in the Jhikhu Khola watershed showed that the forest cover changes are cyclic, and in spite of transfers of management control from the national government to the community it is evident that the forest cover has not improved significantly in the past few years. In addition, the forest quality is degrading as shown by the loss of biodiversity and soil nutrients. The lack of fodder and fuelwood is widespread, and the majority of female farmers noted that the availability of these resources is declining resulting in an increase in the workload of women.

Restricting access to conserve forests is the obvious answer promoted by the Forestry Department and the community groups, but this creates a new problem and poor farmers that have no access to private forests suffer the most. We suggest that afforestation with nitrogen fixing fodder trees and grasses be promoted in community forests, rather than simple closure for natural regeneration. With community involvement and proper enforcement of rotational access it is possible to regenerate biodiversity and provide short-term biomass for those female farmers who are under the greatest stress. These are not easy solutions and a delicate balance has to be achieved between protection and limited or rotational use. Only a massive educational effort, a reduction in population pressure, and a focus on the needs of the poorer women, can set the stage for improving the production and sustainability of the community forests in the region.

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