Fuelwood harvest, management and regeneration of two community forests in Central Nepal

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From July to December 2003 we studied the impact of forest resource use and management practices on community structure and regeneration of locally managed *Shorea robusta* (sal) forest in the mid-hills of central Nepal. We carried out a household survey in two villages (Namjung village of Gorkha and Khari village of Dhading district), and studied the community structure and regeneration of important multipurpose tree species (*Shorea robusta* Gaertn. and *Schima wallichii* (DC.) Korth.) in community forests. Dependency on forests has been decreasing due to limited access to resources, decrease in cattle number and the cultivation of more fuelwood and fodder trees in non-forested land. Nonetheless, forests remain the major source of fuelwood, supplying 63% of the total. Alternative energy sources (biogas and solar cell) were not significant at the time of our study. *S. robusta* was the dominant tree in both forests, with high relative density (74%) in Namjung forest (NF) and 50% in Khari forest (KF); its importance value index (IVI) was 171 in NF and 152 in KF. Tree density of sal in NF was the highest (909 tree ha^{-1}) among the reported values in references for the same species. Both forests had comparatively low species diversity (1.09 in NF and 1.30 in KF); local management appears to contribute to reduced diversity. Regeneration of sal was sustainable and fairly high, with a typical reverse-J-shaped size class diagram (in NF), a good predictor of mono-dominant sal forest. Regeneration of *S. wallichii* was unsustainable in both forests.

Key words: *Schima wallichii*, *Shorea robusta*, size class diagram, species diversity

Rural people depend on forest resources for their energy needs, fodder, timber and employment. Fuelwood is one of the most important forest resources, accounting for an estimated 7% of the world's total energy supply (FAO 1999). It plays a major role (80%) in the energy supply of Nepal, and its consumption is increasing by 2.0% per annum (Shrestha 2000). Fuelwood has the potential to be an attractive renewable source of energy because it is CO_2-neutral and economically affordable for rural people. Fuelwood consumption is not and will not be the main cause of deforestation; non-forest land is and will continue to be the main source of fuelwood (RWEDP 1997). However, some people believe that the demand for fuelwood in developing countries can only be met by over-exploitation of forests, which is the major cause of deforestation (Schulte-Bisping et al. 1999). To resolve these conflicting views, we need adequate reliable data, which, in the case of Nepal, is lacking (Shrestha 2002).

Forested areas, a major source of fuelwood, are decreasing at the rate of 1.8% per annum in Nepal (FAO 2001) and all five Development Regions suffer fuelwood deficits (RWEDP 1997). The impact of fuelwood collection on forests has been controversial and its role in rural livelihoods and deforestation the subject of considerable debate. The practice of using a few selected species for fuelwood and absolute conservation of dominant species in community-managed forests may affect the regeneration process and community structure of forests. The impact of fuelwood collection on forests is largely determined by the extent of peoples' relative dependency on forested and non-forested lands for fuelwood.

To elucidate the relationship between fuelwood consumption and forest structure, the use patterns of fuelwood in two villages of central Nepal and their forests were studied with the following specific objectives: 1) to quantify the use of forest resources (fuelwood and fodder) by local people; 2) to identify the relative importance of forest and non-forest sources of fuelwood and fodder; and 3) to assess the impact of local management on forest structure and regeneration.

Materials and methods

Study site

We surveyed fuelwood consumption in two mid-hill villages of central Nepal: Majhitar of Namjung Village Development Committee (VDC), Gorkha district, and Kumaltari of Khari VDC, Dhading district; we refer to these as NV and KV, respectivly. There were 78 households in NV and 116 in KV; about 90% households were engaged in subsistence agriculture. They obtained timber from the forest, but fuelwood and fodder were obtained from both farmland and forest.

We studied vegetation structure and regeneration in *Jhakreko Pakha*, or "Namjung forest"(NF) near NV and Devisthan Community Forest, or "Khari forest" (KF) near KV. NF lies on the south-east face of a hill with slope 60º at 27º 56' N, 84º 43' E, alt. 500–800m; KF lies on the north-west face of a hill with slope 70º at 27º 56' N, 84º 44' E, alt. 450–1000m. NF has been protected for the past 15 years, and the use of *Shorea robusta* (sal) in any form has been prohibited. Limited timber harvesting for non-commercial purpose was permissible, provided royalties were paid. KF has been protected for the ➤

last four years, and the use of sal and *Terminalia alata* in any form were completely prohibited. The harvest of *Schima wallichii* and *Castanopsis indica* for non-commercial purposes were allowed in KF. Sal is the dominant tree species in both forests; major associated species are *S. wallichii* and *Terminalia alata* in NF and *S. wallichii*, *C. indica* and *Engelhardia spicata* in KF. Grazing was common in both forests. Forest fires were less common in recent years but were more frequent until 4–5 years back. Fallen branches, dead trees and live individuals of shrub species were collected for fuelwood. In KF the practice of thinning has been implemented at limited areas.

Sampling and data analysis
Household survey
We collected field data during October 2003. Using structured questionnaires, we surveyed 12 households (representing >10% of total) in each village. All ethnic groups and economic classes were proportionately represented in the samples. The survey focused particularly on the supply of fuelwood and fodder from farmland and forestland. The woody part of fodder left over by animals is also used as fuelwood; thus it was included in our survey. We determined the number of domestic animals per capita, per capita fuelwood consumption (kg/person/year), and proportion of total supply of tree (woody) fodder and fuelwood derived from forest and farmland.

Forest sampling
In view of the heterogeneous landscape, we chose to use relatively small quadrats of 10m x 10m. Each forest was divided vertically into halves and in each a single quadrat was laid out at altitude increments of 50m. We studied twelve quadrats in NF from 500 to 750 masl and 17 quadrats in KF from 500 to 950 masl. In KF a single quadrat was studied at each of 500, 550 and 950 masl due to the physical inaccessibility of potential sampling sites. We measured diameter at breast height (dbh, at 137 cm height), of all trees (dbh ≥10 cm), and we counted the number of saplings (≥20 cm height and <10 cm dbh) and individuals of shrub species. We did not record seedlings or herbs. We identified plants with the help of standard references (Stainton 1997, Polunin and Stainton 2000). The nomenclature follows DPR (2001). We calculated density (ha^{-1}), frequency (%), and basal area (m^2·ha^{-1}) of trees, as well as their relative values. Importance Value Index (IVI) was calculated as the sum of relative values of density, frequency and dominance (Zobel et al. 1987). Tree density and dbh classes (10–15 cm, 15–20 cm, 20–25 cm, etc.) of sal and *S. wallichii* were used to develop a size-class distribution diagram. Simpson's index of dominance (C) and the Shannon-Wiener index of species diversity (H') were calculated following Barbour et al. (1999). We compared the species diversity of the two forests (tree layer) using the Student t-test following Jayaraman (2000).

Results
Household survey
The average family size was six persons and the average number of domestic animals 12 per family in NF, and seven and 10.5 respectively in KF. Forest resources were being used for non-commercial and domestic purpose. The dependency of local people on forests for fuelwood and fodder had decreased in 50% of households, remained the same in 33% and increased in 17% as compared to 10 years prior to our study. The decrease in dependency, where it occurred, was due to reduced supply, restriction in use, reduced numbers of cattle, and installment of biogas and solar power facilities. Increased use of forest resources was related to increase in family size, increase in number of cattle, and decreased supply of fuelwood and fodder from farm land. The four preferred species for fuelwood were *Schima wallichii*, *Lagerstroemia parviflora*, *Adina cordifolia* and sal. People depended more on forest (63% of total supply) than farmland (37%) for fuelwood (**Table 1**). Per capita fuelwood consumption was 541/kg/person/year in NV and 388 kg/person/year in KV. Fuelwood was used for cooking (both for humans and animals) and for space heating. Generally, fuelwood was cut during February-March, sun-dried for a few weeks and stored in a dry place for use throughout the year. 95% of households used fuelwood for cooking and space heating, and 92% used kerosene

TABLE 1. Comparison of per capita domestic animals, and supply and types of fodder and fuel wood in two villages

Village	Per capita domestic animals	Fodder type (%)		Supply of tree fodder (%)		Per capita fuelwood consumption (kg/person/yr)	Supply of fuelwood (%)	
		Grass	Tree	Forest	Agri. land		Forest	Farm land
Namjung	2.15	50	50	39	61	541	58	42
Khari	1.63	48	52	29	71	388	68	32
Average	1.89	49	51	34	66	464.5	63	37

TABLE 2. Density (D, ha^{-1}), Basal Area (BA, m^2·ha^{-1}) and Importance Value Index (IVI) of tree species at Namjung Forest (NF) and Khari Forest (KF)

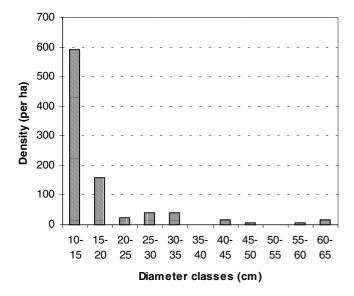| Name	Namjung Forest (NF)			Khari Forest (KF)		
	D	BA	IVI	D	BA	IVI
Shorea robusta Gaertn.	909	30.97	171.23	125	10.88	151.61
Schima wallichii (DC.) Korth.	108	8.27	45.63	84	3.5	92.21
Semecarpus anacardium L.f.	67	1.86	26.01	6	0.078	7.51
Terminalia alata Herne ex Roth	25	0.48	10.36	-	-	-
Syzygium cumini (L.) Skeels	17	0.49	7.31	6	0.078	7.51
Lagerstroemia parviflora Roxb.	17	0.22	6.69	-	-	-
Engelhardia spicata Leschen. ex Blume	17	0.48	4.69	12	0.127	14.85
Cleistocalyx operculatus (Roxb.) Merr. & Perry	17	0.25	6.78	6	0.047	7.31
Mangifera indica Linn.	17	2.07	10.65	6	0.73	11.72
Wendlandia sp.	17	0.19	4.08	6	0.047	7.31
Adina cordifolia (Wild. ex Roxb.) Benth. & Hook. f. ex Brandis	8	0.15	3.26	-	-	-
Castanopsis indica (Roxb.) Miq.	8	0.13	3.21	-	-	-
Total	1227	45.56	299.9	251	15.48	300

FIGURE 1. Density of different diameter classes of trees of *S. robusta* in Namjung forest
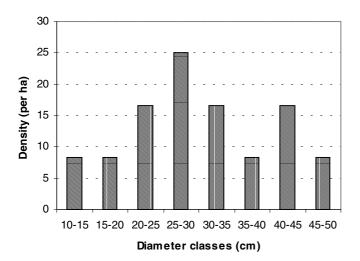

FIGURE 2 Density of different diameter classes of trees of *S. wallichii* in Namjung forest
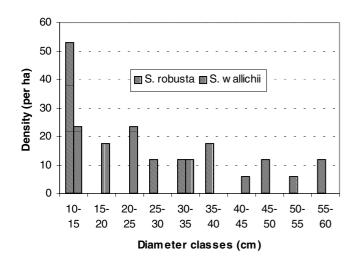

FIGURE 3 Density of different diameter classes of trees of *S. robusta* and *S. wallichii* in Khari forest

for lighting. Most of the households used the "improved stove," which significantly reduced fuelwood consumption. Alternative energy sources such as biogas and solar panels were not widespread: only 5% of the households used biogas and 8% solar power. Many households were facing problems in collecting fuelwood, but they had not installed biogas due to economic constraints and lack of technical know-how. Most, however, believed that the used of biogas was a good idea.

Every household kept domestic animals such as cow, buffalo, and goat. Per capita ownership of domestic animals (0.78) was higher than the national rate (CBS 2002). Due to the highly accidented landscape, buffaloes were kept at home on a permanent basis, while cows and goats were brought to nearby forest and grassland for grazing. As fodder, villagers used grasses (non-woody herbaceous fodder plants) and tree fodder in nearly equal amounts (**Table 1**). Farmland was the major source of tree fodder (66% of total supply). In the past, a greater proportion of fodder had been derived from the forest. Sal was the preferred tree for fodder, but use of this species as fodder was restricted after the inception of community management. People could harvest sal only by thinning in specified months.

Besides timber, fuelwood and fodder, people also used the leafy branches of *Castanopsis indica* for roofing, small trees of *Schima wallichii*, *Holoptelea integrifolia* and *Adina cordifoli*a as support (locally called *thakra*) in growing vegetables, medium sized trees of *S. wallichii* and sal for making plows, and leafy branches of *Engelhardia spicata* and *S. wallichii* as green manure and mulch. Black dye extracted from the bark of mature sal was used for painting doors, windows and verandas. Most of villagers were in favor of the current conservation practices, but some wanted more access to fodder plants such as sal.

Forests

Both forests were dominated by sal, with *S. wallichii* as co-dominant. In NF 12 species were recorded at tree stage (**Table 2**). Density ranged from 8 to 909 ha⁻¹, and basal area ranged from 0.13 to 30.97 m²·ha⁻¹. The total basal area of all tree species was 45.56 m²·ha⁻¹. Sal had the highest IVI (171), which was nearly four times higher than the IVI of the co-dominant species, *S wallichii* (46). Sal was fairly regenerating with a typical reverse-J-shaped size-class distribution (**Figure 1**). The sapling-to-tree ratio was 14:1, with sapling density at 12,642 ha⁻¹. The regeneration of *S. wallichii* was poor, as was reflected in the bell-shaped size-class distribution curve (**Figure 2**). The sapling-to-tree ratio was 1.23:1, and the sapling density was 133 ha⁻¹. In Khari Forest (KF), eight species were recorded in tree stage (dbh >10 cm, **Table 2**). The total basal area of all trees was 15.48 m²·ha⁻¹. KF trees are larger than NF, with average dbh of 30 cm (N = 19) and open canopy. The relative density of sal was 50% whereas that of *S. wallichii*, an important associate species, was 33.46%. Sal regeneration was discontinuous, with individuals not represented in dbh classes of 15–20 cm, 20–25 cm and 40–45 cm (**Figure 3**). Sapling density was 6383 ha⁻¹ (**Table 3**), and sapling-to-tree ratio was 51:1. *S. wallichii* appeared to be regenerating, but its density was very low (**Table 2**). Two dbh classes were absent from the population of *S. walichii* (**Figure 3**). Sapling density was 505 ha⁻¹ and sapling-to-tree ratio was 6:1. Seven tree species in NF and eleven in KF were represented only at the sapling stage (**Table 3**). There were six shrub species in NF and nine in KF (**Table 4**).

Forest fire, grazing and lopping were important pressures on both forests. Fire damage was followed by termite ➤

infestation. We observed saplings that had fallen due to fire damage and subsequent termite infestation. In KF tree felling was very frequent before the beginning of community management. Stumps were present in 65% of quadrats, up to five stumps in a single sample (10 m x 10 m). A total of 31 stumps were recorded (sal 21, *Schima wallichii* 7, *Castanopsis indica* 1, *Wendlandia* 1 and *Lyonia ovalifolia* 1). The total density of stumps was 182 ha^{-1}, which was more than the density of dominant tree (sal, 125 ha^{-1}).

Tree species richness was higher in NF than in KF (**Table 5**). The contribution of a single dominant species (sal) was much greater than other associated species (**Table 2**). Therefore, NF had a higher Simpson's index (C) but a lower Shannon-Wiener index (H') than KF. Despite the small number of tree species, KF had a significantly higher species diversity (t = 2.788, df = 470, p <0.01) due to high species evenness. KF also had high species diversity for shrubs.

Discussion

Use of forest resources

People in the study area depended on forest resources for their subsistence livelihood, primarily as a source of fuelwood and fodder. The contribution of these two forest resources (fuelwood and fodder) to Nepal's national income is significant (Katila 1995). A community forest, if managed on an equitable and sustainable basis, can satisfy these basic needs and improve the livelihood of rural people in Nepal (Maharjan 2003).

There was a wide difference between in two villages studied in per capita fuelwood consumption (**Table 1**). The higher rate in NV was due to the greater number of domestic animals per capita. A significant amount of fuelwood was consumed in cooking animal feed. People used to fell trees for fuel wood but in recent times this practice has been prohibited in the community forest. Woody parts of fodder not consumed by animals were an important source of fuelwood from the agricultural sector. Old and dying fodder trees on agricultural land were harvested for fuelwood. The amount of fuelwood derived from the forest had been decreasing, and people had been spending more time collecting fuelwood. People had been learning to use agricultural residues as fuel, and improved stoves had significantly reduced fuel wood consumption, but the forest was still the major source, supplying 63% of the total fuelwood (**Table 1**).

In comparison to the situation ten years ago, dependency on the forest for fodder and fuelwood has decreased in 50% of households. Extraction of these resources from the forest has decreased and the use of several preferred species has been restricted. This has forced people to grow more fodder trees on their private land, and to make better use of agricultural residues (e.g., the woody parts of fodder), which had not used until few decades back. Most of the villagers were aware that growing trees on agricultural land was useful for soil conservation and as a convenient source of fodder and fuelwood; nevertheless, due to the shortage of crop land, the practice is not common. Concerted efforts by government agencies and non-government organizations to provide support services integrating indigenous knowledge may motivate people to grow more trees on agricultural land (Paudel 2003), thereby reducing pressure on the forest.

S. wallichii was the preferred tree for fuelwood. Regeneration of this species was very poor and discontinuous in both forests (**Figure 2** and **3, Table 3**); this may be directly attributed to fuelwood extraction Unfortunately, use of fossil

TABLE 3. Sapling density (ha^{-1}) of trees in Namjung forest (NF) and Khari forest (KF)

Name	Density	
	NF	KF
Adina cordifolia (Wild. ex Roxb.) Benth. & Hook. f. ex Brandis	16	-
Antidesma acidum Retz. *	-	12
Bridelia retusa (L.) Spreng. *	-	6
Callicarpa vestita Wall. ex C.B. Clarke *	8	6
Castanopsis indica (Roxb.) Miq.	16	206
Cleistocalyx operculatus (Roxb.) Merr. & Perry	142	325
Engelhardia spicata Leschen. ex Blume	42	82
Holoptelea integrifolia (Roxb.) Planch. *	142	200
Kummo *#	24	71
Lagerstroemia parviflora Roxb.	92	59*
Lyonia ovalifolia (Wall.) Drude *	8	224
Mangifera indica Linn.	92	35
Phyllanthus emblica Linn. *	242	29
Schima wallichii (DC.) Korth.	133	505
Semecarpus anacardium L.f.	183	347
Shorea robusta Gaertn.	12642	6383
Syzygium cumini (L.) Skeels	84	12
Terminalia alata Herne ex Roth	160	71*
Terminalia belerica (Gaertn.) Roxb. *	16	-
Terminalia chebula Retz. *	8	6
Wendlandia sp.	317	706
Total	14367	9285

* Tree species represented only by saplings; # Local name

TABLE 4. Density (ha^{-1}) of Shrubs in Namjung forest (NF) and Khari forest (KF)

Name	Density	
	NF	KF
Ardisia solanacea Roxb.	-	247
Eurya acuminata DC.	-	35
Holarrhena pubescens (Buch.-Ham.) Wall. ex D.Don	36	-
Inula cappa Wall. ex DC.	-	212
Maesa macrophylla (Wall.) A. DC	-	53
Melastoma normale D.Don	9	167
Rhus javanica Linn.	318	188
Swida oblonga (Wall.) Sojak	191	935
Woodfordia fruticosa (L.) Kurz.	291	576
Zizyphus sp.	9	47
Total	854	2458

TABLE 5. Simpson's index (C) of dominance and Shannon-Wiener index (H') of species diversity for Namjung forest (NF) and Khari forests (KF)

Plant habit	C		H'	
	NF	KF	NF	KF
Tree	0.55	0.36	1.09	1.30
Shrub	0.30	0.22	1.28	1.98

fuels by rural people is neither economically feasible nor environmentally friendly. Efficient use of available agricultural residues through technical innovations may be a better solution to the problem of diminishing fuelwood supply. An improved wood energy system might help to mitigate climate change by reducing reliance on fossil fuels and sequestering CO_2 (the most important greenhouse gas) in growing trees (Heruela 2003). It would also result in significant foreign exchange saving for countries like Nepal. Alternatively, popularization of biogas and solar cells may reduce dependency on fuelwood.

Forest structure

The community structures of NF and KF were quite distinct in term of the contribution of dominant species and basal area cover. These two forests had an equal number (19) of tree species but seven species in NF and 11 in KF were found only in sapling stage (**Table 3**). Most of the species represented only in sapling stage do not yield high quality timber when they mature to tree, nor are they preferred for fodder or fuelwood. Since the initiation of community management, however, pressure on these species as a source of fodder and fuel wood has increased due to restrictions on the use of the preferred tree species.

The number of species forming tree canopy was high in NF but single dominant species (sal) had very high density and relative density (**Table 2**); therefore NF is developing into mono-dominant sal forest. Density of sal was higher than values reported for sal anywhere else in Nepal (Giri et al. 1999) or India (Negi et al. 2002). Basal area of sal (30.97 $m^2\times ha^{-1}$) and total basal area (45.56 $m^2\times ha^{-1}$) of all trees were also higher than in a Terai sal forest (Giri et al. 1999). However, individual sal trees were small, with average dbh of 18 cm (N = 113). A mono-dominant sal forest (relative density >70%) is particularly susceptible to the sal borer (*Hoplocerambyx spinicornis*) due to lack of ecological balance (Negi et al. 2002). We would recommend that the management of this forest be modified: thinning of sal and restraint in exploitation of other species such as *S. wallichii* can prevent the forest from progressing toward monodominant type.

Although sal was the dominant tree species in KF, its density (125 ha^{-1}) was very low in comparison to Giri et al. (1999) and Negi et al. (2002) and distribution was not uniform (frequency 41%). However, sapling density (**Table 3**) and sapling-to-tree ratio (51:1) for sal was high as compared to NF (14:1), indicating high regeneration potential. This forest may also develop into mono-dominant sal forest if the management practice is not changed.

Density and species richness of the shrub layer was higher in KF than in NF (**Table 4**), which appears to be due to the open canopy condition in former. Intense disturbance and excessive felling of trees in the past resulted in open canopy in KF, allowing the growth of large number of shrub species. Similarly, recent conservation efforts have resulted in a rapid increase in sapling density (**Table 3**) of tree species.

Despite the higher tree species richness in NF (**Table 2**), it has a lower species diversity (**Table 5**). The contribution to forest community of a single dominant species (sal) was very high while other species became rare. It appears that associated species have been over-exploited for sal conservation. Fifteen years of local management have preserved a forest but disturbed the natural ecosystem. KF, which has been conserved for four years, had a significantly higher species diversity (p<0.01) due to higher species evenness (i.e. more uniform distribution of relative density among the species). The decrease

in species diversity due to local extinction of less common species makes the ecosystem less stable. Ecosystem stability cannot be ensured merely by high species diversity, but diversity is certainly a prerequisite for ecosystem stability (Naeem and Li 1997, McCann 2000). Both of these forests had a lower species diversity than natural sal forests studied in India (e.g., Pandey and Shukla 1999, Shankar 2001). Therefore, conservation of species diversity should also be a priority of community forest management.

Regeneration

The reverse-J-shaped size-class distribution (**Figure 1**) of sal in the studied forests indicates sustainable regeneration (Vetaas 2000). The absence of certain larger dbh classes from the population was due to severe disturbance in the past before conservation. Forest conservation greatly increased the sapling density (**Table 3**) and sapling-to-tree ratio. Thus sal will continue to be the dominant species of these forests in future if the same management practice prevail. However, *S. wallichii*, the most important associate of sal in this forest, had a bell-shaped size-class distribution (**Figure 2**), which indicates the lack of sustainable regeneration (Vetaas 2000). Sapling density (**Table 4**), and sapling-to-tree ratios were very low. *S. wallichii* was the most preferred species for fuelwood; with the use of sal restricted, *S. wallichii* was also being harvested to meet timber needs. Finally, regeneration by coppice is weaker in *S. wallichii* than in sal. The combined effect of all these anthropogenic disturbances and inherent behavior has hampered the regeneration *S. wallichii* in NF.

The size-class distribution curve of sal in KF resembled neither a reversed J nor a bell shape (**Figure 3**). Since the lowest diameter class had the highest density, the regeneration potential was high, but regeneration had not been continuous in the past. The poor representation of two successive small-dbh classes might have been due to intense forest fires in successive years, which prevented seedling establishment and sapling recruitment and resulted in the discontinuous population structure of sal in KF. Recent management practice has rapidly increased the sapling density (**Table 3**). Within a few decades this forest may change into a dense forest with closed canopy. The canopy closure occurs at an exponential rate and the time required for full canopy closure depends on the type and magnitude of disturbance and on the species involved in regeneration (Valverde and Silvertown 1997); it may range from 8 to 40 years for tropical and temperate forest. The status of *S. wallichii* in KF was better than that in NF, with high sampling density (**Table 3**) and sapling-to-tree ratio, and good representation of small trees in the population (**Figure 3**). The forest had several moist sites, which are suitable for growth of *S. wallichii*. The open canopy also promoted sapling recruitment and tree growth at early stage.

The regeneration potential of sal was fairly high in both these forests, and regeneration was continuous in NF. The density of sapling and small trees has increased rapidly in recent years as the effect of community management. In Nepal, sustainable regeneration of sal has been reported from both Terai (Rautiainen 1996 and Giri et al. 1999) and the hills (Rai et al. 1999). However, regeneration was not sustainable in natural dense forest with a high density of larger trees (Rai et al. 1999). Sal has been facing a serious threat to its existence in the tropical and subtropical belts of India due to infestation by the sal borer (*Hoplocerambyx spinicornis*) and also to moisture stress caused by the combined effects of intensive grazing, ➤

repeated fire, lopping and indiscriminate harvesting (Negi et al. 2002). Mortality rates of seedling and smaller trees are high under these situations. The problems of stem borer and heart and root rot diseases have also been reported from a leasehold forest in Rupandehi of Nepal (Hartz 1999). Although the extent of damage was not serious, damage frequency and distribution have been increasing and that trend is likely to deteriorate in the future. The problem will be more serious if it spreads into community forests, which are evolving toward mono-dominance due to excessive removal of the unprotected plant species. As noted before, mono-dominant sal forest is more susceptible to sal borer attack (Negi et al. 2002) probably due to local extinction of borer's natural predators. Similarly, large-scale defoliation (>90%) of young sal leaves by red ants has been observed in a few community managed sal forests in Gorkha (Nepal) (personal observation, June 2005). This, obviously, has a negative impact on the growth and survival of individual trees and on the sustainability of the forest. However the community structure and insect-plant interactions in these forests have not been studied.

Conclusions

In comparison to the situation ten years ago, dependency on forests for fodder and fuelwood has decreased in 50% of households due to increased supply from non-forest lands, decrease in cattle number, and limited access to forest. Although fuelwood has been extracted from both forest and non-forest lands, forests were the major source (63%). Limited access to forest has encouraged people to use fuelwood from non-forest sources more efficiently. The trend showed that with technological innovations in fuelwood use, alternative energy (biogas and solar cell), and growth of more trees in non-forest lands, dependency on forests for fuelwood will decrease in the future. The regeneration potential of sal (*Shorea robusta* Gaertn.) was fairly high in both community forests, but community management in the NF and KF appears to be non-sustainable, as the species diversity has been decreasing. The present management practices may lead to the development of mono-dominant sal forests with insignificant contributions from other associated species. *Schima wallichii,* a multiple use plant, has become the most preferred tree species for fuelwood. Regeneration of this species was not sustainable and it has been overexploited for the sake of sal conservation. ∎

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