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Fuelwood Resources along an Altitudinal Gradient in the Central Part of Himachal Pradesh, Northwestern Himalaya

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ABSTRACT: In the mountainous region, still fuelwood is main source of energy especially for cooking, room and water heating etc. Information on species wise extraction and availability of fuelwood species is feebly available. Therefore, present study carried out to study diversity of fuelwood species, annual collection, preference along altitudinal gradient and availability of fuel species in the unprotected forests. Total sixty six species (40 trees and 26 shrubs) were extracted for fuel by the local peoples. A total collection was highest in lower altitudinal zone <1500m (17.4-17.6 kg household^{-1}day^{-1}) whereas minimum in higher zone (13.7-14.6 kg household^{-1}day^{-1}). In the lower altitudinal region (<1500m), Resource use index (RUI) was highest for *Quercus leucotrichophora* (417.2), followed by *Pinus roxburghii* (211.7) and *Rhododendron arboreum* (69.3). In the middle altitudinal zone (1500-2000 m), RUI was highest for *Quercus leucotrichophora* (675.4), followed by *Cedrus deodara* (57.2), *Pinus roxburghii* (57.0), and *Myrica esculenta* (56.8), however, RUI was highest for *Quercus leucotrichophora* (438.9), followed by *Picea smithiana* (416.0), *Pinus wallichiana* (97.2) *Rhododendron arboreum* (80.7) and *Quercus floribunda* (75.9) in the higher altitudinal zone (>2000m). Preferred species showed their availability in fairly large numbers of forest types but the population and regeneration status was poor. Therefore, immediate actions are suggested to sustain current and future demand of fuelwood. The afforestation of degraded, uncultivated and marginal lands through high quality and preferred fuel species might reduce pressure on wild and selective species.

Keywords: Firewood; altitudinal gradient; preference; communities; availability

INTRODUCTION

There are more than three million people living inside the India's protected areas and several million more outside with dependencies on these areas for essential services and goods, such as fuel, fodder and non-timber produce (Kothari, 1996). The relationship among native communities and plant wealth is strongly revealed by well-developed traditional health care practices and a variety of plant uses in ceremonies, routine household uses and trading for economic gain (Singh, 1999). Among these, fuelwood and fodder are two important and critical components of village economy especially in the hills. In the Himalaya, 76% of total natural resource needs are derived from forests and agroforestry systems, mainly because they are free, easy to access and simple to use (Chettri & Sharma, 2006). The growing commercial trade of natural products, in particular plant medicines and crafts, has resulted in the harvest of increasing volumes from wild plant populations (Lange, 1998) and has therefore generated concern about overexploitation (Tiwari, 2000). Furthermore, activities related to wild plants contribute to household incomes by providing employment opportunities and cash income from the sale of some of the products (Walter, 2001). Livelihoods dependent on gathered plants or their parts are threatened by the widely acknowledged on-going loss of plant diversity. This is especially true of wild plants found in human inhabited areas outside protected areas that are subject to high population pressure and various land use demands. These areas experience habitat degradation coming as a consequence of overgrazing, expanding crop agriculture and poor harvesting methods or logging (Kaimowitz et al., 2004). Furthermore, plants outside protected areas are routinely over-exploited. However, geological instability interacting with a complex of problems including human and livestock pressures, deforestation, landslide, soil erosion, water scarcity, infrastructure development, etc. have manifested the fragility of the Himalayan ecosystem (Valdiya, 1992). According to Bawa et al. (2004), over half of the world's poorest people living in environmentally fragile lands cannot sustain the livelihoods of their large and growing population.

Himachal Pradesh, one of the Himalayan States, is blessed with an unparalleled biodiversity which is difficult to find elsewhere in such a magnitude. It has a multitude of floral species to suit the local needs and site conditions. This treasure of useful raw materials has been exploited by the local people in a variety of ways. The local people mostly depend on biological resources for medicine, food/edible, fodder, fuel, timber, agricultural tools, fibre, dyes, aesthetic values and various other purposes. However, other sources of energy are being used by the local peoples but fuelwood is the chief source of energy for activities like culinary, water and space heating etc. Per capita annual consumption of wood in various parts of the Himalaya ranges between 400-1500 kg fresh weights which is very much higher than other parts of India (Campbell and Bhattarai 1984; Metz 1990; Straede and Treue 2006). Fuelwood consumption is highest (2.80 kg $capita^{-1}day^{-1}$) in areas above 2000 m altitude and decreases with decrease in altitude (Bhatt and Sachen 2004**).** Firewood consumption pattern (Rawat et al. 2009; Khuman et al. 2011) along altitudinal gradient (Bhatt and Sachan 2004; Kumar and Sharma 2009; Singh et al. 2010) has been reported in a part of the Himalaya. However, studies also attempt characterization of species for their energy values (Negi and Todaria 1993; Bhatt and Tomar 2002; Chettri and Sharma 2007; Bhatt et al. 2010) and firewood value index (Chhetri and Sharma 2009).

Inspite of the efforts of the above workers pressure use on plant diversity in unprotected forests is feebly studied especially their quantification. Species wise quantitative assessment of the fuel resources has not been done so far except in a few areas (Rana et al, 2012). Therefore, study has been focused to; (i) assess extraction trends of firewood along altitudinal gradient (ii) identify species preference along altitudinal gradient; (iii) assess the available stock of fuel species; and (iv) suggest strategies contributing to the management for conservation and sustainable use of fuel resources based on trend in CRKA

MATERIAL NAD METHODS

Study area: The study area falls in Himachal Himalayan region which is nestled within the North Western folds of the recently designated Global Biodiversity Hotspot of the Himalaya (Mittermeier *et al.,* 2004). The study area (31^0 27.79'-31^0 33.98'N Latitudes and 76^0 59.46'-77^0 03.21' E Longitudes) comprises the stretch of the district from Chail Chowk to Kamrunag *via* Ruhanda (Figure 1). The area covered is approximately 558 Km^2. It is a mountainous region with acute unevenness of terrain from 1300m *amsl* at Chail Chowk to 3050 m *amsl* at Kamrunag peak. The study area falls in Nachan and Suket forest divisions of Mandi district, which is bounded in the north by Kangra district, in the east by Kullu district, in the south by Shimla and Solan districts and in the west by Bilaspur and Hamirpur districts. The geology of the area comprises of Granite Gneiss, Leucogranite, Phyllite, Quartazenite, Minor Limestone, Pebbly Quartzite, Slate, Grit, Streaky and Banded Gneisses, and Schists. The climate is temperate with well marked three seasons *viz*., summer (mid April–mid June), rainy (monsoon) (mid June-September) and winter (October-March) seasons. The temperature ranges between -4^{o}C to 38^{o}C. Average annual rainfall was about 2734.2, 2355.6, 2236.2 mm/ year in 2006, 2007 and 2008, respectively. The vegetation comprises of sub-tropical, temperate and sub-alpine broad leaved and coniferous forests and supports a large number of sensitive biodiversity elements including medicinal and aromatic plants, wild edibles, rare, endangered, native, endemic and wild relatives of crop plants. Besides, the area is bestowed with varied landscape features that provide multitude of habitats to a diverse array of faunal types. The representative villages of the study area are Kaflu, Ratheri, Dhagwain, Matogalu, Kutachi, Sanjala, Badhu, Bharmot, Shillnu, Shakoor, Ruhanda and Khanad. Nomadic tribes like Gujjars and Gaddies also use the forest resources besides the local inhabitants. They use the higher reaches of Kamrunag area in summer.

Survey and selection of villages: Surveys were conducted in the 11 villages located at different altitude and dependent on the study area. It was observed that fuel wood collection starts at the end of September and finishes by the end of December, during winter and in March-April during summer. Based on these observations, it is assumed that on an average inhabitants collect fuel for about 90 days and considered it as total collection days (TCD) (Samant et al. 2000). It was observed after interviewing local peoples and surveys that on an average two individuals per household collect fuel during collection days.

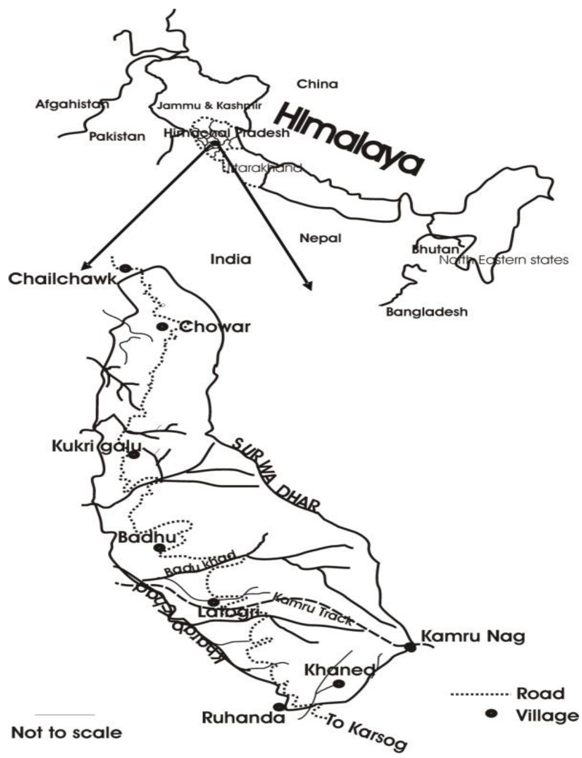

Figure 1: Map of the study area

Sampling and species identification: Village surveys were conducted in October to December in winter and March and April, summer to identify and quantify the fuel resource. The collection was brought in bundles (bogha) to the villages; twenty boghas were sampled in each village in each survey. Amount collected of each species segregated out of each bundle based on local names and weighed using a spring balance (Samant et al. 2000). Living samples (twig containing leaf and flowers) of each species designated by local name were collected with the help of local peoples which were later identified with the help of floras (Collett 1902; Dhaliwal and Sharma 1999; Singh and Rawat 2000). The data for fuel species were compiled for each village.

Data analysis: For individual species, quantum collection (kg household^{-1}day^{-1} and kg household^{-1} year^{-1}), probability of use (PU) indicating species preference and resource use index (RUI) indicating use pressure on species were calculated in each village following Samant et al. (2000).

Total species collection household^{-1}day^{-1} (C_d) = No of individuals household^{-1} responsible for collection x Mean collection (A)

Total collection of the species in all the samples (T)
Where, A = Total collection of the species in all the samples (T)
Number of samples (N)

$$\text{Probability of Use (PU)} = \frac{\sum_{i}^{n} F_i P_i}{\sum_{i}^{n} P_i}$$

Where, Fi= Frequency of collection of a species in the i^{th} village
Pi= Population of the i^{th} village

Resource Use Index (RUI) = Total species collection household^{-1}year^{-1} x PU

Similarity in fuelwood consumption among the villages was determined using Sorenson's Index of similarity (Muller-Dombois and Ellenberg 1974),

$$SI = \frac{2C}{A+B} \times 100$$

Where C=amount of fuel collection common in villages (A and B); A=collection of fuel in the village A, and B=collection of fuel in village, B

Since, similarity of fuelwood collection among villages was observed high and to represent a general scenario of the sanctuary data were pooled.

Phytosociological analysis: On the basis of results of above surveys, to know the current status and regeneration of fuel species in the study area phytosociological surveys were conducted during summer season in 2007 and 2008. It was observed that inhabitants collect fuel up to 2700 m altitude and within distance from 5 km from villages. Plots (each of 50x50 m) were selected and sampled within outreach of the inhabitants covering different habitats. Within each plot, 10 (10x10m) quadrats for trees, seedlings and saplings, each and 20 (5x5m) quadrats for shrubs were randomly laid. Number and dbh (diameter at breast height, 1.37m) for trees was recorded, based on which plants were considered as tree (dbh ≥ 10.1 cm), sapling (dbh 3.2-10.0 cm) and seedling (dbh <3.2 cm) (Saxena and Singh 1982). Density was calculated for trees, saplings and seedlings and relative density, relative basal cover and relative frequency were calculated only for trees. Importance Value Index was calculated for each plot (IVI=relative density + relative basal cover + relative frequency/300). Total 28 forest communities (25 trees and 3 shrubs) were identified based on importance value index and relative density. Density of each fuelwood species for each size class (i.e., tree, sapling and seedling) were analysed and figured only for communities represented ≥2 plots.

RESULTS AND DISCUSSION

Diversity of fuel resources: Sixty six (66) species (40 Trees and 26 Shrubs) were extracted for fuel by the inhabitants. Maximum species (37 spp.) were used in Kafloo village, followed by Matogalu (35 spp.), Ratheri (33 spp.), Shillnu (30 spp.), Badhu (27 spp.), Bharmot (26 spp.), Kutachi (23 spp.), Shakor (20 spp.), Sanjala (19 spp.), Rohanda (18 spp.) and Khanad (15 spp.) (Table 1). Species such as *Quercus leucotrichophora*, *Abies pindrow*, *Cedrus deodara*, *Pyrus pashia*, *Indigofera heterantha*, *Picea smithiana*, *Pinus wallichiana*, *Berberis lycium*, *Celtis australis* and *Desmodium elegans* were mostly used as fuel. However, along an altitudinal gradient maximum number (i.e. 52 species) in both lower and middle altitudinal zone, however only 24 species were used as fuel in higher altitudinal zone. Most of fuel species are also used for fodder, timber, agricultural implements and other purposes by the inhabitants.

Extraction trends of fuel species: A total collection was highest in lower altitudinal zone <1500m (range: 17.4-17.6 kg household^{-1}day^{-1}) whereas minimum in higher zone (range 13.7-14.6 kg household^{-1}day^{-1}) (Table 1). Among the species, total collection was highest for *Quercus leucotrichophora* (1065.0 kg household^{-1} year^{-1}), followed by *Pinus roxburghii* (690.0 kg household^{-1} year^{-1}), and *Myrica esculenta* (300.0 kg household^{-1} year^{-1}) in lower altitudinal zone.

In the middle altitudinal zone , total collection was highest for *Quercus leucotrichophora* (1418.4 kg household^{-1} year^{-1}), followed by *Rhododendron arboreum* (536.4 kg household^{-1} year^{-1}), and *Pinus wallichiana* (390.0 kg household^{-1} year^{-1}) however in higher altitudinal zone, it was highest for *Quercus leucotrichophora* and *Picea smithiana* (1047.0 kg household^{-1} year^{-1}, each), followed by *Pinus wallichiana* (390.0 kg household^{-1} year^{-1}), *Quercus floribunda* (339.0), and *Cedrus deodara* (336.0 kg household^{-1} year^{-1}) (Table 2).

Species preference:

In the lower altitudinal zone, the probability of use (PU) was highest for *Quercus leucotrichophora* (0.40), followed by *Pinus roxburghii* (0.30) and *Randia tetrasperma* (0.22). In the middle altitudinal zone, PU was highest for *Quercus leucotrichophora* (0.43), followed by *Pinus roxburghii* and *Rhododendron arboreum* (0.14, each), *Berebris lycium* and *Desmodium elegans* (0.13, each) *Cedrus deodara* (0.12) however, PU was highest for *Quercus leucotrichophora* (0.40), followed by *Picea smithiana* (0.38), *Desmodium elegans* (0.30), *Indigofera heterantha* (0.23) and *Pinus wallichiana* (0.22) in the higher altitudinal zone. The remaining species showed lesser than above values of PU (Table 2).

Use pressure: Resource Use Index (RUI)

In the lower altitudinal zone, RUI was highest for *Quercus leucotrichophora* (417.2), followed by *Pinus roxburghii* (211.7) and *Rhododendron arboreum* (69.3). In the middle altitudinal zone, RUI was highest for *Quercus leucotrichophora* (675.4), followed by *Cedrus deodara* (57.2), *Pinus roxburghii* (57.0), and *Myrica esculenta* (56.8) however, RUI was highest for *Quercus leucotrichophora* (438.9), followed by *Picea smithiana* (416.0), *Pinus wallichiana* (97.2) *Rhododendron arboreum* (80.7) and *Quercus floribunda* (75.9) in the higher altitudinal zone. The remaining species showed lesser than above values of RUI (Table 2).

Status of Fuel Species: The inhabitants of the villages are dependent on all the identified communities for fuel and fodder. Among the most preferred fuel tree species, *Quercus leucotrichophora* showed its presence in 20 communities, *Picea smithiana* in 10, *Pinus roxburghii* in 05 and *Rhododendron arboreum* in 16 communities. Among the shrub species, *Desmodium elegans* was found in 12, *Rhamnus virgatus* in 05 and *Berberis lycium* in 21 communities.

Among the preferred fuel tree species, *Quercus leucotrichophora* showed highest density in *Quercus leucotrichophora* community (252.5 trees ha^{-1}; 83.75 saplings ha^{-1} & 125.0 seedlings ha^{-1}), followed by *Quercus leucotrichophora-Cornus capitata* mixed (240.0 trees ha^{-1}; 150.0 saplings ha^{-1} & 140.0 seedlings ha^{-1}) and *Quercus leucotrichophora-Cornus macrophylla* mixed (200 trees ha^{-1}; 30.0 saplings ha^{-1} & 40.0 seedlings ha^{-1}) communities; *Picea smithiana* in *Picea smithiana* (236.3 trees ha^{-1} & 122.5 saplings ha^{-1} & 180.0 seedlings ha^{-1}) community, followed by *Abies pindrow- Picea smithiana* mixed (180.0 trees ha^{-1}; 50.0 saplings ha^{-1} & 90.0 seedlings ha^{-1}) and *Picea smithiana-Abies pindrow* mixed (170.0 trees ha^{-1} ; 40.0 saplings ha^{-1} & 100.0 seedlings ha^{-1}) communities; *Pinus roxburghii* in *Pinus roxburghii* (450.7 trees ha^{-1}; 57.9 saplings ha^{-1} & 120.0 seedlings ha^{-1}) community, followed by *Myrica esculenta-Quercus leucotrichophora* mixed (60.0 trees ha^{-1} & 160.0 seedlings ha^{-1}) communities, *Rhododendron arboreum* in *Rhododendron arboreum* community (440.0 trees ha^{-1}; 210.0 saplings ha^{-1} & 210.0 seedlings ha^{-1}), followed by *Quercus leucotrichophora* (153.8 trees ha^{-1}; 15.0 saplings ha^{-1} & 56.3 seedlings ha^{-1}) and *Quercus leucotrichophora-Cornus capitata* mixed (90.0 trees ha^{-1}; 100.0 saplings ha^{-1} & 400.0 seedlings ha^{-1}) communities (Fig. 5.3 a-q). Among the preferred shrub species, *Desmodium elegans* showed highest density in *Quercus leucotrichophora-Cornus macrophylla* mixed community (410.0 Ind ha^{-1}), followed by *Pinus wallichiana* (270.0 Ind ha^{-1}) community; *Rhamnus virgatus* in *Abies pindrow-Picea smithiana* mixed community (100.0 Ind ha^{-1}), followed by *Pinus wallichiana* (30.0 Ind ha^{-1}) community and *Berberis lycium* in *Berberis lycium-Spiraea canescens* mixed community (830.0 Ind ha^{-1}), followed by *Pinus wallichiana* (595.0 Ind ha^{-1}) community (Table 3).

In the hilly areas local inhabitants are dependent on fuel wood for day to day works cooking and warm their rooms to withstand the extreme winter. However, scenario has changed and is changing as compared to the decades or two back, in view of availability of other fuel resources such as LPG, coal and electricity etc. But still firewood is first preference of the inhabitants of the hilly regions due to severe winter condition, cheaper, easy to use especially of low income group. The present attempt has been made to identify utilization pattern, extraction trend of woody species, preference of the local inhabitant of fuel species under high use pressure and their population and regeneration status in the study area. Present study showed fuelwood collection/consumption by villagers between 13-17 kg household^{-1} day^{-1}. Average fuelwood Consumption/collection in the study area is comparative to the reported for Garhwal Hiamalaya (14.65 kg household^{-1} day^{-1}) by Awasthi et al. 2003 and (14.65 kg household^{-1} day^{-1}) by Bhatt et al. 1994 and but lesser than the reported for Kedarnath region (20-25 kg household^{-1} day^{-1}) by Singh et al. 2010; and (17-18 kg household^{-1} day^{-1}) Rana et. al. 2012. Comparatively High collection of dead as well as green fuel wood from forests in villages is due to harsh winter conditions.

Total 66 (40 Trees and 26 Shrubs) species were extracted as fuel by the inhabitants indicating sufficient options for the inhabitant as fuel resources as compared to other studies in higher altitude. This is due to higher diversity in the middle altitudinal range. *Quercus leucotrichophora* is highly preferred and collected in all the altitudinal zones of the study area. Other species preferred for extraction are *Pinus roxburghii, Rhododendron arboreum, Picea smithiana, Berberis lyceum, Desmodium elegans* and *Indigofera heterantha of* which preference varies in the altitudinal range due to availability in that altitudinal zone. High probability of use of these species also indicates high preference for fuel in the villages. These species are preferred as fuel because of different qualities e.g., hard wood, smokeless fire, easy ignition etc. that were observed and evinced by the local people after their use for a long time. Wood of some species such as *Quercus leucotrichphora*, *Rhododendron arboreum, Picea smithiana, Desmodium elegans*, etc. was highly preferred due to their hard wood which provides high energy and burn for longer time. These species also have multiple utility hence, it enhanced use pressure. Therefore, the proper management of these species is required.

The inhabitants were using >70% of native species as fuel with high extraction frequency. Such practices indirectly contribute high pressure on native species and relative protection of non-native species which in long term course may lead to increase in the number of non-native species. Status of species preferred and under high use pressure indicates poor regeneration in different forest communities in outreach of local inhabitants. Therefore, immediate measures are needed to improve the regeneration of fuel species by protecting from grazing and planting etc. in the forests to sustain present and future needs. The afforestation of degraded, uncultivated and marginal lands through high quality fuel species in the villages might reduce pressure on these species (Samant et al. 2000). Further, the energy value of these species also needed to be determined like in the Sikkim Himalaya (Chhetri and Sharma 2007) so that other option could be suggested to the inhabitants and pressure on some specific species could be reduced. In the recent past, electricity and cooking gas are made available in these villages. Still inhabitants have to rely on the woody species from the forests to meet their fuel demand particularly during winter. In protected areas a major source of fuelwood is dead wood created by natural disturbances or natural competition but for other areas it may be felling of living trees too.

Continuous and unscientific use of firewood since a long time has threatened its availability to the local people. Since the ancient time people of villages were close to the nature and they only themselves or through panchayats and committees manage the forests around their villages. No doubt they were using these resources but they also used to afforest and develop areas. But now attitude of people has changed they only use the resources but don't manage and totally dependent of forest department for its development and management. Since, fuel wood is still a preferred energy source in the mountainous region because of its simple use and cost free resource. Many families in the Himalayan region spend most of their time in a year to collect fuel wood and many are earning their livelihood by collecting and selling it. Therefore proper management of forests and plantation of preferred species in waste, marginal and degraded lands would not only benefit inhabitants but also help in conserving environment.

CONCLUSIONS

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Table 1: Human population statistics and number of fuel species extracted in the study area

Name of Village	Total Population	No. of Household	Population Responsible for Collection	No. of Fuel Species	Consumption Kg/hh/day
Lower zone (<1500 m)					
Kafloo	35	8	16	37	17.4-17.6 (17.5)
Ratheri	30	7	14	33	
Shillnu	25	5	10	30	
Middle zone (1500-2000 m)					
Bharmot	1000	100	200	26	15.3-18.6 (16.9)
Matogalu	90	20	40	35	
Badhu	250	50	100	27	
Kutachi	230	35	70	23	
Sanjala	30	14	28	19	
Higher Zone (>2000 m)					
Rohanda	225	45	90	18	13.7-14.6 (14.3)
Shakor	150	17	34	20	
Khanad	80	13	26	15	

Table 2: Total collection (TC), probability of use (PU) and resource use index (RUI) of the fuel species

Species	Local Name	TC/hh/year			RUI			PU		
		<1500m	1500-2000m	>2000m	<1500m	1500-2000m	>2000m	<1500m	1500-2000m	>2000m
Abies pindrow	Tosh	-	82.8	246.0	-	8.3	49.2	-	0.02	0.13
Albbizia lebbek	Siris	48.0	18.0	-	4.8	0.9	-	0.03	0.01	-
Bauhinia variegata	Ka-chnar	63.0	95.4	-	12.6	14.3	-	0.07	0.03	-
Berberis lycium	Kashmal	93.0	111.6	54.0	17.4	15.3	10.1	0.18	0.13	0.18
Bombax ceiba	Semal	108.0	-	-	10.8	-	-	0.03	-	-
Buddleja crispa	Snehli	12.0	3.6	-	1.2	0.2	-	0.03	0.01	-
Buxus wallichiana	Sham-shad	27.0	-	-	6.8	-	-	0.08	-	-
Carissa opaca	Garne	63.0	14.4	-	6.3	0.7	-	0.07	0.01	-
Cedrus deodara	Deodar	225.0	349.2	336.0	46.5	57.2	65.4	0.13	0.12	0.17
Celtis australis	Kharik	168.0	108.0	165.0	30.0	7.6	25.2	0.15	0.06	0.15
Coriaria nepalensis	Phanai	57.0	27.0	-	5.7	2.7	-	0.07	0.02	-
Cornus macrophylla	Khrembal	93.0	190.8	-	32.6	17.5	-	0.12	0.05	-
Cotoneaster bacil-laris	Rhiunsh	33.0	-	9.0	3.3	-	0.9	0.07	-	0.03
Daphniphyllum himalayense	Kaula	-	64.8	-	-	6.5	-	-	0.02	-
Debregeasia salici-folia	Siaru	39.0	-	-	3.9	-	-	0.03	-	-
Debregeasia longi-	Siaru	81.0	59.4	-	11.7	5.3	-	0.10	0.05	-

folia										
Desmodium elegans	Chagla	93.0	129.6	126.0	18.9	18.9	38.4	0.17	0.13	0.30
Deutzia staminea	Brudi	51.0	25.2	-	17.9	2.5	-	0.12	0.02	-
Elaeagnus parviflo-ra	Giai	42.0	18.0	-	6.9	0.9	-	0.10	0.02	-
Ficus nemoralis	Dudhla	108.0	61.2	-	14.4	6.8	-	0.10	0.04	-
Ficus palmate	Fegra	141.0	27.0	-	22.2	1.4	-	0.17	0.02	-
Ficus roxburghii	Tremal	138.0	210.6	-	11.3	31.6	-	0.05	0.06	-
Flemingia semiala-ta	-	45.0	9.0	-	4.5	0.5	-	0.03	0.01	-
Flemingia strobilif-era	-	51.0	-	-	4.2	-	-	0.05	-	-
Glochidion veluti-num	Sa-lambra	39.0	7.2	-	3.9	0.4	-	0.07	0.01	-
Grewia oppositifo-lia	Bihul	141.0	172.8	-	15.5	25.3	-	0.12	0.09	-
Ilex dipyrena	Tarkuc h	-	-	111.0	-	-	11.1	-	-	0.07
Indigofera heteren-tha	Kali kathi	96.0	68.4	90.0	19.1	6.8	20.7	0.15	0.08	0.23
Juglans regia	Akhrot	66.0	30.6	42.0	5.4	3.2	6.3	0.05	0.04	0.05
Lonicera quin-quoqularis	Jamnu	57.0	73.8	-	22.8	8.5	-	0.13	0.06	-
Lyonia ovalifolia	Airean	18.0	70.2	-	0.9	10.8	-	0.02	0.05	-
Morus alba	Shah-tut	69.0	-	-	6.9	-	-	0.03	-	-
Morus serrate	Chem mu	153.0	127.8	48.0	29.1	8.6	3.8	0.13	0.05	0.05
Myrica esculenta	Kaphal	300.0	390.6	-	59.1	56.8	-	0.18	0.12	-
Neolitsea pallens	Paror	-	57.6	135.0	-	11.5	40.5	-	0.04	0.10
Persia duthei	Badrol	-	-	6.0	-	-	0.3	-	-	0.02
Persia gamblei	Badrol	141.0	45.0	-	49.4	2.3	-	0.12	0.01	-
Picea smithiana	Rai	-	187.2	1047. 0	-	18.7	416.0	-	0.04	0.38
Pinus roxburghii	Chir	690.0	293.4	-	211.7	57.0	-	0.30	0.14	-
Pinus wallichiana	Kail	186.0	264.6	390.0	43.1	53.5	97.2	0.12	0.10	0.22
Pistacia integerri-ma	Kakare	51.0	16.2	33.0	5.1	0.8	1.7	0.03	0.01	0.02
Populus ciliata	Popu-lous	54.0	37.8	-	5.4	3.4	-	0.03	0.03	-
Prinsepia utilis	Bhek-hal	69.0	79.2	39.0	8.6	9.7	4.7	0.07	0.07	0.10
Prunus cerasoides	Paja	57.0	41.4	-	13.2	3.1	-	0.15	0.05	-
Prunus cornuta	Jammu	-	68.4	153.0	-	10.8	33.5	-	0.06	0.20
Pyrus pashia	Kainth	84.0	147.6	69.0	22.4	14.0	9.6	0.17	0.09	0.08
Quercus floribunda	Mohru	-	-	339.0	-	-	75.9	-	-	0.15
Quercus glauca	Banni	327.0	-	-	57.0	-	-	0.12	-	-

Quercus leuchotri-cophora	Ban	1065.0	1418.4	1047.0	417.2	675.4	438.9	0.40	0.43	0.40
Quercus semecarpi-folia	Kha-rashu	-	-	189.0	-	-	31.1	-	-	0.08
Randia tetrasperma	Jhagduga	105.0	19.8	-	30.6	1.7	-	0.22	0.03	-
Rhamnus virgatus	Chathau	96.0	66.6	183.0	12.8	6.4	41.1	0.08	0.04	0.20
Rhododendron arboreum	Brass	288.0	536.4	279.0	69.3	78.0	80.7	0.15	0.14	0.13
Rhus cotinus	Chulli	93.0	79.2	-	17.3	11.0	-	0.15	0.06	-
Robinia pseudoaca-cia	Robin-ia	-	21.6	-	-	1.1	-	-	0.01	-
Rosa moschata	Kuja	36.0	14.4	-	4.8	1.4	-	0.08	0.02	-
Rubus ellipticus	Akha	45.0	34.2	-	9.6	3.1	-	0.15	0.05	-
Rubus paniculatus	Akha	-	5.4	-	-	0.3	-	-	0.01	-
Salix tetrasperma	Biunsh	45.0	54.0	-	4.5	3.8	-	0.03	0.04	-
Sorbaria tomentosa	-	21.0	-	-	1.1	-	-	0.02	-	-
Symplocos chinen-sis	Lodge	-	25.2	-	-	2.5	-	-	0.02	-
Toona serrate	Dhar-lin	105.0	59.4	-	11.6	3.0	-	0.08	0.03	-
Viburnum cotoni-folium	Dab	54.0	70.2	-	21.6	8.2	-	0.13	0.06	-
Viburnum nervosum	Thile-nal	-	-	72.0	-	-	18.0	-	-	0.08
Vitex negundo	Banah	81.0	10.8	-	18.3	1.1	-	0.13	0.02	-

Table 3. Status (Ind ha^{-1}) of shrubs used as fuel in the identified forest communities in the Study area

	Community Type																											
Taxa	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**S1**	**S2**	**S3**
Aechmanthera gossy-	46.	-	-	-	-	-	-	70.	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-
*Berberis lycium****	29	160	141	450	22	28	44	30.	20	-	30	-	24	-	28	70.	113	10.	59	-	-	20.	-	20.	830.	-	3.1	4.0
Boehmeria platyphyl-	2.1	10.	6.1	-	-	11	70	-	17	-	-	-	56	-	90.	-	36.	-	-	-	-	-	-	-	-	-	23.	-
*Buddleja crispa****	13.	-	13.	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	50.0	-	-	-
*Carissa opaca****	40.	30.	-	-	30.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coriaria nepa-	2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cotoneaster bacil-	50.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-
Cotoneaster micro-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.3	-	15.	-	60.	70.	30.	-	300.	-	-	-
Debregeasia salicifo-	10.	-	-	-	-	-	-	20.	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Desmodium ele-	32.	-	98.	35.	-	11	-	40.	-	60.	10	-	16	16	-	-	20.	41	27	-	-	-	-	-	-	-	-	-
*Deutzia corymbosa***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.	8.0
*Deutzia staminea****	-	-	36.	-	-	-	-	-	-	30.	-	80	10	-	-	-	8.8	34	35.	-	-	40.	-	-	-	-	33.	62.
Elaeagnus parvifo-	-	-	21.	25.	-	18	-	-	50	-	10	-	-	-	-	-	-	-	35.	-	-	-	-	-	-	-	-	-
*Ficus sarmentosa***	5.0	-	-	-	-	-	-	-	-	60.	-	30	23	-	-	-	-	20.	-	-	-	-	-	-	-	-	-	-
Flemingia semiala-	13	55.	7.8	-	-	-	-	-	-	-	-	-	6.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flemingia strobilif-	14.	225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glochidion veluti-	24	170	25.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
*Hedera nepalensis***	-	25.	11.1	45.	-	-	-	-	70	70.	30	18	6.	50	20.	-	33.	80.	-	40.	-	-	16	80.	-	12	4.6	18.
Indigofera heteran-	88.	60.	132	65.	-	14	13	20.	51	20.	25	-	6.	20	14	-	-	60.	20	-	30	140	65.	80.	20.0	-	-	36.

Lonicera quinquelocu-		-	-	15.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.	-	-	-	-	-	-	70.	-	-
Parthenocissus semi-	12.	230	76.	45.	-	-	40	-	-	70.	-	-	12	13	-	-	7.5	50.	-	-	-	-	-	-	-	-	0.8	-
*Prinsepia utilis****	-	-	27.	-	-	32	-	-	37	-	-	-	33	-	20	-	17.	-	20.	60.	-	260	17.	-	-	-	-	-
*Randia tetrasperma**	19	190	113.	195	-	-	-	-	10	-	-	-	23	60	-	-	-	50.	-	-	-	-	-	-	-	-	-	-
*Reinwardtia indica***	8.6	60.	14.	-	-	-	-	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhamnus purpureus	17.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhamnus triqueter	-	-	8.9	50.	-	-	-	-	-	40.	-	-	43	60	-	-	-	70.	-	-	-	-	-	-	-	-	-	-
*Rhamnus virgatus****	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.	-	30.	-	-	-	-	-	-	10	6.2	-
*Rhus cotinus****	14	50.	17.	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosa macrophylla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.	-	-	-	-	-	-	-	-	-	-	-
*Rosa moschata****	57.	30.	24.	40.	50.	18	-	110	24	60.	11	-	46	90	-	-	11.	12	11	70.	-	-	-	-	-	30.	-	4.0
*Rubus ellipticus***	41	270	57.	25.	17	38	90	120	-	-	-	-	26	-	-	-	-	-	20	80.	-	-	-	-	-	-	-	24.
*Rubus paniculatus****	0.7	35.	-	-	-	-	-	-	-	-	10	60	-	-	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-
Sinarundinaria falca-	-	-	-	-	-	-	-	-	-	100	-	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	-
Sorbaria tomento-	-	-	-	-	-	-	-	-	80	70.	-	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-
*Spiraea canescens***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85.	-	-	-	-	750	-	60.	560.	-	19.	-
Viburnum cotinifoli-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.	-	-	-	-	-	-	-	-	13	15	-
*Viburnum nervosum**	-	15.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.	-	-	-	-	-	-	-	-
*Vitex negundo**	19.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Abbreviations Used: *****=Fuel; ******=Fodder; and *******=Fuel & Fodder

Communities: A=*Pinus roxburghii*; B=*Myrica esculenta*; C=*Quercus leucotrichophora*; D=*Quercus leucotrichophora-Rhododendron arboreum* mixed; E=*Myrica esculenta-Quercus leucotrichophora* mixed; F=*Alnus nitida*; G=*Cornus capitata*; H= *Quercus leucotrichophora-Daphniphyllum himalayense* mixed; I=*Cornus macrophylla-Neolitsea pallens-Rhododendron arboreum*; J=*Quercus leucotrichophora-Cornus capitata* mixed; K= *Neolitsea pallens-Quercus leucotrichophora* mixed; L= *Cedrus deodara*; M=*Neolitsea pallens-Cedrus deodara* mixed; N=*Neolitsea pallens-Alnus nitida* mixed; O=*Rhododendron arboreum*; P=*Picea smithiana*; Q=*Quercus leucotrichophora-Cornus macrophylla* mixed; R=*Pinus wallichiana*; S=*Picea smithiana-Abies pindrow* mixed; T= *Quercus floribunda-Quercus leucotrichophora* mixed; U=*Quercus floribunda*; V=*Neolitsea pallens*; W=*Abies pindrow-Picea smithiana* mixed; X=*Abies pindrow*; Y=*Quercus semecarpifolia;* S1=*Rubus ellipticus-Rosa moschata-Aechmanthera gossypina* mixed; S2=*Spiraea canescens-Berberis aristata* mixed; S3=*Berberis lycium-spiraea canescens* mixed

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