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Extraction, Utilization Pattern and Prioritization of Fuel Resources for Conservation in Manali Wildlife Sanctuary, Northwestern Himalaya

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Abstract: Fuelwood is the main source of the energy in mountainous regions. Hence, annual wood consumption is very high. Information on fuelwood resources, and their extraction and availability is very scanty. Therefore, present study was carried out to study the diversity of fuelwood species, annual collection, preference and availability of fuel species in the forests. Thirty four species (25 trees and 9 shrubs) were extracted for fuel by the inhabitants. Total collection and species preference was highest for *Picea smithiana*, *Cedrus deodara*, *Indigofera heterantha, Pinus wallchiana* and *Sorbaria tomentosa,* respectively. Resource use index indicating use pressure was highest for *P. smithiana*, *C. deodara*, *I. heterantha* and *Abies pindrow*, respectively. Besides native species, some non-native horticultural and agroforestry species such as *Malus pumila*, *P. domestica*, *Celtis australis,* etc. were also being used as fuel. Preferred species showed their availability in eight forest types whereas, 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.

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Keyword: Fuelwood; Resource Use Index; Communities; Conservation

Introduction

The large scale extraction of the forest resources from the natural habitats as fuelwood (220 m tonnes), fodder (250 m tonnes), timber (12 million m^3) and other forest products (approximately 1,700 m tonnes) annually has resulted in depletion of natural resources (Mukherjee 1994; Tewari and Campbell 1995). No doubt that fuelwood demand is not increasing at the rate estimated earlier in 1980s and consumption is also in decline, but increase in demand and consumption in rural areas is still valid (Arnold et al. 2003). Approximately 275 million people in rural India are dependent on forests for at least a portion of their income (World Bank 2006). Whereas in the Himalayan region dependency for major resources is still on forests due to easy access and simple use (Sundriyal and Sharma 1996; Chettri et al. 2002). Per capita annual consumption of wood in various parts of the Himalaya ranges between 400-1,500 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 2,000 m altitude and decreases with decrease in altitude (Bhatt and Sachen 2004). Still fuelwood is the chief energy source for activities like culinary, water and space heating etc..

Exponential rise in human and livestock population caused enormous pressure on forest land and resulting in resource degradation and depletion. Vulnerability of resources particularly fuelwood is subjected to selective use, over exploitation and bad management practices (Sundriyal and Sharma 1996; Chettri et al. 2002). Total 3000 species (20% of total) yield non timber forest products (NTFPs) in India and only 126 species have been commercially developed (Maithani 1994). Only preferred species are collected regardless of their availability for fuelwood and other uses, which is causing high pressure on a small group of plants. Firewood consumption pattern (Rawat et al. 2009; Khuman et al. 2011) along altitudinal gradient (Bhatt and Sachan 2004; Singh et al. 2009) has been reported in a part of the Himalaya. However, studies also attempt characterization of species for their energy values (Negi and Todaria 1993; Chettri and Sharma 2007; Bhatt et al. 2010) and firewood value index (Chhetri and Sharma 2009). The equilibrium between biodiversity protection and natural resource consumption has become a challenge for most developing countries (Millenium Ecosystem Assessment 2005). The condition is unobtrusive particularly in fragile Himalayan ecosystem, which is facing large-scale deforestation and soil erosion. Therefore, it is essential to quantify extraction of fuel resources in order to estimate the impact of fuel extraction on the vegetation and may also be used in proper management of protected and unprotected forests. Such information on the existing fuelwood resources, and their quantum extraction and availability is very scanty. Therefore, present paper focuses on i) diversity and utilization pattern of fuel species; ii) annual collection assessment; iii) species preference and use pressure; iv) availability of fuel species in the forests, and suggests conservation strategies based on observed trends in Manali Wildlife Sanctuary of the Himachal Pradesh in Northwestern Himalaya.

1 Study Area

Manali Wildlife Sanctuary (32°13' to 32° 15'N Latitudes and 77°05' to 77°10' E Longitudes) is located in the North of Kullu District in Himachal Pradesh. The Sanctuary was notified on 26 February, 1954 under the Punjab Birds and Wild Animals Protection Act, 1933 (Gulati et al. 2004). But effective wildlife management was initiated after the creation of a separate wildlife division in Kullu in 1984. The wildlife sanctuary covers an area of 29.03 km^2 with an altitudinal range of 2030-5,865 m asl. The vegetation mainly comprises of temperate, sub-alpine and alpine types. Climatically, the area is unique, the temperature ranges between -4°C to 30°C and mean annual rainfall is 1,080 mm. The inhabitants residing in the periphery of the sanctuary are dependent on the sanctuary for forest products including medicinal, wild edible plants, fuel, fodder, livestock grazing and various other purposes.

2 Methods

2.1 Survey and selection of villages

During the survey it was observed that four villages namely Manali, Dhungari, Nasogi and Banaun located in the surrounding area were dependent on the sanctuary for fuelwood collection, hence, selected for the quantification and utilization pattern of the fuel species. It was observed that fuel wood is collected in the months of April, September, October and November. Based on the observations, it is assumed that on an average inhabitants collect fuel for about 90 days and it is considered as total collection days (TCD) (Samant et al. 2000). It was observed after interviewing local people and conducting survey that on an average two individual per household collect fuel during collection days.

2.2 Sampling and species identification

Village survey was conducted in November and December, 2005 and March and April, 2006 to identify and quantify the fuel resource. The wood collection was brought in bundles (bogha) to the villages; twenty boghas were sampled in each village in each survey. Collected amount of each species segregated out of each bundle based on local names and then 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 people, and 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.

2.3 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 × Mean collection (A). Where, $A = \frac{T}{N}$ (T = Total collection of the species in all the samples, N = Number of samples).

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

where, Fi is frequency of collection of a species in the i^{th} village and Pi is population of the i^{th} village.

RUI = Total species collection household^{-1} year^{-1} × PU

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

$$\text{Similarity Index}(\text{SI}) = \frac{2C}{A+B} \times 100$$

where C=amount of fuel collection common in villages (A and B); A=collection of fuel in 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 pooled.

2.4 Phytosociological analysis

In order to know the current status and regeneration of fuel species in the sanctuary, phytosociological surveys were conducted on the basis of the survey results during summer season in 2006 and 2007. It was observed that inhabitants collect fuel up to 2,700m altitude and within distance from 5 km from villages. Plots (each of 50 × 50 m) were selected and sampled within outreach of the inhabitants covering different habitats. Within each plot, 10 (10 × 10m) quadrats for trees, seedlings and saplings, each and 20 (5 × 5m) quadrats for shrubs were randomly laid. Number and dbh (diameter at breast height, 1.37 m) 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 21 forest communities (18 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. Species found in only single plot is not included for the analysis.

3 Results

3.1 Diversity of fuel resources

Thirty four species (25 trees and 9 shrubs) were extracted for fuel by the inhabitants. Maximum number of species (33 spp., each) were used in Manali and Nasogi villages, followed by Dhungari (31 spp.) and Banaun (27 spp) (Table 1). *Picea smithiana* (Rai), *Cedrus deodara* (Devdar), *Indigofera heterantha* (Kali kathi), *Pinus wallichiana* (Kail), *Aesculus indica* (Khanor), *Abies pindrow* (Tosh), *Sorbaria tomentosa* (Shain), *Alnus nitida* (Kosh), *Desmodium elegans* (Safed kathi) etc. were mostly used as fuel. Horticultural species such as *Malus pumila* was also a major contributor of the fuel resource. Out of total, 25 species were native and 13 were endemic to the Himalayan region. Most fuel species are also used for fodder, timber, agricultural implements and other purposes by the inhabitants (Table 2).

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

Villages	Altitude (m)	Population	Households	Population for fuel collection	No. of fuel species
Manali	2000	1,564	493	986	33
Dhungri	2050	280	59	118	31
Nasogi	2100	498	115	230	33
Banaun	2100	35	5	10	27

3.2 Extraction trends of fuel species

The total collection among villages did not vary (6,237-6,498 kg household^{-1} year^{-1}) significantly. Among the species, the highest collection is for *Picea smithiana* (1,351.1 kg household^{-1} year^{-1}), followed by *Cedrus deodara* (1,347 kg household^{-1} year^{-1}), *Indigofera heterantha* (528.0 kg household^{-1} year^{-1}) and *Malus pumila* (411.0 kg household^{-1} year^{-1}) (Table 3). Similarity analysis of species extraction shows high similarity among villages (Table 4).

3.3 Species preference: PU

PU was highest for *Picea smithiana* (0.51), followed by *Cedrus deodara* (0.49), *Indigofera heterantha* (0.30), *Pinus wallichiana* (0.27) and *Sorbaria tomentosa* (0.23). The remaining species showed < 0.23 PU (Table 3).

3.4 Use pressure: RUI

RUI ranged from 0.20-711.2. It was highest for *Picea smithiana* (711.2), followed by *Cedrus deodara* (669.3), *Indigofera heterantha* (180.5) and *Abies pindrow* (84.9). The remaining species showed RUI <84.9 (Table 3).

3.5 Status of fuel species

Considering the density distribution in different size classes as an indicator of the availability and status of fuelwood species, distribution charts of trees, sapling and seedlings among different communities were prepared (Figure 1). Out of the total fuel species, 7 species (i.e., *Malus pumila, Pyrus communis, Prunus domestica, Prunus avium, Ulmus wallichiana, Morus serrata* and *Robinia pseudoacacia*) were collected from agroforestry system thus not found in the forest communities.

Among the most preferred fuel tree species, *Picea smithiana* showed its presence in 6 communities, *Cedrus deodara* and *Aesculus indica* in 5 communities, respectively, *Pinus wallichiana* in 3 and shrubs, *Desmodium elegans* in 9, *Indigofera heterantha* in 7, *Sorbaria tomentosa* in 5 communities.

Picea smithiana (Rai) showed highest density in *Picea smithiana* (143 trees ha^{-1}; 46.7 saplings ha^{-1} and 38.3 seedlings ha^{-1}), *Cedrus deodara* (68.3 trees ha^{-1}; 6.7 saplings ha^{-1} and 290.0 seedlings ha^{-1}) and *Pinus wallichiana* (56.7 trees ha^{-1}; 60.0 saplings ha^{-1} and 66.7 seedlings ha^{-1}) communities (Figure 1 b, d, e); *Cedrus deodara* (Devdar) showed availability in *Cedrus deodara* (385 trees ha^{-1}; 10.0 saplings ha^{-1} and 106.7 seedlings ha^{-1}) and *Pinus wallichiana* (33.3 trees ha^{-1}; 26.7 saplings ha^{-1} and 43.3 seedlings ha^{-1}) communities (Figure 1 d, e); *Pinus wallichiana* (Kail) in *Pinus wallichiana* community (443.3 trees ha^{-1}; 210.0 saplings ha^{-1} and 220.0 seedlings ha^{-1}) (Figure 1e); and *Aesculus indica* (Khanor) in *Aesculus indica-Acer caesium* mixed community (190.0 trees ha^{-1}; 15.0 saplings ha^{-1} and 90.0 seedlings ha^{-1}) and *Aesculus indica* communities (150.0 trees ha^{-1}; 35.0 saplings ha^{-1} and 100.0 seedlings ha^{-1}) (Figure 1 c, h).

Among the preferred shrub species, *Indigofera heterantha* (Kali kathi) showed highest availability in *Pinus wallichiana* community (607.0 Ind ha^{-1}) and *Picea smithiana* (550.0 Ind ha^{-1}) and *Berberis lycium* (500 Ind ha^{-1}) communities; and *Sorbaria tomentosa* (Shain) in *Picea smithiana* community (332.0 Ind ha^{-1}) (Table 5).

4 Discussion

Fuelwood is one of the daily needs of inhabitants for cooking and warming their rooms in the mountainous region. Woody species from the forests are collected by the local inhabitants including those in the protected areas. Increasing human population and other developmental

Table 2 Diversity, preference, nativity, dominant associates and other uses of the fuel species

Taxa	Preference	Nativity	Dominant associates	Other uses
Picea smithiana (Wall.) Boiss*	1	Reg Himal	*Abies pindrow, Cedrus deodara,*	Ti, Misc
Cedrus deodara G.Don*	2	Reg Himal	*Abies pindrow, Picea smithiana, Pinus wallichiana*	Ti, Md
Indigofera heterentha Wall. ex Baker*	3	Reg Himal	*Abies pindrow, Picea smithiana, Aesculus indica*	Fd
Pinus wallichiana A.B. Jack*	4	Reg Himal	*Cedrus deodara, Quercus floribunda*	Md, Ti, Misc
Aeasculus indica Colber. ex Camb.*	5	Reg Himal	*Abies pindrow, Cedrus deodara, Acer caesium*	Md, Fd, Ed
Abies pindrow Royle*	6	Reg Himal	*Picea smithiana, Cedrus deodara, Acer caesium*	M, Ti, Misc
Sorbaria tomentosa (Lindl.) Rehder	7	Reg Himal As Bor	*Abies pindrow, Picea smthiana Cedrus deodara, Pinus wallichiana*	Fd
Malus pumila Mill.	8	Reg Himal Europe As Bor	-	Ed
Alnus nitida (Spach) Endl.*	9	Reg Himal	*Cedrus deodara, Pinus wallchiana*	Fd, Fz
Desmodium elegans DC.	10	Reg Himal Burma	*Abies pindrow, Picea smithiana, Pinus wallichiana, Aesculus indica*	Fd
Prunus cornuta (Wall.ex Royle) Steud.	11	Europe As Bor	*Aesculus indica, Acer caesium*	Fd, Ed
Quercus floribunda Lindl.*	12	Reg Himal	*Cedrus deodara, Pinus wallchiana*	Fd
Populus ciliata Wall. ex Royle	13	Reg Himal	*Alnus nitida*	Fd
Prunus armeniaca L.	14	Reg Cauc	*Quercus floribunda*	Fd, Ed
Berberis lycium Royle*	15	Reg Himal	*Picea smithiana, Cedrus deodara, Pinus wallichiana*	Md, Ed, Fd
Salix daphnoides Willd.	16	Europe As Bor	*Alnus nitida, Quercus floribunda*	Fd,
Juglans regia L.*	17	As Reg Himal	*Abies pindrow, Cedrus deodara, Aesculus indica*	Ti, Md, Ed
Pyrus pashia Buch.-Ham. ex D.Don	18	Reg Himal	*Quercus floribnda*	Fd,
Viburnum cotinifolium D. Don	19	Reg Himal	*Abies pindrow, Picea smthiana Cedrus deodara*	Md, Ed, Fd
Robinia pseudo-acacia L.	20	Am Bor	-	Fd
Cotoneaster bacillaris Wall. ex Lindl.	21	Reg Himal	*Abies pindrow, Picea smthiana Pinus wallchiana, Aesculus indica*	Fd, Ag tls
Prunus domestica L.	22	Europe Reg Cauc	-	Ed
Ulmus villosa Brandis ex Gamble	23	Europe As Bor	*Alnus nitida, Acer acuminatum, Juglans regia*	Fd
Prinsepia utilis Royle	24	Reg Himal	*Cedrus deodara, Pinus wallichiana*	Md, Ed
Symplocos paniculata Miq.	25	Japan	*Alnus nitida, Acer caesium*	Fd
Prunus avium L.	26	Reg Himal	-	Ed
Ulmus wallichiana Planch.*	27	Ind Or	-	Md, Rg, Fd
Morus serrata Roxb.*	28	Reg Himal	-	Fd
Pyrus communis L.	29	Reg Himal Europe As Bor	-	Ed
Rhamnus triqueter Wall.	30	Reg Himal	*Picea smithiana, Pinus wallichiana, Cedrus deodara*	Fd
Acer caesium Wall. ex Brandis*	31	Reg Himal	*Aesculus indica, Picea smithiana*	Fd
Celtis australis L.	32	Europe As Temp Ind Or	*Alnus nitida, Picea smithiana*	Fd
Rhus javanica L.	33	Reg Himal China Japan	*Aesculus indica, Acer caesium*	Fd, Ed
Spiraea canescens D. Don	34	Reg Himal	*Picea smithiana, Cedrus deodara*	Ag tls

Note: Md=Medicinal; Ed=Edible; Fd=Fodder; Rg=Religious; Ti=Timber; Fz=Fertilizer; Misc.=Miscellaneous; Ag tls=Agricultural tools; Reg=Region; Himal=Himalaya; Ind=Indian; Or=Oriental; As=Asia; Bor=Borealis; Am=America; Cauc= Caucasus; *=Endemic

Table 3 Quantum collection, Probability of Use (PU) and Resource Use Index (RUI) of the fuel species

Taxa	Local name	Habit	Altitudinal range (m)	Collection		PU	RUI
				kg sample^{-1} d^{-1}	kg sample^{-1} yr^{-1}		
Abies pindrow	Tosh	T	2,200-3,000	1.88	337.5	0.250	131.5
Acer caesium	Mandru	T	2,200-3,000	0.08	13.5	0.025	0.7
Aesculus indica	Khanor	T	2,000-3,200	2.25	405.0	0.163	72.9
Alnus nitida	Kolsh	T	2,000-2,800	1.33	238.5	0.100	38.9
Berberis lycium	Kashamal	Sh	2,000-2,800	0.36	65.3	0.100	7.7
Cedrus deodara	Devdar	T	2,400-3,500	7.49	1347.8	0.463	607.3
Celtis australis	Kharik	T	2,000-2,700	0.11	20.3	0.050	1.0
Cotoneaster obtusus	Riunsh	Sh	2,000-2,500	0.24	43.9	0.063	2.7
Desmodium elegans	Safed kathi	Sh	2,000-2,600	0.86	155.3	0.188	29.5
Indigofera heterantha	Kali kathi	Sh	2,000-3,000	3.06	551.3	0.300	180.5
Juglans regia	Ahhrot	T	2,000-3,000	0.53	94.5	0.063	7.7
Morus serrata	Kriun	T	2,000-2,400	0.23	40.5	0.050	2.0
Picea smithiana	Rai	T	2,000-2,400	7.51	1336.1	0.513	711.2
Pinus wallichiana	Kail	T	2,000-2,400	1.11	200.3	0.263	58.5
Pirnsepia utilis	Bhekhal	Sh	2,000-3,000	0.24	42.8	0.050	2.1
Populus ciliata	Populus	T	2,000-2,800	0.68	121.5	0.100	12.2
Prunus domestica	Palum	T	2,000-2,800	0.28	49.5	0.050	2.5
Prunus armeniaca	Shada	T	2,000-2,400	0.66	119.3	0.063	9.7
Prunus avium	Cherry	T	2,000-3,000	0.14	24.8	0.050	1.9
Prunus cornuta	Jammu	T	2,000-2,400	0.66	119.3	0.175	23.4
Pyrus communis	Nakh	T	2,000-2,400	0.16	29.3	0.038	1.5
Malus pumila	Seb	T	2,000-3,000	2.29	411.8	0.100	41.2
Pyrus pashia	Shegal	T	2,000-2,600	0.41	74.3	0.075	5.6
Quercus floribunda	Mohru	T	2,000-2,400	0.84	150.8	0.100	15.1
Rhamnus triqueter	Chaunsha	Sh	2,000-3,000	0.10	18.0	0.038	0.9
Rhus javanica	Titri	T	2,000-2,200	0.10	18.0	0.050	0.9
Robinia pseudo-acacia	Kikar	T	2,000-2,600	0.29	51.8	0.08 8	6.4
Salix daphnoides	Willoo	T	2,000-2,400	0.44	78.8	0.100	7.3
Sorbaria tomentosa	Shain	Sh	2,000-2,800	0.96	173.3	0.213	40.1
Spiraea canescens	Chakhu	Sh	2,400-3,400	0.05	9.0	0.038	0.5
Symplocos chinensis	Lojh	T	2,000-2,500	0.20	36.0	0.013	1.8
Ulmus wallichiana	Mahun	T	2,000-2,600	0.10	18.0	0.050	1.4
Ulmus villosa	Chor	T	2,000-2,500	0.23	40.5	0.063	2.9
Viburnum cotinifolim	Talana	Sh	2,000-3,000	0.03	4.5	0.013	0.2

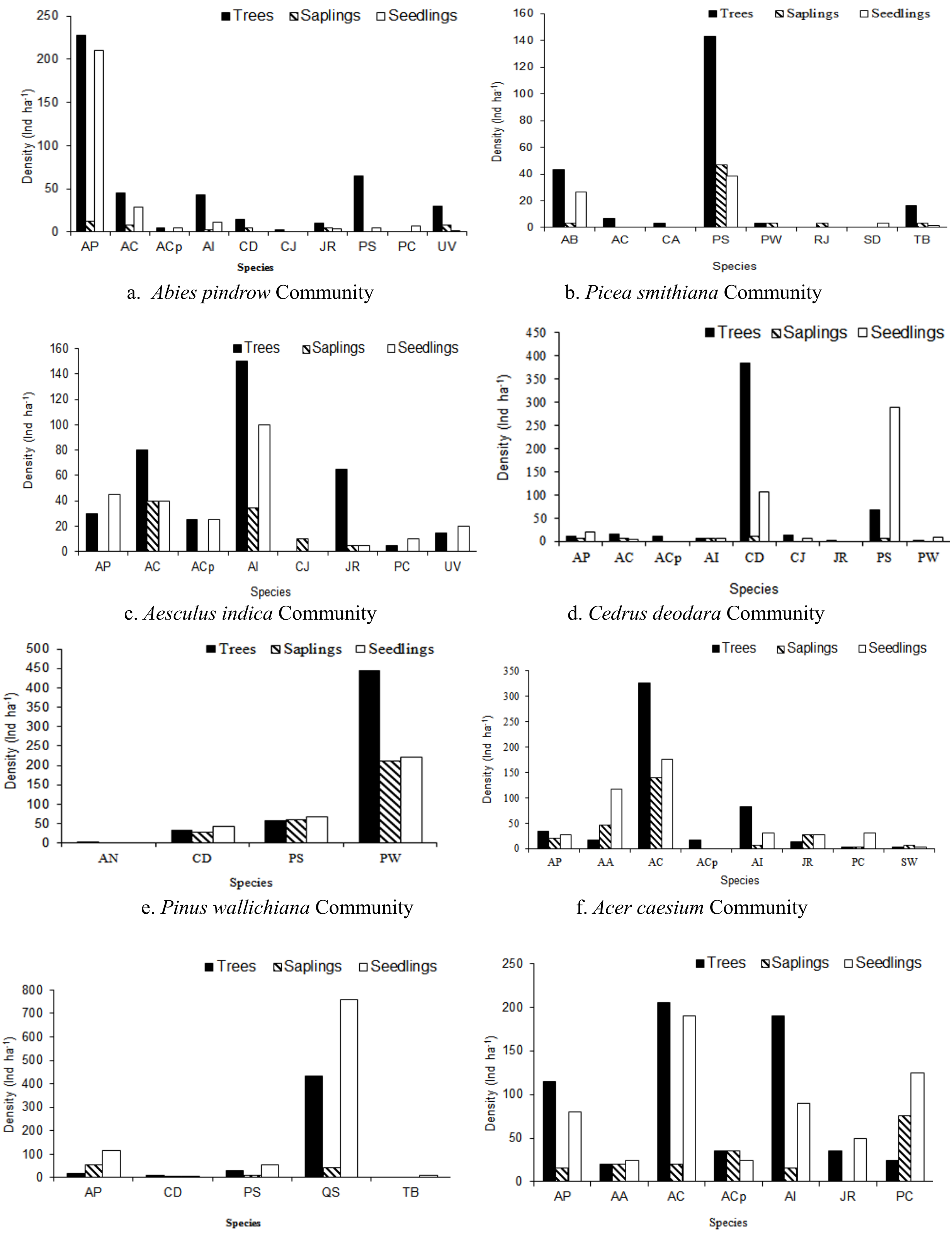
Abbreviations used: T=Tree; Sh=Shrub and H=Herb

Table 4 Similarity index of the villages on the basis of species quantum collection

Villages	Manali	Dhungri	Nasogi	Banaun
Manali	-			
Dhungri	100.0	-		
Nasogi	98.4	96.9	-	
Banaun	95.1	94.1	97.1	-

activities have caused a great pressure on fuel and other resources in the mountains. The present attempt has been made to identify utilization pattern and extraction trend of woody species, local inhabitants' preference to fuel, plant species under high use pressure and their population and regeneration status in the sanctuary. Present study showed fuelwood collection/consumption by villagers is between 17-18 kg household^{-1} day^{-1}. Average fuelwood consumption/collection in the study area is comparatively higher than the reported 14.65 kg household^{-1} day^{-1} (Awasthi et al. 2003) and 14.65 kg household^{-1} day^{-1} (Bhatt et al. 1994) for Garhwal Hiamalaya, but less than the reported 20-25 kg household^{-1} day^{-1} (Singh et al. 2009) for Kedarnath region.

Total 34 fuel species including eight agroforestry species were extracted as fuel by the inhabitants indicating the inhabitants have limited options in fuel resources. This may be due to less, diversity of woody species. More collection of dried as well as green fuel wood from forests is due to



a. *Abies pindrow* Community

b. *Picea smithiana* Community

c. *Aesculus indica* Community

d. *Cedrus deodara* Community

e. *Pinus wallichiana* Community

f. *Acer caesium* Community

g. *Quercus semecarpifolia* Community

h. *Aesculus indica-Acer caesium* Community

Figure 1 Current status of trees, saplings and seedlings in communities showing availability of fuel species in the Manali Wildlife Sanctuary

Abbreviations used in Figure 1: AP=*Abies pindrow*; AA=*Acer acuminatum*; AC=*Acer caesium*; ACp=*Acer cappadocicum;* AI=*Aesculus indica*; BU=*Betula alnoides*; CA=*Celtis australis*; CD=*Cedrus deodara*; CJ=*Corylus jacquemontii*; ID=*Ilex dipyrena*; JR=*Juglans regia*; PC=*Prunus cornuta*; PS=*Picea smithiana*; PW=*Pinus wallichiana*; QF=*Quercus floribunda*; QL=*Quercus leucotrichophora*; QS=*Quercus semecarpifolia*; SC=*Symplocos chinensis*; SD=*Salix daphnoides*; ST=*Salix tetrasperma*; SW=*Salix wallichiana*; UV=*Ulmus villosa*; and TB=*Taxus baccata* subsp. *wallichiana*

Table 5 Density (Ind ha^{-1}) of shrubs used as fuel in different forest communities of the Manali Wildlife Sanctuary

Taxa	Community types										
	a	b	c	d	e	f	g	h	i	j	k
Berberis lyceum	-	187	-	113	197	-	-	-	1970	-	20
Cotoneaster obtusus	2	35	-	5	103	-	-	-	-	-	-
Desmodium elegans	65	125	30	62	357	-	13	110	180	-	30
Deutzia staminea	57	25	5	78	-	23	-	55	-	-	50
Indigofera heterantha	330	550	40	108	607	13	23	-	500	260	110
Lonicera quinquelocularis	-	-	-	-	37	-	-	-	-	-	-
Prinsepia utilis	-	17	-	57	67	-	-	-	300	-	-
Rhamnus triqueter	-	28	-	28	80	-	-	-	-	-	-
Sorbaria tomentosa	20	332	30	53	67	-	-	-	-	-	-
Spiraea canescens	-	20	-	-	193	-	-	-	-	-	80
Viburnum cotinifolium	103	17	30	65	-	33	478	70	-	-	-

Abbreviations Used: a=*Abies pindrow*; b=*Picea smithiana*; c=*Aesculus indica*; d= *Cedrus deodara*; e=*Pinus wallichiana*; f= *Acer caesium*; g= *Quercus semecarpifolia*; h=*Aesculus indica-Acer caesium* mixed; i=*Berberis lycium;* j=*Indigofera heterantha;* and k=*Indigofera heterantha-Spiraea canescens* mixed.

long and harsh winter conditions in the villages. The total collection was highest for *Picea smithiana* *Cedrus deodara* and *Indigofera heterantha* indicating high pressure on these species. High RUI of *Cedrus deodara*, *Picea smithiana* and *Indigofera heterantha* indicated high pressure on these species. These species are preferred as fuel because of different qualities such as hard wood, smokeless fire, easy ignition that were observed and evinced by the local people after their use for a long time. Wood of some species such as *Cotoneaster bacillaris, Abies pindrow, Cedrus deodara, Aesculus indica* was highly preferred as their hard wood provides high energy and can burn for longer time. Wood of *Pinus wallichiana*, *Cedrus deodara, Alnus nitida, Populus ciliata,* was preferred for the easy ignition whereas wood of *Picea smithiana, Indigofera hetarantha, Desmodium elegans* was preferred for its smokeless fire. These species also have multiple utility hence, it enhanced use pressure. Therefore such species require proper management. More than 94% similarity in the utilization pattern of fuel species in villages also indicated increased pressure on selected species.

The inhabitants were using >70% of native species as fuel with high extraction frequency. Such practices indirectly contribute 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, reforestation and afforestation etc. 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.

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 one-fourth of their yearly time in collecting fuel wood and many earn their livelihood by collecting and selling fuel wood. Therefore proper management of preferred species in forests and plantation in waste, marginal and degraded lands would not only benefit inhabitants but also help in conserving environment.

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