Full Length Research Paper

Assessment of fuel resource diversity and utilization pattern in Nargu Wildlife Sanctuary of Himachal Pradesh, NW Himalaya

Pankaj Sharma\textsuperscript{1*} and S. S. Samant\textsuperscript{2}

\textsuperscript{1}National Bureau of Plant Genetic Resources, Regional Station, Phagli, Shimla (HP) - 171 004, India.
\textsuperscript{2}G. B. Pant Institute of Himalayan Environment and Development, Himachal Unit, Mohal-Kullu-175 126, H.P., India.

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Dearth in the studies related to the fuelwood collection trends, conservation and management has prompted the present work. Nargu Wildlife Sanctuary of Himachal Pradesh was assessed for the fuel resources because the region was not evaluated earlier and dependency of the stakeholders on the forest resources was soaring. In the twenty three villages studied, forty five species (33 trees and 12 shrubs) belonging to 23 families of fuel resource were recorded. In the three different altitudinal ranges of the area probability of use (PU) and resource use pattern (RUI) was studied and it was highest for Quercus leucotrichophora A. Camus (1879.30 kg household\textsuperscript{-1} year\textsuperscript{-1}), followed by Rhododendron arboreum Sm. (433.57 kg household\textsuperscript{-1} year\textsuperscript{-1}), Cedrus deodara (Roxb. ex D. Don) G. Don (425.22 kg household\textsuperscript{-1} year\textsuperscript{-1}), Myrica esculenta Buch.-Ham. ex Don (385.05 kg household\textsuperscript{-1} year\textsuperscript{-1}) and Persea duthiei (King. ex Hk.f.) Kostern. (370.96 kg household\textsuperscript{-1} year\textsuperscript{-1}). Among the surveyed villages, maximum total collection (7992 kg/hh/year) was done in Mandra followed by Seri (7524 kg/hh/year) and Drun (7476 kg/hh/year) villages. Of the total, 33 species were native to the Himalayan Region, 06 species native to the Himalayan region and neighboring countries and remaining species were non-natives. Major thrust of the study is to comprehensively manage the species highly-preferred for fuel, diversification of choice of species from natives to non-natives, and their large scale propagation.

Key words: Conservation, endemic, fuelwood, Indian Himalayan Region (IHR), native.

INTRODUCTION

Fuel resources in India continue to be the primary sources of domestic energy in the rural areas. In rural India, fuel wood is the major source of energy for the domestic use. Fuel wood demand in India ranged from 96 to 157 million tons annually including a rural demand of 80 to 128 million tones. This means annual consumption of 148 to 242 million tons per capita (Bhattacharaya and Nanda, 1992). In Himachal Pradesh, a Himalayan state, more than ninety percent of the population resides in rural areas. Here, alternative source of fuel are very limited in the villages so their dependence on the forests is inevitable. Unfortunately these resources are continuously being degraded (Shah, 1982; Khoshoo, 1987) with an alarming rate. However, extraction activities of the plant resources are limited in the protected areas but as far as fuel wood is concerned stakeholders have the rights to avail these resources to some limited extent. Continued unrecorded exploitation has been a threat to the sustenance of this resource even in the protected areas and study for such trends are urgently required. Few earlier studies have already recorded the fuel extraction trends in different parts of the Himalaya (Samant et al., 2000; Dhar et al.,

\*Corresponding author. E-mail: pankajsharmasnr@gmail.com. Tel: 9459517152.
1998) and suggested the suitable conservation strategies. Nargu Wildlife Sanctuary (hereafter, NWLS) of Himachal Pradesh has large human population and is one of the biggest protected areas of the state, so dependence of the stakeholders upon forest resources is massive. Fuel resources in the region have not yet been assessed extensively. So the present work was done in the area with the following objectives. 1) diversity and extraction trend of the fuel resource, 2) annual quantity collected in the area, 3) species preference, 4) probability of use and resource use index, 5) nativity of the species, 6) dominant elements in the forest communities where fuel resource is present, 7) utilization pattern of the fuel resource and 8) to suggest a management strategy for conservation.

MATERIALS AND METHODS

Study area
The NWLS (31°04′N to 32°05′N Latitudes and 76°50′ to 77°04′ E Longitudes) is located in Mandi district of Himachal Pradesh (Figure 1). The Sanctuary was notified in 1972. It covers an area of over 278 Km² with an altitudinal range, 970 to 4000 m amsl. Temperature ranges between -10 to 35°C and mean annual rainfall is 1400 mm. It represents sub-tropical, temperate, sub-alpine and alpine vegetation. The Sanctuary is rich in biodiversity including a large number of mammals and birds. The livelihoods of the local villagers and graziers of 190 villages with 30,000 human population and 50,000 cattle population are dependent on the sanctuary. The inhabitants residing in the periphery are dependent on the Sanctuary for minor forest products (including medicinal and wild edible plants), fuel, fodder, timber, livestock grazing and various other purposes.

Trends of fuel collection
The sanctuary area is having diverse habitats and mostly the inhabitants of the sanctuary are dependent on forest produce for their sustenance. We surveyed 23 villages during 2008 to 2012 for extraction trend of fuel resource in three different altitudinal ranges of the sanctuary (that is, seven villages <1500 m, six villages 1500 to 1800 m and 10 villages >1800 m). In survey of the sanctuary, we found that the natives of the area start collecting fuel wood from end of November to end of February months. So we assume that the inhabitants collect fuel for about 90 days and considered these as total collection days (TCD). The dry fuel wood is stored in lots and used subsequently.

Data analysis
The information was gathered through semi structured questionnaires from the different surveyed villages and pooled together. For each species, mean collection collected (Kg sample⁻¹ day⁻¹; kg household⁻¹ year⁻¹), probability of use (PU) and resource use index (RUI) were calculated as follows:

Mean collection (Kg) of the species, \( A = \frac{T}{N} \)
Where \( T \) = Total collection in all samples, and \( N= \) number of samples;

\[
\text{Mean collection sample}^{-1} \text{day}^{-1}, \text{Cs}= \frac{\sum A \text{TPR}_i}{n=6}
\]

\[
\text{Mean collection household}^{-1} \text{day}^{-1}, \text{Cd} = 2 \text{Cs}
\]

Where \( A = \) mean collection of the species, and \( \text{TPR}_i = \) Total population responsible for collection in the \( i^{th} \) village;

Where 90 was the total collection days per year;

\[
\text{Probability of use, PU} = \frac{\sum F_P}{\sum P}
\]

Where \( F_i = \) frequency of collection of a species in the \( i^{th} \) village; \( P_i = \) population of the \( i^{th} \) village

\[
\text{Resource Use Index, RUI} = CyPu
\]

Where \( Cy = \) mean collection household\(^{-1} \text{year}^{-1}\)

**RESULTS**

**Diversity and extraction trends of fuel resources**

Among the 23 surveyed villages, total 45 species (33 trees and 12 shrubs) belonging to 23 families were used as fuel by the inhabitants. Rosaceae and Pinaceae were the dominant families (5 spp. each); followed by Moraceae (4 spp.); Fagaceae, Lauraceae and Meliaceae (3 spp. each). *Quercus leucotrichophora, Rhododendron arboreum, Neolitsea pallens, Pinus wallichiana, Berberis lyicum, Sorbaria tomentosa, Alnus nitida and Desmodium elegans* were contributed most to collections as fuel (Table 1). Among the surveyed villages, maximum total collection (7992 kg/hh/year) was done in Mandra followed by Seri (7524 kg/hh/year) and Drun (7476 kg/hh/year) villages (Table 2 and Figure 2).

Mean collection was highest for *Q. leucotrichophora* (1879.30 kg household\(^{-1} \text{year}^{-1}\)), followed by *R. arboreum* (433.57 kg household\(^{-1} \text{year}^{-1}\)), *Cedrus deodara* (425.22 kg household\(^{-1} \text{year}^{-1}\)), *M. esculenta* (385.05 kg household\(^{-1} \text{year}^{-1}\)) and *Persea duthiei* (370.96 kg household\(^{-1} \text{year}^{-1}\)). The remaining species showed relatively low values (Table 1). Similar was the use of preference for the species in the entire area of the sanctuary. Species diversity, preference of use, their distribution in different communities, dominant elements of communities, altitude range, and utilization pattern of fuel resource for the entire area is shown in Table 3.

Village wise altitudinal mean fuel collection was more in villages which were below 1500 m and above 1800 m that is, 6672 and 7065 kg household\(^{-1} \text{year}^{-1}\) respectively. It was lesser in 1500 to 1800 m zone (6254 Kg household\(^{-1} \text{year}^{-1}\)). Same trend was shown for mean number of species collected in these altitudinal zones. It was 14, 12.7 and 10 in >1800 m, <1500 m and 1500 to 1800 m respectively (Figure 3).

**Probability of use (PU) and resource use indices (RUI)**

PU was highest for *Q. leucotrichophora* (0.95), followed by *R. arboreum* (0.55), *P. duthiei* (0.14), *C. deodara* and *M. esculenta* (0.12 each) indicating high pressure on these species. The remaining species showed <0.1 PU and reflected their low preference or low availability in the wild. RUI ranged from 0.31 to 945.62. It was highest for *Q. leucotrichophora* (945.62), followed by *R. arboreum* (138.85), *C. deodara* (102.55) and *P. duthiei* (96.86) suggesting their great acceptability as fuel and high anthropogenic pressure on these species. The remaining species showed <96 RUI showing less use value (Table 1 and Figure 4).

**Status and distribution of native and endemic species preferred**

Of the total recorded (45 species), 33 species were native to the Himalayan Region, 06 species native to the Himalayan region and neighboring countries, and remaining species were non-natives. None of the species was found to be endemic to the Indian Himalayan Region (IHR) but there were 15 near endemic species few of these were *Abies pindrow, Cedrus deodara, Rhododendron campanulatum, Rhus wallichii, Indigofera heterantha and Aesculus indica* etc. (Table 1).

**DISCUSSION**

In the present study fuelwood resources and their consumption patterns have been studied in 23 villages of NWLS of Himachal Pradesh. The villages were located in three different altitudinal zones of the Sanctuary namely, <1500 m; 1500 to 1800 m and >1800 m. Number of species and mean collection (Kg household\(^{-1} \text{year}^{-1}\)) of the fuel wood species was more in the lower (<1500 m) and higher (>1800 m) altitude zones. This may be due to the abundance of forests and easily accessible resources in the vicinities of these zones.

The Sanctuary area is mostly dominated by evergreen broad leaved (*Quercus floribunda, Q. leucotrichophora, Quercus semecarpifolia* etc.) and evergreen coniferous (*Abies pindrow, C. deodara, P. wallichiana* etc.) communities. High probability of use (PU) and resource use index (RUI) of *Q. leucotrichophora, R. arboreum, P. duthiei, N. pallens, D. elegans* and *M. esculenta* etc. indicated...
## Table 1. Mean collection, probability of use (PU) and resource use index (RUI) of fuel resource in the NWLS.

| Taxa | Family | Local name | Nativity | Mean collection (Kg/hh/year) | PU | RUI |
|------|--------|------------|----------|-----------------------------|----|-----|
| Abies pindrow Royle* | Pinaceae | Tosh | Reg Himal | 26.09 | 0.01 | 1.90 |
| Aesculus indica | Hippocastanaceae | Khanor | Reg Himal | 46.43 | 0.02 | 7.12 |
| Albizia lebbek Benth. | Mimosaceae | Sirish | As Trop et Subtrop | 109.57 | 0.03 | 29.43 |
| Alnus nitida (Spach) Endl.* | Betulaceae | Kolsh | Reg Himal | 231.65 | 0.09 | 43.41 |
| Thamnocalamus spathiflorus (Trin.) Munro* | Poaceae | Ringar | Reg Himal | 22.43 | 0.01 | 1.54 |
| Berberis lyceum Royle* | Berberidaceae | Kharik | Europe, Aust, Ind Or | 64.70 | 0.03 | 10.80 |
| Buddleja crispa Benth. | Loganiaceae | Sandhiyara | Reg Himal | 36 | 0.05 | 5.4 |
| Cedrus deodara (Roxb. ex D. Don) G. Don* | Pinaceae | Dyar | Reg Himal | 425.22 | 0.12 | 102.55 |
| Celtis australis L. | Ulmaceae | Kharik | Reg Himal | 64.17 | 0.02 | 5.74 |
| Cinnamomum tamala Nees & Ebern* | Lauraceae | Tejpatta | Reg Himal | 13.04 | 0.00 | 1.30 |
| Debregeasia salicifolia (Don) Rendl.* | Urticaceae | Saryahu | As et Afr Trop | 284.35 | 0.07 | 51.73 |
| Desmodium elegans DC. | Fabaceae | Safedkathi | China | 297.39 | 0.08 | 51.76 |
| Ficus palmate Forsk. | Moraceae | Fegra | Afr Trop, Arab, Ind Or | 48.52 | 0.02 | 3.91 |
| Ficus roxburghii Wall. | Moraceae | Triambal | Reg Himal, Burma | 21.39 | 0.01 | 1.90 |
| Ficus nemoralis Wall. ex Mir* | Moraceae | Dudhla | Reg Himal | 18.26 | 0.01 | 1.64 |
| Grewia oppositifolia Buch. ex D. Don | Tiliaceae | Beul | Reg Himal | 116.35 | 0.04 | 25.49 |
| Indigofera heterantha Wall. ex Brand. | Fabaceae | Kali Kathi | Reg Hial | 187.83 | 0.07 | 28.88 |
| Jugulans regia L.* | Juglandaceae | Khor | As Occ, Reg Himal | 6.78 | 0.00 | 0.34 |
| Lyonia ovalifolia (Wall.) Drude | Ericaceae | Bheral | China | 184.17 | 0.07 | 20.69 |
| Melia azadirach L. | Meliaceae | Drek | Reg Himal | 37.57 | 0.01 | 3.76 |
| Morus serrata Roxb. | Moraceae | Chimmu | Reg Himal | 31.83 | 0.01 | 5.03 |
| Myrica esculenta Buch. - Ham. ex Don | Myricaceae | Kafal | As Trop et Subtrop | 385.05 | 0.12 | 72.42 |
| Neolitsea pallens (D. Don) Momi. & Hara ex Hara | Lauraceae | Chhinchiri | Reg Himal | 163.30 | 0.06 | 30.29 |
| Persea duthiei (King. ex Hk.f.) Kostern.* | Lauraceae | Dodru | Reg Himal | 370.96 | 0.14 | 96.86 |
| Picea smithiana (Wall.) Boiss.* | Pinaceae | Rai | Reg Himal | 130.43 | 0.04 | 15.47 |
| Pinus roxburghii Sarg. | Pinaceae | Chil | Reg Himal | 221.74 | 0.06 | 50.37 |
| Pinus wallichiana A.B. Jack. | Pinaceae | Kail | Reg Himal | 110.09 | 0.03 | 10.64 |
| Pistacia integerrima Stew. | Anacardiaceae | Kakare | Aegypt Persia, Reg Himal | 9.39 | 0.00 | 0.47 |
| Prunus armeniaca L. | Rosaceae | Bhekhal | Reg Himal | 25.04 | 0.02 | 5.74 |
| Pyrus pashia Buch. - Ham. ex D. Don* | Rosaceae | Paja | Reg Himal | 103.30 | 0.04 | 28.80 |
| Quercus floribunda Lindl.* | Fagaceae | Moharu | Reg Himal | 107.7 | 0.05 | 9.7 |
### Table 1 Contd.

| Species                          | Family      | Location      | MC         | PU | RUI   | Aegypt | Am | As | Austr | Bor | et | Ind | Japon | LN | MC | Occ | Or | RegHimal | Subtrop | Trop |* |
|----------------------------------|-------------|---------------|------------|----|-------|--------|----|----|-------|-----|----|-----|--------|----|----|-----|----|----------|---------|------|---|
| Quercus leucotrichophora A.Camus | Fagaceae    | Ban           | Reg Himal  | 1879.30 | 0.95 | 945.62 |
| Quercus semecarpifolia Sm.       | Fagaceae    | Kharshu       | Reg Himal  | 39.6    | 0.01 | 2     |
| Rhamnus purpureus Edgew          | Rhamnaceae  | Kubbal        | Reg Himal  | 27.6    | 0.03 | 2.7   |
| Rhododendron arboreum Sm.        | Ericaceae   | Burah         | Ind Or Reg Himal Zeylan | 433.57 | 0.55 | 138.85 |
| Rhus javanica L.                 | Anacardiaceae | Titri       | Reg Himal  | 79.30    | 0.08 | 12.05 |
| Salix semecarpifolia             | Salicaceae  | Bashal        | Reg Himal  | 30.6    | 0.03 | 1.8   |
| Sorbaria tomentosa (Lindl.) Rehder | Rosaceae | Kushti       | Reg Himal As Bor | 84.00    | 0.02 | 11.92 |
| Rhamnus purpureus                | Rhamnaceae  | Kubbal        | Reg Himal  | 27.6    | 0.03 | 2.7   |
| Rhus javanica L.                 | Anacardiaceae | Titri       | Reg Himal  | 79.30    | 0.08 | 12.05 |
| Salix semecarpifolia             | Salicaceae  | Bashal        | Reg Himal  | 30.6    | 0.03 | 1.8   |
| Sorbaria tomentosa               | Rosaceae    | Kushti        | Reg Himal As Bor | 84.00    | 0.02 | 11.92 |

Kg/hh/yr = Kilogram/household/year; PU = Probability of use; RUI = Resource use index; Aegypt = Egypt; Am = America; As = Asia; Austr. = Australia; Bor = Borealis; et = And; Ind = India; Japon = Japan; LN = Local name; MC = Mean collection; Occ = Occidentalis; Or = Oriental; RegHimal = Himalayan region; Subtrop=Sub Tropical; Trop = Tropical;* = Near endemic.

### Table 2. Village wise fuel collection in NWLS.

| Village     | Altitude (m) | Number of House holds | Population responsible for collection | Number of species collected | Total collection (Kg/h/year) |
|-------------|--------------|-----------------------|---------------------------------------|-----------------------------|----------------------------|
| Rihagari    | 1140         | 33                    | 66                                    | 8                           | 6684                       |
| Malwara     | 1313         | 30                    | 60                                    | 14                          | 6804                       |
| Balh        | 1335         | 32                    | 64                                    | 13                          | 6972                       |
| Tikker      | 1370         | 45                    | 90                                    | 18                          | 7296                       |
| Kutahar     | 1394         | 37                    | 74                                    | 9                           | 5484                       |
| Arang       | 1437         | 34                    | 68                                    | 14                          | 6432                       |
| Ropa        | 1452         | 59                    | 118                                   | 13                          | 7032                       |
| Dharmed     | 1628         | 48                    | 96                                    | 6                           | 6120                       |
| Drun        | 1658         | 68                    | 136                                   | 16                          | 7476                       |
| Hurang      | 1693         | 66                    | 132                                   | 7                           | 6120                       |
| Kashala     | 1708         | 26                    | 52                                    | 11                          | 5124                       |
| Badaun      | 1728         | 30                    | 60                                    | 12                          | 7092                       |
| Swar        | 1738         | 28                    | 56                                    | 6                           | 5592                       |
| Mandra      | 1806         | 34                    | 68                                    | 17                          | 7992                       |
| Seri        | 1830         | 51                    | 102                                   | 15                          | 7524                       |
| Bulang      | 1837         | 64                    | 128                                   | 14                          | 6804                       |
| Dhar        | 1845         | 28                    | 56                                    | 10                          | 6348                       |
| Sudhar      | 1890         | 20                    | 40                                    | 14                          | 7092                       |
| Kampan      | 1894         | 31                    | 62                                    | 14                          | 6468                       |
| Jagtang     | 1900         | 30                    | 60                                    | 12                          | 7308                       |
| Graman      | 1909         | 68                    | 136                                   | 15                          | 7152                       |
| ShilhBadhani| 2004         | 28                    | 56                                    | 13                          | 7188                       |
| Kungar      | 2066         | 29                    | 58                                    | 14                          | 6780                       |
Figure 2. Fuel wood collection in NWLS; a) weighing up fuel wood, and b) Stakeholder carrying fuel wood resource.

Table 3. Preferences (1 indicates most preferred), altitudinal range and uses of the fuel species in NWLS.

| Taxa                      | Preference | Altitudinal range | Communities                                                                 | Utilization pattern | Dominant species                                                                 |
|---------------------------|------------|-------------------|------------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------------------|
| Quercus leucotrichophora  | 1          | 1000 - 2600       | Q. leucotrichophora, Q. leucotrichophora-C. deodara mixed, Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora-N. pallens mixed | M, Fd, At           | R. arboreum, Q. leucotrichophora, M. esculenta, Sarcococa saligna                 |
| Rhododendron arboreum     | 2          | 1000 - 2300       | R. arboreum, R. arboreum-A. nitida mixed, R. arboreum-L. ovalifolia mixed, R. arboreum-Q. leucotrichophora mixed | M, Ed               | R. arboreum, Q. leucotrichophora, Indigofera heterantha                          |
| Cedrus deodara            | 3          | 1600 - 2500       | C. deodara, C. deodara-P. wallichiana mixed, C. deodara-Q. leucotrichophora mixed | M, Ti, At, Misc     | C. deodara, S. saligna, Arundinaria spathiflora                                  |
| Persea duthiei            | 4          | 1000 - 2200       | R. arboreum-A. nitida mixed, Q. leucotrichophora-M. esculenta mixed, A. indica-Persea duthiei mixed | Fd, Misc            | R. arboreum, A. nitida, Q. leucotrichophora, S. saligna                          |
| Myrica esculenta          | 5          | 1200 - 2000       | M. esculenta, M. esculenta-A. nitida mixed                                   | M, Ed               | M. esculenta, A. nitida, A.spathiflora                                           |
| Species                  | No. | Height Range | Dominant Herbaceous Layer                                                                 | Pollen Source          |
|-------------------------|-----|--------------|------------------------------------------------------------------------------------------|------------------------|
| Desmodium elegans      | 6   | 1500 - 2800  | C. deodara-P. wallichiana mixed, R. arboreum-L. ovalifolia mixed                        | Fd                     |
| Debregeasia salicifolia | 7   | 1000 - 1700  | R. arboreum-A. nitida mixed, Q. leucotrichophora                                          | M, Fd                  |
| Pinus roxburghii       | 8   | 1000 - 1600  | P. roxburghii, Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora-N. pallens mixed | Ti, At, Misc           |
| Alnus nitida           | 9   | 1300 - 2600  | A. nitida, A. nitida-Q. leucotrichophora mixed, M. esculenta-A. nitida mixed, Q. leucotrichophora | M, Misc                |
| Pyrus pashia           | 10  | 1000 - 2600  | Q. leucotrichophora-M. esculenta mixed, R. arboreum-Alnus nitida mixed                   | Ed, Misc               |
| Neolitsea pallens      | 11  | 1500 - 2700  | Q. leucotrichophora-N. pallens mixed, A. indica-N. pallens mixed                         | Fd, Misc               |
| Albizzia lebbek        | 12  | 1000 - 1500  | R. arboreum-A. nitida mixed, Q. leucotrichophora                                          | Misc                   |
| Indigofera heterantha  | 13  | 1500 - 3500  | Q. leucotrichophora, Q. leucotrichophora-C. deodara mixed, Q. leucotrichophora-M. esculenta mixed | Fd                     |
| Prunus cerasoides      | 14  | 1200 - 1600  | R. arboreum-A. nitida mixed, Q. leucotrichophora, A. nitida-Q. leucotrichophora mixed     | Rel, Misc              |
| Grewia oppositifolia   | 15  | 1000 - 1400  | Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora                              | Fi, Fd                 |
| Lyonia ovalifolia      | 16  | 1200 - 2700  | M. esculenta-A. nitida mixed, R. arboreum-L. ovalifolia mixed                           | M                      |
| Picea smithiana        | 17  | 2200 - 3300  | P. smithiana, P. smithiana-R. arboreum mixed                                            | Ti, At                 |
| Rhus javanica          | 18  | 1200 - 2500  | Q. leucotrichophora, Q. leucotrichophora-C. deodara mixed                               | M, Fd, Ed              |
| Species               | No. | Size (m) | Notes                                                                 | Community Notes                                      |
|----------------------|-----|----------|----------------------------------------------------------------------|------------------------------------------------------|
| Sorbaria tomentosa   | 19  | 1700-2800| Q. leucotrichophora-N. pallens mixed, A. indica-N. pallens mixed     | Misc                                                 |
| Berberis lycium      | 20  | 1000-2700| Q. leucotrichophora-M. esculenta mixed, R. arboreum-Alnus nitida mixed| M, At Q. leucotrichophora, M. esculenta, R. arboreum |
| Pinus wallichiana    | 21  | 1600-2500| P. wallichiana, A. nitida-Q. leucotrichophora mixed,                 | Ti, At Misc P. wallichiana, A. nitida, Berberis lycceum, S. saligna |
| Quercus floribunda   | 22  | 2100-2700| C. deodara-Q. leucotrichophora mixed, P. smithiana-R. arboreum mixed| Fl, Fd C. deodara, Q. leucotrichophora, A. spathiflora |
| Symplocos chinensis  | 23  | 1200-2600| M. esculenta-A. nitida mixed, R. arboreum-L. ovalifolia mixed        | M, Fd At M. esculenta, A. nitida                   |
| Aesculus indica      | 24  | 1500-2800| A. indica, A. indica-N. pallens mixed, A. indica-P. duthiei mixed, R. arboreum-A. nitida mixed, Q. leucotrichophora | M, Fd Ed A. indica, N. pallens, A. indica, P. duthiei |
| Celtis australis     | 25  | 1500-2500| Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora          | Fd M. esculenta, Q. leucotrichophora               |
| Prinsepia utilis     | 26  | 1000-2900| M. esculenta-A. nitida mixed, R. arboreum-L. ovalifolia mixed        | Rel, Misc M. esculenta, R. arboreum                 |
| Buddleja crispa      | 27  | 1200-3200| C. deodara-P. wallichiana                                           | Misc P. wallichiana, Q. leucotrichophora, A. spathiflora |
| Ulmus villosa        | 28  | 1600-3500| C. deodara-P. wallichiana, A. pindrow                               | Fd, Rel, At C. deodara-P. wallichiana, A. pindrow  |
| Morus serrata        | 29  | 1500-2300| Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora         | Fd, Ed Q. leucotrichophora-M. esculenta, Q. leucotrichophora |
| Ficus palmata        | 30  | 1000-1400| M. esculenta-A. nitida mixed, R. arboreum-L. ovalifolia mixed        | Ed, M M. esculenta, A. nitida, J. regia             |
| Melia azadiarach     | 31  | 1000-1500| M. esculenta-A. nitida mixed, J. regia, R. arboreum-L. ovalifolia mixed | M, Misc M. esculenta, A. nitida, J. regia, R. arboreum, L. ovalifolia |
| Rhamnus purpureus    | 32  | 1300-3000| Q. leucotrichophora-M. esculenta, C. deodara-P. wallichiana, A. pindrow | Fd, Misc Q. leucotrichophora, C. deodara, P. wallichiana |

Table 3. Contd.
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| Species                     | Usage | Scientific Name                          | At, Ed, Misc                      |
|-----------------------------|-------|-----------------------------------------|----------------------------------|
| *Viburnum mullah*           | 33    | 1800 - 3000                            | *Q. leucotrichophora-M. esculenta, C. deodara-P. wallichiana* |
| *Prunus armeniaca*          | 34    | 1000 - 2200                            | *M. esculenta-A. nitida mixed, R. arboreum-L. ovalifolia mixed* |
| *Quercus semecarpifolia*    | 35    | 2400 - 3600                            | *P. wallichiana, A. pindrow* |
| *Abies pindrow*             | 36    | 2600 - 3600                            | *Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora* |
| *Ficus roxburghii*          | 37    | 900 - 1400                             | *Q. leucotrichophora-M. esculenta mixed, Q. leucotrichophora* |
| *Salix wallichiana*         | 38    | 1500 - 3600                            | *Q. leucotrichophora, P. wallichiana* |
| *Ficus nemoralis*           | 39    | 1000 - 2000                            | *R. arboreum-A. nitida mixed, Q. leucotrichophora* |
| *Thamnocalamus spathiflorus*| 40    | 1000 - 3300                            | *Q. leucotrichophora, Q. leucotrichophora-C. deodara mixed* |
| *Cinnamomum tamala*         | 41    | 1000 - 1500                            | *Q. leucotrichophora, Q. leucotrichophora-M. esculenta mixed* |
| *Pistacia integerrima*      | 42    | 1000 - 2200                            | *Q. leucotrichophora, Q. leucotrichophora-C. deodara mixed* |
| *Juglans regia*             | 43    | 1700 - 3300                            | *J. regia, M. esculenta-A. nitida mixed* |
| *Toona ciliata*             | 44    | 1000 - 1500                            | *Q. leucotrichophora, R. arboreum-Q. leucotrichophora mixed* |
| *Toona serrata*             | 45    | 1700 - 2400                            | *Q. leucotrichophora, R. arboreum-Q. leucotrichophora mixed* |

At = Agricultural Tools; Ed = Edible; Fd = Fodder; Fl = Fiber; Fl = Fuel; M = Medicinal; Misc = Miscellaneous; Rel = Religious; Ti = Timber.

Frequent use, high preference and high anthropogenic pressure on these species. Degree of endemism for an area is important for prioritization of species for conservation (Myers et al., 2000). Endemic or native species may be competitively inferior to other widespread species (Kessler, 2001). Presence of 33 natives and 15 near endemic add to the significance of the area and also in compliance with the earlier works of the region.

Decrease in abundance of species used as sources of fuel suggests that more detailed information is urgently required on species-level trends and their conservation. A very few studies on the similar patterns and outcomes have been carried out so far in India (Samant et al., 2000; 2006; Singh and Sundriyal, 2009; Rawat et al., 2009; Bhattarai et al., 2009). Studies on development of conventional and in-vitro protocols for the mass scale propagation of these species and their establishment and maintenance in the in-situ and
Figure 3. Village wise altitudinal mean fuel collection and number of species.

Figure 4. Total collections PU and RUI of the Preferred Fuel Species. QL = *Quercus leucotrichophora*, RA = *Rhododendron arboreum*, CD = *Cedrus deodara*, PD = *Persea duthiei*, ME = *Myrica esculenta*, DE = *Desmodium elegans*, DS = *Debregeasia salicifolia*, PR = *Pinus roxburghii*, AN = *Alnus nitida*, PP = *Pyrus pashia*. 
ex-situ conditions are essentially required. Major thrust of the study is to comprehensively manage the species highly-preferred for fuel, diversification of choice of species from natives to non-natives, and their large scale propagation. Addition to this plantation of preferred species in the marginal and degraded lands through stakeholder’s participation should promote conservation and management of fuel resources in the sanctuary.

**Conservation perspectives**

For the conservation and management of fuel resource of NWLS the following measures seem appropriate;

1. Annual extensive surveys to prepare a comprehensive database of fuel resources of NWLS for statistics on annual quantum of collection, species preference, probability of use, resource use index, multiple utility of fuel species.
2. Indigenous knowledge of fuel species of NWLS and their uses to improve planning and implementation of sustainable forest management in the sanctuary.
3. Promote highly preferred fuel species via means of ex-situ and in-situ conservation.
4. Awareness through training and extension programmes by means of various government and non-government agencies.

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