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Population Status of Commercially Important Medicinal Plants in Dehradun Forest Division, Uttarakhand (India)

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Abstract

The objective of forest management in the tropics, in recent decades, has shifted from timber production to biodiversity conservation and maintenance of life support system. However, past forestry practices have greatly influenced the structure of plant communities, preponderance of foreign invasive species, populations of high value medicinal plants as well as other non-wood forest products. We assessed the abundance and distribution of medicinal plants in managed and undisturbed forests of Dehradun Forest Division (DFD), Uttarakhand (India). A total of 80 transects (each 1 km long) were laid in various categories of forest types in DFD. This paper deals with distribution, availability and regeneration status of five commercially important species *viz*., *Justicia adhatoda, Aegle marmelos, Phyllanthus emblica, Terminalia bellirica* and *Terminalia chebula*, across different forest types. The study reveals that open canopy forest patches, *Lantana* infested patches and *Acacia catechu-Dalbergia sissoo* (Khair -Shisam) woodlands in the eastern part of the DFD have excellent potential for the production and sustainable harvest of *Justicia adhatoda*. Areas those are less suitable for timber production *viz*., open hill forests, have greater potential for conservation and development of *Aegle marmelos, Phyllanthus emblica* and *Terminalia bellirica*. For the production and management of high value medicinal plants in the DFD these ecological considerations need to be kept in mind.

Keywords: abundance, distribution, rapid mapping exercise, sustainable harvest

Introduction

Wider socio-economic implications, potential discovery and formulation of new drugs have led to increased demand of wild medicinal plants (MPs) all over the world (Alves and Rosa, 2007). Growing demand for herbal products, in the recent past, has led to a quantum jump in volume of plant material traded globally. World Health Organisation (WHO) estimates that 80% of the human populations in the developing countries rely on traditional medicines, mostly plant drugs, for their primary health care needs. An estimate, by EXIM Bank, puts the international trade on MPs at US$ 60 billion per year, which is growing at the rate of 7% per annum (CRPA, 2001). The MPs also play a vital role in the development of new drugs (Alves and Rosa, 2007). This has caused tremendous pressure on the wild populations of MPs. Two-third of the estimated 50,000 MP species in use are still harvested from the wild, of which, 4,000 - 10,000 species may now be endangered (Hamilton, 2003). In India, *ca*. 7000-8000 MPs are used in Ayurveda, Unani, Siddha, Chinese, Amchi and Homeopathic systems (FRLHT, 2007; WHO, 2007; Joy *et al*., 2001; Rajendran *et al.,* 2008). Less than 2000 species of MPs are used in the treatment of various ailments by the local communities in India (Jain, 1994) and most of them (*ca.* 95%) are harvested from the wild (CRPA, 2001). Owing to increasing demand for MPs, coupled with degradation and fragmentation of natural habitats, over 300 species of Indian medicinal plants have now been pushed to 'Threatened' categories as per IUCN criteria (FRLHT, 2007). Around 70% of India's medicinal plants are found in tropical forests spread across the Western and Eastern Ghats, the Vindhyas, Chota Nagpur plateau, Aravallis, the Terai regions in foothills of Himalayas and North East (Singh *et al.,* 2010).

According to a recent estimate about 960 species of MPs are traded in the country, of which 178 species are extracted in excess of 100 Metric tonnes (MT) per year (Ved and Goraya, 2008). Amla (*Phyllanthus emblica*), Harad (*Terminalia chebula*), Baheda (*Terminalia bellirica)*, Bael (*Aegle marmelos*) and Vasaka (*Justicia adhatoda*) are among the top 20 species that have a large demand. Their annual consumption is 16820 MT, 8158 MT, 3424 MT, 2939 MT and 2701 MT respectively. The annual

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growth rate in terms of trade for Amla, Harad, Bael and Vasaka was estimated to be 22.5%, 9.1%, 9.6% and 10.9% respectively (Planning Commission, 2000) and are collected chiefly from tropical forests of the country (Ved and Goraya, 2008). But it is noteworthy that for most of the species there is a considerable gap between demand and supply. For example, during 2004-05, demand-supply gaps for Amla, Vasaka, Bael, and Harad were 26636.2, 2853.5, 2604.7 and 1365 tonnes respectively. In addition to this statistics, medicinal properties (Tab. 1; Khare, 2007) are more than enough to justify their selection for the current study.

The tropical forests in India have been managed mainly for timber till recently. Although these forests are rich in non-wood forest products (NWFPs) including MPs, very few attempts have been made to quantify the availability and regeneration status of these species. DFD is one of such forested areas which had been traditionally managed for the production of timber dominated by Sal (*Shorea robusta*) in Uttarakhand. Silvicultural operations, in Sal forests, included removal of miscellaneous species and climbers. Only during 1960s a separate working circle of minor forest products was established, which was later (in 1998) named NWFP working circle for the 'management' of fodder, fibre, flosses, and medicinal plants (Working Plan, 2009). Creation of this working circle also allowed extraction of limestone, boulders, fibres and leaves of Maljhan (*Bauhinia vahlii*) and Kanakchampa (*Pterospermum acerifolium*), Semla (*Bombax ceiba*) gum, honey, wax and kattha (from *Acacia catechu*). Presently there is hardly any timber extraction from this division but forestry practices, such as extraction of NTFPs, and assisted natural regeneration of various species is permissible. The division harboured 86 MPs, of which, Amla, Harad, Baheda, Bael and Vasaka (Plate 1) are of high commercial value (Rawat *et al*., 2009). Since the state of Uttarakhand has been projected as 'Herbal State of India', conservation and sustainable use of high value medicinal plants has been given a high priority in various forestry practices (Adhikari *et. al*., 2010; FRLHT, 2003; Rawat *et al*., 2009; Working Plan, 2009). In order to strengthen this activity, rapid survey and mapping of MPs, in various forest divisions of the state, is being carried out by the authors. This paper deals with the availability and regeneration status of selected high value medicinal plants within DFD, based on such survey. Strategies for the better management of high value MP species have been discussed.

Materials and methods

Study area

The Dehradun Forest Division (DFD), located in the state of Uttarakhand, is spread over 454.95 km^2 area [30° 24' to 30° 0' North latitudes and 77° 20' to 78° 10' East longitudes; (Fig. 1)]. The DFD is divided into eight ranges *viz.,* Asarori, Malhan, Lachhiwala, Malsi, Jhanjara, Thano, Barkot and Rishikesh (Fig. 1). The major portion of the DFD lies in Doon Valley, which is characterized by rich alluvial soil and sub-tropical climate. This valley is flanked by the Shivalik ranges on the south and outer Himalaya on the north. The former ranges protect the Valley from heat waves and dust from the plains, making the forest comparatively moist (Gautam *et al.,* 2008). The Climate of the DFD varies from tropical to temperate. The mean annual rainfall of Dehradun is about 2000mm, most of it being received during the monsoon season (June to September). Altitudinal range of the DFD is between 400 m to 1600 m above mean sea level. Forest vegetation is dominated by Sal (*Shorea robusta*), which is further divisible into Doon Valley Sal and Shiwalik Sal, as per the classification of Champion and Seth (1968). Common associates of Sal are *Mallotus philippensis, Terminalia alata, Syzigium cumini,* and *Flacourtia indica*. Understory vegetation is formed by *Clerodendrum viscosum, Ardisia solanacea* and *Justicia adhatoda*. Common forestry practices adopted during 1950's and 60's were removal of miscellaneous species, which were termed as *Kokat* (useless wood), climber cutting, thinning and maintenance of fire lines (Working Plan, 2009; Chauhan *et al.,* 2001; Rawat and Bhainsora 1999). Subsequent to implementation of new Forest Policy (1982), the focus of forest management changed and forestry operations were stopped (Working Plan, 2009). Based on this, Sal forests with natural presence of sub-dominant tree species were considered as natural Sal forests whereas those with only Sal in it were considered managed forests. The forests of the DFD, therefore, are further divisible into seven different categories (strata) *viz.,* Sal forest (managed for timber production), natural Sal (Sal mixed) forest, Sal-

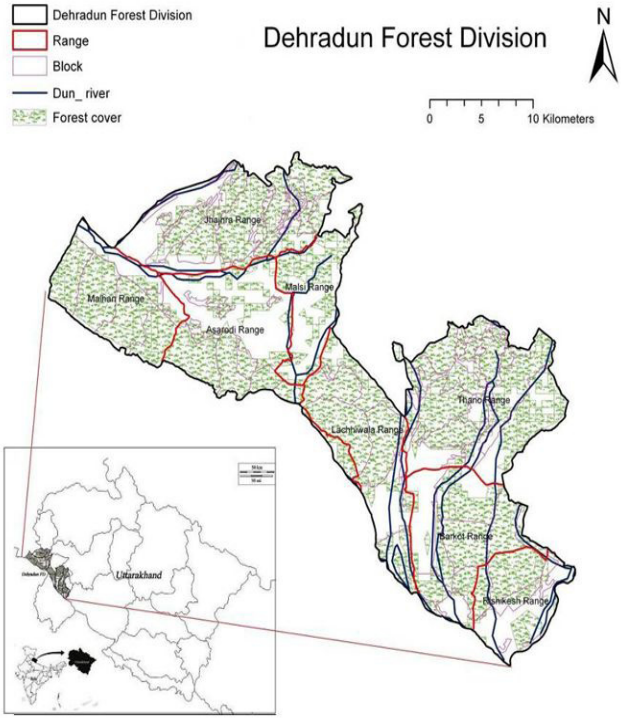

Fig. 1. Location of study area (Dehradun Forest Division and its ranges)

bamboo forest, Khair-Shisam forest, open hill forest (or miscellaneous forests), Sal with plantations and Teak - *Eucalyptus* plantations (Plate 1). Except open hill forests, all other categories have been extensively managed in the past to promote timber production. Although, commercial harvest of NWFPs, especially a few high value medicinal plants, was allowed from the DFD but no attempts have been made to improve the habitat, e.g., removal of aggressive alien invasive, such as *Lantana camara* (Plate 1) and there was no provision of assisted natural regeneration for these species.

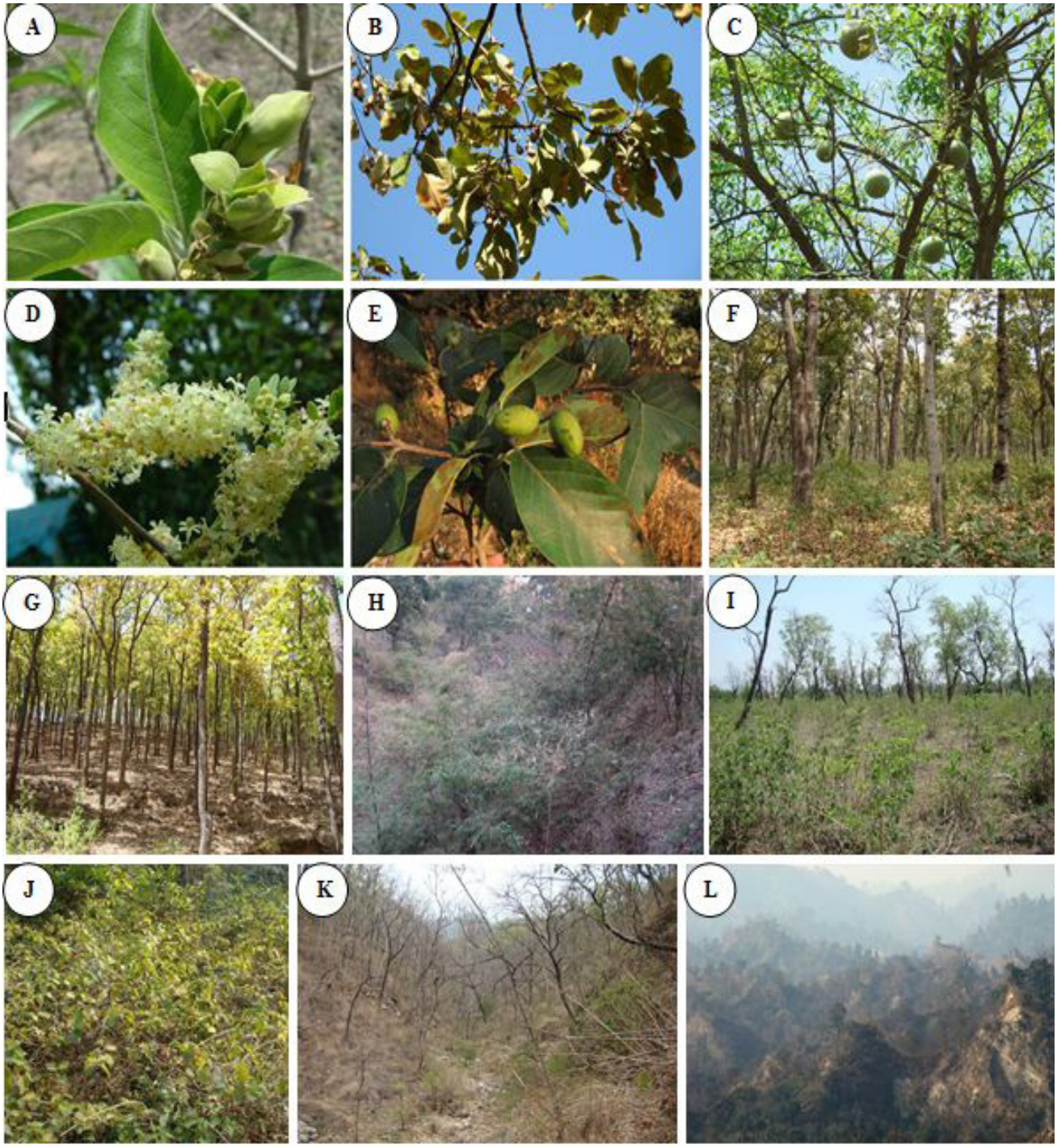

Plate 1. Important medicinal plants and their habitats: A-Vasaka (*Justicia adhatoda*), B-Baheda (*Terminalia bellirica*), C-Bael (*Aegle marmelos*), D-Amla (*Phyllanthus emblica*), E-Harad (*Terminalia chebula*), F-Sal (*Shorea robusta*) Forest, G-Managed Sal Forest, H-Bamboo-Sal Forest, I-Khair-Shisam Forest, J-Invasion of *Lantana*, K-Miscellaneous Dry Forest and L-Open Hill Forest

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Tab. 1. Medicinal properties of high value medicinal plants (MPs) of Dehradun Forest Division (DFD)

Scientific name	Common name	Habit	Medicinal Uses
Justicia adhatoda	Adulsa, Vasa, Vasaka	Shrub	Bronchodilator, respiratory stimulant, antifungal, anti-asthmatic, also use in Menorrhagia
Aegle marmelos	Bael, Bel	Tree	Anti-inflammatory, Anti-diarrheal, effective in asthma and Jaundice
Phyllanthus emblica	Amla, Avala	Tree	Antacid, anti-anemic, antiemetic, astringent, anti-haemorrhagic, anti-diarrheal, anti-diabetic, carminative, antioxidant, diuretic, used in jaundice
Terminalia bellirica	Baheda	Tree	Purgative when half ripe, astringent when completely ripe, antipyretic, used in cough, bronchitis and upper respiratory tract infections
Terminalia chebula	Harad, Haror	Tree	Gentle purgative, astringent, used in flatulence, constipation, diarrhoea, digestive disorders

[Based on Khare, 2007]

Data collection and analysis

The present study was carried out during February to November 2008 through Rapid Mapping Exercise (RME) following Rawat *et al*. (2004). On the basis of reconnaissance, each range was divided into smaller strata. Sampling within each stratum was done along either side of randomly laid transects (each 1km long). In a rugged and hilly terrain it was not feasible to lay a straight line / random transect. Hence, in such cases, transects were laid along least beaten trails. The number of transects varied depending on the size of the forest type in each range. Twenty sample plots were laid along each transect, at an interval of 50 m. Beginning and end of each transect was marked on the field and geographical coordinates were recorded using Global Positioning System (GPS–Garmin 72) in order to plot the locations on the topographic map and for future comparison. The sample plots comprised a 10m radius circular plot (314 m^2) to estimate medicinal tree species density, a concentric 5m circular plot (78.5 m^2) for medicinal shrubs' density and on the outer boundary of smaller circle, four 1 X 1 m quadrats in each cardinal direction for herbaceous MPs' density. A total of 80 transects were laid in various ranges (Tab. 2) *i.e.,* 1600 sample plots, each for tree and shrub species, and 6400 plots for herb species. Availability of MPs and their distribution in various forest types was compared using simple measures such as percent frequency and density.

Tab. 2. Number of transects laid and commercially important medicinal plants (MPs) found in Dehradun Forest Division (DFD)

Range	Transect	Commercially important MPs in sample plots
Asarori	14	32
Malhan	8	26
Jhanjhara	10	22
Lachhiwala	10	27
Rishikesh	8	25
Barkot	12	32
Thano	16	39
Malsi	2	12

Results and discussion

During the present survey 86 MPs were recorded from the entire DFD. Thano range, which possesses all seven forest types, has maximum MPs, *i.e.* 39. Malsi range constitutes only two forest types *viz.* Sal and Natural Sal (Sal mixed) forests and had only 12 MPs. Other ranges of DFD *viz.*, Barkot, Asarori, Lachhiwala, Malhan and Jhanjhara had 32, 32, 27, 26 and 22 MP species respectively (Tab. 2). Highest number of MPs occurred in natural Sal forest (72 species) whereas only three MPs occurred in Teak–*Eucalyptus* plantation. Contradictory to our expectation, managed Sal forests of Dun valley supported as many as 37 MP species. This could be largely due to open edges, natural openings and ravines within this forest. Sal forests having plantations and Khair-Shisam forests supported 20 and 11 MPs respectively (Tab. 3). Out of 86 MPs, five species *viz.*, Amla (*Phyllanthus emblica*), Harad (*Terminalia chebula*), Baheda (*Terminalia bellirica*), Bael (*Aegle marmelos*) and Vasaka (*Justicia adhatoda*), have high demand (Ved and Goraya, 2008) and therefore these species are of high commercial value. Population status and abundance (per hectare density and percent frequency) of these high value MPs, in various forest types of different ranges of the division is discuss further and the regeneration status (seed-

Tab. 3. Important forest types for conservation and development of medicinal plants (MPs) in Dehradun Forest Division (DFD)

Forest Type	MPs	High value MPs for conservation and development
Sal Forest (Managed for Timber production)	37	Dudhi-bel, Sarpagandha
Natural Sal (Sal mixed) Forest	72	**Harad**, Danti, Gaj pipali,
Sal with plantation	20	Guduchi
Teak - *Eucalyptus* plantations	3	Danti, **Baheda**
Khair-Shisam Mixed	11	**Vasaka, Bael,**
Open hill Forest	20	**Amla, Baheda,** Dudhi-bel

Note: Species discussed in the paper are shown in bold.

Tab. 4. Status and abundance of saplings of medicinal trees indicating their regeneration

Sapling and Seedling	Range	Forest type	Density individuals/ha (D/ha)	Frequency (% F)	A/F
Amla	Thano	Natural Sal (Sal mixed)	3.18 ± 1.00	0.04	0.2
		Open Hill	3.18 ± 1.25	0.11	0.4
	Asarori	Open Hill	5.05 ± 2.0	3.97	0.1
Bael	Lachhiwala	Sal forest	6.36 ± 0.22	5	0.2
		Natural Sal (Sal mixed)	11.14 ±0.36	1.25	1.4
	Barkot	Natural Sal (Sal mixed)	13.25 ± 0.54	5.37	0.1
		Khair-Shisam	24.48 ±0.62	3.85	0
	Rishikesh	Natural Sal (Sal mixed)	30.64 ± 4.60	0.82	0.4
		Sal with plantations	50.91 ± 0.99	15	0.2
		Sal forest	57.27 ± 10.00	1.31	0.5
Baheda	Thano	Natural Sal (Sal mixed)	2.55 ± 0.06	2	0.1
		Open Hill	11.14 ± 0.17	6.25	0.1
Harad	Jhanjhara	Sal forest	0.91 ± 0.10	1.43	0.2
	Malsi	Sal forest	31.82 ± 15	0.64	0.1

lings and saplings) of medicinal tree species (Amla, Bael, Baheda and Harad) is given in Tab. 4.

Analysis of the data reveals that Bael had higher abundance in slightly degraded or disturbed forests. It is usually found in a drier miscellaneous forest (Kurien *et al*., 2007).

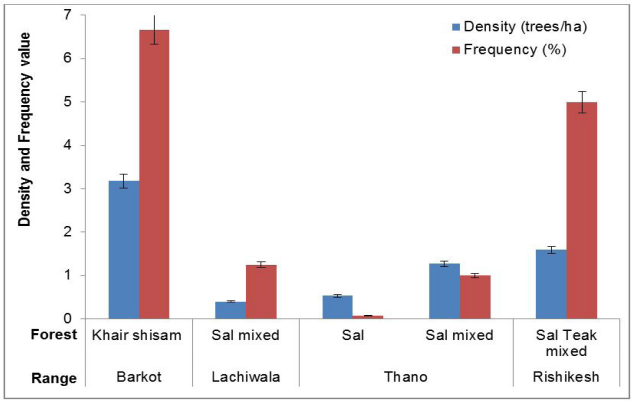

Fig. 2. Population status and distribution of *A. marmelos* (Bael) in different forest types and ranges of Dehradun Forest Division (DFD)

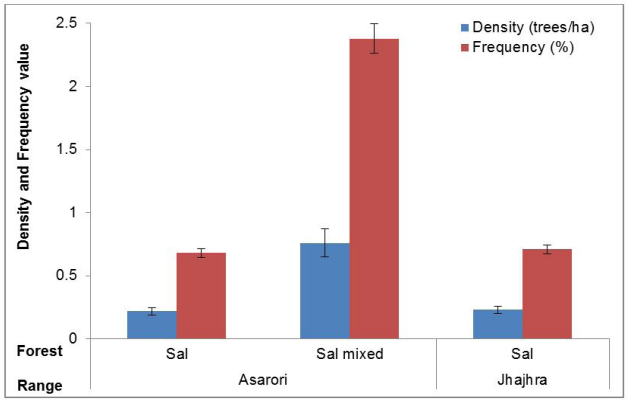

Fig. 3. Population status and distribution of *T. chebula* (Harad) in different forest types and ranges of Dehradun Forest Division (DFD)

Although patchily distributed, it was abundant in Khair-Shisam forest (3.18 ± 0.22 trees ha^{-1}) of Barkot range as compared to Sal and Natural Sal (Sal mixed) forests. The regeneration was fair and found in Khair-Shisham and open hill (miscellaneous) forests but showed maximum abundance in Sal forest (Fig. 2). Drier miscellaneous forest (Plate 1) is favoured not only by Bael but also by Amla (*P. emblica*), Harad (*T. chebula*) and Baheda (*T. bellirica*), which is also reported by Kurien *et al.* (2007). Harad in natural condition occurs sporadically in drier miscellaneous forests and sometimes prefers teak forests (Jansen, 2005) but in the present study, maximum density of Harad was recorded in Natural Sal or Sal mixed forest (0.76 ± 0.11 trees ha^{-1}) (Fig. 3). The regeneration rate was also good in pure Sal forests, present at drier hilly patches of Malsi range of DFD, with sapling density of 31.82 ± 15 individuals ha^{-1}. Russell-Smith *et al.* (2006) infers that species like Amla and Harad presumably require on-going disturbance(s) like fire, which maintains open-canopied habitat conditions. The study in Rajaji National Park (Kurien *et al*., 2007), which is adjacent to the DFD, revealed that these

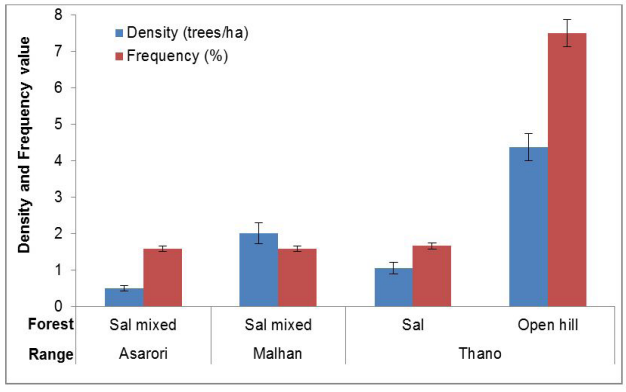

Fig. 4. Population status and distribution of *P. emblica* (Amla) in different forest types and ranges of Dehradun Forest Division (DFD)

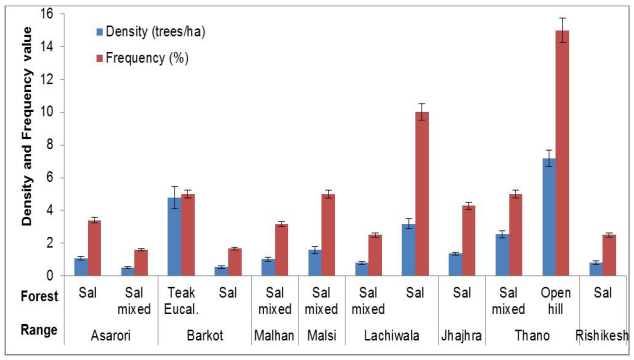

Fig. 5. Population status and distribution of *T. bellirica* (Baheda) in different forest types and ranges of Dehradun Forest Division (DFD)

Note: Teak Eucal. = Teak *Eucalyptus* (Plantation)

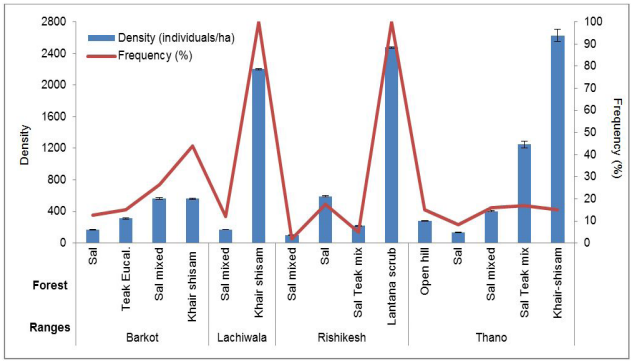

Fig.6. Population status and distribution of *J. adhatoda* (Vasaka) in different forest types and ranges of Dehradun Forest Division (DFD)

Note: Teak Eucal. = Teak *Eucalyptus* (Plantation)

species are among preferred palatable species with high anthropogenic pressure. Amla was found predominantly in hilly terrain, where Natural Sal (Sal mixed) forest is present, while the maximum density was observed in open hill forests (4.38 ± 0.37 trees ha^{-1}) of Thano range (Fig. 4). The same forest showed good regeneration (3.18 ± 1.25 individuals ha^{-1}) though the best regeneration was observed in the open hill forest of Asarori range. Baheda, either, was chiefly found in open hill forest and scarcely distributed in Teak-*Eucalyptus* plantation (4.78 ± 0.67 trees ha^{-1}) and very low density was observed in Sal and Natural Sal (Sal mixed) forest (Fig. 5). Baheda saplings had significantly higher density (11.14 ± 0.17 individuals ha^{-1}) in open hill forests compared to pure Sal and plantations.

Sal dominated forests have low species diversity and poor undergrowth (Champion and Seth, 1968; Puri *et al*., 1989) but Miscellaneous and Sal mixed forests have higher tree diversity (Kurien *et al*., 2007). Interestingly, in present study, many of the targeted species showed good regeneration in Sal and Natural Sal (Sal mixed) forest but mature plants were not so abundant in the same habitat. Many of the edible fruit trees, including Baheda, Amla and Bael, were used by many wild herbivores (Bhatnagar, 1991; Gupta, 1991; Kurien *et al.,* 2007) and could be the cause for dispersal (endozoochory) in different forest types (Janzen, 1984; Wang and Smith, 2002). As well as, these species are among preferred palatable species and are used extensively as fodder species in the study area (Kurien *et al.,* 2007). Various other disturbance factors e.g., fuel wood collection, livestock grazing and encroachment for cultivation and habitation (Gautam *et al*., 2008) make these species more vulnerable.

While Bael, Amla, Baheda and Harad are intensively harvested from the wild (sub-tropical and tropical forests of India), Vasaka is supplied chiefly from cultivation and wasteland (Ved and Goraya, 2008). It has low market value, unlike the above mentioned medicinal trees, but has very high demand. The collection from cultivation can reduce pressure on the wild populations but it cannot replace them. The wild populations of MPs also are preferably used for genetic enrichment of cultivated stock than as raw material for the herbal industry. But *in situ* conservation of MPs allows natural reproductive and evolutionary processes (e.g. pollination, dispersal & animal interaction) to take place (FRLHT, 2002). It was found to be very common throughout DFD and abundant in the eastern part of the DFD, which is drier and prone to anthropogenic pressures. The maximum density was observed in Khair-Shisam forest of Thano range (2628.23 ± 80.0 individuals ha^{-1}) though the distribution was patchy as compared to *Lantana* infested area of Rishikesh range (2475.50 ± 8.74 individuals ha^{-1} in all the sites, *i.e.* 100% frequency) and Khair-Shisam forest of Lachiwala range (2201.86 ± 9.33 individuals ha^{-1} with 100% frequency), where it was abundant and evenly distributed (Fig. 6). Wong *et al.* (2001) suggested that the sustainable use can be defined as 'The use of plant resources at levels of harvesting and in such ways that the plants are able to continue to supply the products required indefinitely'. Therefore, looking at the abundance of the species in the study area, at a given time 20-25% biomass of green foliage, in case of Vasaka, can be harvested from the mature plants. Essentially, a rotational harvest of 4 years among the designated compartments, coupled with regular control of *Lantana* and reseeding of Vasaka after harvest would be desirable for development as well as the harvest of these species.

Conclusions

Given the heterogeneity of the habitat types and highly fertile alluvial soil, the DFD has a tremendous potential to conserve, develop and then sustainably harvest of these MPs. Therefore, open hill (miscellaneous) forests, *Lantana* infested areas and riverine Khair-Shisam patches could be taken up for *in-situ* conservation and development of these MPs species. The open Khair-Shisam woodland in the eastern part of the Division forms early serial stage of forest succession. Considering the high potential but low

abundance of other high value MPs *viz*., Amla, Harad, Baheda in DFD, it is recommended that highly degraded forest patches in western Doon may be taken up for recovery of these species by adopting assisted natural regeneration, reseeding and reducing the biotic interference. Besides these species other important species such as Danti *(Baliospermum montanum),* Sarpagandha (*Rauvolfia serpentina*), Gajpipali (*Scindapsus officinalis*), Guduchi (*Tinospora cordifolia*) and Dudhi-bel (*Vallaris solanacea*) can be conserved and monitored in the NWFP working circle of DFD. For the future conservation and development of high value MPs, their habitat preference and natural associations needs to be considered.

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