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The Availability, Fruit Yield, and Harvest of *Myrica esculenta* in Kumaun (West Himalaya), India

Myrica esculenta *Buch.-Ham. ex D. Don is a popular, potentially income-generating wild edible in the Indian Himalaya. The species prefers* Pinus roxburghii *Sarg.,* Quercus leucotrichophora *A. Cam., and mixed* Quercus *forests, contributing 15–26% of total tree density in the forests. It performs best in* Pinus roxburghii *forests, where its density correlates with* Pinus *tree biomass. The regeneration of* Myrica *is poor in all the habitats. However, recruitment of species increases consistently from abundant Myrica to no-*Myrica *stands. The fruit yield increases with tree size category and differs between habitats. The potential yield at different sites is 2.0–4.2 tonnes/ha, of which 2.8–7.2% is harvested for income generation. The income generated from* Myrica *fruit is significant, considering the regional annual per capita income. The possible impact of fruit harvesting and other disturbance factors on the regeneration of the species is discussed. There are significant options for enhancing the income-generating potential through value addition.*

Keywords: Myrica esculenta *(Kaiphal); nontimber forest products; Himalayan region; rural economy; fruit yield; regeneration; recruitment; Kumaun; India.*

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Introduction

Nontimber forest products (NTFPs) have emerged as a vital income-generating and ecologically sustainable resource in all parts of the world (Tewari and Campbell 1995; Hegde et al 1996; Uma Shankar et al 1996). Among NTFPs in the Himalaya, wild edibles have proved promising. Of the 675 wild edible plant species in the Indian Himalaya, 344 occur in the west Himalaya (Samant and Dhar 1997). Despite this diversity of wild edibles, no attempt has been made to assess the status of their occurrence and availability, harvesting trends, and the potential of wild edibles to generate income.

Myrica esculenta Buch.-Ham. ex D. Don (*Kaiphal*), known for edible fruit and other by-products, is a potential income-generating species in the sub-Himalayan region (Pandey et al 1993). As with other lesser-known wild species (Joyal 1996), the ecological and socioeconomic attributes of *Kaiphal* are not well identified. In an attempt to begin filling this gap in knowledge, the present study aims to assess the availability of species in different habitats, analyze regeneration patterns, quantify realized and potential fruit yield, and evaluate trends of collection and marketing of fruit.

M esculenta is a medium-sized, dioecious, evergreen tree widely distributed between 900–2100 m asl in the Indian Himalaya from Ravi eastward to Assam, Khasi, Jantia, Naga, and the Lushi Hills and extending to Malaya, Singapore, China, and Japan (Osmaston 1927). In the western Himalaya, it occurs mainly in *Pinus roxburghii* (*Chir* pine) (Figure 1), *Quercus leucotrichophora* (*Banj* oak), and mixed *Quercus* forests and is popular with local people for its delicious fruit and processed products such as squash, syrup, and jam (Dhyani and Dhar 1994).

Methodology

Study area and sample plots

The study was conducted in Kumaun (west Himalaya) from 1995 to 1996 at three sites with similar altitudes: Kalika, 1500–2050 m; Binsar, 1400–2100 m; and Jalna, 1500–1960 m (Figure 2). All sites were either *P roxburghii* forests, *Q leucotrichophora* forests, or mixed *Quercus* forests. Each forest type is hereafter referred to as *Myrica* habitat. Considering the relative density (RD) of *Myrica* trees, each habitat type was categorized into three density classes: abundant *Myrica* (>30% RD), scattered *Myrica* (1–30% RD), and no-*Myrica* (with *Myrica* individuals at recruitment stage).

Three sample plots (1 ha each) in each class were randomly identified, and ten 10 m × 10 m quadrats were placed, at random, on each plot.

Vegetation analysis

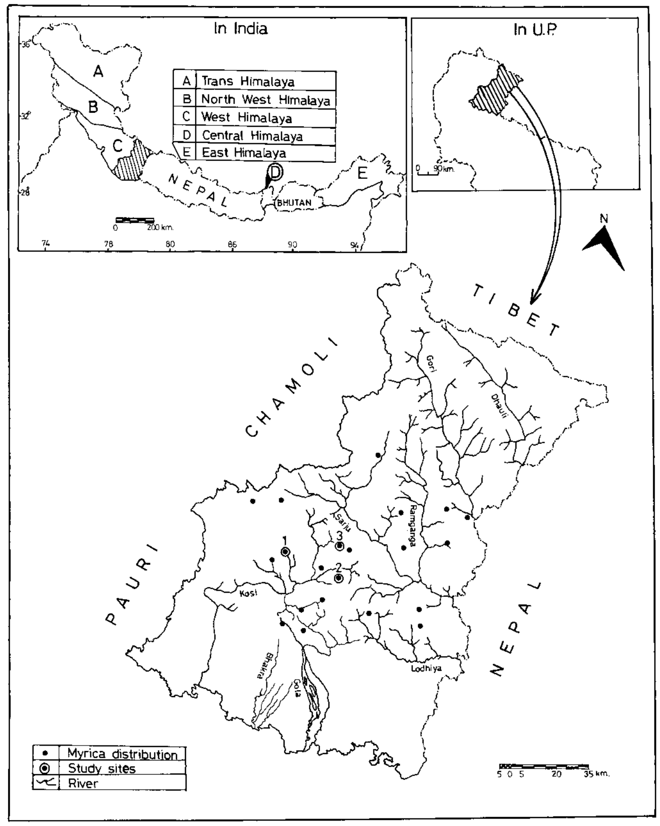
The individuals of all tree species in each quadrat were recorded and CBH (circumference at breast height, 1.3 m from the ground) measured. Individuals were categorized as trees (>31 cm CBH), saplings (11–30 cm CBH), and seedlings (<10 cm CBH). Male and female trees were counted separately. Quadrat data were used for the analysis of density, frequency, and dominance following Misra (1968) and Müller-Dombois and Ellenberg (1974). Density distributions in different size categories (Saxena et al 1984; Rawal 1991) were used to characterize population structure after grouping the individuals into 5 CBH classes: (A) <10 cm, (B) 11–30 cm, (C) 31–65 cm, (D) 66–100 cm, (E) 101–135 cm, and (F) >135 cm.

Fruit yield

Potential fruit yield (kg/tree) was estimated 10–15 days prior to fruit ripening during April–May 1996. Five female trees in each of the 5 CBH classes were marked in all habitats. The number of main branches, the number of offshoots per main branch (ie, the average per 5 randomly observed main branches per tree), and the

FIGURE 1 *Myrica esculenta* (*Kaiphal*) growing in a *Pinus roxburghii* (*Chir* pine) forest. (Photo by authors).

FIGURE 2 Location of the study sites.



amount of fruit per type of offshoot (ie, the average per 5 offshoots from the low, middle, and upper canopy of each tree) were counted for marked individuals. The yield was calculated following Dhyani and Khali (1993).

Fruit-yield data were pooled and mean yield (kg/tree) for each CBH class (A–F) calculated. For each site, fruit yield in tonnes/ha was obtained by multiplying fruit yield per tree by the density of female plants/ha. The total yield for each site was calculated as *total yield = (yield/ha)* × *total area*. The fruit from all CBH classes in different habitats and sites was mixed and weighed in 5 lots of 1 kg each. The amount of fruit in each lot was then counted and the mean value (1800 [±55]) was considered as a standard for conversion into kilograms.

Harvesting and market trends

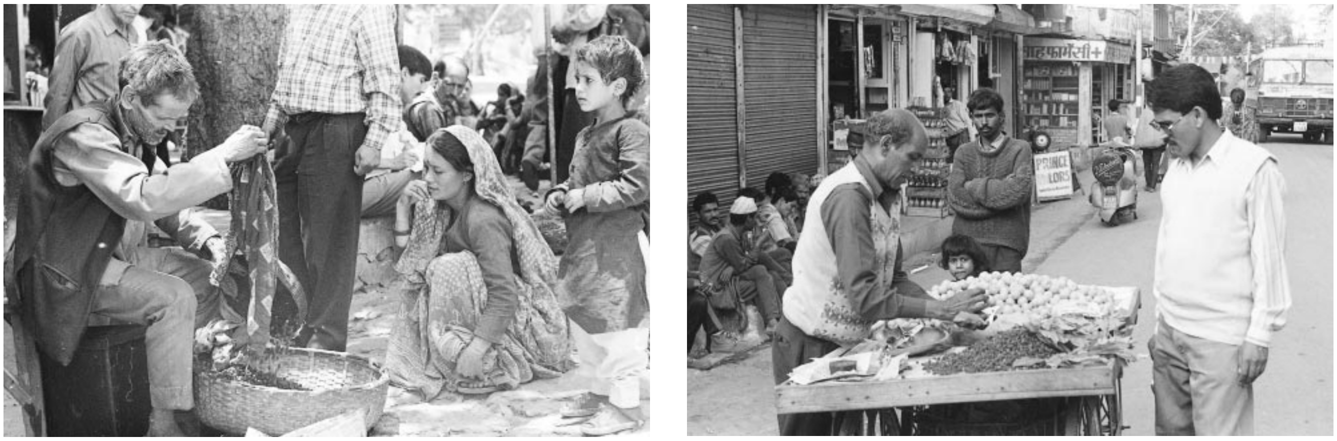
The extent of harvesting and involvement in resource collection were assumed to depend on market availability and accessibility; two of the selected sites (Kalika and Jalna) were found to be fairly easily accessible, while Binsar is far away from the market (Table 1). The peak collection period normally falls in the second week of May and lasts until the first week of June. During this period, information was obtained for three consecutive days at each site.

After identification of the main routes along which the bulk of the harvest was brought to market, the number of persons involved in resource collection (hereafter referred to as collectors) was recorded and grouped into adults and children. Since the fruit supply is carried from forest to market at fixed times (early morning and late evening), it was easy to count the number of persons bearing fruit who passed along these routes. Collection of fruit by villagers for their own consumption was ignored. Ten individuals in each group (adults and children) were randomly interviewed and their harvest weighed to generate data on the average collection per

Sites	Altitude (m asl)	Area (ha)	Distance to market (km)	Access to resource
Kalika	1500–2050	129	Ranikhet (10–15)	Open/easy
Jalna	1500–1960	87	Almora (15–20)	Open/moderate
Binsar	1400–2100	71	Almora (>30)	Open/not easy

TABLE 1 Details of the study sites.

FIGURE 3a,b Collectors, contractors, and retailers are involved in the trade of Myrica fruit. (Photo by authors)



individual, the number of days spent in fruit collection, and the total income generated. The average harvest per day was 15 kg per adult and 9 kg per child. On average, an individual was involved in collection for 35 days per year and the number of persons involved varied from one site to another (Kalika: 50 adults, 30 children; Jalna: 26 adults, 12 children; Binsar: 5 adults, 4 children). For each group, total extraction was calculated as $Te = (C \times D) \times P$, where Te = total extraction, C = collection per day per individual, D = number of days involved in fruit collection, and P = number of persons involved. Since the information was obtained for the peak collection period, the data analysis reflects maximum realized extraction.

TABLE 2 Relative dominance of *M esculenta* in different habitats. ME, *Myrica esculenta*; QL, *Quercus leucotrichophora*; PR, *Pinus roxburghii*; A, tree density/ha; B, seedling density/ha, C, sapling density/ha. Values in parentheses represent density in percent of size category.

	Kalika			Binsar			Jalna		
Forest/species	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Pinus roxburghii									
ME	139 (24.8)	20 (1.7)	65 (16.2)	90 (16.6)	32 (4.1)	93 (10.9)	109 (19.7)	29 (4.3)	88 (24.0)
QL	33 (5.9)	28 (2.4)	134 (33.3)	39 (14.6)	157 (20.3)	318 (37.4)	44 (8.0)	51 (7.5)	136 (37.0)
PR	380 (67.8)	1046 (91.7)	137 (34.0)	350 (64.6)	570 (73.8)	436 (51.2)	393 (71.5)	585 (87.3)	142 (38.7)
Quercus leucotrichophora									
ME	155 (25.8)	13 (2.4)	99 (13.8)	93 (15.4)	24 (4.2)	140 (18.6)	136 (19.0)	21 (6.3)	134 (25.0)
QL	366 (57.9)	228 (43.4)	432 (60.0)	272 (45.1)	273 (48.2)	378 (50.4)	463 (64.9)	200 (60.4)	392 (73.0)
PR	67 (11.2)	250 (47.6)	145 (20.2)	136 (22.5)	214 (37.8)	218 (29.1)	0 (0.00)	0 (0.00)	0 (0.00)
Mixed *Quercus*									
ME	140 (22.9)	2.0 (0.6)	104 (7.6)	103 (16.3)	07 (1.6)	93 (9.2)	99 (15.4)	16 (7.1)	103 (14.5)
QL	147 (24.2)	133 (41.8)	713 (52.0)	223 (33.2)	188 (43.1)	551 (54.6)	246 (38.4)	126 (56.2)	513 (72.2)
PR	136 (22.3)	174 (54.7)	267 (19.5)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

The contractors purchase fruit from the collectors and sell it to retailers for marketing (Figure 3a,b). Both contractors and retailers ($n = 5$) were contacted to obtain information on the benefits accrued in each case. The income values are given in Indian rupees (US$ 1 = IRs 35.00, 1996 exchange rates). Projections of potential income (with *Myrica* fruit processed into squash, jam, or jelly) were made on the basis of reported values (Dhyani and Dhar 1994). The involvement of rural inhabitants as fruit collectors and the income that subsequently accrued (within a 25-km radius of the sites) was also analyzed for three villages at each site. One adult member from each household ($n = 10$) was contacted in each village to gather information on involvement in and extent of fruit collection.

FIGURE 4 Population structure of *Myrica* compared with other dominant trees in different habitats. In each case, percent frequency refers to the relative density of individuals in different size categories.

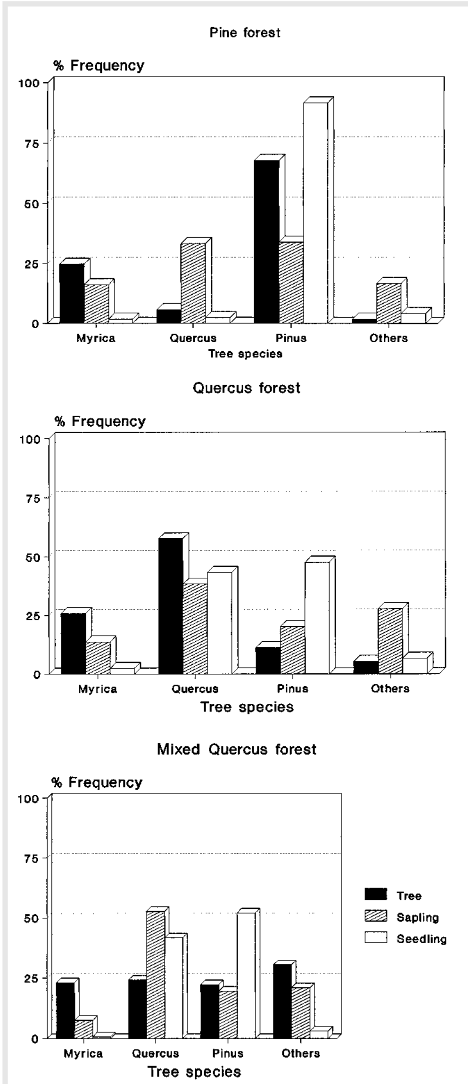
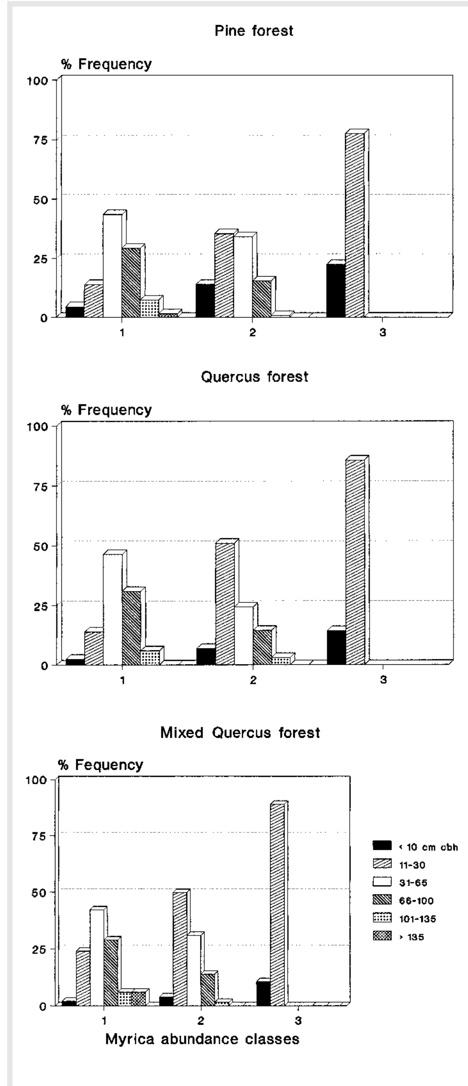


FIGURE 5 Frequency (relative density) of *Myrica* individuals across CBH classes in stands with different levels of abundance (1, abundant *Myrica*; 2, scattered *Myrica*; 3, no *Myrica*).



Statistical analysis

The relationships between various phytosociological parameters, yield, and extraction were statistically tested using the SYSTAT package (Wilkinson 1986).

Results

Species performance

Abundance: On average, *Myrica* tree density varied from 90 individuals/ha (Binsar: *P roxburghii* forest) to 155 individuals/ha (Kalika: *Q leucotrichophora* forest). Among the tree species, the relative density of *Myrica* (15.4–25.8%) ranked second in all habitats, indicating that it is an important tree component in these forests (Table 2).

Myrica tree density had no relationship to total forest tree density. The relationship was similar for recruits (except in *P roxburghii* forests, $r = 0.575$, $P < 0.01$). However, *Myrica* tree density ($r = 0.717$, $P < 0.001$) increased significantly with total forest tree biomass in *P roxburghii* forests (assuming that biomass corresponds to basal area). By contrast, *Myrica* seedling density ($r = -0.466$, $P < 0.05$) and sapling density ($r = -0.540$, $P < 0.05$) declined with increasing forest biomass in these forests. Such relationships were not apparent for other habitats.

Recruitment and population structure: For all habitats, there was a low frequency of *Myrica* seedlings, a higher frequency of saplings (*P roxburghii,* 42.3%; *Q leucotrichophora,* 50.1%; mixed *Quercus,* 54.3%), and a continuous decrease toward higher tree classes (Figure 4). If seedling and sapling density are considered as indicators of recruitment, recruitment consistently increased from abundant *Myrica* stands to no-*Myrica* stands across stands of different abundance levels (Figure 5).

Fruit yield and extraction

Variation in yield: Comparing the different habitats, the maximum fruit yield (42.1 kg/individual) was in *P roxburghii* forests and the minimum (28.9 kg/individual) in mixed *Quercus* forests. There was a positive correlation between fruit yield and tree size category (pine forest, $r = 0.977$, $P < 0.001$; *Quercus* forest, $r = 0.980$, $P < 0.001$; mixed *Quercus* forest, $r = 0.996$, $P < 0.001$; $n = 9$). The mean fruit yield per tree varied significantly depending on the CBH class (LSD 8.24; $P < 0.05$; Table 3). The potential yield/ha ranged between 4.3 tonnes/ha (Kalika) and 2.0 tonnes/ha (Binsar) (Table 4).

Extraction and market trends: Considering that the fruit is harvested randomly and not from any specific habitat, it was important to assess the realized and the potential yields for all the sites (Table 5). The data reveal that only a small proportion of available resource (potential yield) was being harvested (6.3% for Kalika, 2.8% for Binsar, 7.2% for Jalna).

While passing through different stages of trade, the value of the resource changes considerably (ie, collector to contractor at Rs 12.5/kg, contractor to retail market at Rs 18.0/kg, and retailer to consumer at Rs 25.0/kg). *Myrica* fruit contributes 50,000–450,000 rupees per year to the economy of the nearby villages (Table 5). The total value of harvested fruit while passing through different trading phases is relatively high (Rs 100,000–890,000 per season).

Discussion

Ecological patterns

The performance (relative density) of *M esculenta* in different habitats was comparable (*P roxburghii*, 16.6–24.8%; *Q leucotrichophora*, 15.4–25.8%; and mixed *Quercus,* 15.4–22.9%). However, within a habitat, the distribution of the species exhibited heterogeneity (ie, abundant *Myrica,* scattered *Myrica,* and no-*Myrica* stands). Considering the abundance of *Myrica* as an indication of stand maturity, the mature *Myrica* stands (ie, abundant *Myrica*) showed little variation in density across habitat types ($F = 2.824$, not significant), but there was a significant difference across sites ($F = 54.50$,

TABLE 3 Variation in *Myrica* fruit yield (kg/individual) across CBH classes and habitats (C, D, and E refer to CBH classes as defined in the text).[a]

CBH class	Habitat			Mean per CBH class
	P. roxburghii	*Q. leucotrichophora*	Mixed *Quercus*	
C	23.8	15.7	11.7	17.1
D	38.6	35.8	28.5	34.3
E	63.9	51.9	46.4	54.1
Habitat mean	42.1	34.5	28.9	

[a] LSD for habitat ($P > 0.05$) 20.22; LSD for CBH classes ($P > 0.05$) 8.24.

TABLE 4 Resource availability and yield potential of *Myrica esculenta* at different sites and according to different CBH classes.

Site/CBH class	Female plant (individuals/ha)	Fruit yield (kg/individual)	Fruit yield (tonnes/ha)	Fruit yield (tonnes/site)
Kalika				
C	82	18.8	1.5	199
D	61	39.1	2.4	307
E	08	57.2	0.4	59
Binsar				
C	69	14.5	1.0	71
D	25	32.9	0.8	58
E	04	51.0	0.2	14
Jalna				
C	50	17.8	0.9	77
D	41	35.1	1.4	125
E	08	54.0	0.4	37

Site	Yield potential (tonnes)	Realized extraction (tonnes)	Income potential at Rs 25 (x 100,000 Rs)	Realized net income (x 100,000 Rs)			
				Col	Con	Re	Total
Kalika	565.0	35.7	141.0	4.5	1.9	2.5	8.9
Binsar	143.0	4.0	35.8	0.5	0.3	0.2	1.0
Jalna	239.0	17.4	59.8	2.2	0.9	1.3	4.5

TABLE 5 Comparative analysis of yield potential and income realized at different sites with *Myrica* (yield potential refers to total fruit yield in tonnes/site, as given in Table 4). Col, collectors; Con, contractors; Re, retailers.

Sites	*P roxburghii*	*Q leucotrichophora*	Mixed *Quercus*	Site mean
a. Abundant *Myrica* stands[a]				
Kalika	316.7	313.3	300.0	310.0
Jalna	206.7	246.7	190.0	214.4
Binsar	156.0	196.7	183.3	178.7
Habitat mean	226.5	252.2	224.4	
b. Scattered *Myrica* stands[b]				
Kalika	100.0	153.0	120.0	124.4
Jalna	100.0	163.3	190.0	151.1
Binsar	113.3	83.3	183.3	126.6
Habitat mean	104.4	133.1	164.4	

[a]LSD for habitat ($P < 0.05$) = 73.9; for sites = 34.4. F ratio for habitat = 2.824 (not significant); for sites = 54.50 ($P < 0.05$).
[b]LSD for habitat ($P < 0.05$) = 53.3; for sites = 59.4. F ratio for habitat = 4.597; for sites = 1.118 (not significant).

TABLE 6 Difference in *Myrica* tree density (individuals/ha) across habitats and sites.

$P < 0.05$). In contrast, developing stands (ie, scattered *Myrica)* exhibited differences under varying habitat types ($F = 4.597$, $P < 0.05$). However, when sites were compared, this relationship was not significant ($F = 1.118$, not significant) (Table 6). This indicates that, during the development of a *Myrica* stand, the pace of *Myrica* establishment depends greatly on micro (habitat) conditions, irrespective of the nature of macro (site) conditions. The importance of this finding must be considered when developing strategies for afforestation including *Myrica*.

The association of *Myrica* with *P roxburghii* is revealing. Poor recruitment of *Myrica* in mature *P roxburghii* forests is interesting in view of the fact that *P roxburghii* itself is considered a colonizer on newer sites (Singh 1993) in the region. Presumably, after *P roxburghii* becomes established, *M esculenta* starts to colonize, as reflected in the abundance of new recruits in no-*Myrica* stands. Such associations are widely reported in the region, especially in Garhwal Himalaya (Kusum Lata and Bisht 1993). Detailed investigation of this issue is needed.

Poor recruitment of *Myrica* was evident in all habitats. In forestry, poor recruitment is generally attributed to various types of disturbances, for example, fire, grazing, overharvesting, compaction of soil, etc. Further, NTFPs are subject to predation and/or extraction by mammals and human beings, adversely affecting recruitment (Murali et al 1996). These factors may contribute to poor recruitment of *Myrica*. As far as fire is concerned, it is a common phenomenon in *P roxburghii* forests but not in *Quercus* and mixed *Quercus* forests. In protected sites, grazing, harvesting of biomass, and extraction of fruit are expected to be minimal (eg, in Binsar). It also seems unlikely that the pressure of harvesting (which affects less than 8% of the total yield potential) could have drastically reduced natural regeneration as suggested for Amla (*Phyllanthus emblica*) in the Biligiri Rangan Hills in India, where approximately 13% of the fruit is harvested (Uma Shankar et al 1996).

Instead, we believe that physical dormancy due to the hard seed coat might be responsible for poor regeneration. The species responds poorly even in germination trials carried out in nursery conditions. Various presowing treatments, for example, mechanically scarified seeds soaked in GA_3 solution and prechilling for different lengths of time, increased the germination rate by up to 50% (our unpublished data). Furthermore, the species tends to occupy newer sites at a distance from the mature *Myrica* stands, suggesting an ability to invade these despite poor regeneration. Poor recruitment in *Myrica*-dominated stands might also be due to phenolic and other chemical compounds produced by the species (Sun et al 1988). However, this requires further investigation.

FIGURE 6 Children contribute to the income of rural households by collecting and selling *Myrica*. (Photo by authors)

FIGURE 7 In contrast with other minor forest products, harvesting of *Myrica* is an income-generating opportunity for rural women. This potential could be increased if the fruit were processed before being sold to contractors. (Photo by authors)

Potential for income generation

The present study indicates that *Myrica* fruit can contribute to the cash economy of local rural inhabitants (Figure 6). At the village level, an average of 60% of households are involved in the harvest and trade of *Myrica* fruit, wherever the resource is available. An average collection of 73–297 kg per household per season fetches a household Rs 913–3713 (US$ 26–106) per season. This income is significant considering the low annual per capita income in the region (for 1992–1993, Rs 973, or US$ 29.5), particularly in the district of Almora (Rs 594.32, or US$ 17, as calculated at constant 1980–1981 prices; Anonymous 1992–1997). In this respect, the income-generating potential of *Myrica* correlates well with the potential of NTFPs elsewhere (Hegde et al 1996). Moreover, the extraction and trade of *Myrica* fruit are largely carried out by rural women (Figure 7). Generally, women in the region contribute very little to income-generating ventures (Swaroop 1991). Their activities with regard to extraction of minor forest products are mostly confined to noncash collections (Rao and Saxena 1996). *Myrica* therefore offers a potential to improve rural women's income.

Compared to other economically important tree species in the region, for example, *Diploknema butyracea* (Rs 840–10,920, or US$ 24–312/ha) (Tewari 1997), *Myrica* has a higher income-generating potential (Rs 25,000–106,250/ha, or US$ 714–3036/ha). This suggests that the species could play an important role in the future.

Value addition

To achieve optimum benefits, value addition can aid the rural economy. For example, if the total realized extraction of *Myrica*, that is, 57.1 tonnes (from all sites) had been processed as jam, it could have generated Rs 3,150,000 instead of the realized benefits of Rs 1,440,000. Production of squash and syrup could have contributed much more (Dhyani and Dhar 1994). *Myrica* products exceed the economic potential of other promising trees in the region, for example, *Ficus glomerata,* with a net income (jelly) of Rs 48.4/kg, and *F hispida,* with Rs 40.48/kg from jam (Dhyani and Khali 1993). However, these estimates are currently not of great use to the local people because they do not have adequate knowledge of or access to improved processing, packaging technologies, and marketing. Similar cases have been reported elsewhere (Tewari and Campbell 1995).

There is nevertheless a potential for government incentives to promote small-scale village enterprises that could greatly increase rural people's incomes. Such measures can also help to reduce overharvesting and promote conservation (Hegde et al 1996; Uma Shankar et al 1996). Finally, also within the context of ecological and economic sustainability, the availability and yield potential of *M esculenta* in the region is good. There is no danger of depletion considering current extraction trends, so regeneration of *Myrica*, albeit poor, does not pose an immediate problem.

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REFERENCES

Anonymous. 1992–1997. *Uttaranchal Sub Plan.* Volume IV. *Uttaranchal Vikash Vibhag*. Lucknow: Government of Uttar Pradesh, India.
Dhyani PP, Khali MP. 1993. Fruit yield and economics of jelly and jam production from fruits of some promising *Ficus* tree crops. *Ecology of Food and Nutrition* 30:169–178.
Dhyani PP, Dhar U. 1994. Myrica esculenta, *Box Myrtle (Kaiphal).* Himavikas Occasional Publication 3. Almora, India: GB Pant Institute of Himalayan Environment and Development.
Hegde R, Suryaprakash S, Achpth L, Bawa KS. 1996. Extraction of non-timber forest products in the forest of Biligiri Rangan Hills, India. I: Contribution to rural income. *Economic Botany* 50:243–251.
Joyal E. 1996. The palm has its time: an ethnoecology of *Sabal uresana* in Sonora, Mexico. *Economic Botany* 50:446–462.
Kusum L, Bisht, NS. 1993. Quantitative analysis and regeneration potential of moist temperate forest in Garhwal Himalaya. *Indian Journal of Forestry* 11(2):93–106.
Misra R. 1968. *Ecology Work Book*. New Delhi: Oxford and IBH.
Müller-Dombois D, Ellenberg H. 1974. *Aims and Methods of Vegetation Ecology*. New York and London: John Wiley.
Murali KS, Uma Shankar, Uma Shaanker R, Ganeshaiah KN, Bawa KS. 1996. Extraction of non-timber forest products in the forest of Biligiri Rangan Hills, India. 2. Impact of NTFP extraction on regeneration, population structure and species composition. *Economic Botany* 50:252–269.
Osmaston AE. 1927. *A Forest Flora for Kumaun*. Dehradun: Bishen Singh Mahindra Pal Singh.
Pandey G, Sharma BD, Hore DK, Rao NK. 1993. Indigenous minor fruits' genetic resources and their marketing status in north-eastern hills of India. *Journal of Hill Research* 6:1–4.
Rao KS, Saxena KG. 1996. Minor forest products management: problems and prospects in remote high altitude villages of Central Himalaya. *International Journal of Sustainable Development and World Ecology* 3:60–70.
Rawal RS. 1991. *Woody Vegetation Analysis Along Elevational Gradient of Upper Sarju Catchment in Kumaun Himalaya* [PhD thesis]. Nainital, India: Kumaun University.
Samant SS, Dhar U. 1997. Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. *International Journal of Sustainable Development and World Ecology* 4:197–191.
Saxena AK, Singh SP, Singh JS. 1984. Population structure of forests of Kumaun Himalaya: implication for management. *Journal of Environment and Management* 19:307–324.
Singh SP. 1993. Controversies of chir-pine forest expansion in the Central Himalaya. *In:* Rawat AS, editor. *Indian Forestry: A Perspective*. New Delhi: Indus Publishing, pp 307–314.
Sun DW, Zhaw WC, Wang H, Foo LY. 1988. Tannins and other phenolics from *Myrica esculenta* bark. *Phytochemistry* 27:579–583.
Swaroop R. 1991. *Agricultural Economy of Himalayan Region With Special Reference to Kumaun*. Himavikas Occasional Publication 1. Almora, India: GB Pant Institute of Himalayan Environment and Development.
Tewari A. 1997. *Clonal Propagation of Indian Butter Tree [*Aisandra butyracea *(Roxb.) Lam.] Through Tissue Culture* [PhD thesis]. Nainital, India: Kumaun University.
Tewari DD, Campbell JY. 1995. Developing and sustaining non-timber forest products: some policy issues and concerns with special reference to India. *Journal of Sustainable Forestry* 3(1):53–79.
Uma Shankar, Murali KS, Uma Shaanker R, Ganeshaiah KN, Bawa KS. 1996. Extraction of non timber forest products in the forest of Biligiri Rangan Hills, India. 3. Productivity, extraction and prospects of sustainable harvest of Amla (*Phyllanthus emblica*). *Economic Botany* 50:270–279.
Wilkinson L. 1986. SYSTAT: *The System for Statistics*. Evanston, IL: Systat.