

# Himalayan forest database – Thinking beyond dominants

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*Understanding the dynamics of mountain ecosystems, especially in relation to global climate change, requires strengthening of ecological databases. This calls for recognizing both the strengths as well as weaknesses of existing data sets. The existing ecological data sets on the Himalayan forests are considered appropriate for inclusion in any predictive model. However, to address issues of regional and global concerns, these databases need further strengthening. We attempt to highlight some of the weaknesses of Himalayan forest database and provide evidences from a case study of *Myrica esculenta* – a dioecious tree, to establish that hitherto neglected non-dominant species have the potential to reflect changes. Such species also need to be taken into consideration while formulating forest conservation plans in the region.*

THE extent and diversity of Himalayan forests is well known<sup>1</sup> and evidences indicate that these forests differ significantly from both tropical and temperate forests of the world<sup>2</sup>. Such interpretations call for in-depth investigations, especially to understand the significance of variations in patterns within and among forests. This will facilitate the compatibility (and inclusion) of available Himalayan forest data sets with global databases. Until this happens, Zobel and Singh<sup>2</sup> believe ecological generalizations at a global scale and the conclusions drawn about critical global/regional questions may prove erroneous and invalid.

While, on the one hand, recognition of Himalayan database among ecologists at a global level is needed, on the other, and perhaps more importantly, initiatives are required to further strengthen Himalayan forest database so as to enhance our ecological understanding at a local level. This understanding would be effective in addressing issues of conservation and management at local and/or regional level. A critical assessment of available information makes it amply clear that the Himalayan forest database: (i) often exaggerate the ecological value of selected prominent (dominant/co-dominant) taxa and grossly underestimate the role of other associates. As a result, the management and conservation prescriptions largely focus on issues related to dominant taxa; (ii) largely remain silent on possible effect of habitat/spatial heterogeneity on demographic processes (e.g., dispersal, recruitment, survival, etc.) of individual species (including the widely known dominants). As a consequence, potential predictive values associated with a species

remains masked, and questions on inter and intra-specific interactions of plants remain unanswered; (iii) mostly appear biased in favour of hermaphrodite or monoecious group of species. Therefore, many significant dioecy dependent effects on structure and function of forest stands are not accounted for. Among others, these aspects highlight the gaps in Himalayan database. These gaps can be filled only if studies are designed to collect data on individual species in representative forest stands.

Although creation of database on all associates in a forest appears to be a daunting task, studies on selected species, with frequent presence in regional forests and proven sensitivity towards ecological and socio-economic systems, improve applicability and effectiveness of Himalayan forest database. In particular, the species (or their assemblages) with narrow ecological amplitude might emerge as surrogate to reflect changes in forest ecosystem pattern or processes and could provide a basis for effective management. In this context, an attempt was made to generate evidences from a detailed case study of *Myrica esculenta* Buch.-Ham. ex D. Don (vern.-*Kaiphal*) – an ecologically and economically important tree, which frequently forms distinctive stands in Himalayan temperate forests<sup>3</sup>. The species, a dioecious moderate-sized evergreen tree, also offers an opportunity to address hitherto neglected aspects of dioecy-dependent heterogeneity in these forests. The study explores the role of *M. esculenta* in determining the structure of forest communities (Kumaun, west Himalaya, India), and the results are discussed for their wider ecological implications in the region.

## Contribution to community composition

In the region (central Himalaya *sensu* Singh and Singh<sup>4</sup>) chir pine (*Pinus roxburghii*), banj oak (*Quercus leuco-*

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*trichophora*) and mixed broad leaf forests are the most widely distributed community types between 1000 and 2200 m elevation range<sup>1,4</sup>. *M. esculenta* is a common associate of these forests<sup>5,6</sup>. Considering tree density and basal area as major attributes of stand structure, *M. esculenta*-containing stands in these forests showed an overall similarity with the other forest stands (without or with diffused *M. esculenta* individuals) in the region (Table 1). Therefore, from a self-thinning perspective, *Myrica* stands revealed age (growth) similarity of tree individuals with the rest of the regional forests. However, higher density of saplings suggested that the competition among trees for space is not severe in *M. esculenta* stands. This would imply that these stands have scope for further increase in density of smaller trees until a substantial crown overlap develops. Considerably high densities of young (seedling and sapling) individuals in *Myrica* stands need additional explanation. Presumably, these stands provide a better niche for recruitment of dominant species and *M. esculenta* itself<sup>6</sup>. The precise details from local habitat features (i.e. microhabitats) are not available to explain these processes. One important factor could be the nitrogen fixing ability of *Myrica*, which has been reported to change the fertility status of stand elsewhere<sup>7</sup>.

### Favourableness of sites and habitats

*M. esculenta* stands, in all conditions (habitat and canopy conditions), maintain significantly higher male tree density and in most cases, males showed larger mean tree size (Table 2). Studies elsewhere reveal occurrence of differential growth and/or reproductive effort among dioecious plants<sup>8</sup> and that higher proportion of males indicate extremes of species range and resource-poor habitats<sup>9-11</sup>. Therefore, male biased sex ratio of *M. esculenta* could be indicative of its peripheral geographic range of distribution and also an overall resource-poor condition of habitats in the region. However, in order to establish these assumptions, investigations on ecological aspects of the sex ratio, especially from other climatic

extremes, like eastern Himalaya, are needed. Analysis and documentation of such information over a range of spatial extent will prove immensely useful in indicating climate/habitat changes, if any, in the region.

Moreover, in view of sex segregation on a narrow spatial scale (i.e. Kumaun Himalaya), increased femaleness coupled with greater seedling recruitment and establishment of rich sapling banks in high altitude sites, is indicative of overall suitability of these sites. Considering the upper distribution limit of *M. esculenta* around 2200 m asl, the present findings suggest likely expansion of this species towards upper distribution limits. The observation of better germination potential of seed<sup>6</sup> from high altitude provenance further strengthens these possibilities.

### Implications for compositional changes

Overall higher density of young individuals in forest stands with reasonable *Myrica* dominance has significant implications on composition of regional forests. Apparently, the presence of *M. esculenta* in these forest stands facilitates higher recruitment (seedling) and stocking of young (sapling) individuals. The increase was recorded in both the dominant species and in *M. esculenta* also. These observations assume greater significance when a low seedling/sapling density is being reported frequently from the forest stands in the region<sup>12-14</sup>.

*M. esculenta* shows habitat/source specific variations in natural recruitment and seed germinability<sup>6</sup>. The relative high contribution of *Myrica* seedlings and saplings in chir pine forests (Table 2) is indicative that this habitat provides a satisfactory regeneration niche. Also, seeds obtained from this habitat showed higher germination response<sup>6</sup>. All these evidences tend to make one presume a likely future increase of *M. esculenta* density in these forests. Since the fruits of *Myrica* are edible and its seeds are dispersed widely by animals, especially by the rhesus macaque (*Macaca mulata*), common langur (*Presbytis entellus*) and birds, this increase may be expected even in sites away from *Myrica*-prevalent stands.

**Table 1.** Comparison of *M. esculenta* containing stands with values reported for regional (Kumaun, West Himalaya) forests

Forest types	<i>M. esculenta</i> stands <sup>6</sup>				Reported regional value <sup>12</sup>	
	Intact canopy		Disturbed canopy		A	B
	A	B	A	B		
Chir pine	963	43.8	518	29.4	350-590	17-47
Banj oak	775	31.7	650	23.9	320-1560	12-74
Mixed broad leaf	920	36.9	556	25.8	440-1180	18-123

A, Forest mean tree density (ind. ha<sup>-1</sup>); B, total tree basal area (m<sup>2</sup> ha<sup>-1</sup>).

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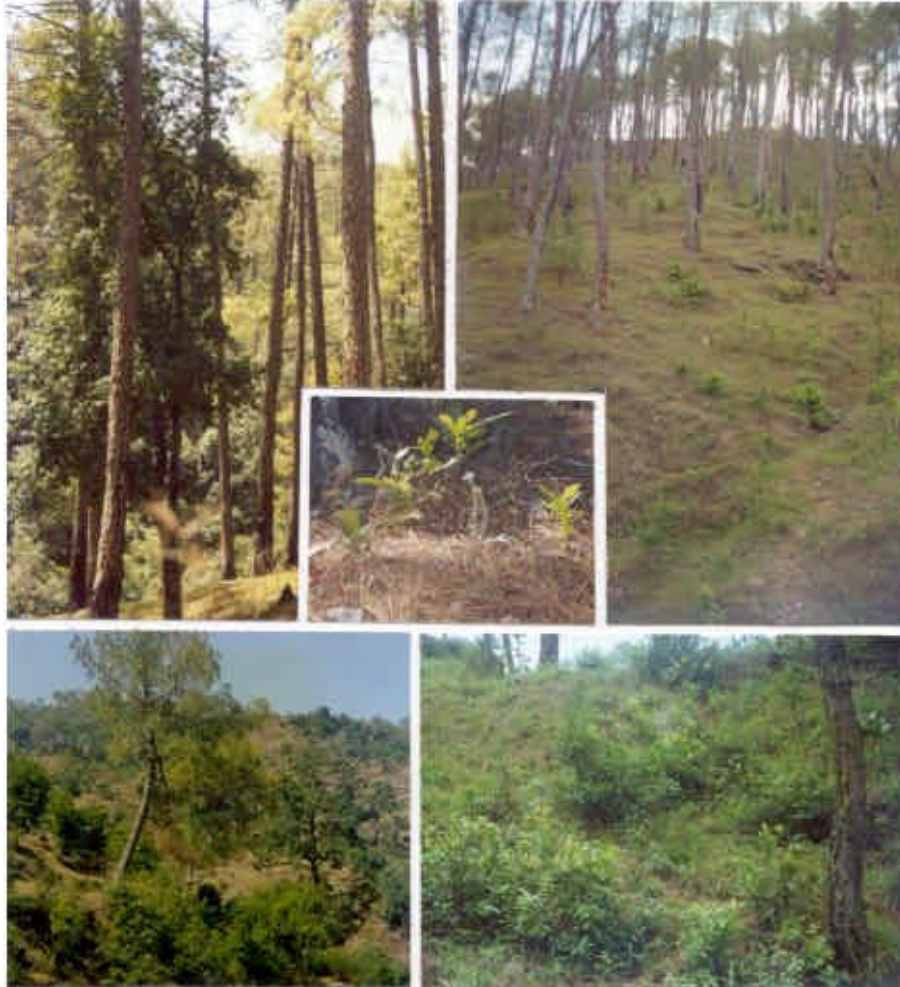
**Table 2.** Patterns of recruitment (seedling and sapling) and male/female tree distribution of *M. esculenta* across habitats and altitude range in Kumaun

Mean altitude (m) of sites and habitats	Intact canopy				Disturbed canopy			
	A (M/F)	B (M/F)	C	D	A (M/F)	B (M/F)	C	D
<b>2050</b>								
Chir pine	58/57	160/120 (17.1) (12.7)	1042 (14.0)	916 (59.5)	65/56	66/40 (14.7) (8.9)	333 (5.2)	291 (12.9)
Banj oak	60/55	180/132 (19.0) (13.9)	2000 (26.1)	375 (15.2)	66/59	116/80 (17.0) (11.3)	958 (12.5)	458 (14.3)
Mixed	74/62	176/132 (18.6) (13.9)	1625 (27.3)	1082 (26.3)	69/52	184/164 (18.9) (16.9)	92 (2.9)	833 (12.9)
<b>1850</b>								
Chir pine	76/56	140/100 (17.7) (12.8)	1000 (15.9)	708 (13.4)	68/68	80/60 (12.3) (9.2)	1167 (15.2)	917 (10.7)
Banj oak	90/85	162/126 (20.0) (15.5)	417 (4.3)	126 (3.3)	76/65	99/76 (13.2) (10.2)	417 (6.2)	333 (5.4)
Mixed	76/56	172/114 (19.8) (13.1)	833 (14.7)	250 (13.3)	60/52	93/50 (16.2) (8.2)	875 (17.8)	417 (12.2)
<b>1750</b>								
Chir pine	84/68	230/133 (17.1) (9.4)	1125 (18.2)	250 (14.9)	76/65	159/93 (16.5) (9.6)	792 (9.5)	83 (4.4)
Banj oak	–	–	–	–	65/68	191/119 (27.9) (17.3)	583 (5.6)	00 (0.0)
Mixed	66/61	192/118 (20.3) (12.5)	792 (11.2)	167 (5.9)	67/58	178/132 (25.6) (18.9)	125 (1.6)	125 (3.3)
<b>1675</b>								
Chir pine	–	–	–	–	–	–	–	–
Banj oak	–	–	–	–	73/63	84/66 (22.8) (17.9)	958 (20.2)	42 (4.2)
Mixed	–	–	–	–	83/78	84/47 (21.0) (11.8)	1208 (23.9)	333 (17.4)
<b>1525</b>								
Chir pine	–	–	–	–	67/55	174/108 (31.5) (19.5)	1500 (26.3)	792 (29.7)
Banj oak	69/68	205/112 (32.3) (17.6)	750 (18.1)	83 (2.7)	–	60/36	333	125
Mixed	–	–	–	–	80/67	(26.3) (15.7)	(4.7)	(8.1)
<b>1325</b>								
Chir pine	–	–	–	–	70/62	26/10 (14.6) (3.1)	1040 (42.3)	125 (17.6)
Banj oak	–	–	–	–	–	–	–	–
Mixed	–	–	–	–	87/63	62/26 (37.3) (15.7)	00 (0.0)	458 (30.6)

A, mean size (CBH – cm) of trees; B, tree density (ind. ha<sup>-1</sup>); C, sapling density (ind. ha<sup>-1</sup>); D, seedling density (ind. ha<sup>-1</sup>); M, male; F, female. Values in parentheses indicate relative proportion to the total forest.

The experiments on seeds obtained from sources located at different altitudes showed significant variation in germination. Seeds from high altitude source revealed significantly high germinability. The findings of laboratory germination more or less followed the pattern of natural regeneration<sup>6</sup>. Such results of altitudinal variation are interesting and merit consideration while describing the future trends of forest vegetation in the region. In general, the marked alterations in regeneration patterns

(individually and/or collectively) are to affect the composition of all three *Myrica* habitats (i.e. *Pinus roxburghii* forest, *Quercus leucotrichophora* forest and mixed broad-leaf forest). The intensity of changes may be more prevalent in stands located at upper limits of *Myrica* distribution (i.e. 2000–2200 m asl). On a wider perspective, when upward migration of life zones (species and forest boundaries) is expected in mountains as a widespread consequence of global warming<sup>15</sup>, the trends of frequent



**Figure 1.** *M. esculenta* finds a satisfactory regeneration niche in *Pinus roxburghii* forests, and provides options for putting these hitherto unused habitats for ecological and economic benefits in the region. (Photo credit: Bhawana Pandey).

*Myrica* recruitment at its upper distribution limit accompanied by the results of differential responses of seed germination and recruitment in forest habitats may provide an insight as to how the composition of regional forests may tend to change in future. This, however, needs to be authenticated through the evidences of future experimental research.

### Implications for management and conservation of regional forests

Preceding discussion leads us to consider fresh management options in forests in the region. For instance, the implications of male-biased sex ratio of *M. esculenta* can be viewed as an overall resource-poor situation of these forest habitats. On the other hand, the increased femaleness of *M. esculenta* accompanied by markedly high recruitment in *Myrica* stands at higher altitudes may

be considered as an evidence of possible upward shift in species/forest boundaries in the region. Such considerations need due attention in management/conservation plans concerning regional forests.

Moreover, the trends of better *Myrica* recruitment (natural regeneration and experimental responses of seed germination) in chir pine forests (Figure 1) have significant implications. These forests, usually forming stands of their own with very few associates in tree and shrub layer, have prevailed and expanded in the region<sup>1</sup>. Despite the proven value for conserving nutrients efficiently on steep hill slopes<sup>16</sup>, on account of their invading nature and poor species richness<sup>1,17</sup>, chir-pine forests are not viewed positively by the conservation biologists and environmentalists<sup>18</sup>. The present investigation has, however, established that these habitats if used properly, can prove beneficial for promotion of *M. esculenta* – an ecologically and economically important species for the region.

## Conclusions

Intensive ecological researches on Himalayan forests have highlighted the significance of voluminous data sets at a global scale. However, overemphasis on dominant and co-dominant taxa has led to biases in ecological interpretations. There is an urgent need to reduce these biases, particularly when the responses of Himalayan ecosystems, as in case of other mountain systems, are being considered as early warning indicators of global climate change. The present ecological study on hitherto little-known tree species (*M. esculenta*) draws reasonably sound conclusions on predictive value of such ecological database. For instance, the data sets provide important clues for: (i) predicting possible changes in composition and boundaries of major forest types in the region, (ii) understanding implications of such changes for addressing issues of forest management especially in the event of climate/habitat change, and (iii) recognizing the importance of dioecy-dependent variations for strengthening the ecological database on Himalayan forests.

1. Singh, J. S. and Singh, S. P., *Forests of Himalaya: Structure, Functioning and Impact of Man*, Gyanodaya Prakashan, Nainital, 1992.
2. Zobel, D. B. and Singh, S. P., *Bioscience*, 1997, **47**, 735–745.
3. Dhyani, P. P. and Dhar, U., *Myrica esculenta, Box myrtle (Kaifal)*, Himvikas Occasional Publication, G. B. Pant Institute of Himalayan Environment and Development, Almora, 1994.

4. Singh, J. S. and Singh, S. P., *Bot. Rev.*, 1987, **53**, 80–192.
5. Bhatt, I. D., Rawal, R. S. and Dhar, U., *Mt. Res. Dev.*, 2000, **20**, 146–153.
6. Pandey, B., Ph D thesis, Kumaun University, Nainital, 2002.
7. Vitousek, P. M. and Walker, L. R., Whiteaker, L. D., Muller-Dombois, D. and Matson, P. A., *Science*, 1989, **238**, 802–804.
8. Lloyd, D. G. and Webb, C. J., *Bot. Rev.*, 1977, **43**, 177–216.
9. Grant, M. C. and Milton, J. B., *Evolution*, 1979, **33**, 914–918.
10. Hoffman, A. J. and Allende, M. C., *Oecologia*, 1984, **61**, 109–114.
11. Ortiz, P. L., Arista, M. and Talavera, S., *Ann. Bot.*, 2002, **89**, 205–211.
12. Singh, S. P., Adhikari, B. S. and Zobel, D. B., *Ecol. Monogr.*, 1994, **64**, 401–421.
13. Singh, S. P., Rawat, Y. S. and Garkoti, S. C., *Curr. Sci.*, 1997, **73**, 371–374.
14. Thadani, R. and Ashton, P. M. S., *For. Ecol. Manage.*, 1995, **78**, 217–224.
15. Haslett, J. R., *Global Ecol. Biol. Lett.*, 1997, **6**, 3–6.
16. Singh, S. P., *Curr. Sci.*, 2002, **82**, 1331–1335.
17. Singh, J. S., Rawat, Y. S. and Chaturvedi, O. P., *Nature*, 1984, **311**, 54–56.
18. Sinha, B., *Down to Earth*, 2002, **10**, 25–27.

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