

Full Length Research Paper

# Comparison of understorey vegetation in exotic and indigenous tree plantations in Shivalik Hills of N. W. Indian Himalayas (Himachal Pradesh)

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Accepted 26 June, 2009

Presently, a total of 104 species belonging to 87 genera under 38 families of flowering plants in exotic (*Eucalyptus citriodora* Hook.) and indigenous (*Pinus roxburghii* Sarg.) tree plantations were determined. There were higher numbers of plant species under the indigenous plantations as compared to the exotic ones. In *Eucalyptus* plantations 60% species were exotic, 36.92% indigenous and 3.08% obscure as compared to 44.44% exotic, 54.33% indigenous and only 1.23% obscure species under *Pinus* ones. The alpha diversity also decreased by 34.73% under the exotic tree plantations of *Eucalyptus*. Evidently, the exotic tree plantations become in-roads for the opportunistic and environmentally flexible species with wide ecological amplitude.

**Key words:** Species diversity, exotic, indigenous, N. W. Indian Himalayas.

## INTRODUCTION

*Eucalyptus citriodora* Hook. is an exotic tree species from Australia whereas *Pinus roxburghii* Sarg. is an Indigenous tree species from Indian Himalayas (Champion and Seth, 1968). Both types of plantations are abundantly found in the Shivalik hills of Himachal Pradesh. It is known that plant communities are more stable and show more heterogeneity under the indigenous tree plantations as compared to the exotic ones (Smart et al., 2005). Till date, no attempt has so far been made to compare the diversity and composition of vegetation under the exotic and indigenous tree plantations in Shivalik Himalayas. The present work was, therefore, undertaken to fill this gap in our understanding.

## STUDY SITE

### Vegetation analysis and methods

The present study was conducted in the Shivalik hills of Hamirpur district (H.P.), India, a region of the n.w. Indian Himalayas (Figure 1) (alt. 860 m), where these plantations grow adjacent to each other (Figure 2). The survey was conducted at three sites within 10 km<sup>2</sup>

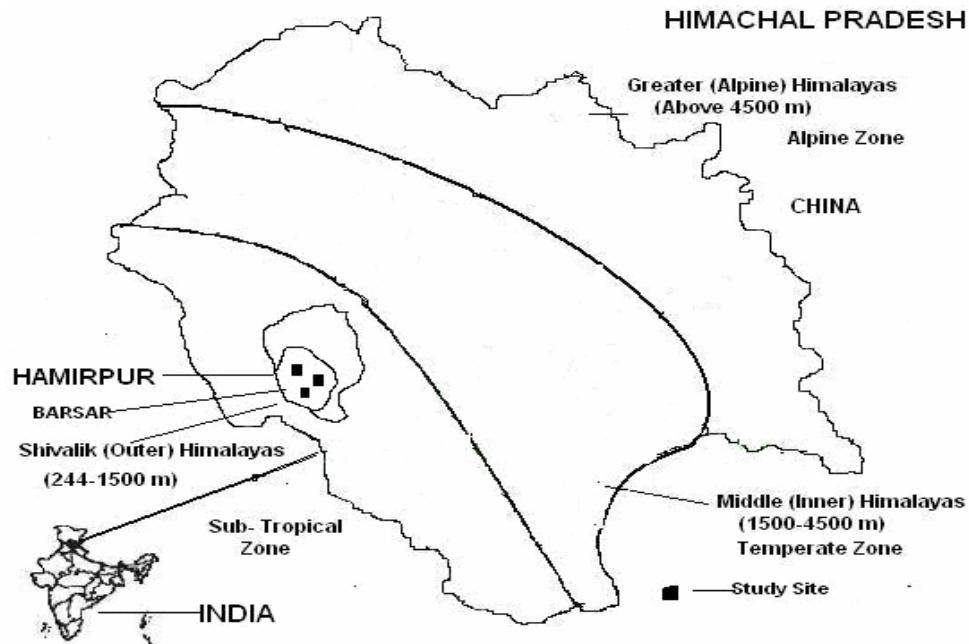
area. At each site 100 quadrants were laid under each type of plantations. The density, dominance, abundance, frequency and importance value index were calculated as per the methods given by Mishra (1968). Various diversity indices of species richness, evenness and dominance were calculated as per the methods given by Ludwig and Reynolds (1988). Vegetation analysis was carried out by random-systematic design and gradsect methods outlined by Barbour et al. (1999) and Singh and Singh (1992).

Plant species collected during the study were identified with the help of regional floras (Polunin and Stainton, 1984; Chowdhary and Wadhwa, 1984). The results were statistically analyzed by using software SPSS ver. 10.0, origin 6 and micorstat. However, for determining the significance of a single treatment with control (paired treatment), student's 2 sample *t* - test was applied and significance was checked at 5% level of significance.

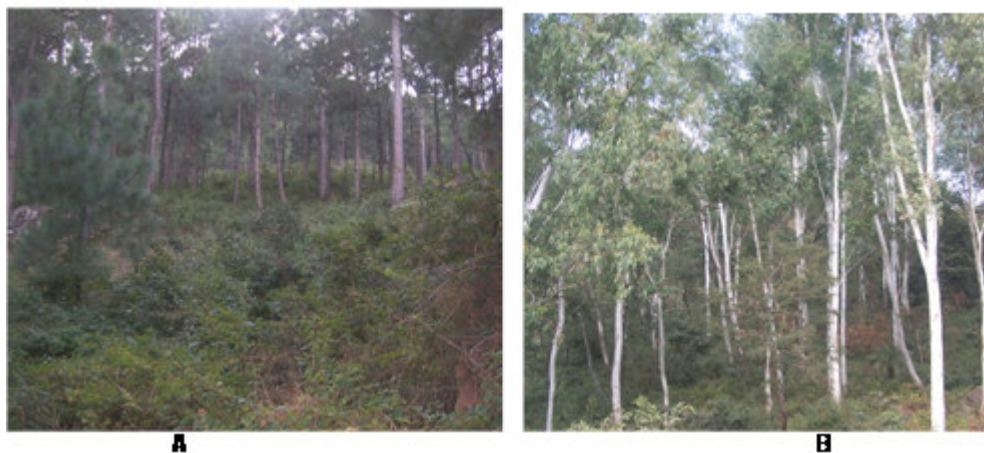
## RESULTS AND DISCUSSION

In the present study an ecological survey was conducted to compare the status of understorey vegetation in exotic and indigenous tree plantations in the Shivalik hills of Himachal Pradesh. A total of 104 species belonging to 87 genera under 39 families of flowering plants were recorded under these two types of plantations. Asteraceae and Fabaceae were found to be most dominant families with 16 and 15 species, respectively (Table 1). Further, sixteen families were represented by 1 species;

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**Figure 1.** Map of the study site in the Shivalik hills of N.W. Indian Himalayas.



**Figure 2.** Monoculture plantations of *Pinus* (A) and *Eucalyptus* (B) in the Shivalik hills of N.W. Indian Himalayas.

**Table 1.** Number of plants, families and different life forms under plantations of *Eucalyptus* and *Pinus*.

S/No.	Parameter	Total number	<i>Eucalyptus</i>	<i>Pinus</i>	% decrease ( <i>Eucalyptus</i> over <i>Pinus</i> )
1	Species	104	65	81*	19.75
2	Genera	87	56	72*	22.22
3	Families	39	21	38*	43.24
4	Herb	59	35	46*	23.91
5	Shrub	28	19	22*	13.64
6	Tree	8	5	6 <sup>ns</sup>	16.67
7	Grass	5	4	4 <sup>ns</sup>	—
8	Climber	1	1	1 <sup>ns</sup>	—
9	Vine	3	1	2*	50

— means no change; \* Values significant and ns non-significant change under *Eucalyptus* plantations at 5% level of significance applied 2 sample *t*-test.

**Table 2.** Number of species and their families found under *Eucalyptus* and *Pinus* plantations.

S/No.	Name of plant	<i>Eucalyptus</i>	<i>Pinus</i>	Both
1	Acanthaceae	2	4	4
2	Amaranthaceae	3	1	3
3	Apiaceae	—	1	1
4	Apocynaceae	1	1	1
5	Araliaceae	—	1	1
6	Asteraceae	11	14	16
7	Berberidaceae	—	1	1
8	Brassicaceae	—	2	2
9	Cactaceae	—	1	1
10	Cannabaceae	—	1	1
11	Commelinaceae	—	1	1
12	Convallariaceae	—	1	1
13	Convolvulaceae	2	2	4
14	Cuscutaceae	—	1	1
15	Cucurbitaceae	—	1	1
16	Euphorbiaceae	6	4	7
17	Fabaceae	13	12	15
18	Flacourtiaceae	—	1	1
19	Lamiaceae	6	3	7
20	Liliaceae	1	1	1
21	Linaceae	—	1	1
22	Malvaceae	2	3	3
23	Meliaceae	—	1	1
24	Menispermaceae	1	1	1
25	Moraceae	—	2	2
26	Nyctaginaceae	1	—	1
27	Oleaceae	—	1	1
28	Oxalidaceae	2	1	2
29	Poaceae	4	4	5
30	Polygonaceae	1	2	2
31	Rhamnaceae	1	2	2
32	Rosaceae	1	1	1
33	Rubiaceae	—	1	1
34	Rutaceae	—	1	1
35	Sapindaceae	—	1	1
36	Scrophulariaceae	1	1	2
37	Solanaceae	2	2	3
38	Tiliaceae	2	1	2
39	Verbenaceae	2	1	2

— Species absent.

six by 2 species each; three by 3; and two by 4, 5 and 7 species each (Table 2). The vegetation under both the plantations harboured 59 herbs, 28 shrubs, 8 trees, 5 grasses, 3 vines and only one climber (Table 1). In all, a total of 42 plant species were common to the *Eucalyptus* and *Pinus* plantations, 39 species recorded only for *Pinus* plantations and 22 species only for *Eucalyptus* plantations.

The understorey vegetation in *Eucalyptus* plantations was characterized by 65 species belonging to 56 genera under 21 families and included 35 herbs, 19 shrubs, 5 trees, 4 grasses and one climber and vine (Tables 2 and 3). Asteraceae and Fabaceae were represented by 11 and 13 species each. Of the remaining families, two families were represented by 6 species; one by 4 and 3 species; seven by 2 species and eight by 1 species each.

**Table 3.** Floristic composition under different plantations along with families, life forms and origin (alphabetical order).

S/No.	Name of Plant	Family	Life form	<i>Eucalyptus</i>	<i>Pinus</i>	Origin
1.	<i>Achyranthes aspera</i> L.	Amaranthaceae	Herb	+	+	I
2.	<i>Adhatoda vasica</i> Nees	Acanthaceae	Shrub	+	+	I
3.	<i>Ageratum conyzoides</i> L.	Asteraceae	Herb	+	+	E
4.	<i>Ageratum houstonianum</i> Mill.	Asteraceae	Herb	+	—	E
5.	<i>Amaranthus viridis</i> L.	Amaranthaceae	Herb	+	—	E
6.	<i>Anisomeles indica</i> (L.) Kunt.	Lamiaceae	Shrub	+	+	I
7.	<i>Artemisia scoparia</i> Waldst. & Kit.	Asteraceae	Herb	—	+	E
8.	<i>Artemisia vulgaris</i> L.	Asteraceae	Herb	—	+	E
9.	<i>Asparagus adscendens</i> Roxb.	Liliaceae	Shrub	+	+	I
10.	<i>Bacopa monnieri</i> (L.) Penn.	Scrophulariaceae	Herb	—	+	I
11.	<i>Barleria cristata</i> L.	Acanthaceae	Herb	—	+	I
12.	<i>Berberis lycium</i> Royle	Berberidaceae	Shrub	—	+	I
13.	<i>Bidens pilosa</i> L.	Asteraceae	Herb	+	+	E
14.	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	Herb	+	—	E
15.	<i>Cannabis sativa</i> L.	Cannabaceae	Herb	—	+	I
16.	<i>Carissa carandas</i> L.	Apocynaceae	Shrub	+	+	I
17.	<i>Cassia angustifolia</i> L.	Fabaceae	Herb	+	+	I
18.	<i>Cassia fistula</i> L.	Fabaceae	Tree	+	—	I
19.	<i>Cassia occidentalis</i> L.	Fabaceae	Shrub	+	+	E
20.	<i>Cassia tora</i> L.	Fabaceae	Herb	+	+	I
21.	<i>Centella asiatica</i> L. Urb.	Apiaceae	Herb	—	+	I
22.	<i>Cereus peruvianus</i> (L.) Mill.	Cactaceae	Herb	—	+	E
23.	<i>Cirsium verutum</i> (D. Don) Spreng.	Asteraceae	Herb	—	+	I
24.	<i>Cocculus indica</i> L.	Menispermaceae	Climber	+	+	I
25.	<i>Colebrookea oppositifolia</i> Sm.	Lamiaceae	Shrub	+	+	I
26.	<i>Commelina paludosa</i> Bl.	Commelinaceae	Herb	—	+	I
27.	<i>Convolvulus pluricaulis</i> Choisy	Convolvulaceae	Herb	—	+	I
28.	<i>Conyza aegyptiaca</i> Ait.	Asteraceae	Herb	—	+	I
29.	<i>Cuscuta reflexa</i> Roxb.	Cuscutaceae	Herb	—	+	I
30.	<i>Cymbopogon martinii</i> (Roxb.) W. Wats.	Poaceae	Grass	—	+	I
31.	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Grass	+	+	E
32.	<i>Dalbergia sissoo</i> Roxb.	Fabaceae	Tree	+	+	I
33.	<i>Dichanthium annulatum</i> (Forssk.) Stapf.	Poaceae	Grass	+	+	I
34.	<i>Dicliptera roxburghiana</i> Nees	Acanthaceae	Herb	+	+	I
35.	<i>Dodonaea viscosa</i> (L.) Jacq.	Sapindaceae	Shrub	—	+	E
36.	<i>Duranta repens</i> L.	Lamiaceae	Shrub	+	—	E
37.	<i>Eclipta alba</i> L.	Asteraceae	Herb	+	—	E
38.	<i>Erigeron karvinskianus</i> DC.	Asteraceae	Herb	—	+	E
39.	<i>Eupatorium adenophorum</i> Spreng.	Asteraceae	Herb or Shrub	+	+	E
40.	<i>Euphorbia granulates</i> L.	Euphorbiaceae	Herb	+	+	E
41.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Herb	+	+	E
42.	<i>Euphorbia microphylla</i> B. Heyne ex Roth	Euphorbiaceae	Herb	+	—	O
43.	<i>Ficus hispida</i> L.	Moraceae	Tree	—	+	I
44.	<i>Ficus religiosa</i> L.	Moraceae	Tree	—	+	I
45.	<i>Flacourtia ramontchi</i> L. Herit	Flacourtiaceae	Shrub	—	+	I
46.	<i>Fumaria indica</i> (Hauskn.) Pugsley	Brassicaceae	Herb	—	+	I
47.	<i>Fumaria parviflora</i> Lam.	Brassicaceae	Herb	—	+	E

Table 3. Contd.

48.	<i>Gnaphalium indicum</i> L.	Asteraceae	Herb	+	+	I
49.	<i>Gomphrena celosioides</i> C. Mart.	Amaranthaceae	Herb	+	—	E
50.	<i>Grewia optiva</i> Drum. ex Burret	Tiliaceae	Tree	+	—	I
51.	<i>Hedera helix</i> L.	Araliaceae	Herb	—	+	E
52.	<i>Indigofera trifoliata</i> L.	Fabaceae	Herb	+	+	E
53.	<i>Inula cappa</i> (Buch.-Ham.) DC.	Asteraceae	Shrub	+	+	I
54.	<i>Ipomoea cairica</i> L. Sweet	Convolvulaceae	Vine	—	+	E
55.	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	Shrub	+	—	E
56.	<i>Ipomoea quamoclit</i> L.	Convolvulaceae	Vine	+	—	E
57.	<i>Jasminum humile</i> L.	Oleaceae	Shrub	—	+	I
58.	<i>Jatropha curcas</i> L.	Euphorbiaceae	Shrub	+	—	E
59.	<i>Justicia simplex</i> D. Don	Acanthaceae	Herb	—	+	I
60.	<i>Lantana camara</i> L.	Verbenaceae	Shrub	+	+	E
61.	<i>Launaea fallax</i> (Jaub. & Spach) Kunt.	Asteraceae	Herb	+	+	E
62.	<i>Leucaena leucocephala</i> (Lam.) de Wit	Fabaceae	Tree	+	+	E
63.	<i>Leucas cephalotes</i> Spreng.	Lamiaceae	Herb	+	—	I
64.	<i>Mallotus philippensis</i> (Lam.) Muell.-Arg.	Euphorbiaceae	Shrub	—	+	E
65.	<i>Medicago lupulina</i> L.	Fabaceae	Herb	+	+	E
66.	<i>Melia azedarach</i> L.	Meliaceae	Tree	—	+	I
67.	<i>Mimosa pudica</i> L.	Fabaceae	Herb	+	+	E
68.	<i>Mukia maderaspatana</i> (L.) M. Roem.	Cucurbitaceae	Vine	—	+	E
69.	<i>Murraya koenigii</i> (L.) Spreng.	Rutaceae	Shrub	+	+	I
70.	<i>Nepeta erecta</i> Benth.	Lamiaceae	Herb	+	—	I
71.	<i>Nepeta linearis</i> Royle ex Benth.	Lamiaceae	Herb	—	+	I
72.	<i>Oxalis corniculata</i> L.	Oxalidaceae	Herb	+	+	O
73.	<i>Oxalis martiana</i> Zucc.	Oxalidaceae	Herb	+	—	E
74.	<i>Parthenium hysterophorus</i> L.	Asteraceae	Herb	+	+	E
75.	<i>Phyllanthus amarus</i> Schumach. & Thonn	Euphorbiaceae	Herb	+	+	E
76.	<i>Physalis minima</i> L.	Solanaceae	Herb	+	—	E
77.	<i>Pogostemon plectranthoides</i> Desf.	Lamiaceae	Shrub	+	—	I
78.	<i>Polygonatum cirrhifolium</i> (Wall.) Royle	Convallariaceae	Herb	—	+	I
79.	<i>Polygonum plebium</i> R. Br.	Polygonaceae	Herb	—	+	I
80.	<i>Randia dumetorum</i> (Retz.) Poir.	Rubiaceae	Shrub	—	+	I
81.	<i>Reinwardtia indica</i> Dumort.	Linaceae	Herb	—	+	I
82.	<i>Rhynchosia capitata</i> (Roth.) DC.	Fabaceae	Herb	—	+	I
83.	<i>Rhynchosia minima</i> (L.) DC.	Fabaceae	Herb	+	—	E
84.	<i>Ricinus communis</i> L.	Euphorbiaceae	Shrub	+	—	E
85.	<i>Robinia pseudoacacia</i> L.	Fabaceae	Tree	+	+	E
86.	<i>Rubus ellipticus</i> Sm.	Rosaceae	Shrub	—	+	I
87.	<i>Rumex dentatus</i> L.	Polygonaceae	Herb	+	+	I
88.	<i>Saccharum munja</i> Roxb.	Poaceae	Grass	+	—	I
89.	<i>Setaria verticillata</i> (L.) Beauv.	Poaceae	Grass	+	+	E
90.	<i>Sida cordifolia</i> L.	Malvaceae	Shrub	+	+	E
91.	<i>Sida rhombifolia</i> L.	Malvaceae	Shrub	+	+	E
92.	<i>Solanum nigrum</i> L.	Solanaceae	Herb	+	+	E
93.	<i>Solanum xanthocarpum</i> Schard. & Wendl.	Solanaceae	Herb	—	+	I
94.	<i>Trifolium repens</i> L.	Fabaceae	Herb	+	+	E
95.	<i>Trigonella emodi</i> Benth.	Fabaceae	Herb	+	—	E

**Table 3.** Contd.

96.	<i>Triumfetta bartramia</i> L.	Tiliaceae	Shrub	+	+	E
97.	<i>Urena lobata</i> L.	Malvaceae	Shrub	—	+	E
98.	<i>Verbascum thapsus</i> L.	Scrophulariaceae	Herb	+	—	E
99.	<i>Vernonia cinerea</i> L. Less	Asteraceae	Herb	+	+	E
100.	<i>Vicia sativa</i> L.	Fabaceae	Herb	—	+	E
101.	<i>Vitex negundo</i> L.	Verbenaceae	Shrub	+	—	I
102.	<i>Xanthium strumarium</i> (Mill.) Torrey & A. Gray	Asteraceae	Herb	+	+	E
103.	<i>Ziziphus jujuba</i> Mill.	Rhamnaceae	Shrub	—	+	I
104.	<i>Ziziphus mauritiana</i> Lam.	Rhamnaceae	Shrub	+	+	I

+ Species present; — Species absent; E = Exotic; I = Indigenous; O = Obscure.

**Table 4.** Exotic, indigenous and species with obscure origin under plantations (Values %).

Type of plantation	Total plants	Exotic	Indigenous	Obscure
<i>Eucalyptus citriodora</i>	65	60.00*	36.92	3.08
<i>Pinus roxburghii</i>	81	44.44	54.33*	1.23
Total under both	104	49.04	50.96	1.92

\* Values significant over those of under *Eucalyptus* at 5% level of significance applied 2 sample *t*-test.

**Table 5.** Diversity, richness, evenness, density and basal area of vegetation under different plantations.

Parameters	<i>Eucalyptus</i>	<i>Pinus</i>
Margalef index of richness (R1)	4.48 ± 0.44	6.51 ± 0.88*
Simpson's index ( $\lambda$ )	0.19 ± 0.01	0.07 ± 0.02*
Shannon's index (H' or $\alpha$ -diversity)	2.18 ± 0.28	3.34 ± 0.17*
Diversity number, N <sub>1</sub>	16.62 ± 1.92	23.39 ± 2.38*
Diversity number, N <sub>2</sub>	10.93 ± 0.84	16.67 ± 1.99*
Index of evenness (Es)	0.69 ± 0.02	0.84 ± 0.03*
Density/m <sup>2</sup>	38.68 ± 1.99	52.82 ± 3.17*
Basal area/m <sup>2</sup>	17.22 ± 1.91	24.29 ± 1.44*
Litter depth/cm	7.27 ± 1.01	11.90 ± 1.45*

– means decrease and + means increase. \* Values significant over those of under *Eucalyptus* at 5% level of significance applied 2 sample *t*-test.

In contrast, the understorey vegetation of *Pinus* plantations were represented by 81 species belonging to 72 genera under 38 families. Like *Eucalyptus* plantations, Asteraceae and Fabaceae were also the dominant families in *Pinus* plantations and represented by 14 and 12 species each. Of the remaining families three were represented by 4 and 3 species; 5 by 2 species and 25 by 1 species each.

The number of species and genera decreased by 19.75 and 22.22% respectively under the *Eucalyptus* plantations as compared to *Pinus* ones. Likewise, under the exotic tree plantation the number of families represented by different species decreased by 43.24% and the number

of herbs, shrubs and trees decreased by 23.91, 13.64 and 16.67%, respectively (Table 1). Grasses and climbers were similar in both the plantations excepting one vine species in *Pinus* plantations (Tables 1 and 3).

Of the 104 species recorded during the present study, 49.04% were found to be exotic and 50.96% indigenous and 1.92% as obscure in their origin (origin untraceable) (Table 3). In *Eucalyptus* plantations 60% species were exotic, 36.92% indigenous and 3.08% obscure (Tables 3 and 4) whereas *Pinus* plantations harboured 44.44% exotic, 54.33% indigenous and 1.23% obscure species (Tables 3 and 4). From this comparison, it can be inferred that exotic plantations with more exotic species under

them become in-roads for the opportunistic and environmentally flexible species with wide ecological amplitude, a feature also earlier recorded by Maskell et al. (2006).

It was quite evident from the present work that exotic tree plantations support a small number of plant species and, as a result lesser diversity of different families as compared to the indigenous ones. This is also evidenced from the comparison of the various parameters of diversity richness, evenness, diversity and basal area of understorey vegetation in both the plantations (Table 5) and it revealed that the indigenous (*Pinus*) plantations harbour greater diversity and density of plants and more stable as compared to the exotic (*Eucalyptus*) ones (Kadavul and Parthasarthy, 1999; Martin, 1999; Christer et al., 2008).

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