Annex F

Details on Ecological Baseline Conditions

Annex FA

Details of Avifauna

FA1 DETAILS OF AVIFAUNA OBSERVED DURING THE THREE SEASON.

FA1.1 AVIFAUNA- AUTUMN SEASON (NOVEMBER 2004)

Table 1.1 List of birds observed in Allain Duhangan catchments in November 20042004

S.No	Species	Scientific Name	Allain	Duhangan
1	Leaf warbler	*Phylloscopus sp.*	+	+
2	Bush warbler	*Cettia sp.*	+	
3	Himalayan griffon	*Gypus himalayensis*	+	+
4	Lammergeier	*Gypaetus barbatus*	+	+
5	Himalayan monal	*Lophophorus impejanus*	+	+
6	Kalij	*Lophura leucomelanos*	+	+
7	Koklass	*Pucrasia macrolopha*		+
8	Snow pigeon	*Columba leuconota*	+	+
9	Speckled wood pigeon	*Columba hodgsonii*	+	
10	Brown wood Owl	*Strix ocellata*	+	
11	Great barbet	*Megalaima virens*	+	+
12	Scaly-bellied woodpecker	*Picus squamatus*	+	+
13	Himalayan woodpecker	*Dendrocopos himalayensis*	+	+
14	Brown fronted woodpecker	*Dendrocopos auriceps*	+	
15	Black headed Jay	*Garrulus lanceolatus*	+	
16	Yellow-billed blue Magpie	*Cissa flavirostris*	+	+
17	Nutcracker	*Nucifraga caryocatactes*	+	+
18	Yellowbilled Chough	*Pyrrhocorax graculus*	+	
19	Large-billed crow	*Corvus macrorhynchos*	+	+
20	White-cheeked bulbul	*Pycnonotus leucogenys*	+	+
21	Black bulbul	*Hypsipetes leucocephalus*	+	+
22	White throated Laughing Thrush	*Garrulax albogularis*	+	
23	Variegated L Thrush	*Garrulax variegatus*	+	+
24	Streaked Laughing Thrush	*Graminicola lineatus*	+	+
25	Goldcrest	*Regulus regulus*	+	+
26	Redstart sp.	*Phoenicurus sp.*	+	
27	Whitecapped redstart	*Chaimarrornis leucocephalus*	+	+
28	Blue whistling Thrush	*Montocola caeruleus*	+	+
29	Eurasian Blackbird	*Turdus merula*	+	+
30	Wren	*Troglodytes troglodytes*	+	
31	Brown Dipper	*Cinclus pallasii*	+	
32	Grey tit	*Parus major*	+	+
33	Greenbacked tit	*Parus monticolus*	+	+
34	Spot winged tit	*Parus melanolophus*	+	+
35	Rufous vented tit	*Parus rubidiventris*	+	+
36	Black throated tit	*Aegithalos concinnus*		+
37	White throated tit	*Aegithalos niveogularis*		+
38	White cheeked Nuthatch	*Sitta europaea*	+	+
39	Himalayan tree creeper	*Certhia himalayana*	+	+
40	White wagtail	*Motacilla alba*	+	
41	Eurasian Tree sparrow	*Passer montanus*	+	+
42	Russet sparrow	*Passer rutilans*	+	
43	Black and Yellow grosbeak	*Mycerobas icteriodides*	+	+
44	Spectacled finch	*Callacanthis burtoni*	+	+
45	Rock bunting	*Emberiza cia*	+	+

FA1.2 AVIFAUNA- WINTER SEASON (JANUARY-MARCH 2005)

Table 1.2 List of birds observed in Allain Duhangan catchments in January-March 2005

Family	Name	Scientific Name
Phasianidae		
	Kalij	*Lophura leucomelanos*
Picidae		
	Scalybellied Woodpecker	*Picus squamatus*
	Himalayan woodpecker	*Dendrocopus himalayensis*
Strigidae		
	Jungle Owlet	*Glaucidium radiatum*
Columbidae		
	Snow Pigeon	*Columbia leuconota*
Acciptridae		
	Himalayan Griffon Vulture	*Gyps himalayensis*
	Lammergeier	*Gypaetus barbatus*
Corvidae		
	Blackheaded Jay	*Garrulus glandarius*
	Goldenbilled Magpie	*Urocissa flavirostris*
	Nutcracker	*Nucigfraga caryocatactes*
	Chough	*Pyrrhocorax pyrrhocorax*
	Large billed crow	*Corvus macrorhynchos*
Cinclidae		
	Brown Dipper	*Cinclus pallasii*
Muscicapidae		
	White capped water redstart	*Chaimarrornis leucocephalus*
	Blue Whistling Thrush	*Monticola caeruleus*
	Collared Blackbird	*Turdus albocinctus*
Sturnidae		
	Myna	*Sturnus vulgaris*
Sittidae		
	White-cheeked Nuthatch	*Sitta leucopsis*
Certhidae		
	Winter Wren	*Troglodytes troglodytes*
	Bartailed tree creeper	*Certhia himalayana*
Paridae		
	Great Tit	*Parus major*
	Green backed tit	*Parus monticolus*
	Rufous vented tit	*Parus rubidiventris*
Aegithalidae		
	Blackthroated Tit	*Aegithalos concinnus*
Pycnonotidae		
	Himalayan Bulbul	*Pycnonotus leucogenys*
Sylviidae		
	Variegated Laughing Thrush	*Garrulax variegatus*
	Streaked Laughing Thrush	*Garrluax lineatus*
	Golden specktacled Warbler	*Seicercus burkii*
Passeridae		
	Eurasian Tree sparrow	*Passer montanus*
Fringillidae		

Family	Name	Scientific Name
	Rock bunting	*Emberzia cia*

FA1.3 AVIFAUNA- SUMMER SEASON (MAY –JUNE 2005)

Table 1.3 List of birds observed during the survey of Allain-Duhangan catchments in Kullu District in May – June 2005.

S.N.	English name	Generic name	Specific name	Allain	Duhangan
1	Ashy Drongo	*Dicrurus*	*leucophaeus*	+	+
2	Asian House Martin	*Delichon*	*dasypus*	+	+
3	Bar-tailed Treecreeper	*Certhia*	*himalayana*	+	
4	Bar-winged Flycatcher-shrike	*Hemipus*	*picatus*	+	+
5	Black and Yellow Grosbeak	*Mycerobas*	*icterioides*	+	
6	Black Bulbul	*Hypsipetes*	*leucocephalus*	+	+
7	Black Drongo	*Dicrurus*	*macrocercus*	+	
8	Black-throated Tit	*Aegithalos*	*concinnus*	+	
9	Blue-whistling Thrush	*Myiophonus*	*caeruleus*	+	+
10	Blue-capped Redstart	*Phoenicurus*	*caeruleocephala*	+	
11	Blue-capped Rock Thrush	*Monticola*	*cinclorhynchus*	+	
12	Blue-fronted Redstart	*Phoenicurus*	*frontalis*	+	+
13	Blue-fronted Robin	*Cinclidium*	*frontale*	+	
14	Blyth's Leaf Warbler	*Phylloscopus*	*reguloides*	+	
15	Brown Dipper	*Cinclus*	*pallasii*	+	+
16	Brown wood Owl	*Strix*	*leptogrammica*	+	
17	Bush Warbler	*Cettia*	*sp.*	+	+
18	Chestnut-crowned Laughing Thrush	*Garrulax*	*erythrocephalus*	+	+
19	Chestnut-tailed Minla	*Minla*	*strigula*	+	
20	Common Iora	*Aegithina*	*tiphia*		+
21	Common Kestrel	*Falco*	*tinnunculus*	+	+
22	Common Rosefinch	*Carpodacus*	*erythrinus*	+	
23	Dark-breasted Rose Finch	*Carpodacus*	*nipalensis*	+	+
24	Dark-sided Flycatcher	*Muscicapa*	*sibirica*	+	
25	Eurasian Blackbird	*Turdus*	*merula*	+	+
26	Eurasian Cuckoo	*Cuculus*	*canorus*	+	
27	Eurasian Hobby	*Falco*	*subbuteo*	+	
28	Fire-capped Tit	*Cephalopyrus*	*flammiceps*	+	
29	Fulvous-breasted Woodpecker	*Dendrocopos*	*macei*		+
30	Goldcrest	*Regulus*	*regulus*	+	+
31	Gold-naped Finch	*Pyrrhoplectus*	*epauletta*		+
32	Great Barbet	*Megalaima*	*virens*	+	+
33	Green-backed Tit	*Parus*	*monticolus*	+	+
34	Grey Bush Chat	*Saxicola*	*ferrea*	+	+
35	Grey Tit	*Parus*	*afer*	+	
36	Grey Wagtail	*Motacilla*	*cinerea*	+	+
37	Grey-headed Canary-flycatcher	*Culicicapa*	*ceylonensis*	+	+
38	Himalayan Bulbul	*Pycnonotus*	*leucogenys*	+	
39	Himalayan Griffon	*Gyps*	*himalayensis*	+	+
40	Himalayan Monal	*Lophophorus*	*impejanus*	+	+
41	Himalayan Woodpecker	*Dendrocopos*	*himalayensis*	+	+
42	Hoopoe	*Upupa*	*epops*	+	
43	Indian Blue Robin	*Luscinia*	*brunnea*	+	
44	Koklass Pheasant	*Pucrasia*	*macrolopha*	+	+

S.N.	English name	Generic name	Specific name	Allain	Duhangan
45	Lammergeier	*Gypaetus*	*barbatus*	+	
46	Large-billed Crow	*Corvus*	*macrorhynchos*	+	+
47	Leaf Warbler	*Phylloscopus*	*sp.*	+	+
48	Little Forktail	*Enicurus*	*scouleri*	+	+
49	Long-legged Buzzard	*Buteo*	*rufinus*	+	+
50	Long-tailed Minivet	*Pericrocotus*	*ethologus*	+	+
51	Orange Bullfinch	*Pyrrhula*	*aurantiaca*		+
52	Orange-flanked Bush Robin	*Tarsiger*	*cyanurus*	+	+
53	Oriental Turtle-Dove	*Streptopelia*	*orientalis*	+	+
54	Pink-browed Rose Finch	*Carpodacus*	*rodochroa*	+	
55	Plumbeous Water-Redstart	*Rhyacornis*	*fuliginosus*	+	+
56	Red-billed Chough	*Pyrrhocorax*	*pyrrhocorax*	+	+
57	Rock Bunting	*Emberiza*	*cia*	+	+
58	Rosy Pipit	*Anthus*	*roseatus*	+	+
59	Rufous-bellied Niltava	*Niltava*	*sundara*		+
60	Rufous-breasted Bush-Robin	*Tarsiger*	*hyperythrus*		+
61	Rufous-naped tit	*Parus*	*rufonuchalis*	+	
62	Russet sparrow	*Passer*	*rutilans*	+	
63	Scaly-bellied woodpecker	*Picus*	*squamatus*	+	+
64	Short-billed Minivet	*Pericrocotus*	*brevirostris*	+	
65	Slaty-blue Flycatcher	*Ficedula*	*tricolor*	+	+
66	Snow Pigeon	*Columba*	*leuconota*	+	+
67	Spotted Nutcracker	*Nucifraga*	*caryocatactes*	+	
68	Spot-winged Tit	*Parus*	*melanolophus*	+	+
69	Streaked Laughing Thrush	*Garrulax*	*lineatus*	+	
70	Tickell's Leaf Warbler	*Phylloscopus*	*affinis*	+	
71	Ultramarine Flycatcher	*Ficedula*	*superciliaris*	+	+
72	Upland Pipit	*Anthus*	*sylvanus*	+	
73	Variegated Laughing Thrush	*Garrulax*	*variegatus*	+	+
74	Verditer Flycatcher	*Eumyias*	*thalassina*	+	
75	Whiskered Yuhina	*Yuhina*	*flavicollis*	+	+
76	White cheeked Nuthatch	*Sitta*	*leucopsis*	+	
77	White-capped Water-Redstart	*Chaimarrornis*	*leucocephalus*	+	+
78	White-eared Bulbul	*Pycnonotus*	*leucotis*	+	
79	White-collared Blackbird	*Turdus*	*albocinctus*		+
80	Oriental White-eye	*Zosterops*	*palpebrosus*		+
81	White-tailed Robin	*Cinclidium*	*leucurum*	+	
82	Winter Wren	*Troglodytes*	*troglodytes*	+	+
83	Yellow bellied Fantail-flycatcher	*Rhipidura*	*hypoxantha*	+	+
84	Yellow-billed Blue Magpie	*Urocissa*	*flavirostris*	+	
85	Yellow-breasted Greenfinch	*Carduelis*	*spinoides*	+	
86	Yellow-throated Fulvetta	*Alcippe*	*cinerea*		+

FA1.3.1 List of pheasants observed during the survey of Allain and Duhangan catchment in Kullu District in May – June 2005.

Table 1.4 List of pheasants observed Allain catchment in Kullu District in May – June 2005

Date	Pheasant	Scientific Name	Altitude (m)	Location	Habitat	Number (sighted/calls)	Sex
31-May-05	Koklass	*Pucrassia macrolopha*	2854	32 16 04 N; 77 14 50 E	Conifer	1 (Calls)	Male
31-May-05	Himalayan	*Lophophorus*	3464	32 16 00 N;	Alpine	2 (calls)	Male

Date	Pheasant	Scientific Name	Altitude (m)	Location	Habitat	Number (sighted/calls)	Sex
	Monal	*impejanus*		77 15 36 E			
4-Jun-05	Himalayan Monal	*Lophophorus impejanus*	2804	32 15 21 N; 77 14 16 E	Mixed	1 (Calls)	Male
6-Jun-05	Koklass	*Pucrassia macrolopha*	2720	32 14 42 N; 77 13 40 E	Conifer	3 (calls)	Male
13-Jun-05	Koklass	*Pucrassia macrolopha*	2811	32 13 40 N; 77 13 22 E	Conifer	1	Female

Table 1.5 List of pheasants observed in Duhangan catchment in Kullu District in May – June 2005.

Date	Name of Pheasant	Scientific Name	Altitude (m)	Location	Habitat	Number (sighted/calls)	Sex
10-May-05	Himalayan Monal	*Lophophorus impejanus*	2249	32 11 49 N; 77 12 53 E	Mixed	1	Male
15-May-05	Himalayan Monal	*Lophophorus impejanus*	3117	32 12 00 N; 77 16 32 E	Alpine	1	Male
15-May-05	Himalayan Monal	*Lophophorus impejanus*	3230	32 11 59 N; 77 16 44 E	Alpine	3	Male
15-May-05	Himalayan Monal	*Lophophorus impejanus*	3236	32 11 53 N; 77 17 05 E	Alpine	1	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3125	32 11 55 N; 77 16 01 E	Alpine	1	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3092	32 11 52 N; 77 15 58 E	Alpine	2	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3092	32 11 51 N; 77 15 56 E	Alpine	1	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3175	32 11 48 N; 77 15 54 E	Alpine	2	Male
17-May-05	Koklass	*Pucrassia macrolopha*	2650	32 11 55 N; 77 16 08 E	Conifer	2 (Calls)	Male
19-May-05	Himalayan Monal	*Lophophorus impejanus*	3280	32 12 14 N; 77 16 10 E	Alpine	1	Female
19-May-05	Himalayan Monal	*Lophophorus impejanus*	3280	32 12 14 N; 77 16 10 E	Alpine	2	Male
19-May-05	Koklass	*Pucrassia macrolopha*	2530	32 12 02 N; 77 16 12 E	Conifer	2 (Calls)	Male
21-May-05	Koklass	*Pucrassia macrolopha*	2350	32 11 48 N; 77 13 58 E	Conifer	2 (Calls)	Male
21-May-05	Koklass	*Pucrassia macrolopha*	2440	32 12 08 N; 77 13 52 E	Conifer	1 (Calls)	Male
21-May-05	Himalayan Monal	*Lophophorus impejanus*	2480	32 11 49 N; 77 13 59 E	Mixed	1	Male

Annex F-B

Details of Mammals

FB1 DETAILS OF MAMMALS OBSERVED DURING THE THREE SEASON.

FB1.1 MAMMALS –AUTUMN (NOVEMBER 2004)

Table 1.1 List of mammals observed during the survey of Allain Duhangan Catchments in Kullu district in November 2004

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Number
Allain						
5/11/04	Leopard	Panthera pardus	2700	32^{0}13′77″ N & 77^{0}13′13″ E	Conifer	Scat
6/11/04	Langur	Semnopithecus entellus	2825	32^{0}15′54″ N & 77^{0}14′57″ E	Mixed forest	1
7/11/04	Yellow throated Marten	Martes flavigulla	2930	32^{0}14′51″ N &77^{0}13′88″ E	Fir forest	2
7/11/04	Pika	Ochotona royeli	2720	32^{0}14′43″ N & 77^{0}13′39 E	Open glade with boulders	1
9/11/04	Jackal		2400	32^{0}13′31 N & 77^{0}12′47 E	conifer with bamboo undergrowth close to Orchard	1
Duhangan						
11/11/04	Langur	Semnopithecus entellus	2399	32^{0}11′88″ N & 77^{0}13′82″ E	Open scrubby Nalla	1
11/11/04	Langur	Semnopithecus entellus	2500	32^{0}11′85″ N & 77^{0}13′79″ E	Conifer	5
12/11/04	Goral	Nemorhaedus goral	2870	32^{0}12′03″ N & 77^{0}15′21″ E	Open cliffs	1
12/11/04	Leopard	Panthera pardus	2936	32^{0}12′04″ N & 77^{0}15′41″E	Open glade	Scat
12/11/04	Yellow throatedMarten	Martes flavigulla	3127	32^{0}12′01″ N & 77^{0}16′02″ E	Open Glade	3
12/11/04	Langur	Semnopithecus entellus	2979	32^{0}12′01″ N & 77^{0}15′59″ E	Mixed forest/open	50
14/11/04	Langur	Semnopithecus entellus	2595	32^{0}11′55″ N & 77^{0}13′94″ E	Open glade	40

FB1.2 MAMMALS –WINTER (JANUARY-MARCH 2005)

Table 1.2 List of Mammals recorded in winter survey

S No	Name	Altitude (m)	Habitat
1	Rhesus	2140	Coniferous
2	Black bear	2385	Open scrub
3	Goral	2575	Coniferous
4	Langur	2502	Open scrub
5	Langur	2434	Open scrub

S No	Name	Altitude (m)	Habitat
6	Jackal	1966	Coniferous
7	Langur	1980	Coniferous
8	Pika	2076	Coniferous
9	Marten	2107	Coniferous
10	Marten	2196	Coniferous
11	Procupine	2104	Orchard
12	Rhesus	2104	Orchard
13	Rhesus	2037	Orchard
14	Jackal	2037	Orchard
15	Procupine	2037	Orchard

FB1.3 MAMMALS –SUMMER (MAY-JUNE 2005)

Table 1.3 List of mammals observed during the survey of Allain catchment in Kullu District in May – June 2005.

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Sign/Number sighted
30-May-05	Pika	*Ochotona roylei*	2854	32 16 04 N; 77 14 50 E	Rocks in Open grassland	9
31-May-05	Leopard	*Panthera pardus*	3242	32 16 07 N; 77 15 20 E	Open	Pug marks
1-Jun-05	Brown Bear	*Ursus arctos*	3134	32 17 02 N; 77 15 30 E	Open	Pug marks (also sighted by a Gaddi shephard
2-Jun-05	Pika	*Ochotona roylei*	2817	32 16 16 N; 77 15 04 E	Rocks in Open grassland	7
3-Jun-05	Brown Bear	*Ursus arctos*	3100	32 15 53 N; 77 14 41 E	Mixed forest	Droppings
3-Jun-05	Brown Bear	*Ursus arctos*	3030	32 15 55 N; 77 14 59 E	Mixed forest	2
5-Jun-05	Long-tailed Marmot	*Marmota caudate*	2823	32 15 50 N; 77 14 32 E	Rocky area in Mixed forest	1
7-Jun-05	Brown Bear	*Ursus arctos*	2714	32 14 55 N; 77 13 41 E	Conifer	Pug marks & Digging
8-Jun-05	Pika	*Ochotona roylei*	2972	32 13 55 N; 77 13 43 E	Rocky area in Conifer forest	3
9-Jun-05	Red Fox	*Vulpes vulpes*	2987	32 13 51 N; 77 13 46 E	Mixed forest	2
10-Jun-05	Pika	*Ochotona roylei*	3040	32 13 53 N; 77 13 52 E	Rocky area in Conifer forest	5
10-Jun-05	Kashmir Flying Sqirrel	*Hylopetes fimbriatus*	2800	32 13 59 N; 77 13 25 E	Conifer	5
10-Jun-05	Red Fox	*Vulpes vulpes*	2800	32 13 59 N; 77 13 25 E	Conifer	2
13-Jun-05	Brown Bear	*Ursus arctos*	2814	32 13 43 N; 77 13 21 E	Conifer	Pug marks & Digging
13-Jun-05	Macaca	*Macaca*	2824	32 13 33 N;	Conifer	4

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Sign/Number sighted
		mulatto		77 13 30 E		

Table 1.4 List of mammals observed during the survey of Duhangan catchment in Kullu District in May – June 2005.

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Sign/Number sighted
11-May-05	Leopard	*Panthera pardus*	2462	32 11 56 N; 77 14 20 E	Conifer	Scat
11-May-05	Langur	*Presbytis entellus*	2462	32 11 56 N; 77 14 20 E	Open	3
12-May-05	Black Bear	*Selenarctos thibetanus*	2493	32 11 51 N; 77 14 20 E	Mixed forest	Pug marks & Droppings
14-May-05	Himalayan Weasel	*Mustela sibirica*	3135	32 12 03 N; 77 16 13 E	Open	1
15-May-05	Pika	*Ochotona roylei*	3230	32 11 59 N; 77 16 44 E	Rocky area in Alpine grassland	3
17-May-05	Brown Bear	*Ursus arctos*	3170	32 11 55 N; 77 16 08 E	Conifer	Pug marks & Droppings
19-May-05	Pika	*Ochotona roylei*	3202	37 12 09 N; 77 16 11 E	Rocky area in Conifer forest	10
19-May-05	Langur	*Presbytis entellus*	3200	37 12 12 N; 77 16 08 E	Conifer	14
21-May-05	Brown Bear	*Ursus arctos*	2480	32 11 49 N; 77 13 59 E	Mixed forest	Pug marks & Digging

Annex G

Consolidated Report on River Ecology Study Conducted by FES

Consolidated Report on the river ecology study at the Allain-Duangan streams, Kullu District, Himachal Pradesh.
May 2006

Foundation for Ecological Security

Consolidated Report on the river ecology study conducted by FES for ERM.

Introduction to the context.
The Foundation for Ecological Security (FES) was contacted by the Environment Resources Management (ERM) with a request to take on a one-year study of the Allain (Alleo is more accurate) Pahli and Duhangan streams near Manali in Himachal Pradesh, in the context of the likely impacts of a hydro-electric project that had been initiated in the two catchments. FES was asked to study the fish fauna and the river ecology and indicate possible impacts of the project as well as suggest mitigation measures.

The EISA has been conducted by ERM, and in stages, draft ESIA documents - of August 2003, December 2003, and subsequent updates which have also been the basis of approvals and sanctions and full-scale implementation of the project. The report of this study therefore needs to be seen in the context of the EISA itself, presenting new findings and adding certain ecological data, and presenting an extended analysis on certain aspects.

The Study Site.
The study site which is the catchment area of the Hydro-electric Project of Allain-Duhangan, lies between latitudes 32 degrees 07' &32 degrees 21' and longitudes 77 degrees 11' E & 77 degrees 22' in Manali Tehsil, Kullu District, Himachal Pradesh. The project lies to the east of the Beas river on its true left bank, and comprises the sub-watersheds of Alleo, Pahli and Duhangan.

The terrain is mountainous, rising from about 1700 meters asl at the Beas river, to about 4,800 meters at the glaciers from where these streams originate. The ridge line above the glaciers in the Duhangan stream go to above 6000 m asl and are nival, or permanently snow-bound. The Duhangan stream originates from Chandratal glacier, at an altitude of 4400 m asl, whereas the Alleo stream is formed by the Hamta and Patroi streams which originate at 4680 m asl and 4800 m asl respectively in the Himalayan range. While both Alleo and Duhangan streams are predominantly glacial, they are joined by several fluvial streams before their confluence with the Beas. The Pahli stream is purely fluvial, receiving a good deal of seasonal snow-melt as well. Located within the sub-watersheds of these streams are the villages of Prini, Hamta and Jagatsukh.

Approach and Methodology.
As detailed in the ToR, the scope of the study was to study the Alleo, Pahli and Duhangan streams and their catchment area, and the studies would include the following:

a) Baseline assessment of current status (for assessing impacts and monitoring) in terms of physical and biological parameters. The physical parameters would include seasonal flow volume variations, turbidity and pH values, while the biological parameters would include details of all kinds of aquatic flora and fauna (including benthos) along different altitudes in project streams;
b) Impact assessment (i.e how will the current status be affected by the project); and
c) To suggest mitigation measures (to minimize impacts and how they can be monitored);

The following outputs would represent data and findings:
1. Seasonal flow volume variations, turbidity and pH values;
2. Presence-absence of fish fauna representing all twelve months of a calendar year; and
3. Analysis of land and water use in the river basins in the context of effects of the project on the riverine ecology.

A yearlong study was undertaken to assess variations across seasons, especially fluxes in flow volumes, water temperatures, TDS and pH values, as well as seasonal presence-absence of fish

fauna. While two professional fishermen cast for fish fauna during the seasonal assessments, a local fisherman was also hired to cast with a rod every month for fish species.

Fish fauna: Fishing nets (cast-nets of two weave densities) and a rod were used in the main stream, and a dip net was used for catching small fishlings from slow flowing pools at the side.

Benthic Macro Invertebrates: A D net and a sieve were used for studying insects present in the sand and sticking to the undersides of stones and other substrate.

Water parameters:
a: ***Temperature*** : Both alcohol and mercury thermometers were used for recording water temperature. The temperatures mentioned here are from the mercury thermometer.

b: ***pH, Electrical Conductivity, Total Deposited Solids [TDS], Total acidity, Potassium and Sodium salts present in the water***: Samples were taken seasonally from all three rivers and tested at the Irrigation and Drainage Department of Govind Ballabh Pant University of Agriculture and Technology Pantnagar, Udham Singh Nagar ,Uttaranchal.

Measurement of flow volumes: The Float Velocity Method was used. The average depth of the rivers were taken at a one foot interval at evenly flowing stretches of the river, and the width at that place also measured. Floating balls were used for measuring the velocity [Nmeter per Second] of the river. For measuring the flow of the river, the width of river, the average depth and the velocity of water was multiplied.

All three sub-watersheds were traversed extensively by us in the four seasons, depending on the snow conditions, right from their confluence with the Beas and upto the glaciers of origin. The flora and fauna was studied for the vicinity of the streams. Intensities and trajectories of land-use were also sought to be understood by discussions with alpine shepherds, buffalo herders, herb collectors, fishermen, agriculturists and other residents of the villages. Discussions were also held with the Project Staff, officials of the Fisheries Department, the National Research Centre for Cold Water Fisheries at Bhimtal, as well as ERM Officers, who also provided us some data.

Habitat Types and ecological features.
The Alleo and Duhangan rivers have a continuum of Stream Orders 1 to 3. The Pahli stream is of Stream Orders 1 and 2. All three streams consist of ephemeral, intermittent and perennial flows and are steeply cascading, descending rapidly with-in the short distance that they traverse, through a series of waterfalls and cascades. Accretion zones of gravel, shingle and sand were in the lower stream reaches close to their confluence with the Beas. Numerous detention ponds for the collection of sand were found constructed in the lower reaches of the Alleo stream only. The pool-riffle ratios and sequence in both Alleo and especially the Duhangan stream were excellent, often 1:1, bearing a very desirable combination of riffles, plunge pools, step pools, runs and glides in the Duhangan. The richness of fish catches in the Duhangan were also testimony to excellent fish habitat, in the lower stream reaches.
The stream lengths and profiles are as follows:

River lengths from glaciers/points of origin, to their confluence with the Beas river:

Duhangan stream = 18.6 kms
Alleo stream = 15.38 kms
Pahli stream = 6.26 kms

Sum total of length of rivers including tributaries:

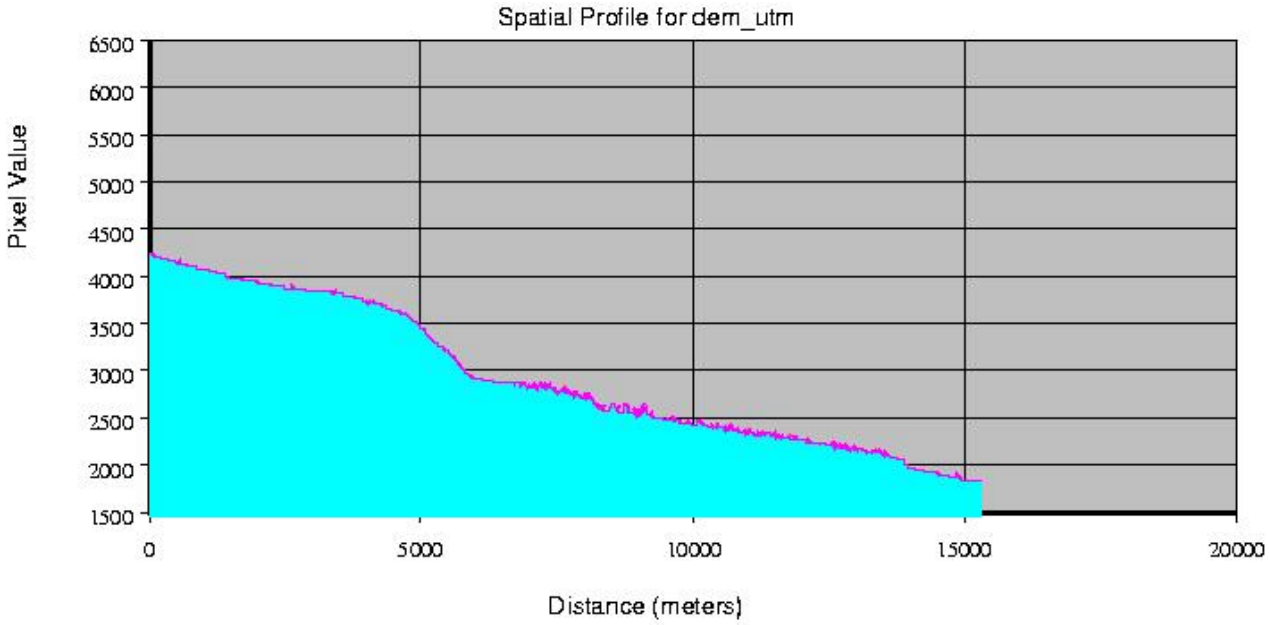
Total length of Duhangan stream = 20.29kms
Total length of Alleo stream including Jabri nala = 44.25kms

Altitude difference between source and confluence of streams:

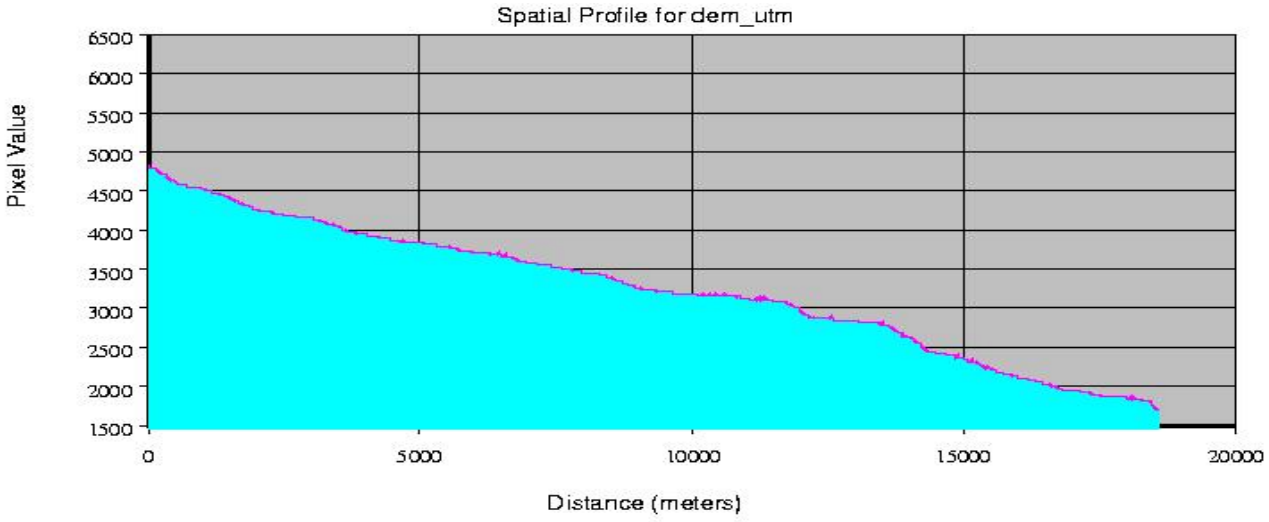
Duhangan stream: 4880m to 1760m
Alleo stream: 4240m to 1840m
Pahli stream: 3920m to 1840m

Spatial Profiles of the three streams studied.

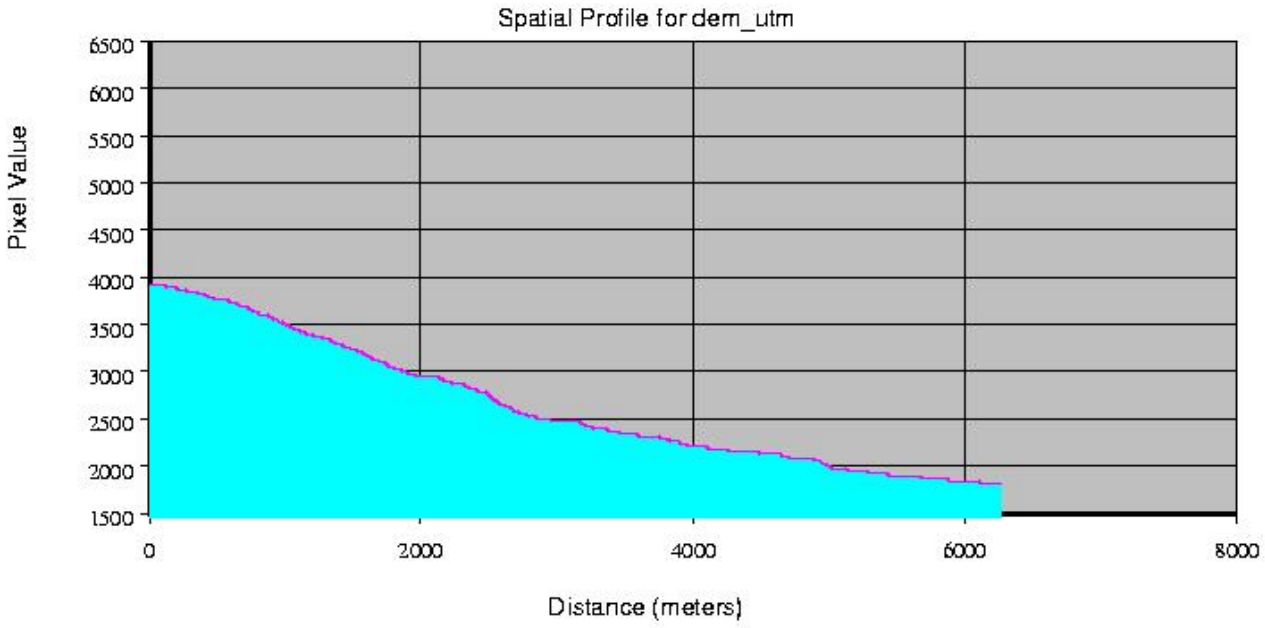
Alleo stream:



Duhangan stream:



Pahli Stream:



The habitat types along these streams were as follows:

1. Glaciers and glacial moraines
2. Sub-alpine Krummholz forests
3. Sub-alpine pastures
4. Alpine marshlands
5. River beds
6. Marshy patches near pastures
7. Mountain cliffs and cut slopes
8. Rocky habitat on mountain slopes
9. Boulder strewn habitat near streams
10. Steep grassy slopes
11. Sheltered gulleys
12. Small streams on mountain slopes.

The following are the details of the data collected.

Flow Measurement [Cubic meter per Second]

1: Alleo stream

S. No.	*Season*	*500 meters above Confluence*	*At Barrage site*
1	Post winter [February 2005]	2.19	
2	Pre monsoon [June 2005]	30.92	
3	Post monsoon [September 2005]	13.99	9.944
4	Winter [January 2006]	3.52	3.307

2: Duhangan stream

S. No.	*Season*	*500 meters above Confluence**	*Below Chhika [at Barrage site]*
1	Post winter [February 2005]	1.04	
2	Pre monsoon [June 2005]	21.88	
3	Post monsoon [September 2005]	5.776	4.052
4	Winter [January 2006]	2.102	1.314

* This includes flows in the two irrigation aqueducts at the banks of Duhangan near Jagatsukh.

3: Pahli stream

S. No.	*Season*	*500 meters above Confluence*
1	Post winter [February 2005]	0.23
2	Pre monsoon [June 2005]	0.78
3	Post monsoon [September 2005]	0.798
4	Winter [January 2006]	0.216

Physical Water Parameters Report

1: Alleo stream

Site	*Season*	*pH*	*Temperature*	*Remarks*	Time
Near Confluence	Post winter [February 2005]	7.29	8	Clear sunny day	1130
	Pre monsoon [June 2005]	6.9	15	5960 feet asl lat 32 13' 508'', long 77 11' 486''	
	Post monsoon [September 2005]	7.8	12	Clear sunny day	1000
	Winter [January 2006]	7.27	6	Clear sunny day	1200
Barrage Site	Post winter [February 2005]	Inaccessible due to heavy snow conditions.			
	Pre monsoon [June 2005]	7.3	12	9250 feet asl lat 32 15' 478'' long 77 15' 398''	
	Post monsoon [September 2005]	7.5	9	Clear sunny day	1130
	Winter [January 2006]	8.5	5	Clear sunny day	1100
Patroi stream	Post monsoon [September 2005]	7.9	10	Clear sunny day	1020
Hamta Glacier	Pre monsoon [June 2005]	7.3	3	12134 feet asl lat 32 13' 814'' long 77 19' 700''	

2: Duhangan stream

Study Area	*Season*	*pH*	*Temperature*	*Remarks*	Time
Near Confluence	Post winter [February 2005]	6.8	8	Clear sunny day	1312
	Pre monsoon [June 2005]	7.6	16	Clear sunny day	
	Post monsoon [September 2005]	7.9	12	Clear sunny day	800
	Winter [January 2006]	8.03	7	Heavily overcast after snowfall	1600
Barrage Site	Post winter [February 2005]	Inaccessible due to heavy snow conditions.			
	Pre monsoon [June 2005]	7.6	6	12808 feet asl	
	Post monsoon [September 2005]	7.9	8	Clear sunny day	1000
	Winter [January 2006]	7.4	4	Clear sunny day after snow fall	1000

3: Pahli stream

Study Area	*Season*	*pH*	*Temperature*	*Remarks*	Time
Near Confluence	Post winter [February 2005]	7.8	6.5		1000
	Pre monsoon [June 2005]	7.5	20	1880 m asl	
	Post monsoon [September 2005]	8.5	12	Clear sunny day	730
	Winter [January 2006]	7.61	5	Clear sunny day	1000

Water Quality report of the samples taken by us and analyzed by the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar

1: ***Water Quality report for the month of February 2005***

Sample No.	*pH*	*EC (mmhos/cm)*	*Total Acidity ppm*	*K ppm*	*Na ppm*	*Cl ppm*	*Ca ppm*	*Carbonates ppm*
Alleo	7.29	0.8	4	4	1.6	2.1	69.92	11700
Pahli	7.8	0.7	2	2	1.4	2.1	65.73	35600
Duhangan	6.8	1.2	8	8	6.3	0.9	69.12	11700

2: ***Water Quality report For the Month of June 2005***

Sample No.	*pH*	*EC (mmhos/cm)*	*TDS mg/l*	*Total Acidity mg/l*	*Alkalinity mg/l*	*Ca mg/l*	*Cl mg/l*	*Turbidity NTU*
Alleo	7.25	1	1	1.25	33	11.49	11.49	16.2
Pahli	7.01	3	2	1	27.5	19.57	19.15	6.3
Duhangan Chhika glacier	6.8	1	3	1.5	33.75	17.24	17.24	8.5
Duhangan	7.14	1	1	1.25	34	21.07	21.07	9.2

3: ***Water Quality report for the month of September 2005***

Sample No.	*pH*	*EC (mmhos/cm)*	*TDS mg/l*	*Ca Mg/l*	*Mg Mg/l*	*Cl mg/l*	*Acidity mg/l*	*Alkalinity mg/l*	*% carbonates*
Hamta stream	7.12	0.7	1	24.9	12.35	12.29	7.5	38.1	1.22
Patroi stream near Barrage	7.02	0.8	0.9	28.74	13.51	8.19	10	42.86	1.23
Alleo near conf.	6.7	0.8	0.9	32.57	13.48	9.56	5	28.57	1.22
Pahli near conf.	6.8	0.7	1	28.74	16.5	6.83	5	33.33	1.23
Duhangan barrage site	7.15	0.8	0.7	24.9	12.84	9.56	7.5	38.1	1.24
Duhangan near conf.	7.37	0.7	0.8	34.48	13.58	8.19	10	33.33	1.23

4: ***Water Quality Report for the month of January 2006***

Sample No.	*pH*	*Cond. S/cm*	*TDS Mg/l*	*Acidity Mg/l*	*Cl Mg/l*	*Alkanity Mg/l*	*Ca Mg/l*	*Mg Mg/l*	*Hardness Mg/l*		
									Ca hardness	Mg hardness	Total hardness
Alleo barrage	8.5	58.8	29.5	0.15	9.92	20	10	3.66	24.97	15.03	40
Alleo near confluence	7.27	13.8	6.9	0.1	14.2	15	10	6.1	24.97	25.03	50
Duhangan Barrage	7.4	25.9	13	0.05	9.92	20	20	2.45	49.94	10.06	60
Duhangan	8.03	27	13.5	0.05	11.33	20	10	1.22	24.97	5.03	30
Pahli	7.61	24.8	12.4	0.1	11.33	25	10	6.1	24.97	25.03	30

Ichthyfauna in the Allain, Pahli and Duhangan streams.

Month	*Alleo*	*Duhangan*	*Pahli*
February	Four spp. of Mollusc Class Pelecypoda.	*Schizothorax richardsonii (Gray)*	
March		*Salmo trutta fario*	
April	*Salmo trutta fario*		
May			
June	*Schizothorax richardsonii (Gray)*	*Salmo trutta fario*	*Schizothorax richardsonii (Gray)*
July	*Schizothorax richardsonii (Gray)*		
August			
September		*Salmo trutta fario*	
October			
November			
December			
January			

The fish species found in these two streams were *Schizothorax richardsonii* (Gray) generically known as Snow trout, and *Salmo trutta fario*, generically the Brown trout. The species referred to in the ESIA by ERM as 'Desi Carp' is actually the snow trout, a schizothoracid and not a carp, which is known locally as *desi*. The fisheries Department has a general list of fish species found in Allain, Duhangan, Ravi, Tirthan, Sainj, Uhl, Baspa, Pabar, Lambadug, Giri, Rana, Nugal Gai, Baner and Bata, among other streams of the Beas. These cover a very large altitude gradient of the Beas, and therefore also include species such as the Mahseer, *Nemachilus*, Barils, *Crossocheilus* and *Glyptothorax* as well, which are not found in Alleo or Duhangan. While the ESIA exercise found

the Alleo and Duhangan streams 'devoid of any fish species', we found two species of fish, namely the Snow trout and the Brown trout in the Alleo, Duhangan and Pahli streams. While our catches were reasonably frequent, and indicated a very good age diversity, the low species diversity could be for two reasons; one being that the altitude gradients of the streams studied by us fall under the trout waters which are rather cold for the other species in the general list, and also because of the introduction of *Salmo trutta*, the Brown Trout and *Oncorhynchus mykiss*, the Rainbow Trout in the Beas by the Fisheries Department. Both these fish are exotics, and very effective predators of other fish and BMIs. Other than the Schizothoracids, perhaps none of the other species have the speed and agility to match them, or a chance to escape predation should they encounter each other even seasonally in transitional or briefly overlapping river habitats.

In both the Duhangan and the Alleo streams there are successive waterfalls about a kilometer and a kilometer and a half upstream of the confluence respectively. These waterfalls are over 10 meters high with deep plunge pools, and because of the nature of the fall over overhanging rock, are not possible for fish to climb or leap over. We therefore found fish fauna only upto these waterfalls in the two streams. In the Pahli stream fish were found up to about 500 meters above the bridge.

Due to very steep gradient profiles and subsequent oxygenation, as well as retention of Dissolved Oxygen instream due to low temperatures in all the three streams, and Duhangan in particular, the waters can be termed as Salmonid. This was further evidenced by the presence of *Salmo trutta* of great age diversity in the lower reaches of the Duhangan. The DO of Duhangan is by inference, anywhere between 9 and 12 mg per litre, depending on the season. ERM's data on the DO in the Beas at Manali is close, ranging from 9.8 in June to 11.6 mg per litre in December.

Benthic Macro Invertebrates

1: Larvae of May Fly (Order Ephemeroptera)
2: Two species of Caddis fly case maker larvae (Order Tricoptera)
3: Moulted remnants of the Common Stone Fly (Order Plecoptera)
4: Larvae of the Dragonfly (Order Odonata, Suborder Anisoptera)
5: Larvae of the Damselfly (Order Odonata, Suborder Zygoptera)
6: Larvae of the Alderfly (Order Megaloptera, Family Sailidae)
7: Larval grub of the Watersnipe Fly Larvae (Diptera, family Athericidae)
8: Predaceous Diving Beetle (Order Coleoptera)
9: 4 species of very small Mollusc filter feeders (Class Pelecypoda)

The existence of EPT taxa in the Duhangan and Alleo streams, and taxa richness of 4 in EPT and a total of 9 in BMI taxa indicate good water quality. Tolerance values to organic pollution on a scale of 0 to 10 for the EPTs range from 0 to 4. However, it is relevant to point out here that with the great influx of migrant labour, for ancilliary construction to the Hydro project as well as the continuing tourist boom, such as road building and house building activity in Prini and Jagatsukh villages has led to all three streams being used for defecation by humans. Pahli is already in bad condition, and the lower reaches of Alleo and Duhangan are also beginning to be affected in this manner.

Floral aspects:

The Forest Types within the Project catchment area broadly fall under the following, based on the Champion and Seth classification system:

1. Western Mixed Coniferous Forests
2. Moist Temperate Deciduous Forests
3. Kharsu Oak Forests
4. Western Himalayan Upper Oak Forests
5. Himalayan Temperate Pastures
6. Western Himalayan Sub Alpine Fir Forests
7. Western Himalayan Sub Alpine Birch-Fir Forests
8. Sub Alpine Pastures
9. Birch Rhododendron Scrub Forests
10. Dwarf Rododendron Scrub
11. Dwarf Juniper Scrub
12. Alpine Pastures.

The upland mountain slopes contain some rich stands of spruce-fir associations, prime communities of blue pine and deodar, and mixed oak forests with an under-storey of yew and maple and the hornbeam. Tree species we encountered within 100 meters of the three streams were as under:

1. *Quercus dilatata*
2. *Quercus semecarpifolia*
3. *Aeschulus indica*
4. *Alnus nitida*
5. *Populus ciliata*
6. *Carpinus viminea*
7. *Juglans regia*
8. *Acer ceasium*
9. *Corylus jacquemontii*

10. *Ulmus wallichiana*

11. *Prunus spp.*

12. *Salix tetrasperma*

13. *Pinus wallichiana*

14. *Cedrus deodara*

15. *Picea morinda*

16. *Betula utilis*

17. *Rhododendron campanulatum.*

A few Chlorophycean members of green freshwater algae such as *Volvox*, and *Chlamydomonas* that form scum, and *Oedogonium*, *Cladophora* and *Chaetophora* on submerged substrata were found, and exhibit a diversity of decomposition rates. This is especially significant for the *Schizothorax* fish populations in the streams under study as well as the Beas, as they feed primarily on micro-algae which remain attached to rocks. Obligate wetland plants such as *Equisetum* growing on hydric soils were few, owing to the great fluxes in flow, but fulcative vegetation such as *Salix tetrasperma* and *Alnus nitida,* an important N fixer, were very rich in the lower stream reaches of the Duhangan.

Reptiles: The ESIA mentions Cobra, the Krait and the Pit Viper as the snake species in the study area. We did find a most unusually patterned juvenile Himalayan Pit Viper *Gloydius himalayanus*, and a proper taxonomic identification was done to confirm this. However, both the Cobra and the Krait (the ESIA does not mention which species within these genus) would be highly unlikely within the altitude range that the study area encompasses. The skink *Asymblepharus ladacensis* was found in surprisingly large populations at the lateral moraines of the glaciers at the head of both the Alleo and Duhangan streams. In the warm temperate zone in the lower reaches of these streams the rock agama *Laudakia himalayanus* was a common sight basking on rocks on sunny days in summer.

Avifauna.

The bird fauna sighted by us during the survey period, **in addition** to those in the list by ERM in the ESIA as as follows:

Spotted Forktail- *Enicurus maculatus*

Little Forktail- *Enicurus scouleri*

Brown Dipper- *Cinclus pallasii*

Citrine Wagtail- *Motacilla citreola*

Snow Pigeon- *Columba leuconota*

Red-billed Chough- *Pyrrhocorax pyrrhocorax*

Lammergeier- *Gypaetus barbatus*

Himalayan Snow Cock- *Tetraogallus himalayansis*

The first four in this list were sighted actually either in the river, or on rocks within the river, their nature being more obligate. These may be added to the list in the ESIA.

Expected effects of the project on the river ecology and recommendations.

We know that rivers are in a sense, the narrators of all that transpires in their river basin, and their intimate biotic and energy interactions with the riparian landscape make them reflect biotic and abiotic changes across the entire basin. In the context of the streams studied the following are some of the physical concerns, and these are put up for consideration by the project proponents, in the interests of effective due process, and in order that they can initiate further remedial and mitigating measures, in addition to some already undertaken:

1. The 192 MW Allain Duhangan hydro project has presented itself to the sanctioning authorities and the public at large as a run-of-the-river scheme, and letter no. J-12001/33/96-IA-1 dated 12.12.2000 from the MoEF according Environmental Clearance for this project notes that the 'scheme is a run-of-the-river scheme' as well. Only 150 lps or about 1% to 10 % of the average flows of water (at high and low seasonal flows respectively) from the Duhangan has been assured to be released along the normal course from the diversion point, and the rest of the flows are diverted through tunnels to another catchment The diversion points on both streams are in the upper reaches, at least half way to the points of origin from the confluence. Therefore flow volumes in at least half the stream lengths will be altered radically. There are however, smaller perennial first order tributary streams further downstream of the diversion points on both Alleo and Duhangan, where some year-round flows will remain and be augmented by seasonal precipitation and run-offs. In the Duhangan stream the downstream supplemental flows are to the order of 788 lps at low flow in the month of February 2005 as per our measurements, and an average of 474 lps in February as per the HPSEB estimates over 24 years between 1971 to 1995. It is these flows that will keep the river running from smaller confluences downstream, and not the contribution of 150 litres per second promised by the project, where even at say 1 meter per second velocity, it would take an impermeable bottomed channel of only 1m wide by 15cm deep to carry 150 lps. Mountain streams having beds that would need to be saturated and rendered hydric by larger and constant flows, and be highly permeable towards subsurface flows in places, would not take these 150 lps very far, if they were not augmented by confluences further downstream, or by intermittent seasonal flows as well.

   The fish species found in these two streams were *Schizothorax richardsonii* , and *Salmo trutta fario*. The low species diversity could do with a combination of these waters being too cold for most other indigenous species found lower in the Beas, and also because of the introduction of Brown trout *Salmo trutta* and Rainbow trout *Oncorhynchus mykiss* into the Beas. Both these species are predatory and while they rely heavily on EPT fauna, also exert a great pressure on *Schizothrax* and other fish species populations.

   That flows be maintained to ensure the 'ecological requirements' and those of the fish fauna, is a precondition set by the MoEF and the Pollution Control Board of HP. There are various interpretations as to what quantities of flow would ensure meeting such ecological requirements.

   We know that very few species of fish have a wide tolerance for habitat features. Species distribute themselves on the basis of preferences based on the presence of individual habitat units. In larger systems, features such as depth, distance from shore and bottom substrates contribute to distribution patterns of fish (Armantrout *et al*. 1998). Due to the construction of dams and other hydro projects along the Beas and its tributaries, and also due to water pollution and various human activities, fish diversity as well as populations are decreasing in

the associated hill streams as well. Tennant (1976) observed that in any part of the year, the water flow should not be less than 10% of the annual waterflow of baseline flow, to sustain short term survival habitat for most aquatic life forms. At this flow rate, the system will provide nesting, nursery and refuge habitat. Stream banks will provide cover for fish, the riparian vegetation will not suffer from lack of water, and large fish can move over riffle areas. Sixty percent of the average flow provides excellent to outstanding habitat for most streams. This flow rate also creates favourable conditions in the adjoining shallow riffle and shoal areas. Tennant also suggested that at this flow rate pools, runs and riffles will be formed and provide the necessary feeding and nursery habitat for most fish, and fish migration would face no problem.

Recommendation: It is recommended that the Project developers may take appropriate measures to upwardly revise the assured flows of 150 lps in both Alleo and Duhangan streams to sustain aquatic flora and fauna. A minimum of 10% of the annual water flow of the baseline flow is to be ensured to sustain short-term survival habitat of most aquatic life forms.

2. At the level of just the Alleo and Duhangan streams, there is no doubt that because of the project, flow regimes, and therefore habitat structures will be significantly impacted. The Duhangan in particular, as described before contains very prime habitat for fish in the lower reaches of the stream. This however, is limited to about a kilometer from the confluence with the Beas from where there is seasonal migration of the species mentioned. It is reasonable to assume that the availability of fish in this section too will certainly be reduced due to change in riffle-pool ratios and flow volumes, and therefore temperatures and DO. The larger question however is, will the seasonally migrating populations of fish in the Beas be significantly impacted by the serious alteration of about two and a half kilometers of open stream habitat near the confluence (fish-habitat restricted by the impassable waterfalls thereafter on both streams), and the alteration in energy flows due to loss of biotic interaction (due to diversion into metal lined tunnels) of the streams from their points of diversion into the tunnels? While the significant alteration of these two streams will certainly reduce biotic interactions, energy sources and reduce EPTs that form a significant part of the diet of *Salmo trutta*, it would only be possible to extrapolate its effects on the fish populations in the Beas after taking into account what proportion and what quality of habitat has been altered along their normal migratory routes, by this among other hydro projects in the other tributaries of the Beas that contain these two species of fish.

   Recommendation: A comparative study of other tributaries of the Beas where similar hydro projects have been commissioned and that contain similar fish species may be done to fairly assess the effect of the altered habitat of the Duhangan stream on the seasonally migrating fish populations.

3. Disturbance in terms of the accelerated felling of trees. As per the ESIA 882 trees in the Alleo site and 470 trees in the Duhangan site were estimated to be affected, or in other words, requiring to be removed for road building etc. While this number seems rather small, we witnessed an associated phenomenon, where a very large number of trees were being felled and transported down to the motor road near the Alleo stream. While it was not possible to estimate the exact number of trees already felled and those currently being felled, it is relevant to say here that a significant number of trees in the upper reaches of the stream basin of Alleo were being felled, far greater than the number mentioned as directly affected by the project.

   This rapid and significant change in the canopy and tree cover in the watershed is a matter of concern, as it will alter sediment flows and biotic interaction with the stream. At a wider level, significant loss of tree cover would result in the loss of habitat and loss of dispersal areas. There is also likely to be an additional pressure on the forests proximate to the dwelling camps for 500 to 1,500 people hired as manual labour over the 5.5 years of construction work.

Recommendation: While the estimated loss of 32.167 hectares of **Forest Land** (and not actual loss of forest cover) directly due to Project activities is planned to be compensated by afforestation of twice the area of land, it would be worthwhile to review the Working Plan for Forest Compartments critically close to the Project Area and to the streams under reference. Instead of accelerating the felling activities due to the facilitation of transportation facilities developed due to the project, the present harvest rates could be reduced to compensate for the expected loss of tree vegetation, rather than limiting to just the mandatory compensatory afforestation, which would take many years of succession to come to the present state.

4. The seismicity of the area, and its predisposition to other severe natural hazards such as floods, landslides and snow avalanches is another area of serious concern. The project area lies fully within the seismic zones IV and V, which are characterized by frequent earthquakes of magnitudes ranging from 5 to 8 on the Richter scale. It is clear that the sensitivity of the area and the high probability of severe earthquakes must be factored into all design and construction aspects of the project.' FES, who conducted this study has also asked for the seismic report but has not been given it so far.

   The 8.25 kilometers of underground head-race tunnels, and the large powerhouse and transformer caverns etc, which are to be excavated through the use of explosives upstream of these two villages, are an area of concern in the context of seismicity, and the fractures and cleavages such heavy use of explosives may increase. Data given by ERM on the quantity of explosives to be used for the entire project is 2,900 kgs, is a highly unlikely figure considering that 860,000 m3 of rock and soil is expected to be excavated, and many kilometers of roads to be built. Project data also shows that while the total soil and 'muck' generated due to excavation would be in the order of approx 860,000 m3 (approx 474,000m3 of soil and 386,000m3 of muck) 30% of which will be used in back-filling, and the remaining 653,000 m3 is proposed to be 'disposed-off' in an area of 13 hectares with a fill height of approximately 5 m at dumping sites. Since more than half of the excavated material is expected to be soil, sufficient care will need to be taken not only to prevent the erosion of such masses of soil into the streams, but to withstand serious earthquake events, and possible landslide, flood episodes and snow avalanches from upslope as well. While the average annual rainfall recorded at Manali is just 1302.96 mm along with an average of 343.25 mm of snow (this will be much higher at the weir and intermediate reservoir sites), the Beas river basin has a history of recurring high magnitude flood events, as recently in early July of 1993, and then in September of 1994, 1995 and 1996.

   Recommendation: The reports on the seismicity of the area, as well as those on the project design need to be considered to plan measures to protect against such eventualities.

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Senior Researcher: Vijay Rawat.

Field Assistant: Manohar Maher.

Fisherman1 from Munsiari: Gopal Ram

Fisherman2 from Munsiari: Dewan Ram

Fisherman from Jagatsukh: Chunni Lal

References:

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Assessment Report of the Compliance Adivsor Ombudsman of the IFC: Complaint regarding Allain Duhangan Hydropower Project. HP, India. March 23,2004.

Implementation Agreement for the Allain Duhangan Hydroelectric Project (192 MW) between the Govt of HP and Rajasthan Spinning and Weaving Mills Ltd.

Letter no. J-12011/33/96-IA-I dated 12.12.2000 of the MoEF according Environmental Clearance for the project.

Himachal Pradesh State Environmental Protection and Pollution Control Board's letter according clearance to the ADHP Project.

Annex H

Wildlife Surveys in Allain-Duhangan Catchments, Himachal Pradesh by WPA India

WILDLIFE SURVEYS IN ALLAIN-DUHUNGAN CATCHMENTS, HIMACHAL PRADESH
Final Report

Submitted to

ERM-India
6th Floor – Block 4B
DLF Corporate Park
DLF City, Phase III
Gurgoan

By

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1. INTRODUCTION

1.1 Background

The Himalaya comprises of five biogeographical provinces -i.e. Trans, North West (Jammu & Kashmir and Himachal Pradesh), West (Garhwal and Kumaun), Central (Sikkim and Darjeeling district of West Bengal) and East Himalaya (Arunachal Pradesh) (*Rodgers and Panwar, 1988*). This whole region supports about 18,440 species of plants, of which at least 25% are endemic to the Himalaya (*Singh & Hajra, 1997; Samant et al., 1998a*). Of the total vascular plants, 1748 species have been reported as medicinal (*Samant et al., 1998 a*), 675 species as wild edibles (*Samant & Dhar, 1997*), 279 species as fodder (*Samant, 1998*), 118 species of essential oil yeilding medicinal plants (*Samant & Palni, 2000*) and 155 sacred plants (*Samant & Pant, 2003*).

The State of Himachal Pradesh includes parts of the Trans and North West Himalaya. Nature has endowed Himachal Pradesh with five major river systems - Satluj, Beas, Ravi, Chenab, and Yamuna – all of which originate from the glaciers of the north-western Himalaya. A large number of hydro power projects have been established or initiated on these rivers to generate electricity and power to the Northern States of the country. The State covers a total geographical area of 55,673 km^2, of which 66% is forest area and there are 32 Protected Areas. The State is known for its rich biological and cultural diversity. The vegetation mainly comprises of tropical, sub-tropical, temperate, sub-alpine and alpine types and supports a large number of medicinal species, wild edibles, wild relatives of crop plants and several native and endemic species. The forests and alpine meadows are major habitats for wildlife. The inhabitants are dependent on the rich biological diversity for medicines, food (wild edible), fuel, fodder, house building, making agricultural tools, fibre, religious and various other purposes, including livestock grazing. However, habitat degradation, over exploitation and development works like construction of roads, hydro power projects, etc. are causing rapid loss of biodiversity.

In view of the concerns regarding the loss and depletion of biodiversity throughout the country, the Ministry of Environment and Forests initiated the preparation of the National Biodiversity Strategy and Action. There upon the Government of Himachal Pradesh developed the State level Strategy and Action Plan for the conservation of biodiversity. Studies on the biodiversity of area related to hydro power projects are included in this Strategy and Action Plan. Now, there is a need to implement the Strategy and Action Plan in the State and initiate studies on biodiversity conservation, especially to assess and predict the loss of biodiversity due to construction of dam, tunnels and roads in the project areas.

Environment Impact Assessment (EIA) is concerned with identifying and assessing the environmental consequences of development projects in an attempt to ensure that the 'best' alternative for development is selected. In the process, 'new' alternatives may emerge, which could achieve the desired objectives at less cost to he environment (WII, 1998).

1.2 Impact on floral and faunal diversity

Floral and faunal diversity of an ecosystem reflects its richness. The fauna of an ecosystem depends on the the flora for food and shelter. Any impact on flora eventually affects the fauna. The hydroelectric power project activities keep at stake the wildlife values (*Uniyal and Mehra, 1996*).

The riparian zone, including streams, rivers and their adjacent riverine forests, make an important corridor for the movement and dispersal of different species. Such areas are being severely impacted by project activities. Poaching of wildlife species and habitat degradation due to cutting, loping and other human use occur in most sites due to the presence of human population and lack of manpower to control the offenders. The overall impact on wild species and their habitats are generally more severe in and around dams, quarrying sites, trench weirs, dumping sites, road network and powerhouse sites.

1.3 Need of study

The primary data obtained from Impact Assessment Studies is very useful in conservation and restoration of wildlife. The Impact Assessment Studies also provide a base for planning strategies, programmes and policies for sustainable development of the ecosystem. Floral components, insects (butterflies, beetles), reptiles, birds, and mammals are preferred for these studies. Insects like tiger beetles and butterflies are very sensitive to any minute change in environment and have proved very fine bio-indicators (*Uniyal and Mathur, 1998*).

2. PROJECT PROFILE

2.1 Background

Himachal Pradesh has five perennial rivers, Sutlej, Beas, Ravi, Chenab and which possess immense potential for the generation of hydro-electricity. The Government of India plans to introduce a tariff subsidy to support the development of hydroelectric power in an effort to improve the nation's energy requirement.

The Rajasthan Spinning and Weaving Mills Ltd. (RSWML), a private limited company incorporated in India, proposes to set up Allain – Duhangan Hydroelectric Project (ADHEP) of 2 x 96 MW (192 MW hydropower generation facility on Allain and Duhangan tributaries of the Beas river) in Tehsil Manali, District Kullu, Himachal Pradesh in India.

2.2 Project location (Site and Surroundings)

The catchment area of the proposed hydel project lies between latitudes 32°21'N and longitudes 77°11'E and 77° 22'E. The project components extend within the villages

of Prini, Hamta and Jagatsukh in Tehsil Manali and to the east of Beas River.
(Refer Fig. 2. 1)

The topography of the region is marked by hilly terrain rising from altitude of 1,700m above mean sea level (amsl) near Beas River (western limits of the catchment area) to 4,800m (amsl) in the glaciers of Himalayan ranges (eastern limits of the catchment area). The Allain stream is formed by Hamta and Patroi streams which originate at an elevation of 4,680m (amsl) and 4,800m (amsl) respectively in the Himalayan ranges, while Duhangan stream originates at an elevation of 4,400m (amsl) from Chandratal glacier in the Himalayan ranges. These two streams are joined by several streams and glaciers before these empty into Beas River downstream of Jagatsukh village.

2.3. Study Area

The Hamta and Jagatsukh catchments (altitudinal range, 1800-4800m) lie between latitudes 32º 07'to 32º 21'N and longitudes 77º 11' to 77º 22'E. Allain and Duhangan are the main streams of these catchments. Both these streams flow east to west before joining the Beas River. Allain stream joins Beas near village Aleo in Manali, while Duhangan stream joins Beas near village Jagatsukh located on the outskirts of Manali. The Allain stream is formed by Hamta and Patroi streams which originate at an elevation of 4680m (amsl) and 4800m (amsl), respectively in the Himalaya and traverse a distance of 18.5km before joining the Beas River at an elevation of about 1800m (amsl). The Duhangan stream originates at an elevation of 5229m (amsl) from Chandertal glacier in the Himalaya and traverses a distance of 19 km before it joins the Beas River. Both streams have a number of vertical falls and are joined by several streams before they merge in the Beas River. On an average, these streams have a steep gradient of 1:7 indicating suitability for hydropower generation. However, such areas are certainly prone to soil erosion.

The vegetation mainly comprises of temperate, sub-alpine and alpine types. The forest zone is mainly dominated by *Quercus floribunda, Cedrus deodara, Pinus wallichiana, Picea smithiana, Abies pindrow, Quercus semecarpifolia, Aesculus indica, Acer acuminatum, Juglans regia and Betula utilis*. These catchments are inhabited by seven villages - Prini, Hamta, Chhaleth, Sethan, Jagatsukh, Shuru and Bhanara. The inhabitants of these are dependent on the plant resources for medicine, wild edible/food, fuel, fodder, house building, making agricultural tools, religious and various other purposes.

2.4. Geology

Geologically, the rock formations of the area belong to the Unfollferous Palaeozoic Group of rock having thrusted contact with older rocks. The region is characterized by well defined three structural units, i.e., Central Crystalline, Kullu Formation, and Dibilana Granite. Each structural unit/formation has a thrusted contact with the other. In these catchments, the rock units exposed belong to Central

Crystallines. The general trend of the foliation of the rock in the rocks of the area varies from NNE-SWW to NW-SE. The area has undergone intense folding which is manifested by megascopic and mesoscopic folds observed in the rock. The folds are asymmetrical and are of plunge type drag folds, mostly seen in gneissic rocks.

Central Crystallines are the oldest formations in the area which consist of Garnetiferous Mica Schist, Kyanite Schist, Staurolite Schist, banded and streaky gneiss and migmatites. The gneiss and schist bands vary in thickness from a few centimeters to over 50meters. These bands grade into each other unperceptibly both along and across their foliation. Micaceous Quartizities, Quartz-Mica Schist, and Caretiferious Mica–Schist are exposed in the upper reaches of Allain Duhangan streams. The Gneisses and Schist show intense folding. Later granites, pegmatites and quartz veins intrude these.

Geology of the Barrage Sites

2.4.1. Allain Barrage Site

The proposed barrage site is at an elevation of about 2740m (amsl) and the valley base at the site is about 50m wide with steep banks. The entire river section is filled with 15 to 20m thick river fill material, while highly jointed and massive gneisses are well exposed on right abutment. The left abutment is covered by hill out-wash. The strike of foliation generally varies from 50ºN, 50ºW–S, 60ºE-N, 60ºS-E, and dip is of the order of 20º to 25º towards Southwest direction. At the barrage axis, the steep abutment slopes in massive gneisses are generally stable. The desilting basin is located on the left bank of Allian stream where space for locating the surface structure is available.

2.4.2. Duhangan Weir Site

The Duhangan weir site is proposed at about 5.5km upsteam of its confluence with river Beas. At this site the valley has very steep banks. Fluio-glacial deposits occupy almost the entire valley section, while porphyritic granitic gneiss with occasional schist bands is exposed on the banks. The strike of foliation here generally varies from 70ºN, 70º E-S, 85º W–N, 85º W–S, E and the dip towards Southwest direction. The weir axis has been selected mainly from topographic considerations and slide prone zones are encountered downstream of the chosen site. In terms of geology, gneisses are well exposed on steep abutments where rock slopes appear to be stable. In view of fresh and hard nature of rock the desilting chamber has been designed as an underground structure on the right bank of Duhangan stream.

2.4.3. Allain Head Race Tunnel

The Allain Head Race Tunnel portal is located on the left bank of Allain stream where bed rock is generally covered by overburden comprising of hill out wash barring exposures of gneisses and mica schist near RD 730 of tunnel alignment approximately at the cross drainage location. The tunnel alignment passes mainly through granitic gneisses and micaceous quartzites with occasional schist bands. The

strike of foliation of rock varies from 50º N, 50º W – S, 60º W to N, 60º W – S, E and dip is of the order of 5º to 25º towards Southwest direction.

2.4.4. Duhangan Head Race Tunnel

The Duhangan Head Race Tunnel passes through micaceous quartzite, granitic-gneiss and mica schist with occasional pegmaestite veins and shear seams. The strike of foliation of rock varies from 60º N, 60º E–S, to E-W with a dip of the order of 20º to 30º towards North direction.

2.4. 5. Surge shaft Site

The area around the proposed Surge shaft site is occupied by quaternary deposits in the form of glacial moraines, fluvio-glacial deposits and outwash materials. No rocky exposures are present close to this site and its vicinity. On the left bank of Allain stream, rocks are fresh and fairly hard but jointed in nature. The strike of foliation varies from 35ºN–S to N, 35 E–S and E with a dip towards East direction. The rock is at places intruded by quartz and pegmatite veins along foliation.

2.4.6. Tailrace Tunnel

The Tailrace Tunnel from the powerhouse crosses Allain stream below the stream bed and after short-cutting the bend in the course of stream, it comes out from the right bank of Allain stream. Bedrock comprising streaky hard and massive gneisses is well exposed on both the banks. The strike of foliation varies from N–S 20º to N, 20º, W–S and E and the dip is of the order of 10º to 15º towards East direction.

2.5. Land use

The land use pattern of the Hamta Jagatsukh catchments has been presented in ***Table 2.1.*** The maximum area is under alpine pastures (24.86%), followed by snow cover (24.20%), stoney rocky waste (22.29%) and forests (18.52%).

The forests have been classified into three categories, viz., dense forest, open forest, and degraded forests.The dense forest represents well-stocked forest area having good crown cover which ranges from 40% and above with no visible canopy cover gaps in between the trees as observed under the mirror stereoscope. Open forest is represented by sparse vegetation cover with average crown cover. The crown cover ranges between 10% - 40%. The degraded forests are poorly stocked and degraded due to natural or anthropogenic interference. The canopy cover ranges below 10% and some of the patches are devoid of any forest cover or undergrowth and may be considered as forest blanks.

Table 2.1. Land Use Pattern of the Hamta-Jagatsukh catchments

Sr. No.	Landuse system	Area(km^2)	% of Total Area
1.	Forest		
	• Dense Forest	20.92	10.78
	• Open Forest	8.46	4.36
	• Degraded Forest	6.97	3.59
	• Forest blank	0.95	0.49
2.	Agricultural area	5.96	3.07
3.	Scrub land	12.32	6.36
4.	Alpine pasture		
	• Dense pasture	43.19	22.27
	• Degraded pastures	5.00	2.58
5.	Stoney/Rocky Waste		
	• Stoney Waste	28.98	14.94
	• Barren land	11.58	5.97
	• Glacial area	2.21	1.14
	• Gullied	0.47	0.24
6.	Snow cover	46.99	24.20
	Total	**194.00**	**100.0**

(Source: Pre EIA report)

2.6. Climate

The climate of the area is cool and dry. In general, three seasons are prevailing in the area - winter season from November to February; summer season from April to June; and rainy season from July to September. However, spring (March) and autumn (October) seasons also prevail in the area for one month each. Snowfall generally occurs in December to February at high elevations. Sometimes, snowfall starts from October and ends in March. During winter, the temperature goes down to -6ºC. The temperature is at the maximum during the months of May and June. The area receives high rainfall compared to the lower Kullu valley. Highest rainfall (195mm) was in the month of January in 2004, and lowest (0.5mm) in the month of March. Maximum humidity is in the months of August and September. The available information on climate and meteorology is presented in ***Fig. 2.2 and Table 2.2.***

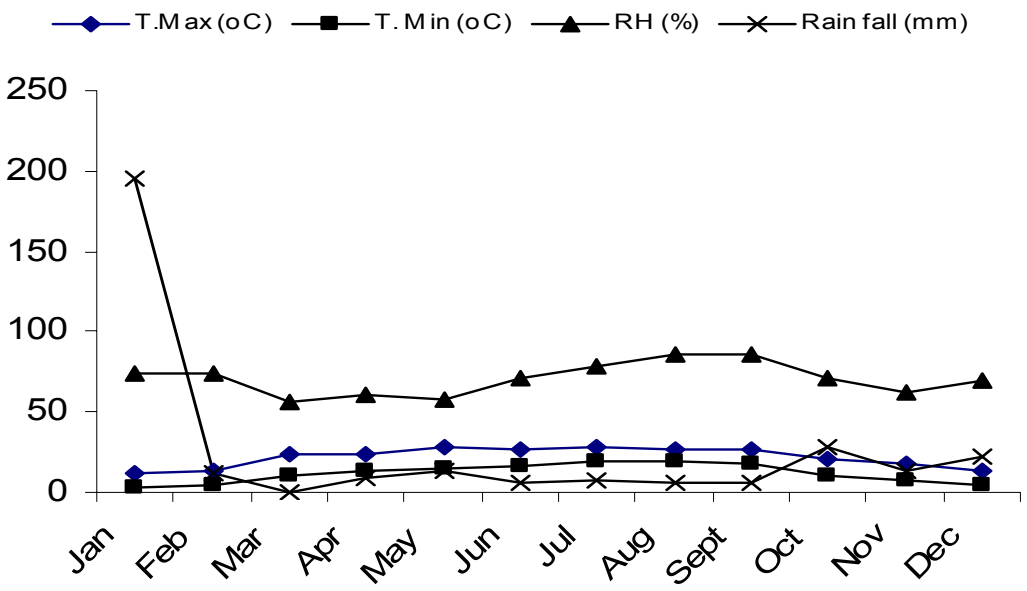


Fig.2. 2. Meteorological Information of Manali area for the year 2004, from IARI Reseach Station, Naggar

Table 2.2. Humidity and temperature monitored at different locations of the project site (Source: Pre EIA Report)

Location	Humidity%			Temperatureºc		
	Min	Max	Avg	Min	Max	Avg
Proposed plant/colony area (vill-Prini)	48.3	86.3	63.57	5.2	16.3	11.74
Proposed Camp office site (vill-Prini)	50.8	79.50	62.91	4.3	14.60	10.12
Proposed Colony site (vill-Jagatsukh)	49.80	71.30	61.22	8.30	13.90	11.94
Proposed Surge shaft site (vill-Hamta)	49.80	71.20	60.97	5.00	13.90	8.38
Proposed switchyard site (vill-Prini)	48.30	70.10	61.10	10.80	17.30	13.77

2.7 Salient features of the project (Fig 2.3)

The proposed hydel project has been contemplated as run-of-the-river scheme to utilize the combined discharge of Allain and Duhangan streams, which are tributaries of river Beas. The proposed project is expected to be completed by end of year 2008.

- The proposed project will consist of an underground power plant that would utilize flows from a combination of glacial snow melt and monsoon rains to supply a total storage capacity of 33ha m via tunnels from catchment basins of the Allain and Duhangan streams.
- The setting for the project is the steep terrain of the Himalaya with the diversion structures on the two streams and an intermediate storage reservoir with a

capacity of 0.195 million m^3 (requiring a barrage measuring approximately 14.5m x 261m).

- All these facilities will be located above elevation of 2700m feeding via a 1.69 km steel lined pressure shaft, an 853m-head 2 unit Pelton turbine Power House to be located in a rock cavern. The project will divert a portion of the flow of the Duhangan to the Allain and combine the flows of the two rivers to feed a single powerhouse with two units each of 96MW capacity each.
- A 220 kV power transmission line (of approximately 185km) will evacuate the power to the northern grid at Nalagarh in district Solan, Himachal Pradesh.

The project has received various approvals including environmental and forest clearances from the Ministry of Environment and Forests (MoEF).

2.8 Access to the Project Components

The access to the project components is by footpath as presently no connecting road is available:

- Allain barrage site.
- Duhangan weir site.
- Intermediate storage reservoir
- Surge Shaft, Pressure shaft and associated works.
- Powerhouse complex and its associated works including tail race tunnel/ channel and switchyard.
- Associated infrastructure (for temporary and permanent residential and non-residential buildings, stores, sheds, water supply, electrification sanitation, cross-drainage works, fencing etc. required during construction and operational phases).

Road

The project area lies on the eastern side of the Beas river in the Kullu valley near Manali, and is approachable by National Highway NH-21 on Chandigarh-Manali Road (via Chandigarh-Ropar-Kiratpur-Bilaspur-Mandi-Kullu-Patlikuhal-Manali-Prini village). Access to the project site at Prini village can be made either from Manali town on Manali-Nagar Road or from Patlikuhal on Nagar-Manali Road. The distances of Manali from Chandigarh are 320 km and from Shimla it is 280 km while Pathankot is 330 km away (Fig 2. 4.).

2.9 Ecological setting

The Allian-Duhangan hydroelectric project (ADHEP) lies in the district of Kullu of Himachal Pradesh. The project area lies between the latitudes 32º 21'N and longitudes 77º11'E and 77º 22'E. The project area falls in Biotic Province 2A (Northwest Himalaya) of biogeographic zone of Himalaya (*Rodgers and Panwar, 1988*). The area exhibits dense and open forests and low forests cover at some places coupled with infrastructural development. Kullu district accounts for a geographical area of 5,503 km^2, out of this

1,631 km^2 and 343 km^2 are dense and open forest cover respectively. Hence, Kullu district has 35.87% forest cover. This is one of the wildlife rich areas in Himachal Pradesh (***Table2.3***.).

Table 2.3. Forest area of Kullu District, Himachal Pradesh.

Area -Kullu district	**Area (km^2)**
Geographical Area	5,503
Legally classified forest area	5,065
Dense forests	1,631
Open forests	343
Total forest area	1,974
% age of geographical area	35.87

Source: (WII – HPFD Project, 2005)

Fig. 2.1 Location of the project area

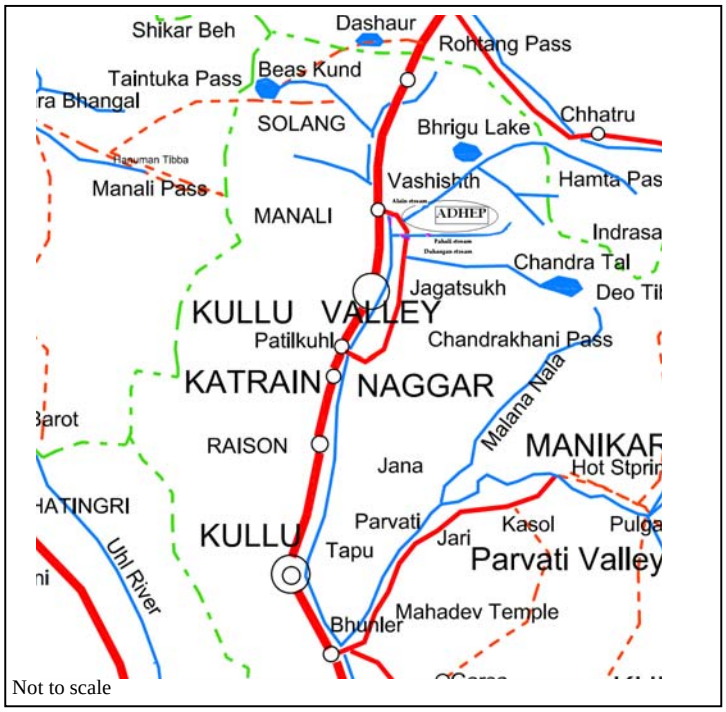


Fig. 2.3 Project components

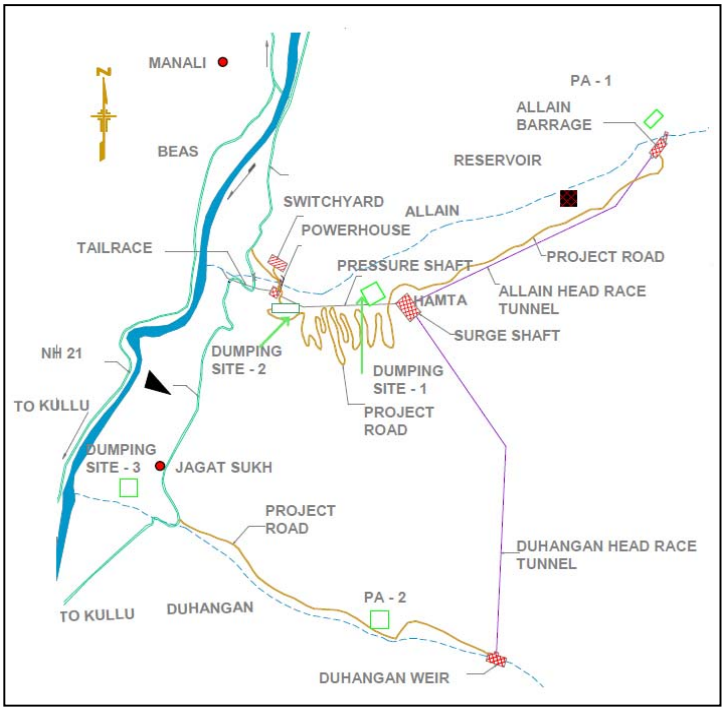
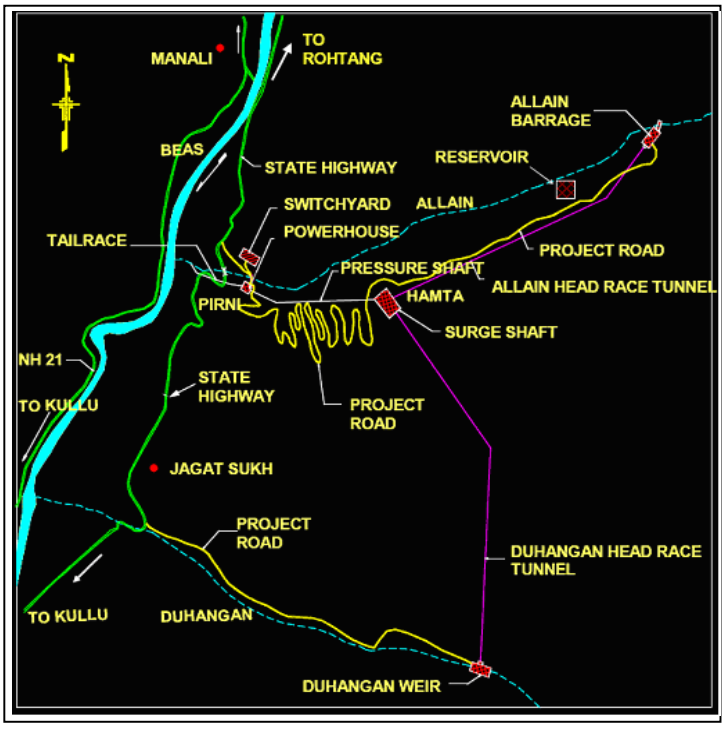


Fig. 2.4 Road Network



A perusal of available literature on the area shows that the following large mammal species are present in the area - Goral, Barking deer, Serow, Musk deer, Himalayan Thar, Leopard, Black bear, Brown bear and at higher altitude (over 4,300m) Bharal and Himalayan Ibex. Some smaller mammals are Porcupine, Yellow throated Marten, Red Fox and Himalayan Weasel.

Among birds, Himalayan Monal, Koklass and Kalij Pheasants are present with over 100 other bird species. Around five species of Pheasants are present (ADHEP, 2003).

The entire area is inhabited by several villages, having agricultural and pasture lands. Paheli, Jabri, Allain, Duhangan, Chor pani and Kala pani are major streams which bisect the project area and ultimately empty into the Beas river.

3. Fauna

3.1 Methods

The study area was divided into three main altitude zones - 2200-2800m, 2800 - 3400m and >3400m. This zonation also corresponds, approximately, to the vegetation types (temperate, sub-alpine and alpine) found in the study area. The lower altitude zone also corresponds to the altitude range of the project site. This altitude range was covered in three surveys – one in October 2005, covering altitude ranges of 2200m-2800m and 2800m–3400m, in February covering only the 2200-2800m altitude and summer covering all the three altitude zones. By conducting three surveys, seasonal changes could also be monitored.

Within these altitude zones, following broad forest types were identified and sampling was stratified according to these broad forest/vegetation types:-

a) **Conifer forests:** These are pure stands of conifer having close canopy and mature trees. Undergrowth was found to the generally low in all forests in Allain area. However, some patches in Duhangan area have good undercover. This is the most dominant type of vegetation in the area.
b) **Degraded Areas**: These were forest areas have conifers but now under sparse tree cover and with no under storey. The area above Prini village upto Hamta village is a good example.
c) **Mixed forests:** These are mixed broadleaf and conifer forests. The broad leaf species are mainly *Juglans*, *Acer*, *Lyonia and Aesculus* forming small pure or mixed stands within conifer.
d) **Open areas**: These are open grasslands and scrub areas forming the sub-alpine and alpine meadows.
e) **Orchards:** Close to villages and pre-dominantly with apple trees. In certain areas, especially in moist drains running through the orchards undergrowth is heavy.
f) **Alpine areas:** Above the tree line, this area is predominantly grassland with some shrub species

Within each altitude zone, point counts were conducted with the five broad habitat types for measuring bird abundance and diversity (Bibby *et al.* 1992). Each count was of seven minutes duration and successive counts were conducted on a trail after every 10 minutes of walking. Three hundred and five point counts were conducted in all during this survey and were located on trails passing through all the broad habitat categories identified. Point counts were generally conducted on fair weather days between 8am -12 noon and from 4 pm to 6.30 pm (light permitting). Fig 3.1 provides the dispersion of sampling effort during point counts.

Bird richness (Margalef's index) and diversity indices (Shanon/ Brillouin index) were calculated using 'Biodiversity Pro' software package. In addition to indices of diversity, a general species list for birds in the area was produced.

Mammal abundance was estimated by generating encounter rates on trails and paths. Encounter rate for each mammal species sighted was produced by dividing the number of individuals sighted by the number of man-hours spent in the field.

3.2 Results

Birds and Mammals: (Autumn season)

Avifauna: ***Altitudinal variation***

Diversity indices were calculated for bird diversity in different altitude zones. The Bruillion diversity index for birds in altitude category I (2200-2800m) was 1.122, much higher than 0.881 for the altitude category II (2800-3400m). The richness index (Margalef's index) also was higher in low altitudes than for mid altitude (5.423 and 3.047 respectively). The indices suggest that the number of species was higher at lower altitudes. Their dispersion also was more even than in the higher areas. This is expected since many breeding birds found in the Western Himalaya migrate to the foothills during winter and, therefore, lower altitudes were more populated than higher ones

Diversity indices were calculated to see the diversity and richness patterns of birds in the five broad habitat categories. These are given in ***Table 3.1***.

Table 3. 1. Showing indices of avian diversity in various vegetation types surveyed in Allain-Duhangan Catchment area in Himachal Pradesh.

Vegetation Types/Index	Brillouin Diversity index	Margalef richness index
Conifer	0.921	3.909
Degraded	1.001	3.816
Mixed	0.793	3.152
Open	0.817	2.864
Orchard	0.732	3.147

From the table, it is clear that avian diversity was similar in most vegetation types.

Although conifer forests were more species rich, the diversity was highest in degraded forests. Open areas had the lowest richness and this was probably due to low cover availability and also because some of the points fell in the high altitude grasslands, which had little bird life in winter.

Similarity indices (Sorensen's quantitative index) were generated to see how similar or dissimilar avifauna was in the vegetation types surveyed. From these analyses it is clear that avifuana (in terms of similarity of species) of orchards was quite different from those of conifer forests, whereas the rest were quite similar in their content.

A comparison was done of bird diversity indices in areas expected to be directly affected by project activities and those which lie away from project activities. The comparisons are given below in ***Table 3.2.***

Table 3.2: Avian diversity indices between point counts at project site and project catchment in Allain Duhangan HEP, Himachal Pradesh.

Indices	**Allain**		**Duhangan**	
	Project Area	**Catchment**	**Project Area**	**Catchment**
Margalef's	3.892	3.672	4.202	4.262
Shanon	1.017	1.006	1.104	1.139
Brillouin	0.872	0.884	0.978	1.038

There does not seem to be much difference in the diversity values of birds between the project activity area and those away from the activity areas (catchments) during the autumn season.

In both the streams (Allain and Duhangan), similarity indices of project areas vs catchment areas were high suggesting that in terms of bird life (species and individual numbers), there was little difference between the two areas in both the streams.

Mammals

Four species of mammals were sighted in Allain nalla. Pika was sighted in a bouler-strewn area within a grassy glade. A solitary Langur was sighted at 2800 m within a mixed forest. A pair of Yellow-throated Marten was seen in a fir forest at 2900 m and lower down, a Jackal was seen within a conifer forest close to village Hamta. Scat of leopard was seen above the Hamta village.

Table 3. 3. Encounter rates (groups/100 man hrs) for mammals in Allain area

Species	**Conifer**	**Degraded**	**Mixed**	**Open**	**Orchard**	**Overall**
Pika	-	-	-	7.4		1.28
Langur	-	-	5.31 (1)	-	-	1.28
Yellow-Throated Marten	5.15	-	-	-	-	1.28

Jackal	5.15		-	-	-	1.28
Total E/R	**10.30**	**-**	**5.31**	**7.4**	**-**	**5.12**

In the Duhangan area, four groups of Langur were seen, one in a conifer area (1 individual), one in mixed forest (50 +) and two in open areas (40+ and 5). A solitary Goral (*Nemorhaedus goral*) was seen on a cliffy hillside, while one group of Yellow-throated Marten (3 individuals) was seen in an open area.

Table 3. 4. Encounter rates (groups/100 man hrs) for mammals in Duhangan area

Species	**Conifer**	**Degraded**	**Mixed**	**Open**	**Orchard**	**Overall**
Langur	10.98(1)	-	7.49 (50)	9.31 (22.5)	-	5.88
Yellow-throated Marten	-	-	-	4.65 (3)	-	1.47 (3)
Goral	-	-	-	4.65 0	-	1.47
Total E/R	**10.98**	**-**	**7.49**	**18.61**	**-**	**8.82**

Encounter rates were produced for all mammalian sightings and converted into individuals seen for every 100-man hours. The highest encounter rate was for Langur in both the sites (Tables 3 & 4). In terms of the altitude the highest encounter rate was also in Langur (Table 5), while the lowest encounter rate was obtained for Pika. The encounter rate was higher in the high altitude zone compared to the lower one.

Table3.5. Encounter rates for various mammal species according to altitude zones

Species	**2200 m - 2800 m**			**2800 m - 3400 m**		
	Allain	**Duhangan**	**Overall**	**Allain**	**Duhangan**	**Overall**
Pika	1.78	-	0.99	-	-	-
Langur	-	6.66	2.97	3.44	9.09	5.00
Yellow throated marten						
Jackal	1.78	-	0.99	-	-	-
Goral	-	-	-	-	9.09	2.5
Total			**3.96**			**12.5**

Impressions

Both Allain and Duhangan areas have forests with many trees measuring over seven meter girth at breast height (gbh). Therefore, the forests are mature. While forests on the side of the Allain stream appear to be dry, on the Duhangan side they appear to be moister. Undergrowth was mainly in the form of fern species, which had dried out during the time of survey, thus providing no understorey to the forests in Allain stream. The forests on the Allain side appeared also to be over-grazed, as evident from the abundance of dung piles from domestic livestock in this area. There were comparatively less signs of grazing on the Duhangan side.

A higher encounter with Pheasant species also suggests better habitat in Duhangan valley. The overall diversity indices, however, suggest little difference in the avifauna of the two areas. The high similarity indices between Allain and Duhangan valleys also indicate a close similarity between the species content of the two areas. However, this may change as more breeding species appear in spring and summer.

The habitats at lower altitudes seemed to be disturbed, which is probably the reason for low mammalian encounter rates. Although we could not spend much time at high altitudes owing to presence of snow, yet encounters of various species were much higherhere. It is expected that in spring /summer more species like Himalayan Black Bear, Musk deer. Himalayan Thar will be encountered as these species have been reported from this area earlier.

These surveys were conducted in early winter and thus only a part of the avifauna was present in the study site. In spring/summer the diversity/richness of bird and mammalian communities is to change as full complement of species will be available.

Appendix 1 List of birds observed in Allain Duhangan catchments in November 2004

S.No	Species	Scientific Name	Allain	Duhangan
1	Leaf warbler	*Phylloscopus sp.*	+	+
2	Bush warbler	*Cettia sp.*	+	
3	Himalayan griffon	*Gypus himalayensis*	+	+
4	Lammergeier	*Gypaetus barbatus*	+	+
5	Himalayan monal	*Lophophorus impejanus*	+	+
6	Kalij	*Lophura leucomelanos*	+	+
7	Koklass	*Pucrasia macrolopha*		+
8	Snow pigeon	*Columba leuconota*	+	+
9	Speckled wood pigeon	*Columba hodgsonii*	+	
10	Brown wood Owl	*Strix ocellata*	+	
11	Great barbet	*Megalaima virens*	+	+
12	Scaly-bellied woodpecker	*Picus squamatus*	+	+
13	Himalayan woodpecker	*Dendrocopos himalayensis*	+	+
14	Brown fronted woodpecker	*Dendrocopos auriceps*	+	
15	Black headed Jay	*Garrulus lanceolatus*	+	
16	Yellow-billed blue Magpie	*Cissa flavirostris*	+	+

17	Nutcracker	*Nucifraga caryocatactes*	+	+
18	Yellowbilled Chough	*Pyrrhocorax graculus*	+	
19	Large-billed crow	*Corvus macrorhynchos*	+	+
20	White-cheeked bulbul	*Pycnonotus leucogenys*	+	+
21	Black bulbul	*Hypsipetes leucocephalus*	+	+
22	White throated Laughing Thrush	*Garrulax albogularis*	+	
23	Variegated L Thrush	*Garrulax variegatus*	+	+
24	Streaked Laughing Thrush	*Graminicola lineatus*	+	+
25	Goldcrest	*Regulus regulus*	+	+
26	Redstart sp.	*Phoenicurus sp.*	+	
27	Whitecapped redstart	*Chaimarrornis leucocephalus*	+	+
28	Blue whistling Thrush	*Montocola caeruleus*	+	+
29	Eurasian Blackbird	*Turdus merula*	+	+
30	Wren	*Troglodytes troglodytes*	+	
31	Brown Dipper	*Cinclus pallasii*	+	
32	Grey tit	*Parus major*	+	+
33	Greenbacked tit	*Parus monticolus*	+	+
34	Spot winged tit	*Parus melanolophus*	+	+
35	Rufous vented tit	*Parus rubidiventris*	+	+
36	Black throated tit	*Aegithalos concinnus*		+
37	White throated tit	*Aegithalos niveogularis*		+
38	White cheeked Nuthatch	*Sitta europaea*	+	+
39	Himalayan tree creeper	*Certhia himalayana*	+	+
40	White wagtail	*Motacilla alba*	+	
41	Eurasian Tree sparrow	*Passer montanus*	+	+
42	Russet sparrow	*Passer rutilans*	+	
43	Black and Yellow grosbeak	*Mycerobas icteriodides*	+	+
44	Spectacled finch	*Callacanthis burtoni*	+	+
45	Rock bunting	*Emberiza cia*	+	+

Appendix 2 List of mammals observed during the survey of Allain Duhangan Catchments in Kullu district in November 2004.

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Number
Allain						
5/11/04	Leopard	*Panthera pardus*	2700	32.13.77 N & 77.13.13 E	Conifer	Scat
6/11/04	Langur	*Semnopithecus entellus*	2825	32.15.54 N & 77.14.57 E	Mixed forest	1
7/11/04	Yellow throatedMarten	*Martes flavigulla*	2930	32.14.51 N &77.13.88 E	Fir forest	2
7/11/04	Pika	*Ochotona royeli*	2720	32.14.43 N & 77.13.39 E	Open glade with boulders	1
9/11/04	Jackal		2400	32.13.31 N & 77.12.47 E	conifer with bamboo undergrowth close to Orchard	1
Duhangan						
11/11/04	Langur	*Semnopithecus entellus*	2399	32.11.88 N & 77.13.82 E	Open scrubby Nalla	1
11/11/04	Langur	*Semnopithecus entellus*	2500	32.11.85 N & 77.13.79 E	Conifer	5
12/11/04	Goral	*Nemorhaedus goral*	2870	32.12.03 N & 77.15.21 E	Open cliffs	1
12/11/04	Leopard	*Panthera pardus*	2936	32.12.04 N & 77.15.41E	Open glade	Scat
12/11/04	Yellow throatedMarten	*Martes flavigulla*	3127	32.12.01 N & 77.16.02 E	Open Glade	3
12/11/04	Langur	*Semnopithecus entellus*	2979	32.12.01 N & 77.15.59 E	Mixed forest/open	50
14/11/04	Langur	*Semnopithecus entellus*	2595	32.11.55 N & 77.13.94 E	Open glade	40

Winter season

The winter survey of the Allain-Duhangan catchments was conducted periodically between 17 January 2005 and 27 March 2005. Owing to heavy snowfall in the region, the winter surveys were restricted to a few areas but these were representative of the lower altitudes of the whole area under study. The aim of the survey was to obtain information about the winter use by animals of the areas falling within the project site.

It was assumed that certain animal species may be utilizing lower altitudes in winter during times of heavy snowfall and thus increasing the importance of the otherwise less frequently used and probably less important lower altitudes. Therefore, it was felt necessary to document the winter use by major animal species of the altitude belt between 2200-2800 meters. Thirty two point counts were conducted for birds during this survey. A total of 65.5 party hours were spent in the field.

Avifauna

A total of 30 species of birds were recorded during the winter survey. Of these, 13 species are biome restricted and thus of some conservation importance. The over all richness index (Margalef) was 3.76, where as the diversity index (Brillouin) was 0.936. A fuller list is provided in Appendix 3.

Mammals

Eight species of mammals were recorded from the areas surveyed ***(Appendix 2).*** However, only two species were actually sighted - Rhesus (3.05 groups/100 hrs; mean group size 4.5 individuals) and Langur (4.58 groups/100 hrs; mean group size 6.6 individuals). Other animals recorded included Goral, Porcupine, Pika, Marten, Jackal and Black bear.

An analysis of animal use of the area was also done by looking for animal dung within a 10 m x 10 m plot. Forty eight percent plots contained only dung from domestic animals while 37% plots contained dung of wild mammal species. Only 10% plots contained dung of both, domestic and wild animals.

Impressions

The low avifaunal richness and diversity can be attributed to the prevalence of winter. Although the number of species present in the low altitude zone was not very different from that found in November, their abundance was lower suggesting that most individuals had moved to lower altitudes. This also caused a decline in the density indices as suggested by the data.

The mammal encounters were low and confined to only two species of primates – the Himalayan Langur and the Rhesus Macaque. Although tracks of Black bear (*Ursus thibetanus*) and Goral (in snow) were found, there was only one set suggesting low

abundance. It was not possible to access altitudes above 2600 m due to heavy snow cover.

Most of the lower altitude seems to be heavily used by domestic cattle as was evident from the proportion of plots found with dung from domestic cattle. The plots with dung from wildlife species appeared to be free from domestic animal use, implying that the wild animals frequented areas were relatively free of domestic cattle (in other words human disturbance).

Appendix 3 List of Birds found during Winter Survey

Family	**Name**	**Scientific Name**
Phasianidae		
	Kalij	*Lophura leucomelanos*
Picidae		
	Scalybellied Woodpecker	*Picus squamatus*
	Himalayan woodpecker	*Dendrocopus himalayensis*
Strigidae		
	Jungle Owlet	*Glaucidium radiatum*
Columbidae		
	Snow Pigeon	*Columbia leuconota*
Acciptridae		
	Himalayan Griffon Vulture	*Gyps himalayensis*
	Lammergeier	*Gypaetus barbatus*
Corvidae		
	Blackheaded Jay	*Garrulus glandarius*
	Goldenbilled Magpie	*Urocissa flavirostris*
	Nutcracker	*Nucigfraga caryocatactes*
	Chough	*Pyrrhocorax pyrrhocorax*
	Large billed crow	*Corvus macrorhynchos*
Cinclidae		
	Brown Dipper	*Cinclus pallasii*
Muscicapidae		
	White capped water redstart	*Chaimarrornis leucocephalus*
	Blue Whistling Thrush	*Monticola caeruleus*
	Collared Blackbird	*Turdus albocinctus*
Sturnidae		
	Myna	*Sturnus vulgaris*
Sittidae		
	White-cheeked Nuthatch	*Sitta leucopsis*
Certhidae		
	Winter Wren	*Troglodytes troglodytes*
	Bartailed tree creeper	*Certhia himalayana*

Paridae		
	Great Tit	*Parus major*
	Green backed tit	*Parus monticolus*
	Rufous vented tit	*Parus rubidiventris*
Aegithalidae		
	Blackthroated Tit	*Aegithalos concinnus*
Pycnonotidae		
	Himalayan Bulbul	*Pycnonotus leucogenys*
Sylviidae		
	Variegated Laughing Thrush	*Garrulax variegatus*
	Streaked Laughing Thrush	*Garrluax lineatus*
	Golden specktacled Warbler	*Seicercus burkii*
Passeridae		
	Eurasian Tree sparrow	*Passer montanus*
Fringillidae		
	Rock bunting	*Emberzia cia*

Appendix 4 List of Mammals recorded in winter survey.

S No	Name	Altitude	Habitat
1	Rhesus	2140	Coniferous
2	Black bear	2385	Open scrub
3	Goral	2575	Coniferous
4	Langur	2502	Open scrub
5	Langur	2434	Open scrub
6	Jackal	1966	Coniferous
7	Langur	1980	Coniferous
8	Pika	2076	Coniferous
9	Marten	2107	Coniferous
10	Marten	2196	Coniferous
11	Procupine	2104	Orchard
12	Rhesus	2104	Orchard
13	Rhesus	2037	Orchard
14	Jackal	2037	Orchard
15	Procupine	2037	Orchard

Summer Season

Avifauna:

Diversity indices were calculated for bird diversity in different altitude zones. The Shannon diversity index for birds in altitude category I (2200-2800) was 0.975, as compared to 0.966 for the altitude category II (2800-3400 m). The Margaleff's richness

index was also almost similar for bird richness at the lower and higher altitude categories (19.348 and 19.799 respectively). These indices suggest that at both the altitudinal categories, the number and dispersion of species was almost similar.

Indices were calculated to see the patterns of bird diversity and richness within the broad habitat categories (Tables 3.6 and 3.7) in Allain and Duhangan areas.

Table 3.6. Indices of avian diversity and richness in various vegetation types surveyed in Allain area in Himachal Pradesh.

Vegetation Types/Indices	Shannon's Diversity Index	Margaleff's Richness Index
Alpine	0.596	22.514
Conifer	0.829	16.892
Degraded	0.741	20.485
Mixed	0.928	19.028
Open	0.586	24.16
Orchard	0.558	20.283

Table 3.7. Indices of avian diversity and richness in various vegetation types surveyed in Duhangan area in Himachal Pradesh.

Vegetation Types/Indices	Shannon's Diversity Index	Margaleff's Richness Index
Alpine	0.794	14.981
Conifer	0.951	17.717
Degraded	0.535	29.665
Mixed	0.989	24.029
Open	0.743	29.665

These tables show differences in the avian diversity and richness in different vegetation types. In the Allain area, maximum avian diversity was encountered in the mixed forest areas followed by areas with conifer and degraded forests. The species richness was maximum in the alpine areas, followed by areas with degraded forests and orchards. Lowest avian diversity and richness were observed in orchard and conifer areas respectively.

In the Duhangan area, although the degraded and open areas were more species rich, the diversity was higher in the mixed and conifer forests. In this area, lowest avian diversity and richness were observed in the degraded and alpine areas, respectively.

Similarity indices (Sorensen's quantitative index) were generated to see how similar or dissimilar avifauna was in the vegetation types surveyed. From these analyses, it was clear that avifuana (in terms of similar species) of alpine areas was

different whereas the rest were quite similar in their content.

A comparison of bird diversity and richness indices in areas expected to be directly affected by project activities and those which lie away from project activities was also carried out (Table 3.8).

Table 3.8. Avian diversity and richness indices between point counts at project catchment and project sites in Allain – Duhangan HEP, Himachal Pradesh.

Diversity Indices	Duhangan		Allain	
	Catchment	Project Impact Area	Catchment	Project Impact Area
Shannon's Diversity Index	1.196	0.822	1.045	0.747
Margaleff's Richness Index	21.792	35.336	20.381	26.666

There were differences in avian diversity indices between catchment and project areas. The ones of catchment area turned out to be higher where as species richness was more in the project impact areas.

Mammals

Seven species of mammals were sighted in Allain area. These were Pika (*Ochotona royeli*), Leopard (*Panthera pardus)*, Brown Bear (*Ursus arctos*), Long-tailed Mormot (*Marmota caudata*), Red Fox (*Vulpes vulpes*), Kashmir Flying Squirrel (*Hylopetes fimbriatus*) and Macaca (*Macaca mulatta*). The details of mammalian encounters are given in Appendix III.

In the Duhangan area, six species of mammals recorded were Pika, Leopard, Brown Bear, Black Bear (*Ursus thibetanus*), Himalayan Weasel (*Mustela sibirica*) and Langur (*Semnopithecus entellus*).

Encounter rates were generated for all mammalian sightings. Encounter rates for mammals were higher in Duhangan area (Table 3.10) as compared to Allain area (table 3.9). The highest encounter rate was for Pika in both the sites, which was followed by Langur. In terms of altitude, highest encounter rate was for Langur (Table 3.11). The encounters were high at higher altitude as compared to lower altitude.

Table 3.9. Encounter rates (individuals/man hour) for mammals in Allain area.

Species	Conifer	Degraded	Mixed	Open	Orchard	Overall
Pika	-	-	-	0.54	-	0.54
Leopard	-	-	-	0.02	-	0.02
Brown Bear	0.06	-	0.04	0.04	-	0.13
Long-tailed Marmot	-	-	-	0.02	-	0.02
Red Fox	0.04	-	0.04	-	-	0.08

Kashmir Flying Squirrel	0.10	-	-	-	-	0.10
Macaca	0.08	-	-	-	-	0.08
Total E/R	**0.27**	**-**	**0.08**	**0.62**	**-**	**0.96**

Table 3.10. Encounter rates (individuals/man hour) for mammals in Duhangan area.

Species	Conifer	Degraded	Mixed	Open	Orchard	Overall
Pika	0.29	-	-	0.03	-	0.32
Leopard	0.03	-	-	-	-	0.03
Brown Bear	0.03	-	-	0.03	-	0.06
Black Bear	0.03	-	0.06	-	-	0.09
Himalayan Weasel	-	-	-	0.03	-	0.03
Langur	0.50	-	-	0.50	-	1.00
Total E/R	**0.88**	**-**	**0.06**	**0.59**	**-**	**1.44**

Table 3.11. Encounter rates for various mammal species according to altitude zones.

	2200-2800 m			2800-3400 m		
Species	**Allain**	**Duhangan**	**Overall**	**Allain**	**Duhangan**	**Overall**
Pika	0.17	-	0.10	0.37	0.32	0.35
Leopard	-	0.03	0.01	0.02	-	0.01
Brown Bear	-	0.03	0.01	0.13	0.03	0.09
Black Bear	-	0.09	0.03	-	-	-
Long-tailed Marmot	-	-	-	0.02	-	0.01
Himalayan Weasel	-	-	-	0	0.03	0.01
Red Fox	0.04	-	0.02	0.04	-	0.02
Kashmir Flying Squirrel	0.10	-	0.06	-	-	-
Langur	-	0.18	0.07	-	0.82	0.33
Macaca	-	-	-	0.08	-	0.05
Total E/R	**0.31**	**0.32**	**0.31**	**0.65**	**1.21**	**0.87**

Impressions:

There was a significant increase in the number of bird species and this was due to the breeders moving up from the plains. The increase in Margalef's index in summer compared to other seasons for all habitats suggests that there was an overall increase in species numbers. The dispersion of species also was more during summer, again suggesting that the number of individuals of each species had showed an increase. Twenty three species found in the catchment area were biome-restricted and therefore of some conservation concern although none of the bird species seen are in the threatened list of the IUCN. However, some pheasants like HImalayan Monal and Koklas and Kalij are listed in schedule I of the Wildlife Protection Act (1972), making them

important species for conservation. Maximum avian diversity was found in the mixed forests followed by conifer forests. Therefore, some loss of bird habitat may occur if any forest of the types preferred by birds is lost.

Bird diversity was more in the general catchment area than in the project impact area. This was perhaps because of better habitat and so also the dispersion of birds. However, an inverse result for Margalef's index suggests that because of patchy habitats in project impact areas, the number of species was probably higher but their individual numbers were low.

The catchment and project impact area continued to be a low mammal encounter area. Surveys on earlier occasions (Garson and Gaston 1992) had recorded presence of Himalayan Thar in high altitude areas of the catchment but none was reported during the present survey. Absence of many large mammals could also suggest local hunting pressures and signs of this were encountered during the survey. Most mammal sightings occurred above 2700 m except during winter when species like Goral were seen much lower down. The project impact area mainly had Jackal, Pika and Langur whereas, in winter Goral also were seen.

Appendix – 5

List of birds observed during the survey of Allain-Duhangan catchments in Kullu District in May – June 2005.

S.N.	English name	Generic name	Specific name	Allain	Duhangan
1	Ashy Drongo	*Dicrurus*	*leucophaeus*	+	+
2	Asian House Martin	*Delichon*	*dasypus*	+	+
3	Bar-tailed Treecreeper	*Certhia*	*himalayana*	+	
4	Bar-winged Flycatcher-shrike	*Hemipus*	*picatus*	+	+
5	Black and Yellow Grosbeak	*Mycerobas*	*icterioides*	+	
6	Black Bulbul	*Hypsipetes*	*leucocephalus*	+	+
7	Black Drongo	*Dicrurus*	*macrocercus*	+	
8	Black-throated Tit	*Aegithalos*	*concinnus*	+	
9	Blue-whistling Thrush	*Myiophonus*	*caeruleus*	+	+
10	Blue-capped Redstart	*Phoenicurus*	*caeruleocephala*	+	
11	Blue-capped Rock Thrush	*Monticola*	*cinclorhynchus*	+	
12	Blue-fronted Redstart	*Phoenicurus*	*frontalis*	+	+
13	Blue-fronted Robin	*Cinclidium*	*frontale*	+	
14	Blyth's Leaf Warbler	*Phylloscopus*	*reguloides*	+	
15	Brown Dipper	*Cinclus*	*pallasii*	+	+
16	Brown wood Owl	*Strix*	*leptogrammica*	+	
17	Bush Warbler	*Cettia*	*sp.*	+	+
18	Chestnut-crowned Laughing Thrush	*Garrulax*	*erythrocephalus*	+	+

19	Chestnut-tailed Minla	*Minla*	*strigula*	+	
20	Common Iora	*Aegithina*	*tiphia*		+
21	Common Kestrel	*Falco*	*tinnunculus*	+	+
22	Common Rosefinch	*Carpodacus*	*erythrinus*	+	
23	Dark-breasted Rose Finch	*Carpodacus*	*nipalensis*	+	+
24	Dark-sided Flycatcher	*Muscicapa*	*sibirica*	+	
25	Eurasian Blackbird	*Turdus*	*merula*	+	+
26	Eurasian Cuckoo	*Cuculus*	*canorus*	+	
27	Eurasian Hobby	*Falco*	*subbuteo*	+	
28	Fire-capped Tit	*Cephalopyrus*	*flammiceps*	+	
29	Fulvous-breasted Woodpecker	*Dendrocopos*	*macei*		+
30	Goldcrest	*Regulus*	*regulus*	+	+
31	Gold-naped Finch	*Pyrrhoplectus*	*epauletta*		+
32	Great Barbet	*Megalaima*	*virens*	+	+
33	Green-backed Tit	*Parus*	*monticolus*	+	+
34	Grey Bush Chat	*Saxicola*	*ferrea*	+	+
35	Grey Tit	*Parus*	*afer*	+	
36	Grey Wagtail	*Motacilla*	*cinerea*	+	+
37	Grey-headed Canary-flycatcher	*Culicicapa*	*ceylonensis*	+	+
38	Himalayan Bulbul	*Pycnonotus*	*leucogenys*	+	
39	Himalayan Griffon	*Gyps*	*himalayensis*	+	+
40	Himalayan Monal	*Lophophorus*	*impejanus*	+	+
41	Himalayan Woodpecker	*Dendrocopos*	*himalayensis*	+	+
42	Hoopoe	*Upupa*	*epops*	+	
43	Indian Blue Robin	*Luscinia*	*brunnea*	+	
44	Koklass Pheasant	*Pucrasia*	*macrolopha*	+	+
45	Lammergeier	*Gypaetus*	*barbatus*	+	
46	Large-billed Crow	*Corvus*	*macrorhynchos*	+	+
47	Leaf Warbler	*Phylloscopus*	*sp.*	+	+
48	Little Forktail	*Enicurus*	*scouleri*	+	+
49	Long-legged Buzzard	*Buteo*	*rufinus*	+	+
50	Long-tailed Minivet	*Pericrocotus*	*ethologus*	+	+
51	Orange Bullfinch	*Pyrrhula*	*aurantiaca*		+
52	Orange-flanked Bush Robin	*Tarsiger*	*cyanurus*	+	+
53	Oriental Turtle-Dove	*Streptopelia*	*orientalis*	+	+
54	Pink-browed Rose Finch	*Carpodacus*	*rodochroa*	+	
55	Plumbeous Water-Redstart	*Rhyacornis*	*fuliginosus*	+	+
56	Red-billed Chough	*Pyrrhocorax*	*pyrrhocorax*	+	+
57	Rock Bunting	*Emberiza*	*cia*	+	+
58	Rosy Pipit	*Anthus*	*roseatus*	+	+
59	Rufous-bellied Niltava	*Niltava*	*sundara*		+
60	Rufous-breasted Bush-Robin	*Tarsiger*	*hyperythrus*		+

61	Rufous-naped tit	*Parus*	*rufonuchalis*	+	
62	Russet sparrow	*Passer*	*rutilans*	+	
63	Scaly-bellied woodpecker	*Picus*	*squamatus*	+	+
64	Short-billed Minivet	*Pericrocotus*	*brevirostris*	+	
65	Slaty-blue Flycatcher	*Ficedula*	*tricolor*	+	+
66	Snow Pigeon	*Columba*	*leuconota*	+	+
67	Spotted Nutcracker	*Nucifraga*	*caryocatactes*	+	
68	Spot-winged Tit	*Parus*	*melanolophus*	+	+
69	Streaked Laughing Thrush	*Garrulax*	*lineatus*	+	
70	Tickell's Leaf Warbler	*Phylloscopus*	*affinis*	+	
71	Ultramarine Flycatcher	*Ficedula*	*superciliaris*	+	+
72	Upland Pipit	*Anthus*	*sylvanus*	+	
73	Variegated Laughing Thrush	*Garrulax*	*variegatus*	+	+
74	Verditer Flycatcher	*Eumyias*	*thalassina*	+	
75	Whiskered Yuhina	*Yuhina*	*flavicollis*	+	+
76	White cheeked Nuthatch	*Sitta*	*leucopsis*	+	
77	White-capped Water-Redstart	*Chaimarrornis*	*leucocephalus*	+	+
78	White-eared Bulbul	*Pycnonotus*	*leucotis*	+	
79	White-collared Blackbird	*Turdus*	*albocinctus*		+
80	Oriental White-eye	*Zosterops*	*palpebrosus*		+
81	White-tailed Robin	*Cinclidium*	*leucurum*	+	
82	Winter Wren	*Troglodytes*	*troglodytes*	+	+
83	Yellow bellied Fantail-flycatcher	*Rhipidura*	*hypoxantha*	+	+
84	Yellow-billed Blue Magpie	*Urocissa*	*flavirostris*	+	
85	Yellow-breasted Greenfinch	*Carduelis*	*spinoides*	+	
86	Yellow-throated Fulvetta	*Alcippe*	*cinerea*		+

Appendix 6

List of pheasants observed during the survey of Allain catchment in Kullu District in May – June 2005.

Date	Pheasant	Scientific Name	Altitude (m)	Location	Habitat	Number (sighted/calls)	Sex
31-May-05	Koklass	*Pucrassia macrolopha*	2854	32 16 04 N; 77 14 50 E	Conifer	1 (Calls)	Male
31-May-05	Himalayan Monal	*Lophophorus impejanus*	3464	32 16 00 N; 77 15 36 E	Alpine	2 (calls)	Male
4-Jun-05	Himalayan Monal	*Lophophorus impejanus*	2804	32 15 21 N; 77 14 16 E	Mixed	1 (Calls)	Male
6-Jun-05	Koklass	*Pucrassia macrolopha*	2720	32 14 42 N; 77 13 40 E	Conifer	3 (calls)	Male
13-Jun-05	Koklass	*Pucrassia macrolopha*	2811	32 13 40 N; 77 13 22 E	Conifer	1	Female

List of pheasants observed during the survey of Duhangan catchment in Kullu District in May – June 2005.

Date	Name of Pheasant	Scientific Name	Altitude (m)	Location	Habitat	Number (sighted/calls)	Sex
10-May-05	Himalayan Monal	*Lophophorus impejanus*	2249	32 11 49 N; 77 12 53 E	Mixed	1	Male
15-May-05	Himalayan Monal	*Lophophorus impejanus*	3117	32 12 00 N; 77 16 32 E	Alpine	1	Male
15-May-05	Himalayan Monal	*Lophophorus impejanus*	3230	32 11 59 N; 77 16 44 E	Alpine	3	Male
15-May-05	Himalayan Monal	*Lophophorus impejanus*	3236	32 11 53 N; 77 17 05 E	Alpine	1	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3125	32 11 55 N; 77 16 01 E	Alpine	1	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3092	32 11 52 N; 77 15 58 E	Alpine	2	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3092	32 11 51 N; 77 15 56 E	Alpine	1	Male
16-May-05	Himalayan Monal	*Lophophorus impejanus*	3175	32 11 48 N; 77 15 54 E	Alpine	2	Male
17-May-05	Koklass	*Pucrassia macrolopha*	2650	32 11 55 N; 77 16 08 E	Conifer	2 (Calls)	Male
19-May-05	Himalayan Monal	*Lophophorus impejanus*	3280	32 12 14 N; 77 16 10 E	Alpine	1	Female
19-May-05	Himalayan Monal	*Lophophorus impejanus*	3280	32 12 14 N; 77 16 10 E	Alpine	2	Male
19-May-05	Koklass	*Pucrassia macrolopha*	2530	32 12 02 N; 77 16 12 E	Conifer	2 (Calls)	Male
21-May-05	Koklass	*Pucrassia macrolopha*	2350	32 11 48 N; 77 13 58 E	Conifer	2 (Calls)	Male
21-May-05	Koklass	*Pucrassia macrolopha*	2440	32 12 08 N; 77 13 52 E	Conifer	1 (Calls)	Male
21-May-05	Himalayan Monal	*Lophophorus impejanus*	2480	32 11 49 N; 77 13 59 E	Mixed	1	Male

Appendix 7

List of mammals observed during the survey of Allain catchment in Kullu District in May – June 2005.

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Sign/Number sighted
30-May-05	Pika	*Ochotona roylei*	2854	32 16 04 N; 77 14 50 E	Rocks in Open grassland	9
31-May-05	Leopard	*Panthera pardus*	3242	32 16 07 N; 77 15 20 E	Open	Pug marks
1-Jun-05	Brown Bear	*Ursus arctos*	3134	32 17 02 N; 77 15 30 E	Open	Pug marks (also sighted by a Gaddi shephard
2-Jun-05	Pika	*Ochotona roylei*	2817	32 16 16 N; 77 15 04 E	Rocks in Open grassland	7
3-Jun-05	Brown Bear	*Ursus arctos*	3100	32 15 53 N; 77 14 41 E	Mixed forest	Droppings
3-Jun-05	Brown Bear	*Ursus arctos*	3030	32 15 55 N; 77 14 59 E	Mixed forest	2
5-Jun-05	Long-tailed Marmot	*Marmota caudate*	2823	32 15 50 N; 77 14 32 E	Rocky area in Mixed forest	1
7-Jun-05	Brown Bear	*Ursus arctos*	2714	32 14 55 N; 77 13 41 E	Conifer	Pug marks & Digging
8-Jun-05	Pika	*Ochotona roylei*	2972	32 13 55 N; 77 13 43 E	Rocky area in Conifer forest	3
9-Jun-05	Red Fox	*Vulpes vulpes*	2987	32 13 51 N; 77 13 46 E	Mixed forest	2
10-Jun-05	Pika	*Ochotona roylei*	3040	32 13 53 N; 77 13 52 E	Rocky area in Conifer forest	5
10-Jun-05	Kashmir Flying Sqirrel	*Hylopetes fimbriatus*	2800	32 13 59 N; 77 13 25 E	Conifer	5
10-Jun-05	Red Fox	*Vulpes vulpes*	2800	32 13 59 N; 77 13 25 E	Conifer	2
13-Jun-05	Brown	*Ursus*	2814	32 13 43 N;	Conifer	Pug marks &

	Bear	*arctos*		77 13 21 E		Digging
13-Jun-05	Macaca	*Macaca mulatto*	2824	32 13 33 N; 77 13 30 E	Conifer	4

List of mammals observed during the survey of Duhangan catchment in Kullu District in May – June 2005.

Date	Animal	Scientific Name	Altitude (m)	Location	Habitat	Sign/Number sighted
11-May-05	Leopard	*Panthera pardus*	2462	32 11 56 N; 77 14 20 E	Conifer	Scat
11-May-05	Langur	*Presbytis entellus*	2462	32 11 56 N; 77 14 20 E	Open	3
12-May-05	Black Bear	*Selenarctos thibetanus*	2493	32 11 51 N; 77 14 20 E	Mixed forest	Pug marks & Droppings
14-May-05	Himalayan Weasel	*Mustela sibirica*	3135	32 12 03 N; 77 16 13 E	Open	1
15-May-05	Pika	*Ochotona roylei*	3230	32 11 59 N; 77 16 44 E	Rocky area in Alpine grassland	3
17-May-05	Brown Bear	*Ursus arctos*	3170	32 11 55 N; 77 16 08 E	Conifer	Pug marks & Droppings
19-May-05	Pika	*Ochotona roylei*	3202	37 12 09 N; 77 16 11 E	Rocky area in Conifer forest	10
19-May-05	Langur	*Presbytis entellus*	3200	37 12 12 N; 77 16 08 E	Conifer	14
21-May-05	Brown Bear	*Ursus arctos*	2480	32 11 49 N; 77 13 59 E	Mixed forest	Pug marks & Digging

Butterfly Survey

Importance of Butterflies in Impact Assessment Studies

As in lowland ecosystems even at high altitudes, butterflies are dominantly found and flourish at highest limits of existence of animal life.

Butterflies play an important role in cross pollination of flowering plants. Adults generally feed on nectar and larvae feed on foliage and are the primary herbivore in the ecosystem (Uniyal and Mathur, 1998). This association of butterflies with plants is highly specific. The distribution of butterfly species depends on the availability of preferred food plant. There are few butterfly species which are associated with grasslands, grassy clearings in woodland open grassland habitats in Himalayas.

As butterflies are very specific to any minute change in the environment hence, they shows distinct pattern of habitat utilization. The nature of vegetation is the important factor which determines the distribution, dependence, and survival of a species in particular habitat. Being highly sensitive to change in environment, they are easily affected by any minor perturbations in the habitat so much, so they have been considered as indicator of environmental quality and also treated as indicator of the health of the ecosystem (Rosenberg *et al. 1986*).

The presence of butterfly emphasizes availability of larval food plant in great abundance. Most butterflies have specific habitat requirements; females usually tend to lay eggs only on selective food plants (*Uniyal and Mathur, 1998*).
There is an intimate association between butterflies and plants and their lives are exceptionally interlinked (Feltwell, 1986).

Thus, butterfly presence, distribution and behaviour directly reflects the changes or in other words the impact of destructive human activities and help in assessing environment quality for conservation of ecosystem.

OBJECTIVES

The following objectives have been outlined for the proposed study:

- To cover the representative habitats of butterflies.
- To measure abundance indices of butterflies.
- To document a general list of butterflies biodiversity.
- To identify impacts of proposed dam on population and Richness of Butterflies.

Intensive study site

The whole project area was divided into two major areas and further transects and sections were made for the ease in monitoring butterfly. The details of division of study area are provided in ***Table 3.12*****.**

(a) Area I- Allain stream

A total of four transects were made in this area. Transects 1, 2, 3 and 4 were further divided into a sections of 16, 18, 8 and 16 respectively. Each section was of 300 m each hence, all transects cover a distance of 18 km (***Fig 3.2, 3.3, 3.4***).

(b) Area – II Duhangan stream

It was further divided into three transects. The transect 1, 2 and 3 were further divided into a section of 12, 15 and 8 respectively. Hence, total covering an area of 12 km (Fig 3.5 & 3.6)

Table 3.12. Shows the Major areas, transects, sections and their description.

AREA I (ALLAIN STREAM)		
TRANSECT	**SITE NAME**	**SECTIONS**
1.	Allain barrage to surge shaft site.	16
2.	Pasture land (Above surge shaft site).	18
3.	Surge shaft site to Hamta village.	8
4.	Hamta village to Kullu-Manali state highway.	16
Total distance covered (km)		18
AREA II (DUHANGAN STREAM)		
5.	Jagatsukh to Kala pani.	12
6.	Kala pani to Duhangan weir site.	15
7.	Kala pani stream.	8
Total distance covered (km)		12

Fig. 3.2 Location of transect 1 for collection of butterfly samples

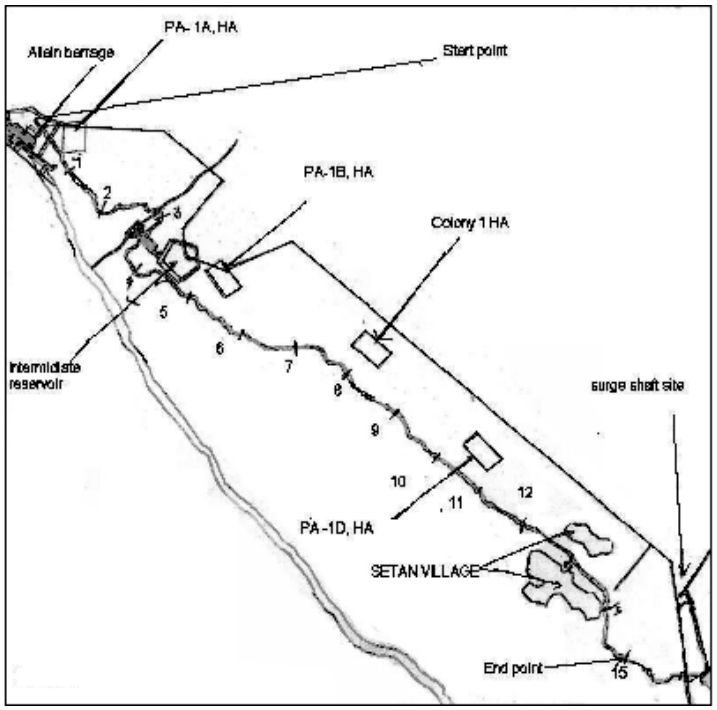


Fig. 3.3 Location of transect 2 for collection of butterfly samples

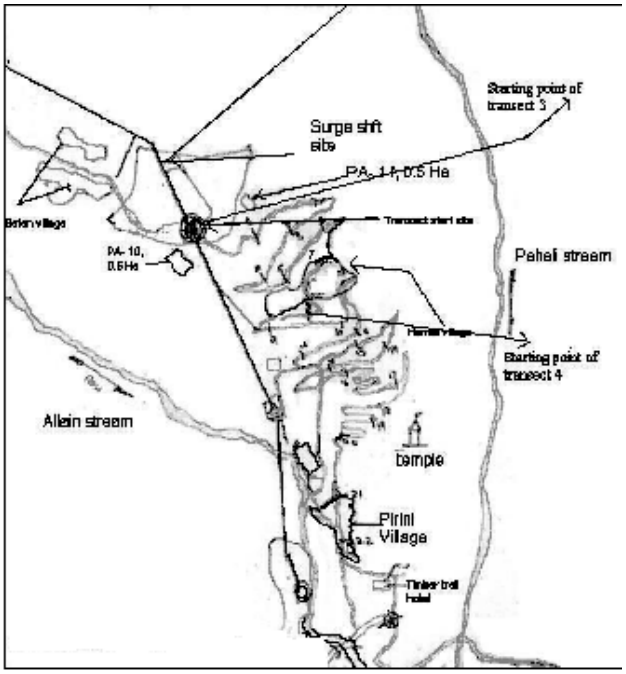


Fig 3.4 Location of Transects 3 and 4

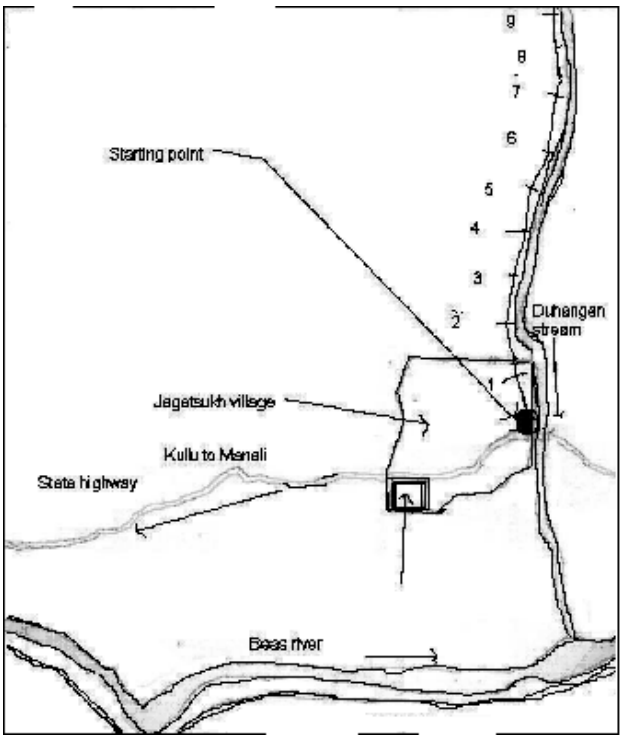


Fig 3.5 Location of Transect 5

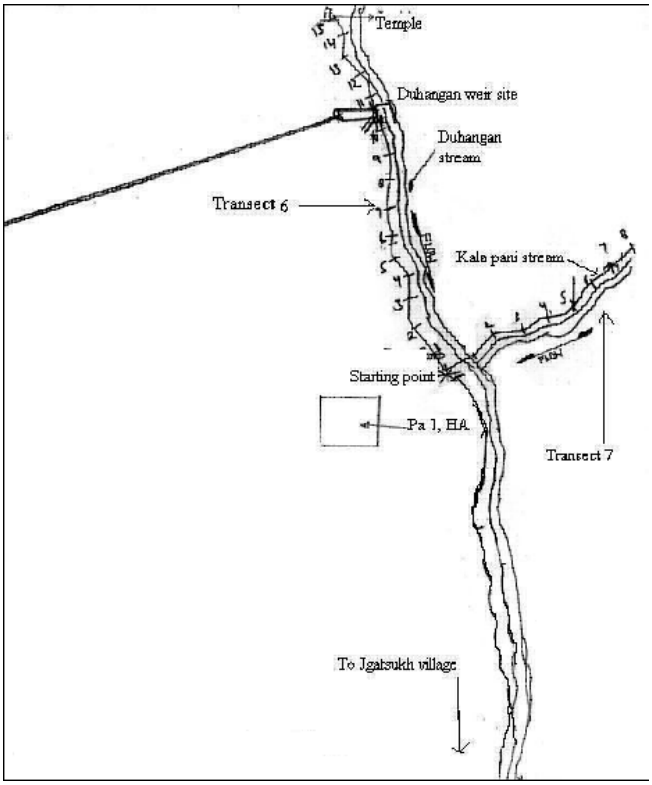


Fig 3.6 Location of transects 6 & 7

Methods for the study

Collection

Collections of various families of butterflies were made around all two main streams (Allain-Duhangan) used for the proposed project and in surrounding important areas. The study area comprises various forest types, scrubs, and alpine pastures ranging from 2,300 m to over 3,500 m above sea level (Fig 4). The survey was conducted in the month of October 2005.

The butterfly collections were carried out in the early hours of the day because butterflies are usually active at early sunrise therefore, it was easy to observe and collect them. Broadly, following methods were adopted for the collection.

(a) Aerial netting:

Aerial net was used to collect flying butterflies. Soft bodied butterflies were gently removed from the bottom of the bag, after it becomes enclosed in the bag bay a rabid twist of the handle; often the fold of the net enclosing the butterfly was removed after killing vapours of the killing agent.

Equipment

(a) Killing bottle:

Killing bottle was used to kill and preserve insect without affecting its colour. Glass jar with a layer of Benzene was used as a killing agent. The liquid was poured over a layer of cotton and one or two filter paper were used to soak cotton and also to prevent the specimen form coming in direct contact with cotton. The butterflies were handled carefully while, they are put inside the bottle or taken out to prevent any morphological damage.

(b) Polythene packets:

Polythene packets were used to keep butterflies in the field. The extreme care was taken while keeping butterflies in the polythene packets to avoid any damage till preservation.

Preservation for taxonomic study

(a) Spreading:

It is a process to arrange the wings for taxonomic study, with the help of spreading board which consist of two parallel pieces of soft wood with an inner groove lined by cork. A properly relaxed specimen with a pin thrust vertically, was inserted inside the groove so that the wing bases remain at level with the edge of top part. Two narrow paper strips were used to hold and spread the wings, and after adjustment of the wings at a desirable position the collected specimen was pinned using a fine pin.

(b) Pinning:

Collected butterflies were pinned for detailed identification.

Plate 1. Instruments used in study.

Butterflies were collected and preserved in such a manner so as to allow examination of the specimens even after along lapse of time. This necessitates undistorted spreading, pinning and labeling with complete information of the collection *viz,* date, time, location, scientific name and family. The specimens once pinned were arranged in wooden insect collection boxes. (Plate 1.). Naphthalene balls were used in the insect boxes for safe preservation against any pest or fungal attack.

Taxonomic keys for identification

The purpose of a taxonomic key is to facilitate identification of a specimen (Mayer, 1974). For identification of butterflies the reference key, pictorial key and illustrations as provided by Mani (1986); Haribal (1992) and Evans (1932) were used.

Butterfly monitoring

Butterfly was monitored to measure abundance indices in proposed project area. The whole area was traversed by foot and butterflies were recorded 5 m ahead of the recorder. Separate counts were made for each section and transect. The butterfly recorded once was neglected, if it comes to the trail next time. The location of each transects and their sections in study area are shown in Fig 1 – 5.

5.2.1 Line transect technique

Line transect technique is used to measure abundance indices of butterflies. It has been referred as standard for butterfly monitoring (Pollard, 1977). Four transects were made in aerial and three transects in area II. Each specimen was recorded and separate count was made in each section.

6. RESULTS

The study area was extensively surveyed in order to find out abundance indices, species richness, and biodiversity and occurrence variation of the butterflies from Date 14-10-2005 to 4-11-2005. A total of 14 species belonging 14 genera of 5 families were recorded in all 7 transects of study area (Fig 10 to 16.)**,** (Table 3.13.) and (Plate 2, 3 & 4.).

Allain Stream--- Area I

In transect 1. A total 3 families belonging to 10 genera and 10 butterfly species were documented. The dominant species was Dark clouded yellow (*Colias electo fieldi*). About 80 specimen of this species were observed along the transect. The second dominant species was *viz,* Common brimstone (*Gonepteryx rhamni nepalensis*), Queen of Spain fritillary (*Issorea lanthania*) etc. *Aulocera brahminus* was rarely found in this area. In transect 2. A total 4 families belonging to 12 genera and 12 butterfly species were found. The dominant species was Large hedge blue (*Celastrina huegeli*). About 138 specimen of this species were observed along the transect. The second dominant species was *viz,* Common brimstone (*Gonepteryx rhamni nepalensis*), Dark clouded

yellow (*Colias electo fieldi*) etc. Hill jezebel (*Delias belladona*) was rarely found in this area. In transect 3. A total 4 families belonging to 11 genera and 11 butterfly species were documented. The dominant species was Queen of Spain fritillary (*Issorea lanthania*). About 24 specimen of this species were observed along the transect. Lofty path white (*Pontia callidice*) Yerburis sailor (*Neptis yerburi*) were rarely found in this area. In transect 4. A total 5 families belonging to 13 genera and 13 butterfly species were documented. The dominant species was Large hedge blue (*Celastrina huegeli*). About 71 specimen of this species were observed along the transect. The second dominant species was *viz,* Common brimstone (*Gonepteryx rhamni nepalensis*), Queen of Spain fritillary (*Issorea lanthania*) etc. While, Dark clouded yellow (*Colias electo fieldi*) was rarely found species in this area.

Duhangan stream --- Area II

Queen of Spain fritillary (*Issorea lanthania*) was totally absent from this transect 7. A total 5 families belonging to 11 genera and 11 butterfly species were documented. The dominant species was Large hedge blue (*Celastrina huegeli*). About 328 specimen of this species were observed along the transect. The secondly dominant species were *viz,* Indian cabbage white (*Pieris canidia indica*) and Common copper (*Lycaenia phlaeas*) was rarely found in this area. While, Common fourring *(Ypthima hubenri)* was totally absent in this rea. In transect 6. A total 5 families belonging to 11 genera and 11 butterfly species were documented. The dominant species was Large hedge blue (*Celastrina huegeli*). About 232 specimen of this species were observed along the transect. The secondly dominant species were *viz,* Indian cabbage white (*Pieris canidia indica*) and Common copper (*Lycaenia phlaeas*). Common fourring (*Ypthima hubenri*) was rarely found in this area.

In transect 7. A total 4 families belonging to 10 genera and 10 butterfly species were documented. The dominant species was Large hedge blue (*Celastrina huegeli*). About 29 specimen of this species were observed along the transect. Indian tortoiseshell (*Vaneesa kashmiriensis*) was rarely found species in this area.

Fig 10-16. shows the fluctuation in the number of specimen recorded of rare and dominant species throughout the Transect 1-7 in area I and in area II.

6.1 Possible Impact on Butterfly Habitat

The Area 1 is prominently degraded; green patches are out of sight at some places e.g; Surge shaft site and Setan village. The prominent plants were *Juglans regia, Cedrus deodara* and *Pinus sp.* The defecation by labourers in open is damaging the natural habitat. Wood-cutting work by labourers and villagers is also harming the butterfly habitat. The project work for some years would certainly affect the whole ecosystem and the species like yellow white and purple brown can be in danger. While, in Area 2 the work has yet not started thus, the butterflies are easily visible in this area. The area is covered by green dense forests and prominently the shrubs of *cannabis sp.*

Plate 2. Common butterflies in the study area.

Dark Clouded Yellow (*Colias electo fieldi***)**

Common brimstone (*Gonepteryx rhamni nepalensis***)**

Plate 3. Common butterflies in the study area.

Indian cabbage white (*Pieris canidia indica***)**

Indian tortoiseshell (*Vaneesa kashmiriensis***)**

Plate 4. Common butterflies in the study area

Queen of Spain fritillary (*Issorea lanthania*)

Table 4.13. List of butterflies found in the study area.

S.No	Scientific name	Vernacular name	Family
1.	*Gonepteryx rhamni nepalensis*	Common brimstone	Pieridae
2.	*Pieris canidia indica*	Indian cabbage white	Pieridae
3.	*Pontia callidice*	Lofty path white	Pieridae
4.	*Colias electo fieldi*	Dark clouded yellow	Pieridae
5.	*Delias belladona*	Hill jezebel	Pieridae
6.	*Aulocera brahminus*	Indian tortoiseshell	Nymphalidae
7.	*Vaneesa kashmiriensis*	Queen of Spain fritillary	Nymphalidae
8.	*Issorea lanthania*		Nymphalidae
9.	*Neptis yerburi*	Yerburis sailor	Nymphalidae
10.	*Ypthima hubenri*	Common fourring	Nymphalidae
11.	*Lycaenia phlaeas*	Common copper	Lycaenidae
12.	*Celastrina huegeli*	Large hedge blue	Lycaenidae
13.	*Parage schakra*	Common wall	Satyridae
14.	*Graphium sarpedon sarpedon*	Common blue-bottle	Papilionidae

Fig 10. Shows occurence variation of dominant and rare species of butterfly in Transect 1.

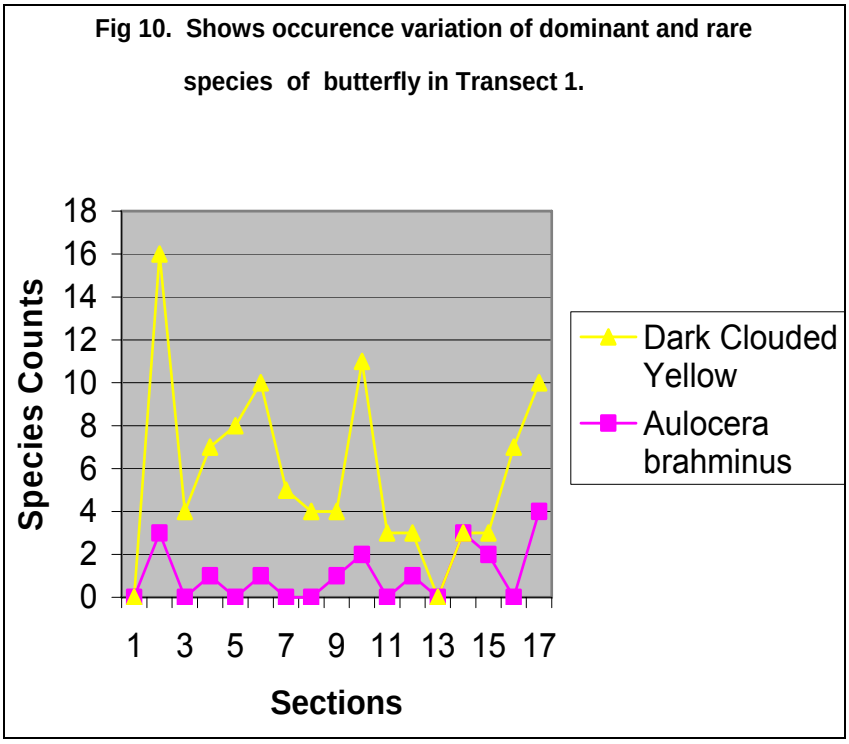


Fig 11. Shows occurrence variation of dominant are rare species of butterfly in Transect 2.

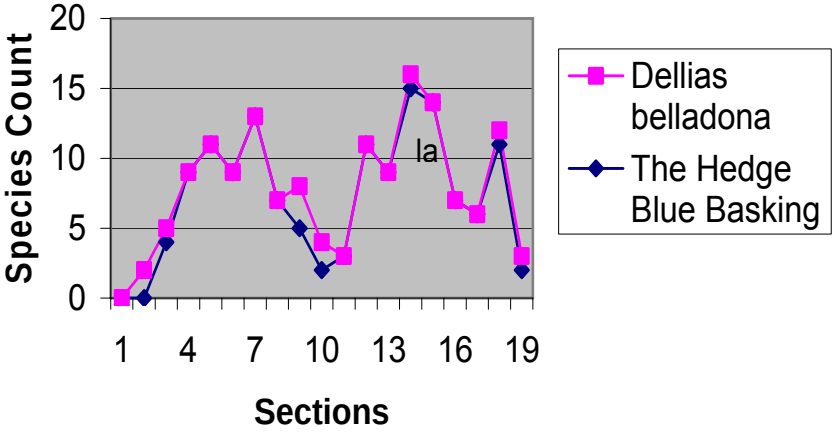


Fig 12. Shows Occurrence variatiion of Dominant and rare species in Transect 3.

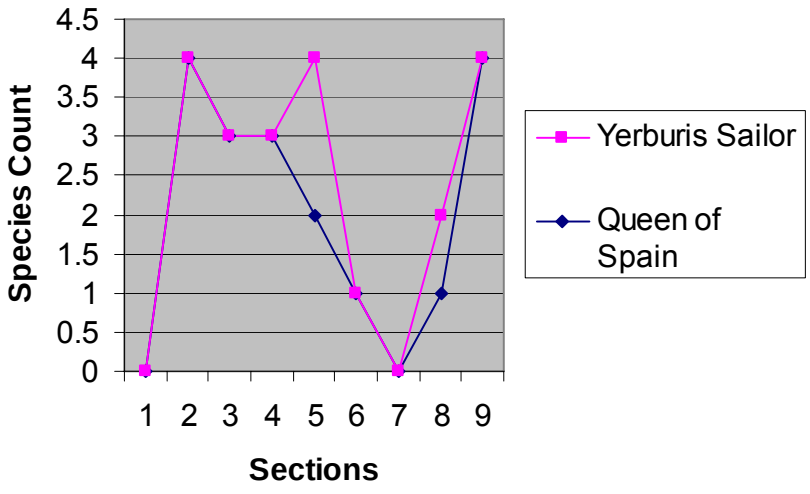


Fig 13. Showing occurrence variation of dominant and rare butterflies in transect 4.

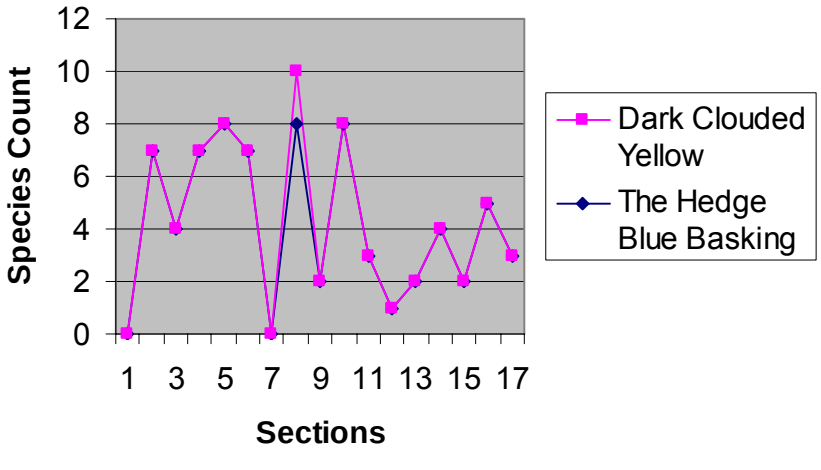


Fig 14. Showing occurrence variation of dominant and rare butterflies in transect 5.

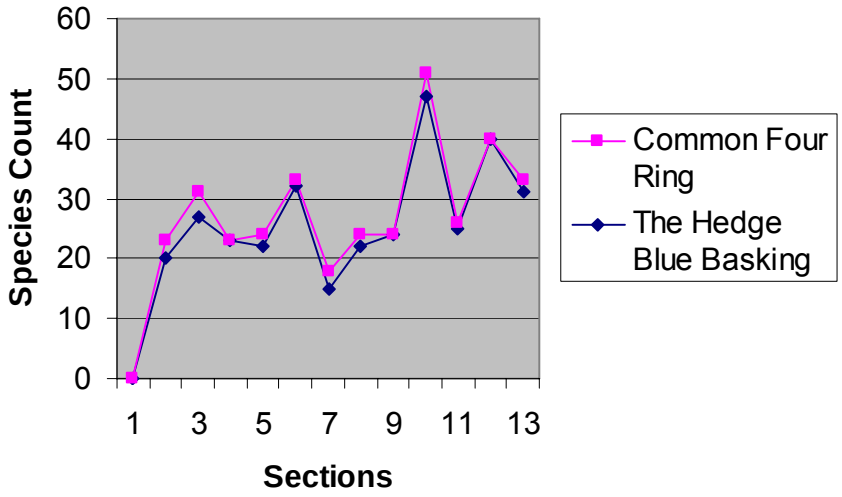


Fig. 15. Shows occurence variation of dominnat and rare species in transect 6.

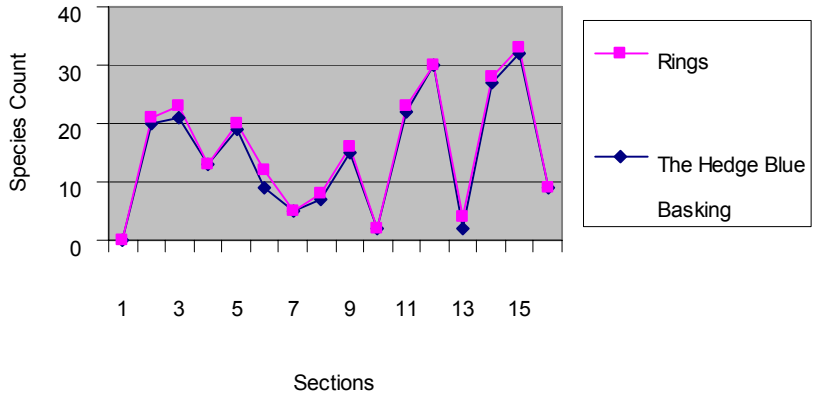
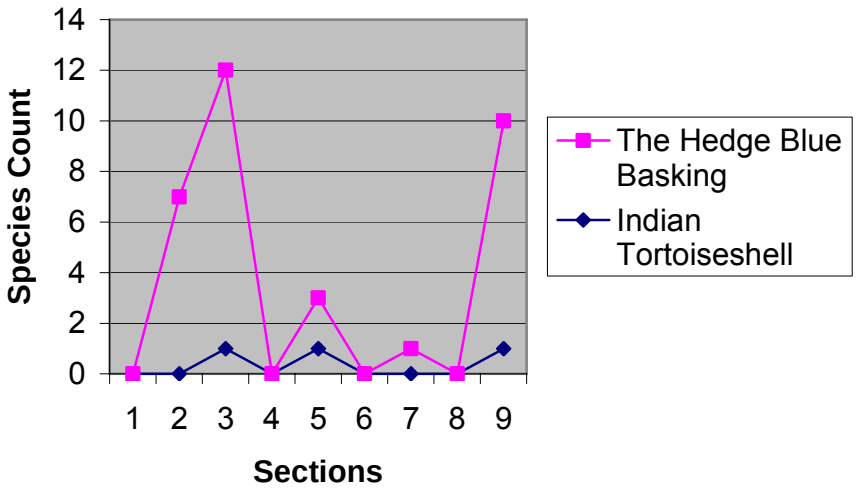


Fig 16. Shows occurence variation of dominnat and rare species in Transect 7.



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4. FLORISTICS

4.1 Methodology

Survey, Sampling and Identification of the Species

Surveys were conducted between 1800-4000m in Hamta and Jagatsukh catchments throughout the year. The samples of the plant species were collected, and identified with the help of local flora (Choudhury & Wadhawa, 1984; Dhaliwal & Sharma, 1999; Singh & Rawat, 2000). For each species, information on altitudinal range, habitat (s), life forms, etc. was gathered. All the identified species were listed, and analyzed for floristic diversity.

Selection of Sites and Habitats for Vegetation Sampling

Sites were selected on each and every accessible aspect between 1800-4000m along an altitudinal gradient. The habitats were identified based on the physical characters and dominance of the vegetation. Sites having closed canopy with high percent of humus and moisture were considered as moist habitats whereas low percent of the same as dry habitats. The sites having >50% boulders of the ground cover had been considered as bouldary habitat, and the sites facing high anthropogenic pressures had been considered as degraded habitat.

Survey, Sampling, Identification and Analysis of Data

The field surveys and samplings were conducted during the summer season within the selected sites along an altitudinal gradient. In each site, a plot of 50x50m was laid. Trees, saplings and seedlings were sampled by randomly placed 10, 10x10m quadrats; shrubs by 10, 5x5m quadrats; herbs by 20, 1x1m quadrats in each plot. The size and number of quadrats were determined following Misra, 1968 and Kersaw, 1973. For the collection of data from these quadrats standard ecological methods (Curtis & McIntosh, 1950; Grieg-Smith, 1957; Kersaw, 1973; Muller-Dombois & Ellenberge, 1974; Dhar *et al.,* 1997; Joshi & Samant, 2004; and Samant & Joshi, 2004) were followed. Circumference at breast height (cbh at 1.37m from ground) for each tree individual was recorded. Based on cbh, the tree individuals were considered as tree (cbh $\geq$ 31.5 cm), sapling (cbh 10.5-31.4 cm) and seedling (cbh < 10.5 cm). Shrubs were considered as the woody species having several branches arising from their base (Saxena & Singh, 1982) and herbs are those plants aerial parts of which survive only one season however, may survive by underground roots/rhizomes/bulbs, *etc.* From each site, samples of each species were collected and identified in the Institute with the help of florulas and research papers (Choudhury & Wadhawa, 1984; Dhaliwal & Sharma, 1999; Singh & Rawat, 2000; Khullar, 1994, 2000, *etc.*).

Data analysis has been done following standard ecological methods (Curtis & Mc Intosh, 1950; Grieg-Smith, 1957; Kersaw, 1973; Muller-Dombois & Ellenberge, 1974; Dhar *et al.,* 1997; Samant *et al.,* 2002, Samant & Joshi 2004; and Joshi & Samant, 2004). Community wise frequency and abundance of species has been calculated as:

$$\text{Frequency} = \frac{\text{Number of communities in which species present}}{\text{Total number of communities}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of communities x mean density of species}}{\text{Total number of communities of species occurrence}}$$

For trees, Basal Area and Importance Value Index (IVI) have also been computed. Basal Area and Total Basal Area were calculated as:

Basal Area= $\prod r^2$ where r= radius

Total Basal Area (TBA) = Mean basal area x density

IVI has been calculated as the sum of relative frequency, relative density and relative basal area. The abundance data of different sites were pooled to get community averages in terms of density, Total Basal Area and IVI. Communities were identified based on the IVI.

Assessment of Resource Utilization Pattern

Seven villages *i.e.,* Prini, Hamta, Chhaleth, Sethan, Jagatsukh, Bhanara, and Shuru located in these catchments have been selected to generate information on the resource utilization pattern of the inhabitants. Knowledgeable persons, Vaidhyas from each village were interviewed. Among the village experts, one person was hired to survey and collect the useful plant species from wild habitats. Information on the local names, altitudinal range, life forms, part (s) used, and use values including indigenous knowledge and practices was gathered. Fresh samples of the useful species were collected and identified with the help of florulas (*Choudhury & Wadhawa, 1984; Dhaliwal & Sharma, 1999; Singh & Rawat, 2000; Khullar, 1994, 2000, etc.*). For the external use, the useful part is crushed and converted into paste. The paste is used to cure diseases and heal the wounds. But, for internal use the paste is mixed with 4-5 teaspoonful of water and given to patients. The information was compiled and analyzed for the utilization pattern following Samant *et al.* (2002a).

Identification of the Rarity of the Species

The rarity of the species has been identified based on the habitat preference, population size, distribution range and anthropogenic pressure (*Samant et al., 1998, 1996b*) and also, categorization of these species as Critically Endangered, Endangered, Vulnerable, Near Threatened, *etc.* have been done following (*Samant et al., 1998a&b; Dhar et al., 2002; Ved et al., 2003; and Samant & Pal, 2003*).

4. 2 Results

Qualitative assessment of plant diversity of the Hamta Jagatsukh catchments

Species Diversity

The present study recorded 619 species of vascular plants i.e., Angiosperms (97 families, 227 genera and 560 species), Gymnosperms (3 families, 6 genera and 8

species) and Pteridophytes (16 families, 25 genera and 51 species). Of the total species, 45 species were trees, 85 species shrubs, 438 species herbs and 51 species pteridophytes (Table 4.1.1). Among the angiosperm families, Asteraceae (59 spp.); Rosaceae (38 spp.); Poaceae (31spp.); Lamiaceae (26 spp.); Ranunculaceae (24 Spp.); Fabaceae and Apiaceae (20 spp. each); and Scrophulariaceae (19 spp.) are the dominant families. Papavaraceae, Podophyllaceae, Linacae, Aquifoliaceae, Vitaceae, Tiliaceae, Meliaceae, Vitaceae, Coriariaceae, Begoniaceae, Dipsacaceae, Morinaceae, Myrsinaceae, Buxaceae, Cannabaceae, Cuscutaceae, Polemoniaceae, Verbenaceae, Phytolaccaceae, Loranthaceae, Corylaceae, Asparagaceae, Loganiaceae, Malvaceae, Moraceae, Juglandaceae and Cucurbitaceae etc. were the monotypic families. Among genera, *Carex* (9 spp.), *Pedicularis* (7 spp.), *Potentilla* (6 spp.) and *Galium*, *Rubus, Clematis*, *Impatiens, Prunus* (5 spp., each) were the dominant genera. Among gymnosperms, the family Pinaceae (04 spp.), and Genus, *Juniperus* (3 species) are dominant. Amongst Pteridophytes, the families, Dryopteridaceae (10 spp.), Athyriaceae (06 spp.) and Aspleniaceae (05 spp.), and generas, *Polystichum* (10 spp.), *Athyrium* (6spp.), *Asplenium* (5spp.), *Pteris*, *Lepisorus* and *Adiantum* (4 spp., each) were species rich (Appendix).

Table 4.1.1. Taxonomic description of the floristic diversity of Hamta and Jagatsukh Catchments

Taxonomic group	Families	Genera	Species	Trees	Shrubs	Herbs	Ferns
Angiosperms	97	227	560	39	83	438	-
Gymnosperms	3	6	8	5	3	-	-
Pteridophytes	16	25	51	-	-	-	51
Total	**116**	**258**	**619**	**44**	**86**	**438**	**51**

Altitudinal distribution

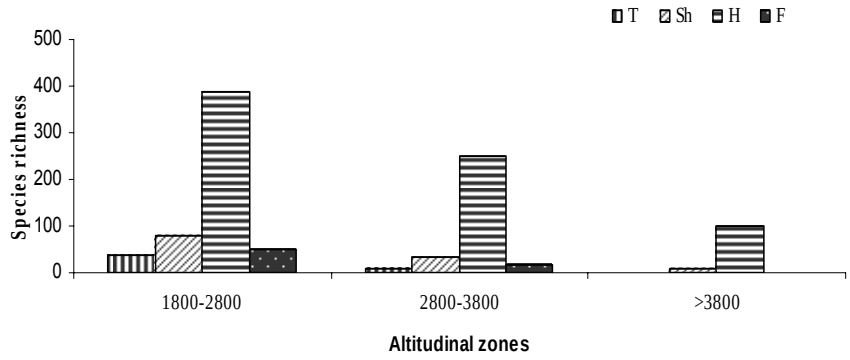
Altitudinal distribution of the species is presented in Fig.4.1.1. Maximum number of species (554) were reported in the altitude zone, 1800-2800m, followed by the altitude zone 2800-3800m (314 species). The altitude zone >3800m showed minimum number of species (107). Some important species of the altitudinal zone, 1800-2800m are *Pinus wallichiana, Picea smithinana, Abies pindrow*, *Ulmus villosa, U.wallichiana, Taxus baccata* subsp. *wallichiana, Quercus floribunda, Indigofera heterantha, Sorbaria tomentosa, Berberis lycium, Paris polyphylla, Podophyllum hexandrum, Polygonatum verticillatum, Angelica glauca, Dioscorea deltoidea, Viola biflora,* etc. The Important species of the altitudinal zone, 2800-3800m are *Acer acuminatum, Betula utilis, Abies pindrow, Quercus semecarpifolia, Rhododendron campanulatum, R. anthopogon, Berberis jaeschkeana, Arnebia benthamii, Dactylorhiza hatagirea, Bergenia stracheyi, Rheum australe, Picrorhiza kurrooa, Aconitum heterophyllum, Meconopsis aculeata*. The notable species of the altitudinal zone >3800m were *Betula utilis, Dactylorhiza hatagirea, Juniperus recurva, J. indica, Bergenia stracheyi, Rheum webbianum, Oxyria digyna, Picorhiza kurrooa, Aconitum heterophyllum,* etc. Some of the species have wide range of distribution. The notable species are *Geranium nepalense, Cerastium fontanum, Selinum tenuifolium, Heracleum candicans, Taraxacum officinale, Swertia angustifolia,*

Leucas lanata, etc.

Quantitative assessment of vegetation in Hamta Jagatsukh catchments
Site Characteristics

Total 54 sites have been sampled in both Hamta and Jagatsukh catchments for the analysis of vegetation. 29 sites were sampled in Allain catchment along an altitudinal range, 1990-3700m, amsl and 25 sites in Duhangan catchment along an altitudinal range, 1860-3850m, amsl. The sampling of the vegetation was done between latitudes $32^0$11.206'' N to $32^0$16.120' N and longitudes $77^0$12.415' E to $77^0$18.885' E**.** Study covers all the accessible habitats and aspects. Shady Moist habitat represented maximum sites (15 sites) in both the Hamta and Jagatsukh catchments, followed by riverine habitat (10 sites), degraded and bouldary (6 sites, each) and Alpine meadows (4 sites). Maximum sites (17 sites) represented in North West aspect, followed by West (12 sites) and South (7) aspects. Slope ranges form 10^0 to 75^0. Site characteristics and geo-references of the sampled sites have been presented in Table 4.2.1.

Fig. 4.1.1. Altitudinal distribution of floristic diversity



Abbreviations used: T=Trees; Sh=Shrubs; H=Herbs; F=Ferns

Table 4.2.1. Site characteristics and Geo-references of the sites sampled in Hamta and Jagatsukh catchments

Site No.	Altitude (m)	Habitat	Community	Slope (^{o})	Latitude	Longitude	Aspect
A. Hamta Catchment							
1*	1992	D	PP -ID	55	$32^0$13.683' N	$77^0$12.497' E	N W
2*	2012	SM	QF	35	$32^0$13.486' N	$77^0$12.415' E	N W
3*	2020	SM	PW	35	$32^0$13.419' N	$77^0$12,443' E	N W
4*	2780	SM	PS	60	$32^0$13.522' N	$77^0$13.199' E	N W
5*	2481	D	UV	60	$32^0$13.951' N	$77^0$12.905' E	W
6*	2730	SM	PS	45	$32^0$13.647' N	$77^0$13.346' E	SW
7*	2804	R	PS	40	$32^0$13.489' N	$77^0$13.521' E	SE

8*	2229	D	CD	40	$32^0$13.362' N	$77^0$12.621' E	W
9	2105	R	UV	55	$32^0$13.946' N	$77^0$12.762' E	NW
10*	2250	Dr	PW	65	$32^0$13.604' N	$77^0$12.670' E	W
11	2221	SM	PS	50	$32^0$13.215' N	$77^0$12.493' E	NW
12	2903	R	AP	52	$32^0$16.010' N	$77^0$14.050' E	W
13	3029	AM	VG	50	$32^0$16.120' N	$77^0$15.009' E	W
14	3248	B	BU	50	$32^0$16.012' N	$77^0$15.281' E	NW
15	3131	SM	AP	65	$33^0$15.391' N	$77^0$15.621' E	NW
16*	2771	R	AA	40	$32^0$15.540' N	$77^0$14.571' E	NW
17*	2785	R	QS	10	$32^0$15.643' N	$77^0$14.472' E	NW
18*	2790	SM	AP	50	$32^0$15.261' N	$77^0$14.231' E	SW
19	3180	Ro	BU-AA	65	$32^0$14.770' N	$77^0$14.430' E	N
20	3440	AM	JI	45	$32^0$14.533' N	$77^0$14.690' E	NW
21	3560	B	CF-SC-AV	45	$32^0$14.372' N	$77^0$14.849' E	W
22	3491	Sc	RS-BJ	53	$32^0$14.214' N	$77^0$14.676' E	SW
23*	2735	S	AP	50	$32^0$14.604' N	$77^0$13.655' E	W
24*	2748	D	PS	45	$32^0$14.234' N	$77^0$13.418' E	NW
25	2818	S	AP	65	$32^0$14.689' N	$77^0$13.394' E	S
26	3050	S	AP-QS	30	$32^0$13.576' N	$77^0$13.865' E	SE
27	3147	SM	QS	35	$32^0$13.662' N	$77^0$14.009' E	SW
28	3013	OS	VG	50	$32^0$13.640' N	$77^0$13.430' E	S
29*	2618	B	JR	30	$32^0$14.114' N	$77^0$13.195' E	W
B. Jagatsukh Catchment							
1	2266	SM	PS	75	$32^0$11.613' N	$77^0$13.571' E	NE
2	2225	R	PS	40	$32^0$11.552' N	$77^0$13.345' E	NW
3	2170	SM	PS	60	$32^0$11.667' N	$77^0$13.216' E	N
4	2063	Dr	PS	20	$32^0$11.698' N	$77^0$12.919' E	N
5	2445	D	PS	65	$32^0$11.261' N	$77^0$12.882' E	W
6	2461	SM	AP	65	$32^0$11.279' N	$77^0$12.946' E	N
7	2508	R	AP	50	$32^0$11.206' N	$77^0$12.938' E	NW
8	2479	D	PS	45	$32^0$11.283' N	$77^0$13.158' E	NW
9	2456	SM	AI-PS	70	$32^0$11.411' N	$77^0$13.479' E	NE
10	2510	Ro	PS	80	$32^0$11.340' N	$77^0$13.501' E	SW
11*	2067	B	QF	40	$32^0$11.842' N	$77^0$12.924' E	S
12*	2130	Sh/B	IH-ST	45	$32^0$11.795' N	$77^0$13.773' E	SW
13*	2380	OG	IH-RR-SC	20	$32^0$11.834' N	$77^0$14.019' E	W
14	2389	SM	PW	70	$32^0$11.951' N	$77^0$14.005' E	S
15*	2291	B	PS-AI	45	$32^0$11.748' N	$77^0$13.842' E	SW
16	2365	Ro	PW	75	$32^0$11.799' N	$77^0$13.514' E	S
17*	2693	SM	AP	65	$32^0$11.959' N	$77^0$14.816' E	W
18	2788	R	AA	50	$32^0$12.005' N	$77^0$15.077' E	NW

19	3713	AM	RB-PA-AT-PB	55	$32^0$11.500' N	$77^0$18.436' E	NW
20	3777	B	DI-AT- SC	35	$32^0$11.445' N	$77^0$18.751' E	S
21	3851	AM	RA	60	$32^0$11.302' N	$77^0$18.504' E	N
22	3230	R	BU-AA	35	$32^0$11.918' N	$77^0$16.885' E	S
23	3160	SM	BU	50	$32^0$11.958' N	$77^0$16.212' E	N
24*	3185	S	AA	40	$32^0$11.850' N	$77^0$16.153' E	NW
25*	3120	R	BU-AA	10	$32^0$12.018' N	$77^0$16.192' E	W

Abbreviations Used: PP-ID=*Pyrus pashia-Ilex dipyrena*; QF= *Quercus floribunda*; PW=*Pinus wallichiana*; PS=*Picea smithiana*; UV=*Ulmus villosa*; AP=*Abies pindrow*; AA=*Acer acuminatum*; JR=*Juglans regia*; QS-AP=*Quercus semecarpifolia-Abies pindrow* mixed*;* QS=*Quercus semecarpifolia;* BU-AA=*Betula utilis-Acer acumintum*; PS-AI= *Picea smithiana-Aesculus indica*; PW=*Pinus wallichiana*; VG=*Viburnum grandiflorum*; JI=*Juniperus indica*; RS-BJ=*Rosa sericea-Berberis jaeschkeana*; RA=*Rhododendron anthopogon*; IH-ST=*Indigofera heterantha-Sorbaria tomentosa*; IH-RR-SC=*Indigofera heterantha-Rabdosia rugosa-Spiraea canescens* mixed; RB-PA-AT-PB=*Rhodiola bupleuroides-Potentilla atrosanguinea–Anaphalis triplinervis-Phlomis bracteosa*; DI-AT-SC=*Dipsacus inermis -Anaphalis triplinervis-Sibbaldia cuneata*; CF-SC-AV=*Carex foliolosa-Sibbaldia cuneata-Artemisia vestita;* S=South; W=West; N=North, SW=South West; NW=North West; SE=South East; D=Degraded; SM=Shady Moist; R=Riverine; Dr=Dry forest; AM=Alpine Meadows; B=Bouldary; Ro=Rocky; Sc=Shrubbery; OS=Open Slope

* Sites representing high project impact area

Community Diversity, Distribution Pattern, Species Composition and Structure

A total of 23 communities (Forests: 14; Shrubs: 02; Alpine Scrubs: 4; & Alpine Herbs: 03) have been identified based on Importance Value Index and Relative density, respectively from the Hamta Jagatsukh Catchments between 1800-4800m. Forest communities were represented by evergreen coniferous communities (*i.e., Abies pindrow, Pinus wallichiana*, *Picea smithiana* and *Cedrus deodara*); broad leaved evergreen communities (*i.e., Quercus floribunda,* and *Q. semecarpifolia*); evergreen coniferous-broad leaved deciduous communities (*i.e., Abies pindrow-Acer acuminatum*, *Picea smithiana-Aesculus indica*); evergreen coniferous and broad leaved community (i.e. *Abies pindrow- Quercus semecarpifolia*); evergreen-deciduous broad leaved community (i.e*. Ilex Dipyrena- Pyrus pashia* mixed); broad leaved deciduous communities (*i.e., Acer acuminatum, Ulmus villosa, Betula utilis, Juglans regia* and *Betula utilis-Acer acuminatum* mixed). The community types, altitudinal distribution, representation in sites, habitats, and major tree associates have been presented in Table 4.3.1. Amongst the communities, *Picea smithiana* community represented maximum sites (12 sites), followed by *Abies pindrow* (08 sites), *Pinus wallichiana* (04 sites), and remaining communities represented < 4 sites. The alpine communities were represented by Scrub communities (i.e., *Juniperus indica*; *Rhododendron anthopogon*; *Rosa sericea-Berberis jaeschkeana*; and *Viburnum grandiflorum*. herb communities (i.e., *Rhodiola bupleuroides-Potentilla atrosanguinea–Anaphalis triplinervis-Phlomis bracteosa*; *Dipsacus inermis-Sibbaldia cuneata-Anaphalis triplinervis*; *Carex foliosa-*

Sibbaldia cuneata-Artemisia vestita). The distribution patterns of communities along an altitudinal gradient and within the habitats are presented in Table 4.2.2.

Over all, 324 species (Trees: 23; Shrubs: 53; Herbs: 249) were recorded. Amongst the communities, Picea smithiana showed maximum number of species i.e., 192 species (Trees: 14; Shrubs: 29; Herbs: 149), followed by Abies pindrow 136 species (Trees: 11; Shrubs: 21; Herbs: 104) and Ulmus villosa 119 species (Trees: 5; Shrubs: 20; Herbs: 94) communities. Minimum number of species were recorded in Quercus semecarpifolia (Trees: 5; Shrubs: 2; Herbs: 34).

Amongst the identified forest communities, in the Hamta-Jagatsukh Catchments, the total tree density ranged from 30.0-1280.0 Ind ha^{-1} and total basal area from 0.74-1964.20m^2 ha^{-1}. *Pinus wallichiana* community had maximum tree density (120-1280 Ind ha^{-1}), followed by *Betula utilis-Acer acuminatum* mixed community (240-1020 Ind ha^{-1}), *Quercus semecarpifolia* (880-930 Ind ha^{-1}) and *Betula utilis* (850-920 Ind ha^{-1}), communities. *Abies pindrow* community showed maximum range of total basal area (12.4-1964.2 m^2 ha^{-1}), followed by *Quercus semecarpifolia* (382.2-1725.1 m^2 ha^{-1}) and *Picea smithiana* (10.8-1597.5m^2 ha^{-1}). *Quercus semecarpifolia-Abies pindrow* (1289.6 m^2 ha^{-1}) and *Cedrus deodara* (845.6 m^2 ha^{-1}), communities were represented in one site only. Among the alpine scrub communities, density ranged from 260-2090 Ind ha^{-1} and herb density ranged from 5390-9830 Ind ha^{-1}. *Rasa sericea-Berberis jaeschkeana* mixed community had maximum density (2090 Ind ha^{-1}), followed by *Juniperus indica* (1010 Ind ha^{-1}) and *Rhododendron anthopogon* (750 Ind ha^{-1}) communities. Amongst the alpine herb communities, *Carex foliosa-Sibbaldia cuneata-Artemisia vestita* mixed community had maximum herb density (9830 Ind ha^{-1}), followed by *Rhodiola bupleuroides-Potentilla atrosanguinea–Anaphalis triplinervis-Phlomis bracteosa* mixed community (9190 Ind ha^{-1})(Table 4.2.2).

Table 4.2.2. Community types, their Distribution, Density and Total Basal Area in Hamta and Jagatsukh Catchments, Himachal Pradesh

	Communities	SR	Habitat (s)	Altitudinal range (m)	Slope (^{o})	TBA (m^2ha^{-1})	Density (Ind ha^{-1})
A.	**Forests**						
1	***Pyrus pashia-Ilex dipyrena*** mixed	1	D	1992	55	0.74	60
2	*Picea smithiana*	12	SM, Ro, D, R	2063-2804	40-70	10.8-1597.5	30-640
3	*Pinus wallichiana*	4	SM, Ro, D	2020-2389	35-75	38.6-680.9	120-1280
4	*Abies pindrow*	8	SM, R	2461-3131	50-65	12.5-1964.2	70-720
5	*Quercus floribunda*	2	B, SM	2012-2067	35-40	31.4-83.6	250-330
6	*Acer acuminatum*	3	R, SM,	2771-3185	40-50	356.0-375.9	380-410
7	*Betula utilis*	2	SM, B	3160-3248	50	109.9-353.3	520-850
8	*Ulmus villosa*	2	D, R	2481-2105	55-60	3.4-382.8	50-370
9	*Quercus semecarpifolia*	2	R, SM	2785-3147	10-35	382.9-1725.1	880-930
10	*Cedrus deodara*	1	D	2229	40	845.6	230
11	***Betula utilis-Acer acuminatum*** mixed	3	R, RO	3120-3231	10-65	223.3-941.1	240-1020
12	***Picea smithiana-Aesculus indica*** mixed	2	SM, B, SW	2291-2456	45-70	10.1-427.8	150-360
13	*Juglans regia*	1	B	2618	30	694.2	380
14	***Quercus semecarpifolia-Abies pindrow*** mixed	1	SM	3050	30	1289.6	810
B.	**Shrubs**						
15	*Sorbaria tomentosa-Indigofera heterantha* mixed	1	D	2130	45	-	520

16	*Indigofera heterantha –Rabdosia rugosa -Spiraea canescens* mixed	1	D	2380	20	-	3890
C.	**Alpine Scrubs**						
17	*Juniperus indica*	1	AM	3440	45	-	1010
18	*Rosa sericea-Berberis jaeschkeana* mixed	1	AS	3851	60	-	2090
19	*Viburnum grandiflorum*	2	AM	3013-3030	50	-	260-350
20	*Rhododendron anthopogon*	1	Sc	3491	53	-	700
D.	**Alpine Herbs**						
21	*Dipsacus inermis-Sibbaldia cuneata-Anaphalis triplinervis* mixed	1	B	3777	35	-	5390
22	*Carex foliosa-Sibbaldia cuneata-Artemisia vestita* mixed	**1**	B	3560	45	-	9830
23	*Rhodiola bupleuroides-Potentilla atrosanguinea- Anaphalis triplinervis-Phlomis bracteosa* mixed	1	AM	3713	55	-	9190

Abbreviations used: SR=Site Representation; TBA=Total Basal Area; IVI=Importance Value Index; S=South; W= West; N= North; E=East; SW=South West; NW= North West; SE=South East; D=Degraded; SM=Shady Moist; R=Riverine; Dr=Dry forest; AM=Alpine Meadows; B=Bouldary; Ro=Rocky; Sc= Alpine Scrubs; OS=Open Slope

Table 4.2.3. Distribution pattern, latitude and longitude ranges of communities and their major associates in Hamta and Jagatsukh catchments

	Communities	Altitude range (m)	Aspects	Latitude	Longitude	Major associate
A	**Forests**					
1	*Pyrus pashia-Ilex dipyrena* mixed	1992	NW	$32^0$13.683' N	$77^0$12.497' E	*Quercus floribunda*
2	*Picea smithiana*	2063-2804	NW, NE, N, W, SW, SE	$32^0$11.261' - $32^0$14.234' N	$77^0$12.493'- $77^0$13.571' E	*Aesculus indica, Abies pindrow, Juglans regia*
3	*Pinus wallichiana*	2020-2389	S, NW, W	$32^0$11.799' - $32^0$13.604' N	$77^0$12.443'- $77^0$14.005' E	*Cedrus deodara, Picea smithiana*
4	*Abies pindrow*	2461-3131	W, N, NW	$32^0$11.206' - $32^0$16.010' N	$77^0$12.938'- $77^0$15.842' E	*Aesculus indica, Picea smithiana, Acer acuminatum*
5	*Quercus floribunda*	2012-2067	NW, S	$32^0$11.842' - $32^0$13.604' N	$77^0$12.415'- $77^0$12.924' E	*Picea smithiana*
6	*Acer acuminatum*	2771-3185	NW	$32^0$11.850' - $32^0$15.540' N	$77^0$14.571'- $77^0$16.153' E	*Betula utilis, Abies pindrow, Quercus semecarpifolia*
7	*Betula utilis*	3160-3248	N,NW	$32^0$11.958' - $32^0$16.012' N	$77^0$15.281'- $77^0$16.212' E	*Acer acuminatum, Abies pindrow*
8	*Ulmus villosa*	2481-2105	W	$32^0$13.683' - $32^0$13.951' N	$77^0$12.767'- $77^0$12.905' E	*Prunus cornuta, Salix daphnoides, Celtis australis*
9	*Quercus semecarpifolia*	2785-3147	NW, SW	$32^0$13.662' - $32^0$15.643' N	$77^0$14.009'- $77^0$14.472' E	*Betula utilis, Taxus baccata* subsp. *wallichiana, Abies pindrow*
10	*Cedrus deodara*	2229	W	$32^0$13.362' N	$77^0$12.621'E	*Picea smithiana, Pinus wallichiana*

11	*Betula utilis- Acer acuminatum* mixed	3120-3231	S, W, N	$32^0$11.918' - $32^0$14.770' N	$77^0$14.430'- $77^0$16.885' E	*Prunus cornuta, Abies pindrow*
12	*Picea smithiana-Aesculus indica* mixed	2291-2456	NE	$32^0$11.799' - $32^0$13.486' N	$77^0$13.479'- $77^0$13.742' E	*Abies pindrow, Cedrus deodara*
13	*Juglans regia*	2618	W	$32^0$14.144' N	$77^0$12.493'- $77^0$13.195' E	*Aesculus indica, Picea smithiana*
14	*Q uercus semecarpifolia-Abies pindrow* mixed	3050	SE	$32^0$13.576' N	$77^0$13.665' E	*Taxus baccata* subsp. *wallichiana, Picea smithiana*
B.	**Shrubs**					
15	*Indigofera heterantha - Sorbaria tomentosa* mixed	2130	SW	$32^0$11.795' N	$77^0$13.773' E	*Cyathula tomentosa, Spiraea canescens*
16	*Indigofera heterantha – Rabdosia rugosa -Spiraea canescens* mixed	2380	W	$32^0$11.834' N	$77^0$14.019' E	*Prinsepia utilis, Sorbaria tomentosa*
C.	**Alpine Scrubs**					
17	*Juniperus indica*	3440	NW	$32^0$14.533' N	$77^0$14.690' E	*Rosa sericea, Cotoneaster acuminatum*
18	*Rosa sericea -Berberis jaeschkeana* mixed	3851	N	$32^0$14.214' N	$77^0$14.676' E	*Juniperus indica, cotoneaster acuminatus*
19	*Viburnum grandiflorum*	3013-3030	S, W	$32^0$13.640'- $32^0$16.120' N	$77^0$13.430'- $77^0$15.009'E	*Rosa sericea, Cotoneaster acuminaum*
20	*Rhododendron anthopogon*	3491	SW	$32^0$11.302' N	$77^0$18.504' E	*Rosa sericea*
D.	**Alpine Herbs**					
21	*Dipsacus inermis-Sibbaldia cuneata-Anaphalis triplinervis*	3777	S	$32^0$11.445' N	$77^0$18.751' E	*Potentilla atrosanguinea,*

	mixed					*Sibbaldia cuneata*
22	*Carex foliosa-Sibbaldia cuneata-Artemisia vestita* mixed	3560	NW	N32^{0}14.372' N	77^{0}14.849' E	*Anaphalis busua, Potentilla atrosanguinea*
23	*Rhodiola bupleuroides-Potentilla atrosanguinea-Anaphalis triplinervis-Phlomis bracteosa* mixed	3713	NW	32^{0}11.500' N	77^{0}18.436' E	*Anemone rupicola*

Abbreviations used: SR=Site Representation; S=South; W=West; N=North; E=East; SW=South West; NW=North West; SE=South East; D=Degraded; SM=Shady Moist; R=Riverine; Dr=Dry forest; AM=Alpine Meadows; B=Bouldary; Ro=Rocky; Sc=Alpine Shrubbery; OS=Open Slope

4.2.3. Communities: Composition, Structure and Regeneration Pattern

Composition, structure and regeneration pattern of the communities identified in Hamta- Jagatsukh Catchments have been described below:

A. Forests Communities

1. Pyrus pashia-Ilex dipyrena mixed community

This community has been represented in 1 site of Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1
Composition and structure

A total of 91 species (Trees: 5; Shrubs: 19; Herbs: 67) were recorded in this community. The total tree density and total basal area were 60.00 Ind ha^{-1} and 0.74m^2 ha^{-1}, respectively. *Pyrus pashia,* (Density: 20.00 Ind ha^{-1}, Basal area: 0.33m^2 ha^{-1}, IVI: 118.76) was the dominant tree and *Ilex dipyrena* (Density: 20.00 Ind ha^{-1}, Basal area: 0.22m^2 ha^{-1}, IVI: 98.07), and *Quercus floribunda* (Density: 20.00 Ind ha^{-1}, Basal area: 0.19m^2 ha^{-1}, IVI: 83.16) were codominant trees of this community (Table 4.4.4, 5, & 6).

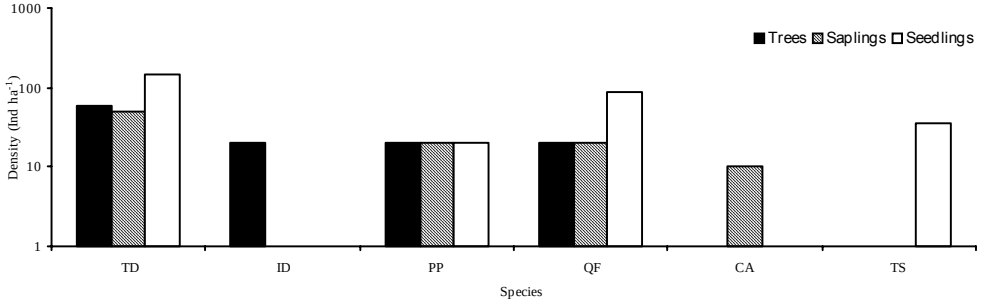
Among the shrubs highest density was shown by *Sarcococa saligna* (20.9%), followed by *Rabdosia rugosa* (12.3%), *Indigofera heterantha* and *Hedera nepalense* (9.8%, each) (Table 4.2.7), and among herbs highest density was shown by *Carex brevicaulis* (16.7%), followed by *Stellaria media* (7.7%) and *Chrysopogon echinulatus* (7.05%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Pyrus pashia-Ilex dipyrena* mixed community have been presented in Fig. 4.2.1

Total seedlings and saplings densities were 155.00 Ind ha^{-1} and 10.00 Ind ha^{-1}, respectively. Among the saplings, *Pyrus pashia* and *Quercus floribunda* showed high density (20.00 Ind ha^{-1} each), followed by *Celtis australis* (Density: 10.00 Ind ha^{-1}). Among seedlings, highest density was shown by *Quercus floribunda* (90.00 Ind ha^{-1}), followed by *Toona serrata* (36.36 Ind ha^{-1}) and *Pyrus pashia* (20.00 Ind ha^{-1}).

Fig. 4.2.1. Population structure of *Pyrus pashia-Ilex dipyrena* community



Abbreviations used: TD=Total density; ID=*Ilex dipyrena*; PP= *Pyrus pashia;* QF=*Quercus floribunda* CA=*Celtis australis;* and TS= *Toona serrata*

2. Picea smithiana community

This community has been represented in 12 sites in both the Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 192 species (Trees: 14; Shrubs: 32; Herbs: 146) were recorded in this community. The total tree density and total basal area were 346.80 Ind ha^{-1} and 757.23m^2 ha^{-1}, respectively. *Picea smithiana* (Density: 200.83 Ind ha^{-1}, Basal area: 712.75m^2 ha^{-1}, IVI: 218.30) was the dominant tree and, *Abies pindrow* (Density: 50.83 Ind ha^{-1}, Basal area: 40.34 m^2 ha^{-1}, IVI: 37.72), *Rhus javanica* (Density: 18.33 Ind ha^{-1}, Basal area: 0.36m^2 ha^{-1}, IVI: 8.48) and *Pinus wallichiana* (Density: 15.83 Ind ha^{-1}, Basal area: 0.03 m^2 ha^{-1}, IVI: 4.86) were the major tree associates (Table 4.4.4, 5, & 6).

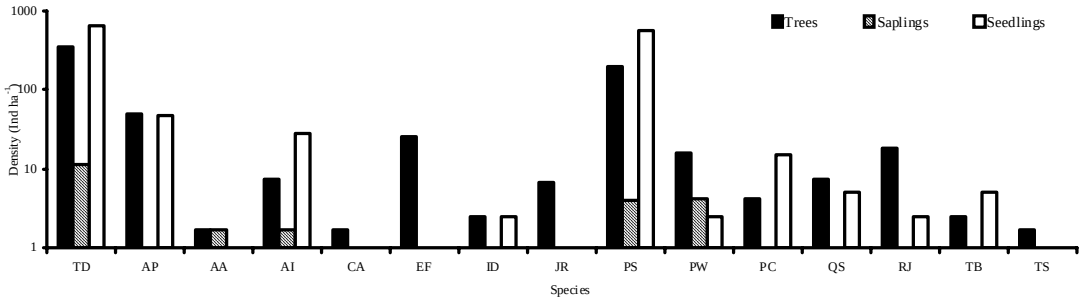
Among the shrubs highest density was shown by *Sorbaria tomentosa* (40.50%), followed by *Viburnum cotonifolium* (18.20%) and *Rubus ellipticus* (6.20%) (Table 4.2.7), and among herbs highest density was shown by *Adiantum capillus-veneris* (6.11%), followed by *Fragaria nubicola* (5.86%) and *Carex nubigena* (5.14%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Picea smithiana* community have been presented in Fig. 4.2.2.

Total seedlings and saplings densities were 655.00 Ind ha^{-1} and 11.6 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Picea smithiana* (4.20 Ind ha^{-1}), followed by *Pinus wallichiana* (4.2 Ind ha^{-1}), and seedlings, highest density was shown by *Picea smithiana* (547.50 Ind ha^{-1}), followed by *Abies pindrow* (47.50 Ind ha^{-1}) and *Aesculus indica* (27.50 Ind ha^{-1}). The remaining species showed less regeneration and *Celtis australis, Acer acuminatum* and *Juglans regia* showed no regeneration.

Fig. 4.2.2. Population structure of *Picea smithiana* **community**



Abbreviations used: TD=Total density; AP= *Abies pindrow*; AA=*Acer acuminatum*; AI = *Aesculus indica*; CA=*Celtis australis*; EF=*Euonymus fimbriatus*; ID=*Ilex dipyrena;* JR=*Juglans regia*; PS=*Picea smithiana*; PW=*Pinus wallichiana*; PC=*Prunus cornuta*; QS=*Quercus semecarpifolia*; RJ=*Rhus javanica*; TB=*Taxus baccata* subsp*. wallichiana*; and TS=*Toona serrata.*

3. *Pinus wallichiana* community

This community has been represented in 4 sites of the both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 103 species (Trees: 9; Shrubs: 27; Herbs: 67) were recorded in this community. The total tree density and total basal area were 477.50 Ind ha^{-1} and 372.39m^2 ha^{-1}, respectively. *Pinus wallichiana* (Density: 367.50 Ind ha^{-1}, Basal area: 225.61.45m^2 ha^{-1}, IVI: 204.72) was the dominant tree and *Cedrus deodara* (Density: 97.5.00 Ind ha^{-1}, Basal area: 146.06m^2 ha^{-1}, IVI: 70.19) and *Picea smithiana* (Density: 5.00 Ind ha^{-1}, Basal area: 0.67m^2 ha^{-1}, IVI: 9.42) were the major tree associates (Table 4.4.4, 5, & 6).

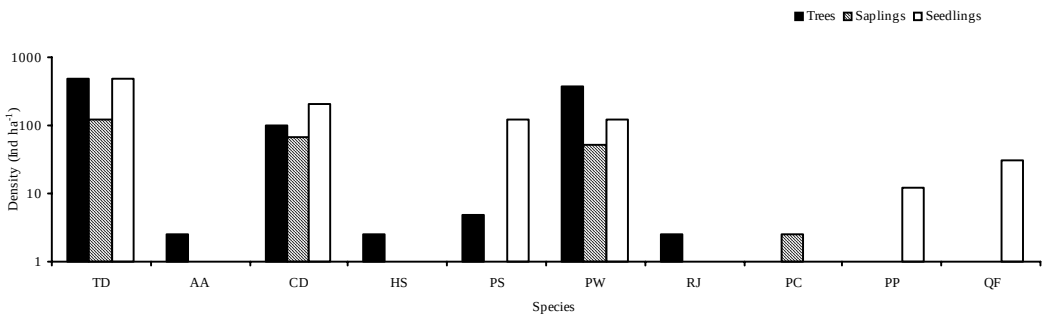
Among the shrubs, highest density was shown by *Indigofera heterantha* (18.2%), followed by *Desmodium elegans* (15.70%) and *Berberis lycium* (12.90%), (Table 4.2.7), and among herbs, highest density was shown by *Carex brevicaulis* (27.40%), followed by *Eragrostis pilosa* (5.98%) and *Chrysopogon gryllus* (4.68%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Pinus wallichiana* community have been presented in Fig. 4.2.3.

Total seedlings and saplings densities were 495.00 Ind ha^{-1} and 123.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Cedrus deodara* (67.50 Ind ha^{-1}), followed by *Pinus wallichiana* (52.50 Ind ha^{-1}) and *Prunus cornuta* (2.50 Ind ha^{-1}), and among seedlings, highest density was shown by *Cedrus deodara* (207.5 Ind ha^{-1}), followed by *Picea smithiana* and *Pinus wallichiana* (122.50 Ind ha^{-1} each). *Hippophae salicifolia*, *Acer acuminatum* and *Rhus javanica* did not show regeneration.

Fig. 4.2.3. Population structure of *Pinus wallichiana* community



TD=Total density; AA=*Acer acuminatum*; CD=*Cedrus deodara*; HS=*Hippophae salicifolia;* PS=*Picea smithiana*;

PW=*Pinus wallichiana*; RJ=*Rhus javanica*; PC=*Prunus cornuta*; PP=*Pyrus pashia:* and QF=*Quercus floribunda*

4. *Abies pindrow* Community

This community has been represented in 8 sites of the both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 134 species; (Trees: 10; Shrubs: 20; Herbs: 104) were recorded in this community. The total tree density and total basal area were 455.62 Ind ha^{-1} and 807.14m^2 ha^{-1}, respectively. *Abies pindrow* (Density: 307.50 Ind ha^{-1}, Basal area: 743.79 m^2 ha^{-1}, IVI: 204.67) was the dominant tree and, *Picea smithiana* (Density: 45.00 Ind ha^{-1}, Basal area: 9.50 m^2 ha^{-1}, IVI: 41.03) and *Acer acuminatum* (Density: 37.88 Ind ha^{-1}, Basal area: 31.47 m^2 ha^{-1}, IVI: 17.6) were the major tree associates (Table 4.4.4, 5, & 6).

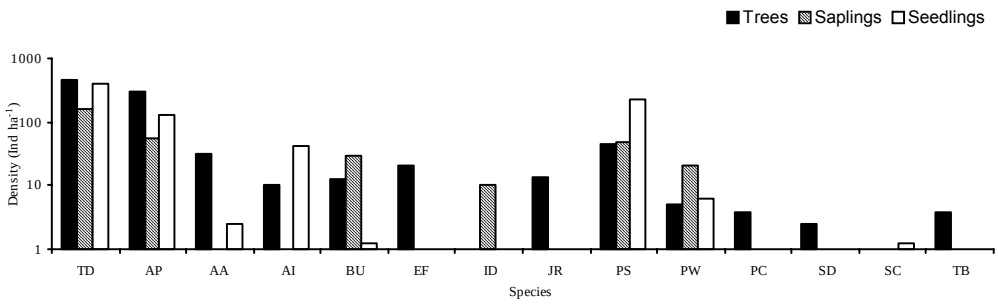
Among the shrubs, highest density was shown by *Sorbaria tomentosa* (30.90%), followed by *Viburnum cotonifolium* (30.10%) and *Indigofera heterantha* (14.40%) (Table 4.2.7), and among herbs, highest density was shown by *Trifolium pratense* (11.90%), followed by *Fragaria nubicola* (5.89%) and *Adiantum capillus-veneris* (4.55%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Abies pindrow* community have been presented in Fig.4.2.4.

Total seedlings and saplings densities were 410.00 Ind ha^{-1} and 163.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by Abies pindrow (55.00 Ind ha^{-1}), followed by *Picea smithiana* (47.50 Ind ha^{-1}), and *Betula utilis* (30.00 Ind ha^{-1}), and seedlings, highest density was shown by *Picea smithiana* (226.3.00 Ind ha^{-1}), followed by *Abies pindrow* (130.00 Ind ha^{-1}) and *Aesculus indica* (42.50 Ind ha^{-1}). The remaining species showed poor regeneration. *Prunus cornuta, Taxus baccata* subsp*. wallichiana* and *Juglans regia* showed no regeneration.

Fig. 4.2.4. Population structure of *Abies pindrow* community



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum;* AI= *Aesculus indica*; BU=*Betula utilis*; EF=*Euonymus fimbriatus*; ID=*Ilex dipyrena*; JR=*Juglans regia*; PS=*Picea smithiana*; PW=*Pinus wallichiana*; PC= *Prunus cornuta*; SD=*Salix daphnoides;* SC=*Symplocos chinensis* and TB =*Taxus baccata* subsp *wallichiana*

5. *Quercus floribunda* community

This community has been represented in 2 sites of the both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 86 species (Trees: 8; Shrubs: 21; Herbs: 57) were recorded in this community. The total tree density and total basal area were 295.00 Ind ha^{-1} and 99.32m^2 ha^{-1}, respectively. *Quercus floribunda* (Density: 285.50 Ind ha^{-1}, Basal area: 57.51m^2 ha^{-1}, IVI: 292.4) was the dominant tree and *Picea smithiana* (Density: 10.00 Ind ha^{-1}, Basal area: 41.81m^2 ha^{-1}, IVI: 7.55) is the only tree associates (Table 4.4.4, 5, & 6).

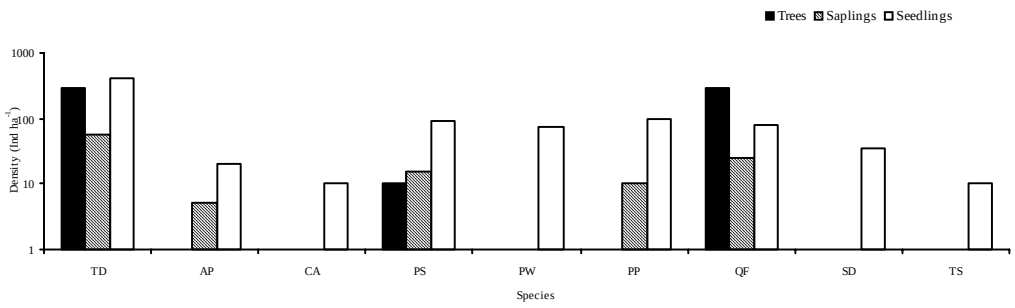
Among the shrubs, highest density was shown by *Berberis lycium* (34.50%), followed by *Prinsepia utilis* (12.30%) and *Spiraea canescens* (12.10%), (Table 4.2.7), and among herbs, highest density was shown by *Carex nubigena* (12.70%), followed by *Trifolium pratense* (7.00%) and *Galium aparine* (4.64%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Quercus floribunda* community have been presented in Fig. 4.2.5.

Total seedlings and saplings densities were 420.00 Ind ha^{-1} and 55.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Quercus floribunda* (25.00 Ind ha^{-1}), followed by *Picea smithiana* (15.00 Ind ha^{-1}) and *Pyrus pashia* (10.00 Ind ha^{-1}), and among seedlings, highest density was shown by *Pyrus pashia* (100.00 Ind ha^{-1}), followed by *Picea smithiana* (90.00 Ind ha^{-1}) and *Quercus floribunda* (80.00 Ind ha^{-1}). High regeneration of *Pyrus pashia*, *Pinus wallichiana* and *Salix daphnoides* indicates the proliferation of these species in this community.

Fig. 4.2.5. Population structure of *Quercus floribunda* community



Abbreviations used: TD=Total density; AP=*Abies pindrow;* CA=*Celtis australis;* PS=*Picea smithiana;* PW=*Pinus wallichiana*; PP=*Pyrus pashia*; QF= *Quercus floribunda*; SD=*Salix daphnoides*; and TS=*Toona serrata*

6. *Acer acuminatum* Community

This community has been represented in 3 sites of the both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

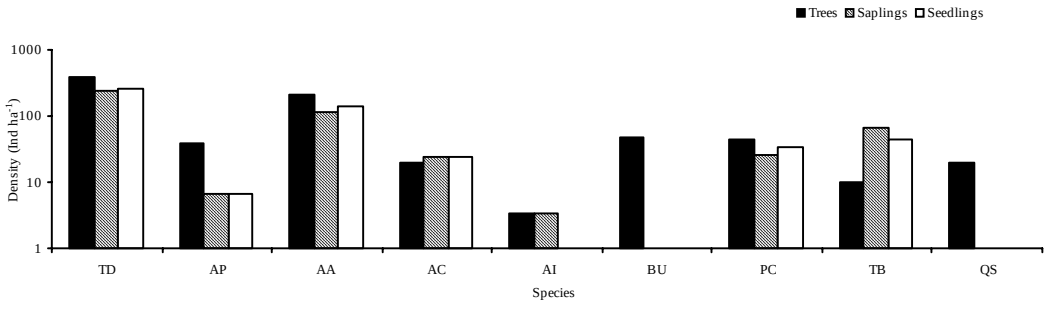
A total of 50 species (Trees: 8; Shrubs: 5; Herbs: 37) were recorded in this community. The total tree density and total basal area were 390.00 Ind ha^{-1} and 365.07m^2 ha^{-1}, respectively. *Acer acuminatum* (Density: 206.67 Ind ha^{-1}, Basal area: 303.43m^2 ha^{-1}, IVI: 179.2) was the dominant tree and *Betula utilis* (Density: 46.66 Ind ha^{-1}, Basal area: 17.86m^2 ha^{-1}, IVI: 30.67) and *Prunus cornuta* (Density: 43.33 Ind ha^{-1}, Basal area: 12.38m^2 ha^{-1}, IVI: 29.7) were the major tree associates (Table 4.4.4, 5, & 6).

Among the shrubs, highest density was shown by *Rosa macrophylla* (39.40%), followed by *Viburnum cotonifolium* (23.50%) and *Deutzia corymbosa* (10.90%) (Table 4.2.7), and among herbs, highest density was shown by *Bistorta amplexicaulis* (14.10%), followed by *Pteris cretica* (9.49%) and *Agrostis pilosula* (8.70%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in Acer acuminatum community have been presented in Fig. 4.2.6.
Total seedlings and saplings densities were 250.00 Ind ha^{-1} and 243.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Acer acuminatum* (116.70 Ind ha^{-1}), followed by *Taxus baccata* subsp*. wallichiana* (66.67 Ind ha^{-1}) and *Prunus cornuta* (26.67 Ind ha^{-1}), and among seedlings, highest density was shown by *Acer acuminatum* (143.30 Ind ha^{-1}), followed by *Taxus baccata* subsp*. wallichiana* (43.33 Ind ha^{-1}) and *Prunus cornuta* (33.33 Ind ha^{-1}). *Betula utilis* and *Quercus semecarpifolia* showed no regeneration in this community.

Fig. 4.2.6. Population structure of *Acer acuminatum* community



Abbreviations used: TD=Total density; AP=*Abies pindrow;* AA=*Acer acuminatum;* AC=*Acer caesium*; AI=*Aesculus indica;* BU=*Betula utilis;* PC= *Prunus cornuta;* TB=*Taxus baccata* subsp. *wallichiana*; and QS=*Quercus semecarpifolia*

7. *Betula utilis* Community

This community has been represented in 2 sites of the both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 79 species (Trees: 5; Shrubs: 21; Herbs: 53) were recorded in this community. The total tree density and total basal area were 665.00 Ind ha^{-1} and 244.92m^2 ha^{-1}, respectively. *Betula utilis* (Density: 445.50 Ind ha^{-1}, Basal area: 174.35m^2 ha^{-1}, IVI: 170.4) was the dominant tree and *Acer acuminatum* (Density: 150.00 Ind ha^{-1}, Basal area: 63.49m^2 ha^{-1}, IVI: 100.02) and *Prunus cornuta* (Density: 25.00 Ind ha^{-1}, Basal area: 1.17m^2 ha^{-1}, IVI: 9.73) were the major tree associates (Table 4.4.4, 5, & 6).

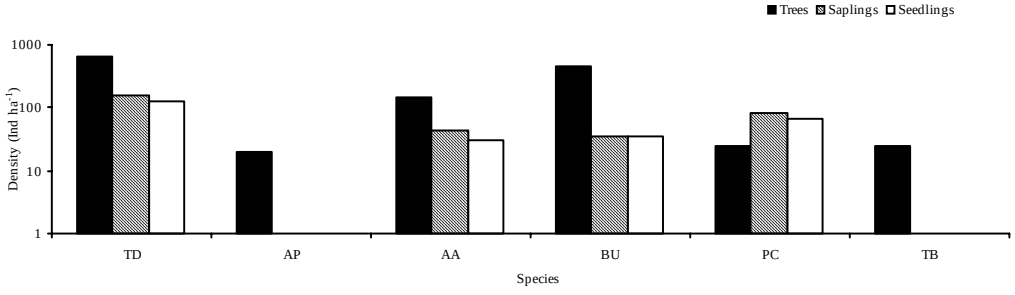
Among the shrubs, highest density was shown by *Viburnum cotonifolium* (37.20%), followed by *Rosa macrophylla* (29.0%) and *Rhododendron campanulatum* (9.67%) (Table 4.2.7), and among herbs, highest density was shown by *Thalictrum cultratum* (9.45%), followed by *Impatiens bicolor* (8.40%) and *Carex nubigena* (5.64%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Betula utilis* community have been presented in Fig. 4.2.7.

Total seedlings and saplings densities were 130.00 Ind ha^{-1} and 160.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Prunus cornuta* (80.00 Ind ha^{-1}), followed by *Acer acuminatum* (45.00 Ind ha^{-1}) and *Betula utilis* (35.00 Ind ha^{-1}). Among seedlings, highest density was shown by *Prunus cornuta* (65.00 Ind ha^{-1}), followed by *Betula utilis* (35.00 Ind ha^{-1}) and *Acer acuminatum* (30.00 Ind ha^{-1} each). *Abies pindrow* and *Taxus baccata* subsp. *wallichiana* did not show regeneration.

Fig. 4.2.7. Population structure of *Betula utilis* community



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum*; BU=*Betula utilis*; PC=*Prunus cornuta* and TB=*Taxus baccata* subsp. *wallichiana*

8. *Ulmus villosa* community

This community has been represented in 2 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 119 species (Trees: 5; Shrubs: 20; Herbs: 94) were recorded in this community. The total tree density and total basal area were 210.00 Ind ha^{-1} and 193.07m^2 ha^{-1}, respectively. *Ulmus villosa* (Density: 105.00 Ind ha^{-1}, Basal area: 185.15m^2 ha^{-1}, IVI: 178.38) was the dominant tree and *Prunus cornuta* (Density: 55.00 Ind ha^{-1}, Basal area: 3.80m^2 ha^{-1}, IVI: 26.38) and *Picea smithiana* (Density: 20.00 Ind ha^{-1}, Basal area: 2.80m^2 ha^{-1}, IVI: 38.04) were major tree associates (Table 4.4.4, 5, & 6).

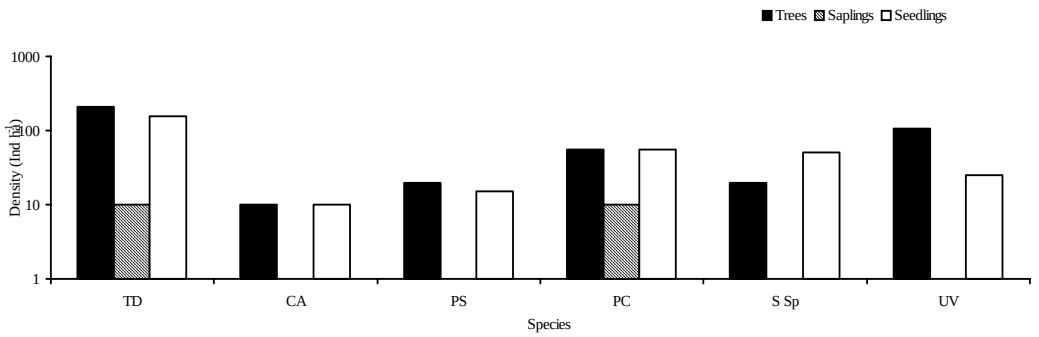
Among the shrubs, highest density was shown by *Sorbaria tomentosa* (29.30%) followed by *Rubus ellipticus* (12.40%), *Berberis lycium* (11.90%) and *Viburnum mullaha* (8.90%) (Table 4.2.7), and among herbs, highest density was shown by *Carex nubigena* (12.90%), followed by *Trifolium pratense* (7.75%) and *Cyanodon dactylon* (6.48%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Ulmus villosa* community have been presented in Fig. 4.2.8.

Total seedlings and saplings densities were 155.00 Ind ha^{-1} and 10.00 Ind ha^{-1}, respectively. Among the saplings, only *Prunus cornuta* showed regeneration (10.00 Ind ha^{-1}) and among seedlings, highest density was shown by *Prunus cornuta* (100.00 Ind ha^{-1}), followed by *Salix daphnoides* (50.00 Ind ha^{-1}) and *Ulmus villosa* (25.00 Ind ha^{-1}).

Fig. 4.2.8. Population structure of *Ulmus villosa* community



Abbreviations used: TD=Total density; CA=*Celtis australis*; PS=*Picea smithiana;* PC= *Prunus cornuta;* ST= *Salix daphnoides*; and UV=*Ulmus villosa*

9. *Quercus semecarpifolia* community

This community has been represented in 2 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 76 species (Trees: 8 species; Shrubs: 2 species; Herbs: 66 species) were recorded in this community. The total tree density and total basal area were 905.00 Ind ha^{-1} and 105.32m^2 ha^{-1}, respectively. *Quercus semecarpifolia* (Density: 795.00 Ind ha^{-1}, Basal area: 104.9m^2 ha^{-1}, IVI: 243.39) was the dominant tree and *Taxus baccata* subsp*. wallichiana* (Density: 50.00 Ind ha^{-1}, Basal area: 0.17m^2 ha^{-1}, IVI: 22.58) and *Betula utilis* (Density: 20.00 Ind ha^{-1}, Basal area: 0.03m^2 ha^{-1}, IVI: 7.22) were the major tree associates (Table 4.4.4, 5, & 6).

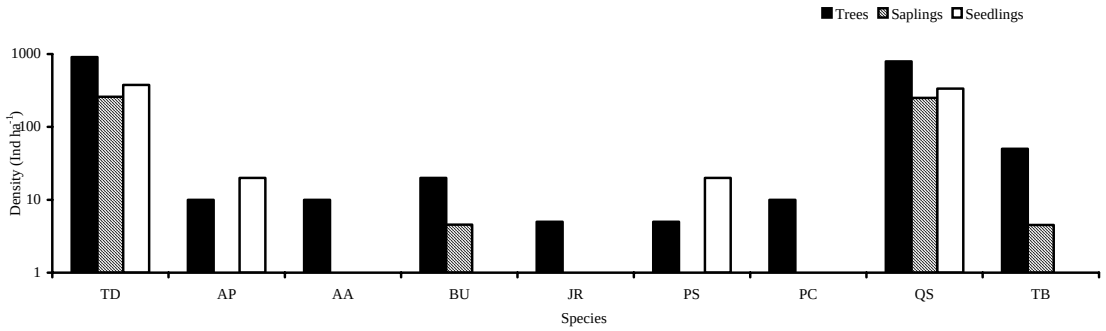
Among the shrubs, highest density was shown by *Viburnum mullaha* (58.50%), followed by *Clematis buchananiana* (29.0%) and *Rosa macrophylla* (12.00%) (Table 4.2.7), and among herbs, highest density was shown by *Bistorta amplexicaulis* (10.60%), followed by *Impatiens arguta* (7.03%) and *Circaea alpina* (6.99%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Quercus semecarpifolia* community have been presented in Fig. 4.2.9.

Total seedlings and saplings densities were 375.00 Ind ha^{-1} and 259.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Quercus semecarpifolia* (250.0 Ind ha^{-1}), followed by *Taxus baccata* subsp*. wallichiana* (4.50 Ind ha^{-1}) and *Betula utilis* (4.50 Ind ha^{-1}), and among seedlings, highest density was shown by *Quercus semecarpifolia* (335.00 Ind ha^{-1}), followed by *Picea smithiana* (20.00 Ind ha^{-1}) and *Abies pindrow* (20.00 Ind $ha^{-1)}$. *Acer acuminatum* and *Prunus cornuta* showed no regeneration in this community.

Fig. 4.2.9. Population structure of *Quercus semecarpifolia* community



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum*; BU=*Betula utilis*; JR=*Juglans regia*:

PC=*Picea smithiana*; PC=*Prunus cornuta*; QS=*Quercus semecarpifolia*; and TB=*Taxus baccata* subsp. *wallichiana*

10*. Cedrus deodara* community

This community has been represented in 1 site of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 44 species (Trees: 3; Shrubs: 8; Herbs: 33) were recorded in this community. The total tree density and total basal area were 230.00 Ind ha^{-1} and 846.89m^2 ha^{-1}, respectively. *Cedrus deodara* (Density: 190.00 Ind ha^{-1}, Basal area: 842.89m^2 ha^{-1}, IVI: 251.50) was the dominant tree and, *Picea smithiana* (Density: 20.00 Ind ha^{-1}, Basal area: 1.45m^2 ha^{-1}, IVI: 24.25) and *Pinus wallichiana* (Density: 20.00 Ind ha^{-1}, Basal area: 1.26 m^2 ha^{-1}, IVI: 24.23) were the major tree associates (Table 4.4.4, 5, & 6).

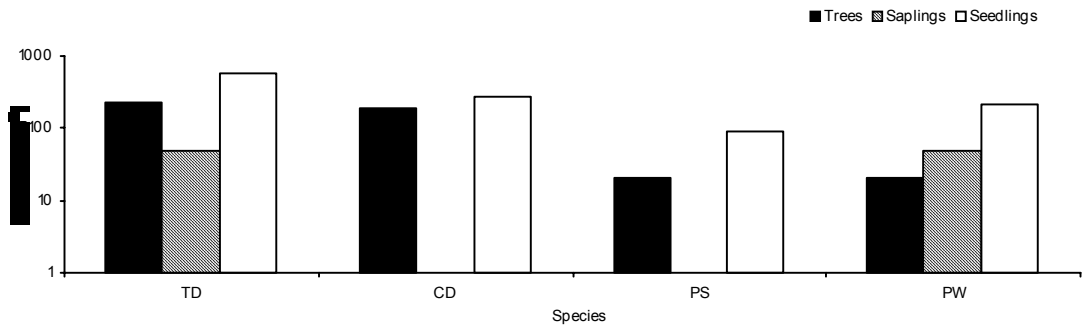
Among the shrubs, highest density was shown by *Indigofera heterantha* (39.20%), followed by *Buddleja crispa* (19.70%) and *Berberis lycium* (12.5%) (Table 4.2.7), and among herbs, highest density was shown by *Carex nubigena* (16.30%), followed by *Oxalis corniculata* (8.37%) and *Trifolium pratense* (7.44%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Cedrus deodara* community have been presented in Fig. 4.2.10.

Total seedlings and saplings densities were 580.00 Ind ha^{-1} and 50.00 Ind ha^{-1}, respectively. In the saplings, only *Abies pindrow* (50.00Ind ha^{-1}) showed regeneration, and among seedlings, highest density was shown by *Cedrus deodara* (270.00 Ind ha^{-1}), followed by *Pinus wallichiana* (220.00 Ind ha^{-1}) and *Picea smithiana* (90.00 Ind ha^{-1}).

Fig. 4.2.10. Population structure of *Cedrus deodara* community



Abbreviations used: TD=Total density; CD=*Cedrus deodara*; PS=*Picea smithiana*; AN=*Alnus nitida;* and PW= *Pinus wallichiana*

11. Betula utilis-Acer acuminatum mixed community

This community has been represented in 3 sites of the both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1

Composition and structure

A total of 84 species (Trees: 6; Shrubs: 8; Herbs: 70) were recorded in this community. The total tree density and total basal area were 340.00 Ind ha^{-1} and 313.69m^2 ha^{-1}, respectively. *Betula utilis* (Density: 143.33 Ind ha^{-1}, Basal area: 154.13m^2 ha^{-1}, IVI: 127.5) was the dominant tree and *Acer acuminatum* (Density: 126.67 Ind ha^{-1}, Basal area: 162.87m^2 ha^{-1}, IVI: 115.5) and *Prunus cornuta* (Density: 36.67 Ind ha^{-1}, Basal area: 27.78m^2 ha^{-1}, IVI: 27.39), respectively were the co-dominant species (Table 4.4.4, 5, & 6).

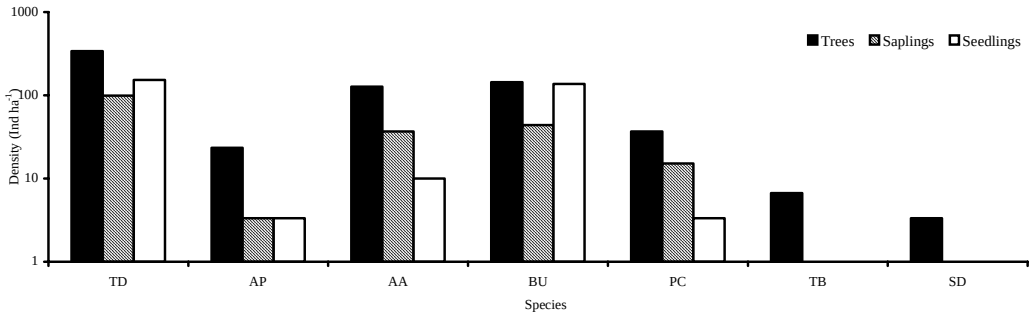
Among the shrubs, highest density was shown by *Viburnum cotonifolium* (37.30%), followed by *Rosa macrophylla* (29.00%) and *Rhododendron campanulatum* (9.46%) (Table 4.2.7), and among herbs, highest density was shown by *Impatiens bicolor* (7.07%), followed by *Agrostis pilosula* (6.82%) and *Carex foliosa* (6.47%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Betula utilis-Acer acuminatum* community have been presented in Fig. 4.2.11.

Total seedlings and saplings densities were 153.00 Ind ha^{-1} and 99.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Betula utilis* (43.89 Ind ha^{-1}), followed by *Acer acuminatum* (36.67 Ind ha^{-1}) and *Prunus cornuta* (15.50 Ind ha^{-1}), and among seedlings, highest density was shown by *Betula utilis* (136.70 Ind ha^{-1}), followed by *Acer acuminatum* (10.00 Ind ha^{-1}) and *Prunus cornuta* (3.33 Ind ha^{-1}). *Salix daphnoides* and *Taxus baccata* subsp. *wallichiana* did not show regeneration.

Fig. 4.2.11. Population structure of *Betula utilis-Acer acuminatum* **mixed community**



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum*; BU=*Betula utilis*; PC=*Prunus cornuta*; TB=*Taxus baccata* subsp. *wallichiana* and SD= *Salix daphnoides*

12. Picea smithiana–Aesculus indica mixed community

This community has been represented in 2 sites of the Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 73 species (Trees: 7; Shrubs: 14; Herbs: 52) were recorded in this community. The total tree density and total basal area were 330.00 Ind ha^{-1} and 218.92m^2 ha^{-1}, respectively. *Picea smithiana* (Density: 160.00 Ind ha^{-1}, Basal area: 85.45m^2 ha^{-1}, IVI: 133.5) was the dominant tree and, *Aesculus indica* (Density: 80.00 Ind ha^{-1}, Basal area: 103.95m^2 ha^{-1}, IVI: 71.64) was codominant tree species and *Abies pindrow* (Density: 45.00 Ind ha^{-1}, Basal area: 28.85m^2 ha^{-1}, IVI: 30.35) was the major tree associate (Table 4.4.4, 5, & 6).

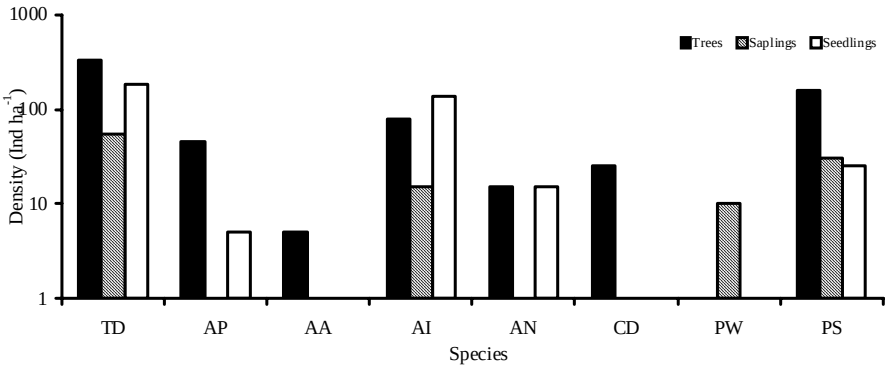
Among the shrubs, highest density was shown by *Rubus ellipticus* (26.60%), followed by *Indigofera heterantha* (18.40%) and *Desmodium elegans* (14.30%), (Table 4.2.7), and among herbs, highest density was shown by *Carex nubigena* (19.30%), followed by *Polygonum recumbens* (9.89%) and *Adiantum capillus-veneris* (8.30%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Picea smithiana–Aesculus indica* mixed community have been presented in Fig. 4.2.12.

Total seedlings and saplings densities were 180.00 Ind ha^{-1} and 55.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Picea smithiana* (30.00 Ind ha^{-1}), followed by *Aesculus indica* (15.00 Ind ha^{-1}) and *Pinus wallichiana* (10.00 Ind ha^{-1}), and among seedlings, highest density was shown by *Aesculus indica* (135.00 Ind ha^{-1}), followed by *Picea smithiana* (25.00 Ind ha^{-1}) and *Alnus nitida* (15.00 Ind ha^{-1}). *Cedrus deodara* and *Acer acuminatum* showed no regeneration.

Fig. 4.2.12. Population structure of *Picea smithiana – Aesculus indica* **community**



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum;* AI=*Aesculus indica;* AN=*Alnus nitida*; CD=*Cedrus deodara*; PW=*Pinus wallichiana*; PS=*Picea smithiana*

13. Juglans regia community

This community has been represented in 1 site of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 47 species (Trees: 3; Shrubs: 4; Herbs: 40) were recorded in this community. The total tree density and total basal area were 380.00 Ind ha^{-1} and 69.420m^2 ha^{-1}, respectively. *Juglans regia* (Density: 340.00 Ind ha^{-1}, Basal area: 68.89m^2 ha^{-1}, IVI: 260.40) was the dominant tree and *Aesculus indica* (Density: 30.00 Ind ha^{-1}, Basal area: 0.49m^2 ha^{-1}, IVI: 30.03) and *Picea smithiana* (Density: 10.00 Ind ha^{-1}, Basal area: 0.24m^2 ha^{-1}, IVI: 9.81) are the major tree associates (Table 4.4.4, 5, & 6).

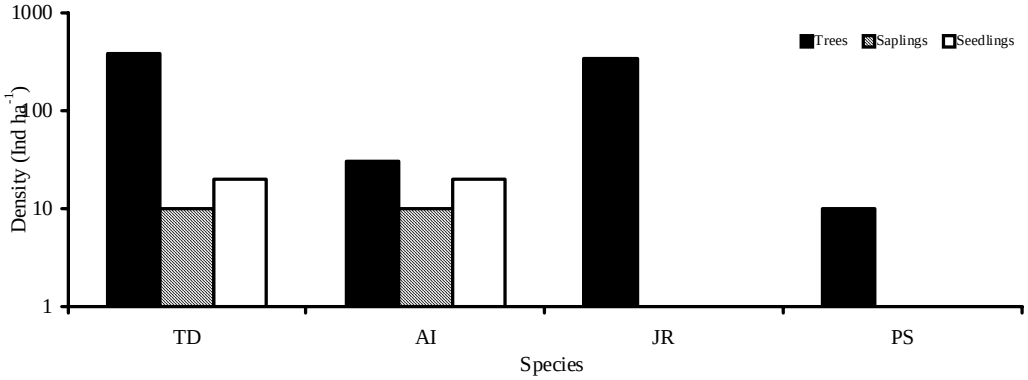
Among the shrubs highest density was shown by *Prinsepia utilis* (41.70%), followed by *Rosa brunonii* (22.20%) and *Viburnum cotonifolium* (19.40%) (Table 4.2.7), and among herbs highest density was shown by *Pteris cretica* (12.2%), followed by *Eragrostis pilosa* (9.78%) and *Festuca rubra* (9.76%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Juglans regia* community have been presented in Fig 4.2.13.

Total seedlings and saplings densities were 10.00 Ind ha^{-1} and 20.00 Ind ha^{-1}, respectively. Among the seedlings and saplings, only *Aesculus indica* 10.00 Ind ha^{-1} and 20.00 Ind ha^{-1}, respectively showed regeneration. *Picea smithiana* and *Juglans regia* did not show regeneration.

Fig. 4.2.13. Population structure of *Juglans regia* community



Abbreviations used: TD=Total density; AI=*Aesculus indica;* JR= *Juglans regia*; and PS=*Picea smithiana*

14. Quercus semecarpifolia-Abies pindrow mixed community

This community has been represented in 1 site of the Hamta catchment. The altitudes, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 41 species (Trees: 5; Shrubs: 2; Herbs: 34) were recorded in this community. The total tree density and total basal area were 810.00 Ind ha^{-1} and 128.96m^2 ha^{-1}, respectively. *Quercus semecarpifolia* (Density: 280.00 Ind ha^{-1}, Basal area: 725.9m^2 ha^{-1}, IVI: 123.10) was the dominant tree and *Abies pindrow* (Density: 220.00 Ind ha^{-1}, Basal area: 459.0m^2 ha^{-1}, IVI: 91.84) and *Taxus baccata* subsp*. wallichiana* (Density: 270.00 Ind ha^{-1}, Basal area: 93.9m^2 ha^{-1}, IVI: 69.64) were codominant tree species (Table 4.4.4, 5, & 6).

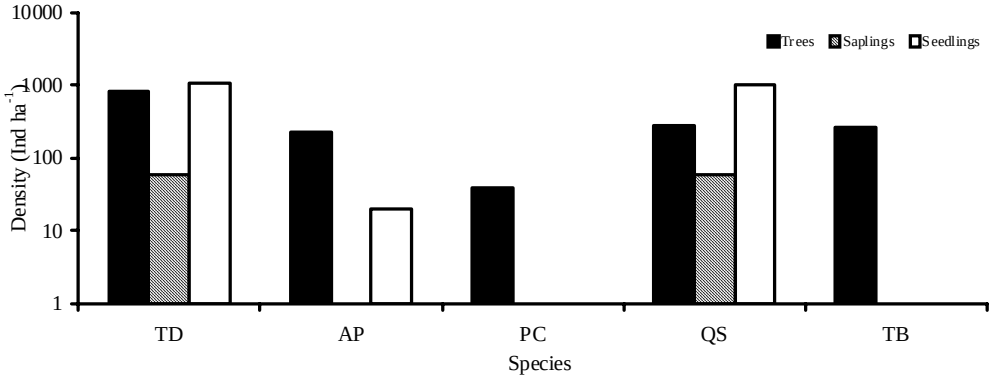
Among the shrubs, highest density was shown by *Viburnum cotonifolium* (67.6%), followed by *Cotoneaster obtusus* (16.90%) and *Smilax vaginata* (5.64%) (Table 4.2.7), and among herbs, highest density was shown by *Impatiens arguta* (15.8%), followed by *Fragaria nubicola* (11.70%) and *Carex brevicaulis* (7.17%) (Table 4.2.8).

Regeneration pattern

The total density and regeneration pattern of different species in *Abies pindrow-Quercus semecarpifolia* mixed community have been presented in Fig. 4.2.14.

Total seedlings and saplings densities were 1040.00 Ind ha^{-1} and 60.00 Ind ha^{-1}, respectively. Among the saplings, only *Quercus semecarpifolia* (60.00 Ind ha^{-1}) showed regeneration and among seedlings, highest density was shown by *Quercus semecarpifolia* (1020.00 Ind ha^{-1}), followed by *Abies pindrow* (20.00 Ind ha^{-1}). *Taxus baccata* subsp*. wallichiana* and *Picea smithiana* did not show regeneration.

Fig.4.2.14. Population structure of *Quercus semecarpifolia-Abies pindrow* **mixed community**



Abbreviations used: TD=Total density; AP= *Abies pindrow*; PS=*Picea smithiana;* PC=*Prunus cornuta*; QS=*Quercus semecarpifolia*; and TB= *Taxus baccata* subsp. *wallichiana*

B. Shrubs

15. *Sorbaria tomentosa-Indigofera heterantha* mixed community

This community has been represented in 1 site of the Jagatsukh catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 48species (Shrubs: 6; Herbs: 42) were recorded in this community. The total shrub density was 520 Ind ha^{-1}. *Sorbaria tomentosa* (34.65%) was the dominant shrub, *Indigofera heterantha* (32.67%) and *Desmodium elegans* (13.86%) were the co-dominant shrubs (Table 4.2.7). Among herbs, highest density was shown by Oplismenus *undulatifolius* (11.20%), followed by *Oxalis corniculata* (9.76%) and *Eragrostris pilosa* (7.26%) (Table 4.2.8).

16. *Indigofera heterantha–Rabdosia rugosa-Spiraea canescens* mixed community

This community has been represented in 1 site of the Jagtsukh catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 47 species (Shrubs: 14; Herbs: 33) were recorded in this community.The total shrub density was 3890 Ind ha^{-1}. *Rabdosia rugosa* (17.80%) was the dominant shrub, *Indigofera heterantha* (16.90%) and *Spiraea canescens* (12.1%) were the co-dominant shrubs (Table 4.2.7). Among herbs highest density was shown by *Impatiens arguta* (12.40%), followed by *Trifolium pratense* (10.92%) and *Pteridium aquilinum* (6.55%) (Table 4.2.8).

C. Alpine Scrubs

17. *Juniperus indica* community

This community has been represented in 1 site of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 36 species (Shrubs: 3; Herbs: 33) were recorded in this community. The total shrub density was 1010 Ind ha^{-1}. *Juniperus indica* (48.10%) was the dominant shrub and *Cotoneaster acuminatus* (38.50%) was the co-dominant shrub species (Table 4.2.7). Among herbs highest density was shown by *Chaerophyllum reflexum* (19.20%), followed by *Poa alpina* (9.42%) and *Trigonella emodi* (8.88%) (Table 4.2.8).

18. *Rosa sericea-Berberis jaeschkeana* mixed community

This community has been represented in 2 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 44 species (Shrubs: 9; Herbs: 35) were recorded in this community. The total shrub density ranged from 260-350 Ind ha^{-1}. *Rosa sericea* (38.30%) was the dominant shrub; *Berberis jaeschkeana* (17.70%) and *Juniperus indica* (13.80%) were the co-dominant shrubs (Table 4.2.7). Among the herbs highest density was shown by *Allium wallichii* (17.20%), followed by *Eragrostis minor* (6.90%) and *Bistorta affinis* (5.79%) (Table 4.2.8).

19. *Viburnum grandiflorum* community

This community has been represented in 2 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 66 species (Shrubs: 3; Herbs: 63) were recorded in this community. The total shrub density ranged from 260-350 Ind ha^{-1}. *Viburnum grandiflorum* (68.00%) was the dominant shrub and *Rosa sericea* (13.33%) and *Cotoneaster microphylla* (10.70%) were the co-dominant shrubs (Table 4.2.7). Among herbs, highest density was shown by *Trifolium pratense* (11.20%), followed by *Origanum vulgare* (5.78%) and *Osmunda claytoniana* (5.25%) (Table 4.2.8).

20. *Rhododendron anthopogon* community

This community has been represented in 1 site of the Jagatsukh catchment. The altitude, latitudes and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 25 species (Shrubs: 3; Herbs: 22) were recorded in this community.The total shrub density was 700 Ind ha^{-1}. *Rhododendron anthopogon* (41.40%) was the dominant shrub and *Clemais barbellata* (22.02%) and *Rosa sericea* (14.80%) were the co-dominant shrubs (Table 4.2.7). Among herbs, highest density was shown by *Potentilla atrosanguinea* (11.10%), followed by *Potentilla argyrophylla* (9.63%) and *Nepeta laevigata* (7.50%) (Table 4.2.8).

D. Alpine Herbs

21. *Dipsacus inermis-Sibbaldia cuneata-Anaphalis triplinervis* mixed community

This community has been represented in 1 sites of the Hamta catchment. The

altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 18 herbs were recorded in this community.The total herb density was 5390 Ind ha^{-1}. *Dipsacus inermis* (14.80%) was the dominant species and *Sibbaldia cuneata* (11.7 %), *Anaphalis triplinervis* (11.10 %) and *Rhodiola bupleuroides* (6.54 %) were the co-dominant species (Table 4.2.8).

23. *Carex foliosa-Sibbaldia cuneata-Artemisia vestita* mixed community

A total of 24 herbs were recorded in this community. This community has been represented in 1 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

The total herb density was 9830 Ind ha^{-1}. *Carex foliosa* (11.50 %) was the dominant species and *Sibbaldia cuneata* (11.20%), *Artemisia vestita* (7.14%) and *Potentilla atrosanguinea* (5.81 %) were the co-dominant species (Table 4.2.8).

23. *Rhodiola bupleuroides–Potentilla atrosanguinea-Anaphalis triplinervis-Phlomis bracteosa* mixed community

A total of 38 herbs were recorded in this community.This community has been represented in 1 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

The total herb density was 9190 Ind ha^{-1}. *Rhodiola bupleuroides* (12.80 %) was the dominant species, *Anaphalis triplinervis* (10.65 %), *Phlomis bracteosa* (6.82 %) and *Potentilla atrosanguinea* (5.81 %) were the co-dominant species (Table 4.2.8).

Table 4.2.4. Community wise Density (Ind ha^{-1}) of the Tree species in Hamta-Jagatsukh catchments

Taxa	Community Types													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Abies pindrow	-	58	-	308	-	40	20	-	10	-	23	80	-	220
Acer acuminatum	-	2	3	32	-	207	150	-	10	-	127	-	-	-
A. ceasium	-	-	-	-	-	20	-	-	-	-	-	8	-	-
Aesculus indica	-	8	-	10	-	86	-	-	-	-	-	110	30	-
Alnus nitida	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula utilis	-	-	-	-	-	47	445	-	20	-	143	-	-	-
Cedrus deodara	-	-	5	13	-	-	-	-	-	190	-	-	-	-
Celtis australis	-	2	-	-	-	-	-	10	-	-	-	-	-	-
Hippophae salicifolia	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Euonymus fimbriatus	-	25	-	20	-	-	-	-	-	-	-	-	-	-
Ilex dipyrena	20	2	-	-	-	-	-	-	-	-	-	-	-	-
Juglans regia	-	7	-	14	-	-	-	-	5	-	-	-	340	-
Picea smithiana	-	201	98	45	10	-	-	20	5	20	-	360	10	40
Pinus wallichiana	-	16	368	5	-	-	-	-	-	20	-	-	-	-
Prunus cornuta	-	42	-	4	-	43	25	55	10	-	37	-	-	-
Pyrus pashia	20	-	-	-	-	-	-	20	-	-	-	-	-	-
Quercus floribunda	-	-	-	-	285	-	-	-	-	-	-	-	-	-
Q. semecarpifolia	20	8	-	-	-	20	-	-	795	-	-	-	-	280
Rhus javanica	-	18	3	-	-	-	-	-	-	-	-	-	-	-
Salix daphnoides	-	-	-	3	-	-	-	-	-	-	3	-	-	-
Taxus baccata subsp. *wallichiana*	-	3	-	4	-	10	25	-	50	-	7	-	-	270
Toona serrata	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Ulmus villosa	-	-	-	-	-	-	-	105	-	-	-	-	-	-

Abbreviations Used: 1= *Ilex dipyrena-Pyrus pashia* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Betula utilis*; 8=*Ulmus villosa*; 9=*Quercus semecarpifolia*; 10=*Cedrus deodara*; 11= *Betula utilis -Acer acuminatum* mixed; 12=*Picea smithiana-Aesculus indica* mixed; 13=*Juglans regia*; 14= *Quercus semecarpifolia-Abies pindrow* mixed

Table 4.2.5. Community wise Total Basal Area (m^2ha^{-1}) of the Tree species in Hamta-Jagatsukh catchments

Taxa	Community Types													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Abies pindrow	-	40.3	-	743.8	-	25	5.27	-	1.55	-	4.79	28.9	-	460
Acer acuminatum	-	0.2	0.03	31.47	-	303	63.5	-	0.35	-	127	0.15	-	-
A. ceasium	-	-	-	-	-	3.42	-	-	-	-	-	-	-	-
Aesculus indica	-	0.91	-	6.177	-	0.1	-	-	-	-	-	104	4.97	-
Alnus nitida	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-
Betula utilis	-	-	-	13.99	-	17.9	174	-	0.25	-	154	-	-	-
Cedrus deodara	-	-	146	-	-	-	-	-	-	843	-	0.15	-	-
Celtis australis	-	0.03	-	-	-	-	-	0.35	-	-	-	-	-	-
Euonymus fimbriatus	-	0.04	-	0.02	-	-	-	-	-	-	-	-	-	-
Hippophae salicifolia	-	-	0.5	-	-	-	-	-	-	-	-	-	-	-
Ilex dipyrena	0.18	0.03	-	-	-	-	-	-	-	-	-	-	-	-
Juglans regia	-	0.52	-	0.166	-	-	-	-	0.1	-	-	-	689.0	-
Picea smithiana	-	713	0.68	9.505	41.8	-	-	2.7	0.1	1.46	-	85.5	0.25	10.1
Pinus wallichiana	-	0.03	226	0.575	-	-	-	-	-	1.26	-	-	-	-
Prunus cornuta	-	0.13	-	0.025	-	12.4	1.17	3.8	0.2	-	27.8	-	-	-
Pyrus pashia	0.33	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus floribunda	0.22	-	-	-	57.5	-	-	-	-	-	-	-	-	-
Q. semecarpifolia	-	0.42	-	-	-	2.83	-	-	1049	-	-	-	-	726
Rhus javanica	-	0.36	9.65	-	-	-	-	-	-	-	-	-	-	-
Salix daphnoides	-	-	-	0.013	-	-	-	0.9	-	0.07	-	-	-	-
Taxus baccata subsp. *wallichiana*	-	0.08	-	0.525	-	0.02	0.55	-	1.6	0.07	-	-	-	93.9
Toona serrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ulmus villosa	-	0.01	-	-	-	-	-	185.2	-	-	-	-	-	-

Abbreviations Used: 1=*Ilex dipyrena-Pyrus pashia* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Betula utilis*; 8=*Ulmus villosa*; 9=*Quercus semecarpifolia*; 10=*Cedrus deodara*; 11=*Betula utilis-Acer acuminatum* mixed; 12=*Picea smithiana-Aesculus indica* mixed; 13=*Juglans regia*; 14= *Quercus semecarpfolia -Abies pindrow* mixed

Table 4.2.6. Community wise Importance Value Index (IVI) of the Tree species in Hamta-Jagatsukh catchments

Community Types														
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Abies pindrow	-	37.6	-	204.7	-	27.9	10.3	-	6.5	-	21.6	30.4	-	91.8
Acer acuminatum	-	1.7	3.9	17.6	-	179.2	100.0	-	6.2	-	115.5	10.0	-	-
A. ceasium	-	-	-	-	-	15.4	-	-	-	-	-	-	-	-
Aesculus indica	-	10.4	-	1.1	-	2.4	-	-	-	-	-	71.6	30.0	-
Alnus nitida	-	-	-	-	-	-	-	-	-	-	-	33.1	-	-
Betula utilis	-	-	-	17.6	-	30.7	170.4	-	7.2	-	127.6	-	-	-
Cedrus deodara	-	-	70.2	-	-	-	-	-	-	251.5	-	21.4	-	-
Celtis australis	-	2.0	-	-	-	-	-	43.5	-		-	-	-	-
Euonymus fimbriatus	-	0.75	-	0.85	-	-	-	-	-	-	-	-	-	-
Hippophae salicifolia	-	-	8.0	-	-	-	-	-	-		-	-	-	-
Ilex dipyrena	98.1	3.3	-	-	-	-	-	-	-		-	-	-	-
Juglans regia	-	4.2	-	3.7	-	-	-	-	3.1		-	-	260.2	-
Picea smithiana	-	217.3	9.4	41.0	7.6	-	-	38.2	3.7	24.3	-	133.5	9.8	15.4
Pinus wallichiana	-	4.9	205.0	3.4	-	-	-	-	-	24.2	-	-	-	-
Prunus cornuta	-	2.8	-	2.2	-	29.7	9.7	26.4	7.4	-	27.4	-	-	-
Pyrus pashia	118.8	-	-	-	-	-	-	-	-	-	-	-	-	-
Quercus floribunda	83.2	-	-	-	292.4	-	-	-	-	-	-	-	-	-

Q.semecarpifolia	-	2.8	-	-	-	10.6	-	-	243.4	-	-	-	-	123.1
Rhus javanica	-	8.5	3.9	-	-	-	-	-	-	-	-	-	-	-
Salix daphnoides	-		-	6.1	-	-	-	13.5	-	-	2.7	-	-	-
Taxus baccata subsp. *wallichiana*	-	1.5	-	2.6	-	4.0	9.6	-	22.6	-	5.5	-	-	69.6
Toona serrata	-	3.8	-	-	-	-	-	-	-	-	-	-	-	-
Ulmus villosa	-	-	-	-	-	-	-	178.4	-	-	-	-		-

Abbreviations Used: 1=*Ilex dipyrena-Pyrus pashia* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Betula utilis*; 8=*Ulmus villosa*; 9=*Quercus semecarpifolia*; 10=*Cedrus deodara*; 11=*Betula utilis-Acer acuminatum* mixed; 12=*Picea smithiana-Aesculus indica* mixed; 13=*Juglans regia*; 14= *Quercus semecarpifolia-Abies pindrow* mixed

Table 4.2.7. Community wise Relative Density (%) of the Shrubs in Hamta and Jagatsukh Catchments

Taxa	Community Types																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Asparagus filicinus	-	1.9	-	-	0.9	-	-	1.2	-	-	-	7.3	-	-	-	-	-	-	-	-
Berberis lycium	7.4	5.3	12.9	1.2	34.5	-	-	11.9	-	12.5	-	-	-	-	-	2.8	-	-	-	-
B. jaescchkeana	-	-	-	-	-	-	3.3	-	-	-	4.7	-	-	-	-	-	-	17.7	-	15.32
Buddleja crispa	0.5	-	3.3	-	-	-	-	-	-	19.7	-	-	-	-	-	-	-	-	-	-
Boehmeria platyphylla	-	-	-	-	-	5.23	-	-	-	-	-	-	-	-	-	8.7	-	-	-	-
Clematis barbellata	-	-	0.4	-	-	-	-	0.2	-	-	-	0.73	-	-	-	3.3	-	-	-	22.02
C. buchanniana	-	0.3	-	-	-	7.85	-	-	29	-	-	-	-	4.23	-	-	-	-	-	-
Cotoneaster obtusus	-	2.4	-	6.2	-	6.8	-	4.2	-	-	0.9	-	-	16.9	18.8	-	-	-	-	-
C. microphylla	0.1	-	0.5	1.5	0.7	-	-	-	-	2.5	-	-	-	5.63	6.3	-	-	5.26	10.7	-
C. acuminatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.5	-	8.1	-
Cyathula tomentosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	-
Desmodium elegans	9.6	5.3	15.7	5.9	4.1	-	-	3.5	-	3.33	-	14.3	-	-	13.9	9	-	-	-	-
Deutzia corymbosa	-	0.1	1.7	-	-	10.9	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-
D. staminea	0.7	-	1.5	1.0	0.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elaeagnus	1.4	1.0	0.9	-	4.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

conferta																				
Elsholtzia flava	-	1.7	2.3	1.0	-	-	-	1.6	-	-	-	-	-	-	3.0	2.1	-	-	-	-
Euonymus echinatus	-	-	-	-	-	-	-	-	-	-	-	3.87	-	-	-	-	-	-	-	-
Ficus sarmentosa	-	0.3	2.1	2.8	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedera nepalense	9.8	1.3	2.7	3.4	2.0	-	-	-	-	-	-	1.2	-	-	-	-	-	-	-	-
Hypericum oblongifolium	-	0.3	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indigofera heterantha	9.8	2.9	18.2	14.4	7.0	-	-	7.3	-	39.2	-	18.4	16.7	-	32.7	16.9	-	-	-	-
I. gerardiana	-	1.2	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.6	-	-
Juniperus indica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48.1	13.8	-	-
J. communis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.5	13.9	-	-
Jasminum humile	0.9	-	2.8	-	0.9	-	-	1.2	-	-	-	-	-	-	-	4.9	-	-	-	-
Leptodermis lanceolata	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leycesteria formosa	-	0.5	0.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lonicera angustifolia	5.1	-	2.1	-	-	-	-	1.3	-	-	-	-	-	-	-	2.3	-	2.4	-	-
L. quinquelocularis	-	2.3	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myrsine africana	-	-	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Parthenocissus semicordata	-	0.3	-	-	-	-	-	-	-	-	-	1.5	-	-	-	-	-	-	-	-
Prinsepia utilis	8.3	2.8	6.1	0.8	12.3	-	-	2.3	-	5	-	-	41.7	-	9.9	4.4	-	-	-	-
Rhamnus triqueter	-	0.3	2.1	-	2.7	-	-	-	-	-	-	2.9	-	-	-	3.1	-	-	-	-
Rhododendron anthopogon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41.4
R. campanulatum	-	-	-	2.2	-	-	9.67	-	-	-	9.5	-	-	-	-	-	-	-	-	6.3
R. lepidotum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.44	-	14.8
Rosa sericea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	38.3	13.3	-
R. macrophylla	-	-	-	-	-	39.4	29.0	-	12	-	26.0	-	-	-	-	-	-	-	-	-
R. brunoni	0.3	0.3	1.1	3.4	3.1	-	-	3.7	-	5	10.8	-	22.2	-	-	-	-	-	-	-
Rabdosia rugosa	12.3	-	4.0	-	7.5	-	-	3.7	-	10.8	-	-	-	-	5.9	17.8	-	-	-	-
Rubus lasiocarpus	0.4	2.7	-	-	-	6.2	-	1.2	-	-	-	-	-	-	-	-	-	1.91	-	-
R. ellpticus	-	6.2	4.2	1.6	0.2	-	-	12.4	-	2.5	-	26.6	-	-	-	6.7	-	-	-	-
Salix denticulata	-	0.5	0.9	2.6	0.2	-	8.07	0.7	-	-	5.7	4.6	-	-	-	-	-	-	-	-
Sarcococa saligna	20.9	0.9	-	5.0	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Smilax aspera	1.6	0.7	-	0.3	-	-	5.65	-	-	-	-	-	-	-	-	-	-	-	-	-

S. vaginata	-	-	-	-	1.8	-	6.97	-	-	-	-	0.9	-	5.64	-	1.3	-	-	-	-
Sorbaria tomentosa	1.4	40.5	6.2	30.9	0.4	-	-	29.3	-	-	-	4.8	-	-	34.7	2.6	-	-	-	-
Spiraea bella	-	-	-	-	-	-	-	-	-	-	0.9	-	-	-	-	-	-	-	-	-
S. canescens	4.9	0.1	1.3	2.0	12.1	-	-	3.7	-	-	-	0.7	-	-	-	12.1	-	-	-	-
Viburnum mullaha	-	-	0.9	-	-	-	-	8.9	58.5	-	-	-	-	-	-	-	-	-	-	-
V. cotonifolium	-	18.2	1.2	30.1	-	23.5	37.2	-	-	-	41.3	12.1	19.4	67.6	-	-	-	5.2	-	-
V. grandiflorum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68.0	-

Abbreviations Used: 1= *Pyrus pashia-Ilex dipyrena* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Betula utilis*; 8=*Ulmus villosa*; 9=*Quercus semecarpifolia*; 10=*Cedrus deodara*; 11=*Betula utilis -Acer acuminatum* mixed; 12=*Picea smithiana-Aesculus indica* mixed; 13=*Jugans regia*; 14=*Quercus semecarpifolia-Abies pindrow* mixed; 15=*Indigofera heterantha-Sorbaria tomentosa* mixed; 16=*Indigofera heterantha-Rabdosia rugosa- Spiraea canescens* mixed; 17=*Juniperus indica*; 18=*Rosa sericea-Berberis jaeschkeana* mixed; 19=*Viburnum grandiflorum*; 20=*Rhododendron anthopogon*

Table 4.2.8. Community wise Relative Density (%) of the Herbs in Hamta-Jagatsukh Catchments

Taxa	Community Types																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Achyranthes bidentata	-	0.38	0.56	-	-	-	-	-	-	0.77	0.89	-	0.16	-	0.29	-	-	-	-	-	-	-	-
Achillea millefolium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.34
Aconitum heterophyllum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.96	2.78	-	-
Adenocaulon himalaicum	-	-	-	-	-	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	-	-	-
Adiantum capillus-veneris	0.41	6.11	3.92	4.55	-	5.18	-	2.99	6.22	4.62	-	8.30	-	-	-	-	-	-	-	-	-	-	-
A. venustum	-	-	-	-	-	-	1.12	-	-	-	-	-	2.45	2.66	0.98	-	-	-	-	-	-	-	-
A. pedatum	-	-	-	-	-	0.87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agrimonia pilosa	0.81	0.33	1.24	0.42	-	-	-	-	-	-	-	0.30	0.33	-	-	-	-	-	1.59	-	-	-	-
Agrostis munroana	-	0.43	1.38	3.11	2.38	-	-	0.88	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. pilosula	-	-	-	-	-	8.70	-	-	-	-	6.82	-	-	-	-	-	-	-	-	-	-	-	-
Ainsliaea aptera	-	1.38	0.42	-	-	0.95	0.15	-	0.93	-	0.38	2.20	-	1.59	-	-	-	-	-	-	-	-	-
A. latifolia	-	-	-	0.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ajuga bracteosa	-	0.46	0.11	-	-	-	-	0.42	-	0.77	-	-	-	-	-	-	-	-	-	-	-	-	-
Allium wallichii	-	-	-	-	-	-	-	-	-	-	2.42	-	-	-	-	-	-	17.2	0.85	-	-	-	-
Amaranthus hybridus	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anemone rivularis	-	-	-	-	-	-	-	-	-	-	1.39	-	-	-	0.29	-	-	-	-	-	-	-	-
A. rupicola	-	-	-	1.48	-	-	3.80	1.37	3.96	-	-	-	-	-	-	-	2.72	2.69	5.84	8.15	-	-	-
Anaphalis triplinervis	-	0.01	-	0.40	-	-	1.39	-	1.74	-	-	-	-	-	-	-	-	-	-	13.0	11.1	5.61	10.65
A.nepalensi	-	0.03	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	1.78	-	-	-	-	-	-

s																							
A. busua	-	-	-	-	-	-	-	-	*1.12*	-	-	*0.20*	-	-	-	-	-	*3.63*	*1.73*	-	-	-	-
Angelica glauca	-	-	*0.55*	-	-	-	*0.46*	-	*0.03*	-	*0.43*	-	-	-	-	-	-	-	-	-	-	-	-
Apluda mutica	-	*0.13*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aquilegia pubiflora	-	*0.08*	-	-	-	-	-	-	-	*0.49*	-	-	-	-	-	-	-	-	-	-	-	-	-
Aralia cachemirica	-	*0.10*	-	*0.55*	-	-	-	*0.42*	-	-	-	*1.20*	-	-	-	-	-	-	-	-	-	-	-
Arctium lappa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arenaria festucoides	-	*0.21*	-	-	-	-	-	*0.88*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arisaema intermedium	-	*0.21*	-	-	-	-	*2.09*	-	*1.94*	-	*4.33*	-	*0.88*	-	-	-	-	-	*0.16*	-	-	-	-
A. jacquemontii	-	*0.13*	-	*0.81*	-	-	*1.61*	*0.18*	*1.03*	-	*1.82*	-	-	-	-	-	-	*0.14*	*0.60*	-	-	-	*1.82*
Artemisia parviflora	-	*0.29*	*1.60*	-	*0.19*	-	*3.36*	-	*1.09*	-	*1.65*	-	-	-	*0.34*	-	-	*3.13*	*0.78*	-	-	-	-
A.vestita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*5.00*	-	*7.14*	*0.45*
Arundinella setosa	-	*0.25*	-	-	-	-	-	-	-	-	-	-	*9.17*	-	-	-	-	-	-	-	-	*1.25*	-
Arundnaria spathiflora	-	*0.74*	-	-	-	-	-	-	-	-	-	-	-	-	-	*3.74*	-	-	-	-	-	-	-
Asplenium anograngnoides	-	-	-	*0.62*	-	-	*0.46*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. dalhousiae	-	-	-	-	-	-	-	-	-	-	-	-	*2.72*	-	-	-	-	-	-	-	-	-	-
A. variense	-	*0.02*	*0.06*	*0.22*	-	-	-	*0.48*	*1.87*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aster himalensis	-	*0.00*	*0.00*	-	-	-	*0.42*	-	-	-	*1.15*	-	*0.68*	*0.64*	*0.88*	*1.08*	-	*2.33*	*0.10*	-	*4.21*	*1.71*	-
A. peducularis	-	*0.30*	*0.18*	*0.37*	*0.37*	-	-	-	-	-	-	*0.40*	-	-	-	-	-	-	-	-	-	-	-
Astragalus chlorostachys	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*1.16*	-	-	-	-
Athyrium	-	-	-	*0.20*	-	*1.88*	*3.25*	-	-	-	-	-	-	-	-	-	-	-	*1.00*	-	-	-	-

anisopterum																							
A .atkinsonii	-	0.30	-	0.98	2.45	-	-	0.92	4.04	0.19	0.65	-	-	1.75	-	-	-	-	0.50	-	-	-	-
A. attenuatum	1.13	0.42	-	-	-	-	-	-	-	-	1.56	-	-	-	-	-	-	-	1.41	-	-	3.37	-
A. pectinata	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
Bergenia ciliata	-	0.35	-	-	0.22	-	-	-	-	-	-	0.50	-	-	-	-	-	-	-		-	-	-
B. stracheyi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.93	-	-	-
Bistorta affinis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.79	3.83	4.72	-	2.45	-
B. amplexicaulis	-	0.63	-	1.98	-	14.1	2.90	-	10.6	-	1.73	-	0.33	1.33	-	-	-	-	-		-	-	-
Bromus japonicus	-	0.02	-	1.47	-	-	4.09	-	-	-	0.97	-	-	-	3.82	-	3.85	-	0.60	-	-	-	-
B. racemosus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.78	-	-	-	-
Bupleurum atroviolaceum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.13	-	-	-	-	-
B. candolii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.97
B. falcatum	-	0.24	-	-	0.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. lanceolatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.18
Calamintha umbrosa	0.74	1.18	0.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calanthe tricarinata	-	-	-	0.20	-	-	-	-	-	-	-	0.44	-	-	-	-	-	-	-	-	-	-	-
Caltha palustris	-	-	-	1.61	-	-	-	-	-	-	2.28	-	-	-	-	-	2.13	-	-	-	-	-	-
Campanula colorata	1.22	-	-	0.78	0.97	-	1.24	-	2.80	-	-	-	-	0.40	-	-	-	-	-	-	-	-	-
Cannabis sativa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.48	1.37	-	-	-	-	-	-	-
Capsella bursa-pastoris	2.03	0.64	0.37	-	1.11	-	-	-	-	1.58	-	-	-	-	0.88	0.50	-	-	-	-	-	-	-
Cardamine impatiens	-	-	-	-	-	-	-	-	-	-	-	1.18	-	-	-	-	-	-	-	-	-	-	-
C.	-	-	-	0.43	-	-	-	1.66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

macrophylla																							
Cardiocrinum giganteum	-	-	-	-	-	-	-	-	-	-	-	0.11	-	-	-	-	-	-	-	-	-	-	-
Carduus adelbergii	-	-	-	0.24	-	-	-	-	-	-	-	-	0.16	-	-	0.62	-	-	0.20	-	-	-	-
Carex brevicaulis	16.7	1.47	27.4	2.93	-	-	-	-	-	-	-	-	9.17	7.17	-	-	1.36	3.13	2.28	-	-	-	-
C. cruciata	-	0.61	-	1.88	-	-	-	-	-	-	-	5.07	-	-	-	-	-	-	-	-	-	-	-
C. setigera	-	0.25	-	-	-	-	-	-	-	-	-	-	7.34	-	-	-	-	-	-	-	-	-	-
C. nivalis	-	-	-	-	-	4.53	-	-	-	-	4.58	-	-	-	-	-	-	-	-	-	-	-	-
C. foliosa	-	-	-	-	-	6.79	-	-	-	-	6.47	-	-	-	-	-	-	-	-	-	-	11.5	-
C. nubigena	-	5.14	-	0.55	12.7	-	5.64	12.9	-	16.3	0.76	19.30	-	-	-	6.86	-	-	-	-	-	-	-
Carpesium pedunculari s	-	-	-	0.14	-	0.72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cephalanthera longifolia	-	0.60	-	0.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerastium cerastioides	-	-	-	-	-	-	-	0.35	-	-	-	-	-	0.96	2.35	-	-	-	-	-	-	-	-
C. fontanum	-	1.05	-	-	-	-	-	-	2.03	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaerophyllum reflexum	-	0.03	-	1.54	0.11	-	-	-	0.93	-	-	-	1.87	-	-	-	19.2	-	-	-	-	-	-
Chenopodium botrys	0.89	0.35	-	0.73	-	-	-	-	-	-	-	-	-	5.74	1.18	0.21	-	-	-	-	-	-	-
Chielanthus acrostica	-	0.50	-	-	-	-	-	-	-	-	-	0.77	-	-	-	-	-	-	-	-	-	-	-
Chrysopogon echinulatus	7.05	2.63	2.46	-	-	-	-	5.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. gryllus	-	-	4.68	-	6.16	-	-	-	-	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-
Cryptogramma stellarii	-	-	-	-	-	-	-	-	-	-	0.48	-	-	-	-	-	-	-	-	-	-	-	-
Cicerbita macrorhiza	-	0.34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Circaea	-	-	-	-	-	-	-	-	6.99	-	-	-	-	-	-	-	-	-	-	-	-	-	-

alpina																							
Cirsium wallichii	*0.32*	*0.26*	*-*	*0.35*	*0.74*	*0.18*	*-*	*2.18*	*-*	*0.49*	*0.18*	*0.33*	*0.87*	*-*	*1.97*	*-*	*-*	*-*	*0.20*	*-*	*-*	*-*	*-*
Codonopsis rotundifolia	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.47*	*-*	*-*	*-*	*-*
Coniogramme intermedia	*-*	*1.83*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.66*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Corydalis diphylla	*-*	*0.01*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.54*	*-*	*-*	*-*	*-*	*0.48*	*-*	*-*	*-*	*1.71*	*-*
C. govaniana	*-*	*0.04*	*-*	*0.79*	*-*	*0.54*	*-*	*-*	*-*	*-*	*1.21*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*5.19*	*-*	*-*
Craniotome furcata	*-*	*0.38*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.23*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Cremanthodium arnicoides	*-*	*-*	*-*	*0.20*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.18*	*-*	*-*	*-*	*-*	*-*	*-*
Cuscuta reflexa	*-*	*0.9*	*-*	*-*	*-*	*0.4*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Cyanotis vaga	*-*	*-*	*0.14*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.73*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Cymbopogon martinii	*-*	*-*	*-*	*-*	*0.37*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Cyanodon dactylon	*1.54*	*0.20*	*1.46*	*-*	*0.48*	*-*	*-*	*6.48*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Dactylorhiza hatagirea	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.83*	*-*	*-*	*-*	*-*
Delphnium denudatum	*-*	*-*	*-*	*-*	*-*	*-*	*0.39*	*-*	*-*	*2.87*	*1.62*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.83*	*-*	*-*	*-*
Dicentra roylei	*0.97*	*0.14*	*-*	*-*	*-*	*-*	*-*	*0.53*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Dicliptera roxbughiana	*-*	*-*	*-*	*-*	*1.48*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Digitaria cruciata	*-*	*-*	*-*	*0.92*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Dioscorea deltoidea	*3.33*	*-*	*1.22*	*1.42*	*1.52*	*-*	*-*	*2.02*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3.3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Diplazium esculentum	*0.73*	*0.39*	*1.14*	*-*	*-*	*-*	*-*	*1.22*	*-*	*-*	*-*	*-*	*-*	*-*	*3.92*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Dipsacus inermis	*-*	*-*	*-*	*-*	*-*	*-*	*0.23*	*-*	*-*	*-*	*0.49*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*14.8*	*-*	*-*
Dryopteris	*-*	*-*	*-*	*0.38*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.15*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*

wallichii																							
D. barbigera	-	-	-	-	-	-	-	-	-	-	0.67	-	-	-	0.64	-	-	-	-	-	-	-	-
D. panda	-	0.18	0.73	-	-	-	-	-	0.31	-	-	2.64	-	-	-	-	-	-	-	-	-	-	-
Duchesnia indica	-	2.25	0.35	-	-	-	-	-	-	-	0.18	-	-	-	3.88	-	-	-	-	-	-	-	-
Elsholtzia ciliata	-	-	1.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Epilobium latifolium	-	-	-	-	0.15	-	-	-	-	-	0.97	-	-	-	-	-	1.59	-	1.67	-	-	-	-
E. cylindricum	-	0.19	-	-	-	-	-	0.26	1.24	-	1.39	-	-	-	-	-	-	-	-	-	-	-	-
E. hirsutum	-	-	-	2.39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eragrostis pilosa	1.38	0.18	5.98	3.94	1.34	-	-	3.87	-	5.00	-	-	9.78	-	7.26	-	-	-	-	-	-	-	-
E. minor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.90	-	-	-	-	0.91
Erigeron boneriensis	-	-	0.06	-	0.22	-	-	-	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-	-
E. canadensis	-	0.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euphrassia himalaica	0.41	-	-	-	1.48	-	-	-	-	-	-	-	-	-	-	-	-	-	1.99	-	-	-	-
Fagopyrum dibotrys	0.97	0.37	1.46	0.18	0.28	-	-	1.14	-	-	-	3.25	-	-	1.27	2.16	-	-	-	-	-	-	-
Festuca rubra	-	1.05	-	-	-	-	-	0.59	-	-	-	-	9.78	-	-	6.24	-	-	-	-	-	-	-
Filipendula vestita	-	0.00	-	0.29	-	-	-	1.48	-	-	-	-	-	-	-	-	-	-	0.61	-	-	-	-
Fragaria nubicola	4.53	5.86	1.46	5.89	1.86	3.40	2.04	-	1.68	1.63	2.54	0.55	-	11.7	3.19	-	-	-	3.40	-	-	-	-
Fritillaria roylei	-	0.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gagea lutea	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Galinsoga parviflora	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-
Galium asperifolium	-	-	-	-	-	-	-	-	-	-	0.26	-	-	2.71	-	3.24	-	-	-	-	-	-	-
G. acutum	-	0.04	2.50	-	-	-	-	-	-	-	2.56	0.89	-	-	-	-	-	-	-	-	-	-	-
G. aparine	-	0.00	-	0.40	4.64	1.92	1.95	1.97	0.62	3.27	-	-	-	-	2.42	-	-	-	-	-	-	-	-

G. rotundifolium	*1.69*	*0.35*	*0.41*	*-*	*0.30*	*1.63*	*-*	*0.35*	*0.31*	*-*	*-*	*0.65*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Gentiana carinata	*-*	*0.04*	*-*	*-*	*-*	*-*	*-*	*1.44*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Geranium nepalense	*3.89*	*0.68*	*0.87*	*1.39*	*-*	*-*	*2.12*	*1.13*	*4.97*	*-*	*-*	*-*	*1.63*	*-*	*3.77*	*5.41*	*1.95*	*5.52*	*4.78*	*-*	*-*	*-*	*-*
G. wallichianum	*-*	*0.69*	*-*	*-*	*4.14*	*1.27*	*-*	*-*	*-*	*3.46*	*0.97*	*-*	*-*	*-*	*-*	*-*	*0.74*	*-*	*-*	*-*	*-*	*-*	*-*
Geum elatum	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*4.44*	*-*	*-*	*-*	*5.59*	*3.83*	*1.02*
G. roylei	*-*	*0.09*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Girardinia diversifolia	*0.17*	*0.20*	*0.39*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.57*	*1.62*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Goldfusia dalhousiana	*-*	*-*	*-*	*-*	*0.74*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Goodyera repens	*-*	*0.04*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Hackelia uncinata	*-*	*-*	*-*	*0.49*	*-*	*-*	*1.39*	*-*	*0.75*	*-*	*0.84*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.47*	*-*	*-*	*7.76*	*0.23*
Hedychium spicatum	*-*	*-*	*0.93*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Heracleum candicans	*-*	*0.44*	*-*	*0.72*	*-*	*-*	*1.95*	*0.35*	*0.56*	*-*	*1.82*	*-*	*-*	*-*	*-*	*-*	*-*	*0.78*	*0.66*	*2.22*	*5.19*	*-*	*-*
H. wallichii	*-*	*-*	*-*	*0.18*	*-*	*-*	*-*	*-*	*-*	*-*	*0.39*	*0.50*	*-*	*-*	*-*	*-*	*-*	*0.13*	*-*	*-*	*-*	*-*	*1.70*
Herminium monorchis	*-*	*0.02*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.17*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Hypericum elodeoides	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.07*	*-*	*-*	*-*	*-*
Impatiens arguta	*-*	*-*	*-*	*-*	*0.15*	*-*	*-*	*1.35*	*7.03*	*-*	*-*	*4.13*	*1.83*	*15.8*	*1.97*	*12.4*	*-*	*-*	*-*	*-*	*-*	*-*	*5.00*
I. racemosa	*-*	*0.37*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.29*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
I. bicolor	*-*	*1.21*	*0.20*	*1.26*	*-*	*1.22*	*8.40*	*-*	*-*	*-*	*7.79*	*-*	*-*	*-*	*-*	*0.21*	*-*	*-*	*0.35*	*-*	*-*	*-*	*-*
Iris milessii	*2.51*	*4.04*	*2.95*	*-*	*1.11*	*-*	*-*	*4.15*	*-*	*-*	*-*	*-*	*0.27*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Jaeschkia oligosperma	*-*	*-*	*-*	*0.92*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Jurinella macroceph	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.60*

ala																							
Juncus bufonius	-	0.01	-	-	0.15	-	-	-	-	0.96	-	2.16	-	-	-	-	0.95	0.86	0.35	-	-	-	-
Lathyrus emodi	-	-	-	-	-	-	-	-	-	-	-	-	-	1.27	-	-	-	-	-	-	-	-	-
Lectuca lessertiana	-	0.07	-	0.82	-	-	1.21	0.88	-	-	-	-	-	-	-	-	0.53	-	-	-	-	-	-
Lepisorus nudus	-	0.26	0.06	0.49	-	-	1.43	-	2.80	-	5.33	-	-	5.31	-	-	-	-	-	-	-	-	-
Lespedeza girardiana	-	0.09	-	-	-	-	-	-	2.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lecanthus pedunculari s	-	-	-	-	-	-	0.56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ligularia amplexicaul is	-	-	-	2.27	-	-	0.74	-	-	-	0.28	-	-	-	-	-	-	-	-	0.28	4.44	1.71	0.91
Lindelophia longiflora	-	-	-	-	-	-	0.23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lotus corniculatus	-	-	-	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Malva verticillata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.37	-	-	-	-	-	-	-	-
Mazus suculosus	-	-	0.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melothria heterophyll a	-	-	-	-	-	-	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meconopsis aculeata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.56	-	-	0.85
Morina longifolia	-	-	-	0.62	-	-	-	-	0.09	-	0.81	-	-	-	-	-	-	-	-	-	4.86	-	-
Myriactis nepalensis	-	0.17	-	0.18	-	-	-	-	-	-	-	-	-	0.64	-	-	-	-	0.19	-	-	-	-
Nepeta leucophylla	-	0.40	0.39	-	-	-	-	-	-	-	-	-	-	-	-	2.91	2.66	1.93	-	5.83	-	-	-
N. laevigata	-	1.03	0.29	0.34	0.51	1.92	0.84	-	2.24	-	1.54	-	0.12	5.10	-	-	-	3.13	1.75	7.50	4.81	3.83	-
Onychium contiguum	-	2.31	0.06	1.77	5.50	-	-	0.44	-	-	-	-	5.77	-	0.88	2.70	-	-	2.21	-	-	-	-
Ophiogloss um petiolatum	-	0.12	0.55	-	-	-	-	0.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Oplismenus undulatifolius	*4.37*	*-*	*2.88*	*-*	*5.27*	*-*	*-*	*0.60*	*-*	*1.92*	*-*	*3.87*	*-*	*-*	*11.2*	*2.70*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Origanum vulgare	*-*	*-*	*3.41*	*1.56*	*1.86*	*-*	*-*	*-*	*2.24*	*-*	*0.87*	*0.66*	*-*	*-*	*-*	*2.70*	*-*	*-*	*5.78*	*-*	*-*	*-*	*-*
Osmunda claytoniana	*-*	*0.15*	*-*	*4.24*	*0.15*	*0.65*	*4.51*	*-*	*2.61*	*-*	*1.60*	*-*	*-*	*-*	*-*	*-*	*1.36*	*-*	*5.25*	*-*	*-*	*-*	*-*
O. japonica	*-*	*0.01*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Oreorchis indica	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*4.44*	*-*	*-*	*-*	*-*	*-*	*-*
Oxalis corniculata	*6.39*	*0.04*	*1.12*	*0.49*	*4.19*	*-*	*-*	*4.19*	*-*	*8.37*	*-*	*-*	*0.90*	*-*	*9.76*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
O. corymbosa	*-*	*0.29*	*-*	*1.73*	*-*	*0.58*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Oxyria digyana	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.39*	*-*	*-*	*0.28*
Oxytropis cashmiriana	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.40*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Paris polyphylla	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Parnassia nubicola	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*4.44*	*4.14*	*-*	*-*	*-*	*-*	*-*
Parochetus communis	*-*	*0.66*	*-*	*-*	*-*	*-*	*-*	*2.60*	*2.73*	*-*	*-*	*-*	*0.90*	*1.91*	*-*	*-*	*-*	*-*	*1.20*	*-*	*-*	*-*	*-*
Persicaria capitata	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.18*	*6.47*	*0.60*	*-*	*-*	*-*	*-*
Pedicularis hoffmeisteri	*-*	*-*	*-*	*1.52*	*-*	*-*	*1.52*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.35*	*-*	*1.75*	*0.83*	*-*	*-*	*2.73*
P. pectinata	*-*	*-*	*-*	*0.78*	*-*	*-*	*1.49*	*1.37*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Pellaea nitidula	*-*	*-*	*0.25*	*0.94*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Phleum alpinum	*-*	*-*	*-*	*0.64*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.40*	*-*	*-*	*-*	*-*
Phlomis bracteosa	*-*	*-*	*-*	*0.84*	*-*	*1.45*	*1.39*	*-*	*-*	*-*	*0.16*	*-*	*0.27*	*-*	*-*	*-*	*-*	*-*	*2.01*	*-*	*3.61*	*-*	*6.82*
Phymatopteris stracheyi	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.18*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Phytolacca acinosa	*-*	*1.03*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.24*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Pilea umbrosa	*-*	*0.36*	*-*	*-*	*-*	*1.20*	*-*	*-*	*-*	*-*	*-*	*-*	*0.87*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Picrorhiza kurooa	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2.78*	*-*	*-*	*-*

Pimpinella diversifolia	-	-	-	-	-	-	-	-	-	-	-	-	0.24	-	-	-	-	-	-	-	-	-	-
Plantago lanceolata	0.09	0.01	-	-	1.74	-	0.93	0.99	-	-	0.23	-	-	-	-	-	-	-	-	-	-	-	-
P. ovata	-	0.09	-	-	0.67	-	-	0.35	0.09	0.49	0.65	-	-	-	-	-	2.66	8.63	-	-	-	-	1.36
Pleurospermum angelicoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.39	2.22	1.63	-
Poa annua	-	-	-	-	-	-	-	-	-	-	1.40	-	-	-	0.37	-	-	-	-	-	-	-	-
P. alpina	-	-	-	-	-	-	1.63	-	-	-	1.95	-	-	-	-	-	9.47	-	-	-	-	-	2.98
Podophyllum hexandrum	-	0.34	-	0.62	-	-	1.43	-	-	-	2.42	-	-	-	-	-	-	-	0.53	1.48	3.89	0.46	-
Polemonium coeruleum	-	-	0.01	-	-	-	-	-	0.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polygonatum cirrhifolium	-	0.01	1.26	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-
P. multiflrum	-	0.25	-	-	-	-	-	-	-	-	2.60	0.39	-	-	-	-	-	-	-	-	-	-	-
P. verticillatum	-	0.30	0.25	-	-	0.96	-	0.32	-	-	0.17	-	-	-	-	-	-	1.13	4.25	-	-	-	-
Polygonum nepalense	2.59	3.76	1.36	1.25	1.22	3.19	-	4.71	-	-	-	-	-	1.33	4.17	0.42	0.12	-	-	-	-	4.90	3.75
P. hydropiper	-	0.02	-	-	-	-	-	-	2.33	-	-	-	2.81	-	-	-	-	-	-	-	-	-	-
P. recumbens		-	-		-	-	-	-	1.55	-	0.16	9.89	-	-	-	-	-	-	-	-	-	-	-
P. plebium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.98
Polypodioides amoena	-	-	-	-	-	-	-	0.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polystichum prescottianum	-	-	-	1.58	-	2.54	2.09	0.74	-	-	0.58	-	-	2.71	-	-	2.66	0.48	-	-	-	-	1.14
P. neolobatum	-	-	-	-	-	-	-	-	-	-	-	-	0.33	-	-	-	-	-	-	-	-	-	-
P. nepalense	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.83	-	-	-	-	-	-
P. squarrosum	-	1.47	0.39	0.21	-	-	-	0.18	0.42	-	-	-	3.13	0.85	-	-	-	-	-	-	-	1.44	-

P. laciniatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.74	-	-	-	-
P. wilsonii	-	-	-	0.49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.53	-	-	-	-
Potentilla argyrophylla	-	0.02	-	2.26	-	-	-	-	-	3.17	-	-	-	-	-	-	1.32	1.66	-	9.63	-	-	-
P. microphylla	-	2.48	-	-	-	-	-	0.42	-	-	-	-	1.96	1.33	-	-	-	-	3.99	-	-	-	4.84
P. atrosanguinea	-	-	-	2.94	-	-	-	-	3.35	-	3.12	-	-	-	-	-	-	-	0.13	11.1	-	7.14	5.81
Primula denticulata	-	-	-	-	4.08	-	0.56	0.74	-	-	-	0.04	-	-	-	-	3.77	1.45	-	-	4.81	-	-
P. rosea	-	0.04	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-
P. involucrata	-	0.85	0.59	-	-	0.32	-	-	-	-	0.90	-	-	-	4.47	7.49	-	1.34	-	-	-	-	1.14
Prunella vulgaris	-	0.23	0.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pteracanthus alatus	0.81	0.29	-	-	-	-	-	-	-	-	-	3.14	-	-	-	0.62	-	-	-	-	-	-	-
Pteridium aquilinium	-	2.02	0.92	-	4.23	-	0.93	-	-	-	-	1.66	-	-	-	6.55	-	-	0.50	-	-	-	-
Pteris cretica	1.78	3.59	0.31	3.72	0.22	9.49	1.11	-	-	-	0.32	0.26	12.2	-	1.13	-	-	-	2.09	-	-	-	-
P. vittata	-	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus laetus	-	0.10	-	0.34	1.63	-	-	0.65	-	-	-	-	-	-	-	-	-	-	0.33	6.48	-	-	-
Rhodiola bupleuroides	-	-	-	-	-	-	-	-	0.37	-	0.33	-	-	-	-	-	-	-	-	-	6.19	-	12.8
Rhynchospermum verticillatum	0.32	1.54	0.99	0.42	0.91	-	-	0.28	-	-	-	0.18	-	-	-	-	-	-	-	-	-	-	-
Rheum australe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.56	-	-	0.26
Rosularia rosulata	-	1.05	-	-	1.34	-	-	0.44	-	1.44	-	1.77	-	-	-	-	-	-	-	-	-	-	-
Rubia cordifolia	2.40	0.12	0.23	0.24	1.25	-	0.8	-	-	-	-	-	0.23	-	-	-	-	-	-	-	-	-	-
Rumex hastatus	0.24	0.51	0.11	0.56	-	7.46	1.86	1.23	0.49	1.25	-	0.96	2.17	-	1.37	-	-	0.55	1.98	-	-	-	-
R.	-	0.55	0.0	0.76	1.19	-	-	-	-	-	1.65	-	-	-	-	-	-	0.86	1.59	-	-	-	-

nepalensis			*0*																					
Saccharum filifolium	*2.92*	*0.10*	*6.53*	*-*	*-*	*-*	*-*	*0.62*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
S. spontaneum	*-*	*-*	*3.03*	*-*	*-*	*-*	*-*	*-*	*-*	*0.49*	*-*	*1.66*	*-*	*-*	*1.84*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Salvia lanata	*-*	*0.03*	*0.13*	*-*	*0.04*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
S. moorcroftiana	*-*	*0.35*	*-*	*0.15*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Sanicula alata	*-*	*1.12*	*0.56*	*0.28*	*-*	*-*	*-*	*0.44*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Saussurea piptathera	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2.05*
Scrophularia decomposita	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2.76*	*0.91*
S. himalensis	*-*	*0.03*	*-*	*0.18*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.98*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Sedum ewersi	*-*	*-*	*-*	*-*	*0.45*	*-*	*-*	*0.56*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.71*	*-*
Selinum tenuifolium	*6.07*	*1.08*	*-*	*2.16*	*-*	*0.18*	*4.03*	*2.25*	*0.81*	*-*	*1.37*	*-*	*-*	*-*	*-*	*2.29*	*3.47*	*1.38*	*2.13*	*3.89*	*-*	*3.61*	*2.14*
S. vaginatum	*-*	*0.19*	*-*	*0.37*	*-*	*-*	*4.51*	*-*	*0.61*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2.66*	*3.13*	*0.27*	*3.33*	*-*	*3.61*	*2.27*
Senecio chrysanthemoides	*-*	*0.64*	*-*	*-*	*0.15*	*-*	*-*	*-*	*-*	*-*	*0.89*	*0.66*	*-*	*-*	*-*	*-*	*-*	*-*	*1.67*	*-*	*-*	*-*	*-*
S. graciliflorus	*-*	*-*	*-*	*0.43*	*-*	*1.81*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2.83*	*-*	*-*
S. rufinervis	*-*	*-*	*-*	*-*	*-*	*0.49*	*0.23*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Sibbaldia cuneata	*-*	*0.19*	*-*	*0.16*	*-*	*-*	*0.23*	*-*	*-*	*-*	*1.13*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.14*	*-*	*11.7*	*11.2*	*-*
Silene conoidea	*1.22*	*-*	*-*	*-*	*-*	*-*	*-*	*0.15*	*-*	*-*	*-*	*0.74*	*-*	*-*	*-*	*-*	*-*	*-*	*1.33*	*-*	*-*	*-*	*-*
Sisymbrium officinale	*1.70*	*0.18*	*-*	*-*	*0.52*	*-*	*-*	*-*	*-*	*2.19*	*-*	*0.65*	*-*	*-*	*-*	*-*	*-*	*1.38*	*-*	*-*	*-*	*-*	*-*
S. macrophylla	*-*	*-*	*-*	*0.37*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.40*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Smilacina	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.15*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*

pupurea																							
Stachys sericea	-	-	-	0.35	-	-	-	1.35	0.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stellaria media	7.77	0.76	-	0.13	2.12	-	-	-	-	2.12	-	-	-	-	3.82	0.54	-	-	-	-	-	-	-
S. monosperma	-	0.16	-	-	1.04	-	-	-	0.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Strobilanthus atropurpureus	0.40	2.17	-	2.45	-	1.36	-	1.23	0.61	-	-	4.87	0.82	1.06	-	-	-	-	-	-	-	-	-
S. wallichii	-	-	-	2.15	-	2.54	-	0.74	0.84	-	0.32	2.51	-	1.27	-	-	-	-	-	-	-	-	-
Swertia angustifolia	-	-	-	-	-	0.18	0.23	-	-	-	0.22	-	-	-	-	-	-	-	-	-	-	-	-
S. paniculata	-	-	-	-	-	-	-	0.40	-	-	-	-	-	-	-	-	-	-	-	-	-	3.61	-
Tanacetum dolichophyllum	-	-	-	0.65	-	-	-	0.18	-	-	0.22	-	-	-	-	-	1.66	-	0.60	-	-	-	0.91
Taraxacum officinale	-	-	0.25	0.27	-	-	0.23	0.49	-	-	1.19	-	-	-	-	-	2.13	2.17	0.27	-	2.55	-	2.73
Tegetes minuta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.58	-	-	-	-	-	-	-
Thlaspi arvense	-	0.67	0.63	0.92	0.30	-	-	4.85	-	-	-	-	-	-	4.31	-	-	-	-	-	-	-	-
Thalictrum cultratum	3.23	0.93	0.20	0.54	1.24	1.27	9.45	-	2.05	-	-	1.18	-	2.12	-	-	-	1.13	-	-	-	-	-
T. foliolosum	0.48	1.43	-	-	-	-	-	-	-	-	3.12	1.25	-	-	-	0.19	-	-	0.10	-	-	-	1.99
Thermopsis barbata	-	-	-	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thymus linearis	-	-	0.77	-	2.49	-	-	1.48	-	5.29	-	-	-	-	-	-	-	-	-	-	-	-	-
Trifolium pratense	4.45	2.69	0.25	11.90	7.00	8.66	4.42	7.75	4.66	7.44	2.29	0.66	3.84	-	6.37	10.92	-	-	12.6	-	-	-	-
Trigonella emodi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.88	3.14	-	-	-	-	4.09
Trillidium govanianum	-	0.08	-	0.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turitis glabra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Urtica dioica	*0.24*	*0.09*	*0.55*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.34*	*-*	*3.82*	*0.33*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
U. parviflora	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.98*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
U. purpurea	*-*	*1.53*	*0.21*	*1.83*	*0.07*	*-*	*-*	*0.25*	*-*	*-*	*-*	*2.66*	*-*	*-*	*0.78*	*0.92*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Valeriana hadwickii	*-*	*-*	*-*	*-*	*-*	*-*	*0.50*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
V. jatamansi	*-*	*3.53*	*-*	*0.62*	*-*	*-*	*0.14*	*-*	*1.31*	*-*	*-*	*1.64*	*0.43*	*6.91*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.82*
Verbascum thapsus	*-*	*0.53*	*0.58*	*-*	*1.11*	*-*	*-*	*-*	*-*	*0.19*	*-*	*-*	*-*	*-*	*0.74*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Vincetoxicum hirudinaria	*-*	*-*	*-*	*-*	*-*	*-*	*0.93*	*-*	*-*	*-*	*0.69*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.80*	*-*	*-*	*-*	*-*
Viola biflora	*1.62*	*1.33*	*-*	*-*	*-*	*-*	*-*	*1.74*	*-*	*1.44*	*-*	*-*	*1.74*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
V. canescens	*-*	*3.27*	*2.87*	*1.32*	*1.26*	*-*	*-*	*-*	*-*	*1.92*	*0.17*	*0.89*	*-*	*3.82*	*0.86*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*0.60*
Youngia japonica	*3.24*	*0.11*	*-*	*-*	*0.48*	*-*	*-*	*0.74*	*-*	*0.38*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1.63*	*-*
	100	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Abbreviations Used: 1= *Pyrus pashia-Ilex dipyrena mixed; 2=Picea smithiana; 3=Pinus wallichiana; 4=Abies pindrow; 5=Quercus floribunda; 6=Acer acuminatum; 7=Betula utilis; 8=Ulmus villosa; 9=Quercus semecarpifolia; 10=Cedrus deodara; 11= Acer acuminatum-Betula utilis mixed; 12=Picea smithiana-Aesculus indica mixed; 13=Jugans regia; 14=Abies pindrow-Quercus semecarpifolia mixed; 15=Indigofera heterantha-Sorbaria tomentosa mixed; 16=Indigofera heterantha-Rabdosia rugosa- Spiraea canescens mixed; 17=Juniperus indica; 18=Rosa sericea-Berberis jaeschkeana mixed; 19=Viburnum grandiflorum; 20=Rhododendron anthopogon; 21=Dipsacus inermis-Sibbaldia cuneata-Anaphalis triplinervis mixed; 22=Carex foliosa-Sibbaldia cuneata-Artemisia vestita mixed; 23=Rhodiola bupleuroides- Potentilla atrosanguinea-Anaphalis busua-Phlomis bracteosa mixed*

4.2.4. Species diversity (H')

Community wise diversity of trees, seedlings, saplings, shrubs and herbs has been presented in Table 4.4.8. In general, species diversity (H') for trees ranged from 0.15-1.51, seedlings from 0.70-1.83, saplings from 0.18-1.47, shrubs from 0.33-2.30 and herbs from 2.73-4.20. Highest diversity of trees was reported in *Acer acuminatum* community (1.508), followed by *Picea smithiana* and *Picea smithiana- Aesculus indica* mixed (1.37, each). It was lowest in *Quercus floribunda* community (0.15). Among the seedlings, highest diversity was reported in *Quercus floribunda* community (1.83), followed by *Ulmus villosa* (1.43) and *Pinus wallichiana* (1.32) community. It was lowest in *Acer acuminatum* (0.45). Among the saplings, highest diversity was reported in *Abies pindrow* (1.47) community, followed by *Acer acuminatum* (1.33) and *Picea smithiana* (1.29) community. Lowest diversity was reported in *Quercus semecarpifolia* (0.45) community.

Amongst shrubs, *Ilex dipyrena-Pyrus pashia* mixed community showed highest diversity (4.85), followed by *Quercus floribunda* (3.89) and *Picea smithiana-Aesculus indica* mixed communities (2.85) and *Quercus semecarpifolia* community (0.33) showed the lowest diversity. Amongst herbs, highest diversity was shown by *Picea smithiana* community *(*4.20), followed by *Abies pindrow* (3.93) and *Acer acuminatum* (3.80) community.

Table 4.2.9. Community wise diversity of trees, saplings, seedlings, shrubs and herbs in the Hamta-Jagatsukh Catchments

	Community Types	Trees	Saplings	Seedlings	Shrubs	Herbs
1	*Abies pindrow*	1.13	1.47	1.06	2.35	3.93
2	*Abies pindrow-Quercus semecarpifolia* mixed	1.24	-	-	0.54	2.91
3	*Acer acuminatum*	1.51	1.33	1.21	1.15	3.05
4	*Acer acuminatum- Betula utilis* mixed	1.28	1.13	0.45	1.07	3.80
5	*Betula utilis*	0.96	0.69	0.69	1.11	3.56
6	*Cedrus deodara*	0.58	-	1.01	1.35	2.88
7	*Ilex dipyrena-Pyrus pashia* mixed	1.10	1.06	0.92	4.85	3.24
8	*Juglans regia*	0.40	-	-	0.90	3.02
9	*Picea smithiana*	1.37	1.29	0.70	2.30	4.20
10	*Picea smithiana-Aesculus indica* mixed	1.37	1.00	0.80	2.85	3.27
11	*Pinus wallichiana*	0.66	0.77	1.32	2.81	3.22
12	*Quercus floribunda*	0.15	1.24	1.83	3.89	3.48

13	*Quercus semecarpifolia*	0.57	0.18	0.00	0.33	3.45
14	*Ulmus villosa*	1.29	-	1.43	2.41	3.62
15	*Indigofera heterantha -Rabdosia rugosa-Spiraea canescens* mixed	-	-	-	2.52	3.02
16	*Juniperus indica*	-	-	-	0.99	3.03
17	*Rhododendron anthopogon*	-		-	0.85	2.80
18	*Viburnum grandiflorum*	-	-	-	0.57	3.32
19	*Indigofera heterantha -Sorbaria tomentosa* mixed	-	-	-	1.51	2.88
20	*Rosa sericea -Berberis jaesckiana* mixed	-	-	-	1.78	3.15
21	*Rhodiola bupleuroides-Potentilla atrosanguinea- Anaphalis triplinervis-Phlomis bracteosa* mixed	-	-	-	-	3.19
22	*Dipsacus inermis-Sibbaldia cuneata-Anaphalis triplinervis* mixed	-	-	-	-	2.73
23	*Carex foliosa-Sibbaldia cuneata-Artemisia vestita* mixed	-	-	-	-	2.89

4.3. Quantitative assessment of Vegetation in High Project Impact Area of Hamta and Jagatsukh Catchments

4.3.1. Community Diversity, Distribution Pattern, Species Composition and Structure

A total of 14 communities (Forests: 12; shrubs: 2) have been identified based on Importance Value Index and Relative density, from High Project Impact Area of the Hamta and Jagatsukh Catchments between 1800-3200m. Forest communities were represented by evergreen coniferous communities (*i.e., Abies pindrow, Pinus wallichiana*, *Picea smithiana* and *Cedrus deodara*); broad leaved evergreen communities (*i.e., Quercus floribunda,* and *Q. semecarpifolia*); Evergreen coniferous-broad leaved deciduous communities (*i.e., Abies pindrow-Acer acuminatum* mixed*, Picea smithiana-Aesculus indica* mixed,); Evergreen- deciduous broad leaved community (i.e., *Ilex dipyrena- Pyrus pashia* mixed); broad leaved deciduous communities (*i.e., Acer acuminatum, Ulmus villosa, Juglans regia,* and *Acer acuminatum-Betula utilis* mixed). The community types, altitudinal distribution, representation in sites, habitats, and major tree associates have been presented in Table 4.3.1. Amongst the communities, *Picea smithiana* and *Abies pindrow* community (3 sites, each), represented maximum sites, followed by *Pinus wallichiana, Acer acuminatum* and *Quercus floribunda* (2 sites, each), and remaining communities represented < 2 sites.

Over all, 284 species (Trees: 18; Shrubs: 46; Herbs: 220) were recorded. Amongst the communities, *Picea smithiana*community showed maximum number of

species 137 (Trees: 8; Shrubs: 29; Herbs: 100), followed by *Pinus wallichiana* 95 species (Trees: 8; Shrubs: 20; Herbs: 67) and *Abies pindrow* 94 species (Trees: 8; Shrubs: 14; Herbs: 72) communities. Minimum numbers of species were recorded in *Cedrus deodara* community 44 species (Trees:3;Shrubs:8;Herbs:33).

Amongst the identified forest communities in the high project impact area, the total tree density ranged from 60.0-1280.0 Ind ha^{-1} and total basal area from 0.74-1964.20m^2 ha^{-1}. *Pinus wallichiana* community had maximum tree density (160-1280 Ind ha^{-1}), followed by *Quercus semecarpifolia* (930 Ind ha^{-1}), *Acer acuminatum-Betula utilis* mixed community (470-720 Ind ha^{-1}), and *Picea smithiana* (220-640 Ind ha^{-1}), communities. *Abies pindrow* community showed maximum range of total basal area (1122.20-1964.20 m^2 ha^{-1}), followed by *Picea smithiana* (580.80-1126.40m^2 ha^{-1}), *Cedrus deodara* (845.60m^2ha^{-1}) and *Juglans regia* (694.20 m^2ha^{-1}), communities (Table 4.3.1).

Table 4.3.1. Community Types of their Distribution, Density and Total Basal Area in High Project Impact Area

	Community Types	**SR**	**Habitats**	**Aspect**	**Altitudinal range (m)**	**Slope (°)**	**TBA (m^2/ha)**	**Density (Ind/ha)**	**Major Associates**
A.	**Forests**								
1	*Ilex dipyrena -Pyrus pashia* mixed	1	D	NW	1992	55	0.74	60	*Quercus floribunda*
2	*Picea smithiana*	3	SM, R	NW, SW, SE	2730-2804	40-60	580.8-1126.4	220-640	*Abies pindrow, Prunus cornuta*
3	*Pinus wallichiana*	2	SM, Dr	NW, W	2020-2250	35-65	39.2-594.1	160-1280	*Cedrus deodara, Picea smithiana*
4	*Abies pindrow*	3	SM, S	SW, W	2693-2790	50-65	1122.9-1964.2	470-720	*Picea smithiana, Acer acuminatum*
5	*Quercus floribunda*	2	SM, B	S, NW	2012-2067	35-40	314.2-83.614	250-330	*Picea smithiana*
6	*Acer acuminatum*	1	R	NW, S	2771-3185	40-50	333.3-356.1	380-410	*Betula utilis, Abies pindrow*
7	*Ulmus villosa*	1	D	W	2481	55	382.70	370	*Prunus cornuta, Salix daphnoides*
8	*Quercus semecarpifolia*	1	R	NW	2785	10	382.90	930	*Taxus baccata* subsp. *wallichiana, Betula utilis*
9	*Cedrus*	1	D	W	2229	40	845.60	230	*Picea*

	deodara								*smithiana, Pinus wallichiana*
10	*Betula utilis-Acer acuminatum* mixed	1	R	W	3120	10	223.27	240	*Abies pindrow, Taxus baccata* subsp. *wallichiana*
11	*Picea smithiana-Aesculus indica* mixed	1	B	SW	2291	45	10.10	150	*Cedrus deodara, Alnus nitida*
12	*Juglans regia*	1	B	W	2618	30	694.20	380	*Aesculus indica, Picea smithiana*
B.	**Shrubs**								
13	*Indigofera heterantha - Sorbaria tomentosa* mixed	1	S	SW	2130	45	-	520	*Cyathula tomentosa, Spiraea canescens*
14	*Indigofera heterantha-Rabdosia rugosa-Spiraea canescens* mixed	1	D	W	2380	20	-	3890	*Prinsepia utilis, Sorbaria tomentosa*

Abbreviations used: SR=Site Representation; TBA=Total Basal Area; IVI=Importance Value Index; S=South; W= West; N= North, E=East; SW=South West; NW= North West; SE=South East; D=Degraded; SM=Shady Moist; R=Riverine; Dr=Dry forest; B=Bouldary; Sc= Alpine Scrubs

4.3.2. Communities: Composition, Structure and Regeneration Pattern

1. Pyrus pashia-Ilex dipyrena mixed community

This community has been represented in 1 site of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

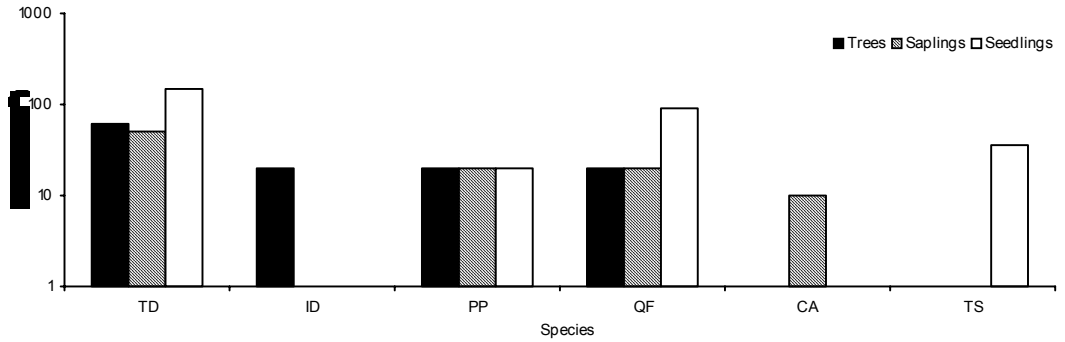
A total of 93 species (Trees: 5; Shrubs: 21; Herbs: 67) were recorded in this community. The total tree density and total basal area were 60.00 Ind ha^{-1} and 0.74m^2 ha^{-1}, respectively. *Pyus pashia* (Density: 20.00 Ind ha^{-1}, Basal area: 0.33m^2 ha^{-1}, IVI: 118.76) was the dominant tree and *Ilex dipyrena* (Density: 20.00 Ind ha^{-1}, Basal area: 0.22m^2 ha^{-1}, IVI: 98.07), and *Quercus floribunda* (Density: 20.00 Ind ha^{-1}, Basal area: 0.19m^2 ha^{-1}, IVI: 83.16) were co-dominant trees of this community (Table 4.3.2, 3 & 4).

Among the shrubs highest density was shown by *Sarcococa saligna* (17.7%), followed by *Rabdosia rugosa* (10.4%) and *Indigofera heterantha* and *Hedera nepalense* (9.8%, each) (Table 4.3.5.), and among herbs highest density was shown by *Carex brevicaulis* (16.7%), followed by *Stellaria media* (7.7%) and *Chrysopogon echinulatus* (7.05%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Pyrus pashia-Ilex dipyrena* mixed community have been presented in Fig. 4.3.2.1. Total seedlings and saplings densities were 155.00 Ind ha^{-1} and 10.00 Ind ha^{-1}, respectively. Among the saplings, *Pyrus pashia* and *Quercus floribunda* showed high density (20.00 Ind ha^{-1}, each), followed by *Celtis australis* (Density: 10.00 Ind ha^{-1}). Among seedlings, highest density was shown by *Quercus floribunda* (90.00 Ind ha^{-1}), followed by *Toona serrata* (36.36 Ind ha^{-1}) and *Pyrus pashia* (20.00 Ind ha^{-1}).

Fig. 4.3.2.1. Population structure of *Pyrus pashia-Ilex dipyrena* community



Abbreviations used: TD=Total density; ID=*Ilex dipyrena*; PP= *Pyrus pashia;* QF=*Quercus floribunda* CA=*Celtis australis,* and TS= *Toona serrata*

***2. Picea smithiana* community**

This community has been represented in 4 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 137 species (Trees: 8; Shrubs: 32; Herbs: 97) were recorded in this community. The total tree density and total basal area were 412 Ind ha^{-1} and 1063.93m^2 ha^{-1}, respectively. *Picea smithiana* (Density: 270.83 Ind ha^{-1}, Basal area: 957.20m^2 ha^{-1}, IVI: 220.50) was the dominant tree and, *Abies pindrow* (Density: 97.50 Ind ha^{-1}, Basal area: 103.70 m^2 ha^{-1}, IVI: 54.50), *Quercus semecarpifolia* (Density: 22.50 Ind ha^{-1}, Basal area: 1.67m^2 ha^{-1}, IVI: 8.49) and *Prunus cornuta* (Density: 12.50 Ind ha^{-1}, Basal area:

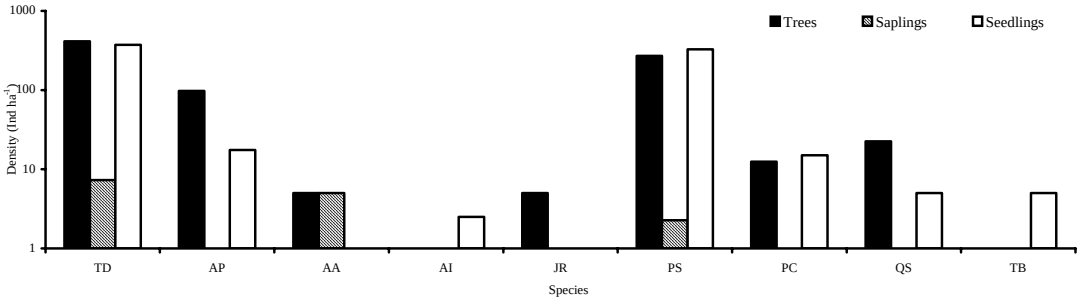
0.50 m^2 ha^{-1}, IVI: 8.51) were the major tree associates (Table 4.3.2, 3 & 4).

Among the shrubs highest density was shown by *Sorbaria tomentosa* (48.42%), followed by *Viburnum cotonifolium* (22.25%), *Berberis lycium* (6.20%) and *Cotoneaster obtusus* (5.34%) (Table 4.3.5.). Among herbs, highest density was shown by *Galium aparine* (6.94%), followed by *Viola canescens* (4.18%) and *Carex brevicaulis* (4.10%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Picea smithiana* community have been presented in Fig. 4.3.2.2. Total seedlings and saplings densities were 372.50 Ind ha^{-1} and 7.30 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Acer acuminatum* (5 .00 Ind ha^{-1}), followed by *Picea smithiana* (2.5 Ind ha^{-1}), and seedlings, highest density was shown by *Picea smithiana* (327.50 Ind ha^{-1}), followed by *Abies pindrow* (17.50 Ind ha^{-1}), and *Prunus cornuta* (15.00 Ind ha^{-1}). The remaining species showed less regeneration and *Juglans regia* showed no regeneration.

Fig. 4.3.2.2. Population structure of *Picea smithiana* community



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum;* AI= *Aesculus indica*; JR=*Juglans regia*; PS=*Picea smithiana*; PC= *Prunus cornuta*; QS=*Quercus semecarpifolia*, and TB =*Taxus baccata* subsp. *wallichiana.*

3. *Pinus wallichiana* community

This community has been represented in 2 sites of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 95 species (Trees: 8; Shrubs: 20; Herbs: 67) were recorded in this community. The total tree density and total basal area were 710.00 Ind ha^{-1} and 336.60m^2 ha^{-1}, respectively. *Pinus wallichiana* (Density: 575.00 Ind ha^{-1}, Basal area: 196.20m^2 ha^{-1}, IVI: 186.60) was the dominant tree and *Cedrus deodara* (Density: 115.00 Ind ha^{-1}, Basal area: 118.70m^2 ha^{-1}, IVI: 73.30) and *Picea smithiana* (Density: 10.00 Ind ha^{-1}, Basal area: 1.35m^2 ha^{-1}, IVI: 21.80) were the major tree associates (Table 4.3.2, 3

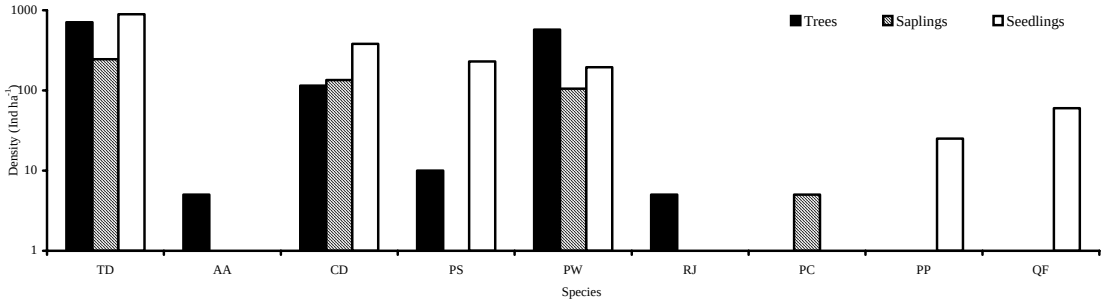
& 4).

Among the shrubs, highest density was shown by *Berberis lycium* (21.45%) followed by *Indigofera heterantha* (20.2%), and *Desmodium elegans* (11.04%) (Table 4.3.5.), and among herbs, highest density was shown by *Carex brevicaulis* (33.40%), followed by *Iris milesii* (6.55%) and *Chrysopogon gryllus* (5.46%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Pinus wallichiana* community have been presented in Fig 4.3.2.3. Total seedlings and saplings densities were 890.00 Ind ha^{-1} and 245.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Cedrus deodara* (135.00 Ind ha^{-1}), followed by *Pinus wallichiana* (105.00 Ind ha^{-1}) and *Prunus cornuta* (5.00 Ind ha^{-1}), and among seedlings, highest density was shown by *Cedrus deodara* (380.00 Ind ha^{-1}), followed by *Picea smithiana* (230.00 Ind ha^{-1}), and *Pinus wallichiana* (195.00 Ind ha^{-1} each). *Acer acuminatum* and *Rhus javanica* did not show regeneration.

Fig. 4.3.2.3. Population structure of *Pinus wallichiana* community



Abbreviations used: TD=Total density; AA=*Acer acuminatum*; CD=*Cedrus deodara*; PS=*Picea smithiana*; PW=*Pinus wallichiana*; RJ=*Rhus javanica*; PC=*Prunus cornuta*; PP=*Pyrus pashia*; QF=*Quercus floribunda*; and RJ=*Rhus javanica*

4. *Abies pindrow* Community

This community has been represented in 3 sites of the Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 94 species (Trees: 8; Shrubs: 14; Herbs: 72) were recorded in this community. The total tree density and total basal area were 600.00 Ind ha^{-1} and 1332.84m^2 ha^{-1}, respectively. *Abies pindrow* (Density: 513.30 Ind ha^{-1}, Basal area: 1305.50 m^2 ha^{-1}, IVI: 240.30) was the dominant tree and, *Picea smithiana* (Density: 43.30 Ind ha^{-1}, Basal area: 22.70 m^2 ha^{-1}, IVI: 26.70) and *Acer acuminatum* (Density: 13.33 Ind ha^{-1}, Basal area: 1.43 m^2 ha^{-1}, IVI: 11.10) were the major tree associates (Table 4.3.2, 3 & 4).

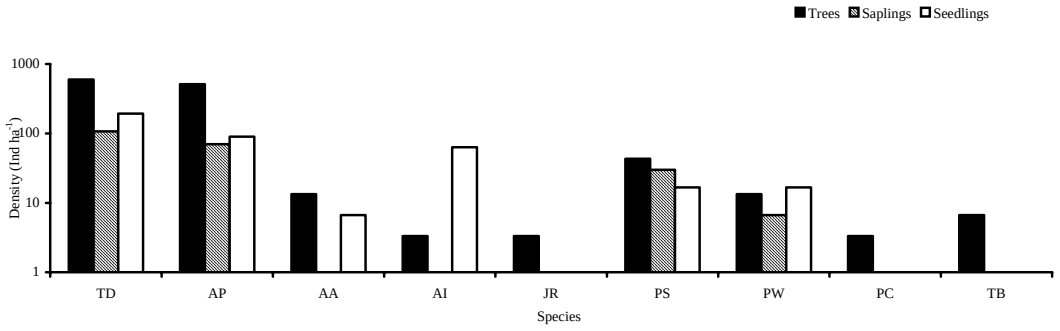
Among the shrubs highest density was shown by *Viburnum cotonifolium*

(27.91%), followed by *Indigofera heterantha* (9.47%), and *Rosa brunonii* (8.47%) (Table 4.3.5), and among herbs, highest density was shown by *Trifolium pratense* (14.35%), followed by *Adiantum capillus-veneris* (7.99%), and *Pteris cretica* (6.36%) (Table 4.3.6).
Regeneration pattern

The total density and regeneration pattern of different species in *Abies pindrow* community have been presented in Fig. 4.3.2.4.

Total seedlings and saplings densities were 193.30 Ind ha^{-1} and 106.7 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Abies pindrow* (70.00 Ind ha^{-1}), followed by *Picea smithiana* (30.00 Ind ha^{-1}), and *Pinus wallichiana* (6.67 Ind ha^{-1}), and seedlings, highest density was shown by *Abies pindrow* (90.00 Ind ha^{-1}), followed by *Aesculus indica* (63.33 Ind ha^{-1}), *Picea smithiana* and *Pinus wallichiana* (16.67 Ind ha^{-1}, each). The remaining species showed less regeneration. *Prunus cornuta, Taxus baccata* subsp*. wallichiana* and *Juglans regia* showed no regeneration.

Fig. 4.3.2.4. Population structure of *Abies pindrow* community



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum;* AI= *Aesculus indica*; JR=*Juglans regia*; PS=*Picea smithiana*; PW=*Pinus wallichiana*; PC= *Prunus cornuta*; PW=*Pinus wallichiana*; and TB =*Taxus baccata* subsp. *wallichiana.*

5. *Quercus floribunda* community

This community has been represented in 2 sites of the Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 88 species (Trees: 8; Shrubs: 23; Herbs: 57) were recorded in this community. The total tree density and total basal area were 295.00 Ind ha^{-1} and 99.32m^2 ha^{-1}, respectively. *Quercus floribunda* (Density: 285.50 Ind ha^{-1}, Basal area: 57.51m^2 ha^{-1}, IVI: 292.4) was the dominant tree and *Picea smithiana* (Density: 10.00 Ind ha^{-1}, Basal area: 41.81m^2 ha^{-1}, IVI: 7.55) is the only tree associates (Table 4.3.2, 3 & 4).

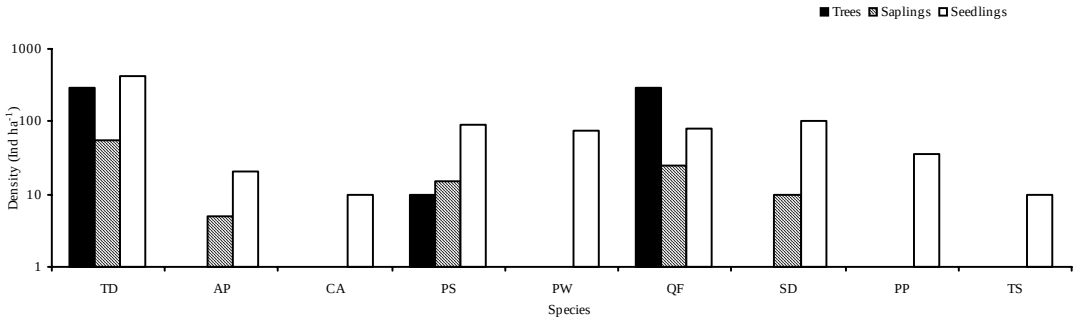
Among the shrubs, highest density was shown by *Berberis lycium* (31.00%), followed by *Prinsepia utilis* (11.10%) and *Spiraea canescens* (11.00%) (Table 4.3.5), and among herbs, highest density was shown by *Carex nubigena* (12.70%), followed by

Trifolium pratense (7.00%) and *Galium aparine* (4.64%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Quercus floribunda* community have been presented in Fig. 4.3.2.5. Total seedlings and saplings densities were 420.00 Ind ha^{-1} and 55.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Quercus floribunda* (25.00 Ind ha^{-1}), followed by *Picea smithiana* (15.00 Ind ha^{-1}) and *Pyrus pashia* (10.00 Ind ha^{-1}), and among seedlings, highest density was shown by *Pyrus pashia* (100.00 Ind ha^{-1}), followed by *Picea smithiana* (90.00 Ind ha^{-1}) and *Quercus floribunda* (80.00 Ind ha^{-1}). High regeneration of *Pyrus pashia*, *Pinus wallichiana* and *Salix daphnoides* indicates the proliferation of these species in this community.

Fig. 4.3.2.5. Population structure of *Quercus floribunda* community



Abbreviations used: TD=Total density; AP=*Abies pindrow;* CA=*Celtis australis;* PS=*Picea smithiana;* PW=*Pinus wallichiana*; QF= *Quercus floribunda*; SD=*Salix daphnoides*; PP=*Pyrus pashia*; and TS=*Toona serrata*

6. *Acer acuminatum* Community

This community has been represented in 2 sites in both Hamta and Jagatsukh catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

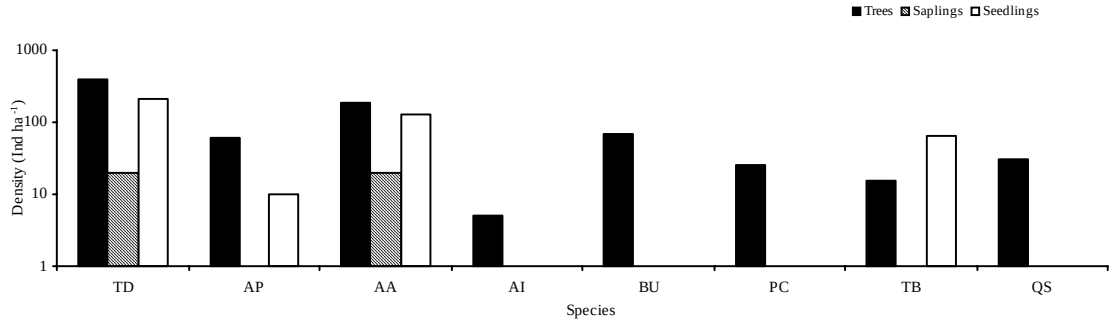
A total of 46 species (Trees: 7; Shrubs: 3; Herbs: 36) were recorded in this community. The total tree density and total basal area were 395.00 Ind ha^{-1} and 359.69m^2 ha^{-1}, respectively. *Acer acuminatum* (Density: 190.00 Ind ha^{-1}, Basal area: 285.05m^2 ha^{-1}, IVI: 167.00) was the dominant tree and *Betula utilis* (Density: 70.00 Ind ha^{-1}, Basal area: 26.80m^2 ha^{-1}, IVI: 46.01) and *Abies pindrow* (Density: 60.00 Ind ha^{-1}, Basal area: 37.54m^2 ha^{-1}, IVI: 41.87) were the major tree associates (Table 4.3.2, 3 & 4).

Among the shrubs, highest density was shown by *Rosa macrophylla* (62.22%), followed by *Viburnum cotonifolium* (28.89%) and *Deutzia corymbosa* (8.89%) (Table 4.3.5), and among herbs, highest density was shown by *Bistorta amplexicaulis* (14.29%), followed by *Trifolium pratense* (12.04%) and *Pteris cretica* (7.69%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Acer acuminatum* community have been presented in Fig. 4.3.4.6. Total seedlings and saplings densities were 205.00 Ind ha^{-1} and 20.00 Ind ha^{-1}, respectively. Among the saplings, only *Acer acuminatum* (20.00 Ind ha^{-1}) showed regeneration. Among seedlings, highest density was shown by *Acer acuminatum* (130.00 Ind ha^{-1}), followed by *Taxus baccata* subsp*. wallichiana* (65.00 Ind ha^{-1}) and *Abies pindrow* (10.00 Ind ha^{-1}). *Aesculus indica, Prunus cornuta, Betula utilis* and *Quercus semecarpifolia* showed no regeneration in this community.

Fig. 4.3.2.6. Population structure of *Acer acuminatum* community



Abbreviations used: TD=Total density; AP=*Abies pindrow;* AA=*Acer acuminatum;* AI=*Aesculus indica;* BU=*Betula utilis;* PC= *Prunus cornuta;* TB=*Taxus baccata* subsp. *wallichiana* and QS=*Quercus semecarpifolia*

7. *Ulmus villosa* community

This community has been represented in 1 site of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

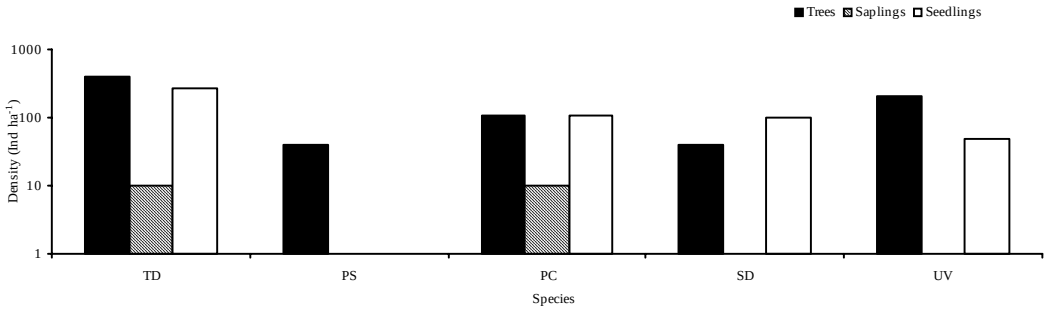
Composition and structure

A total of 85 species (Trees: 4 species; Shrubs: 16 species; Herbs: 65 species) were recorded in this community. The total tree density and total basal area were 400.00 Ind ha^{-1} and 382.40m^2 ha^{-1}, respectively. *Ulmus villosa* (Density: 210.00 Ind ha^{-1}, Basal area: 368.20m^2 ha^{-1}, IVI: 200.20) was the dominant tree and *Prunus cornuta* (Density: 110.00 Ind ha^{-1}, Basal area: 7.60m^2 ha^{-1}, IVI: 52.80) and *Salix daphnoides* (Density: 40.00 Ind ha^{-1}, Basal area: 1.80m^2 ha^{-1}, IVI: 27.10) were major tree associates (Table 4.3.2, 3 & 4).

Among the shrubs, highest density was shown by *Rubus ellipticus* (25.79%), followed by *Viburnum cotonifoilum* (20.53%) and *Indigofera heterantha* (7.29%) ((Table 4.3.5), and among herbs, highest density was shown by *Carex nubigena* (15.80%), followed by *Trifolium pratense* (11.47%) and *Cyanodon dactylon* (9.48%) (Table 4.3.6).
Regeneration pattern

The total density and regeneration pattern of different species in *Ulmus villosa* community have been presented in Fig. 4.3.2.7. Total seedlings and saplings densities were 260.00 Ind ha^{-1} and 10.00 Ind ha^{-1}, respectively. Among the saplings, only *Prunus cornuta* showed regeneration (10.00 Ind ha^{-1}) and among seedlings, highest density was shown by *Prunus cornuta* (110.00 Ind ha^{-1}), followed by *Salix daphnoides* (100.00 Ind ha^{-1}) and *Ulmus villosa* (50.00 Ind ha^{-1}).

Fig. 4.3.2.7. Population structure of *Ulmus villosa* community



Abbreviations used: TD=Total density; PS=*Picea smithiana*; PC= *Prunus cornuta*; SD= *Salix daphnoides* and UV=*Ulmus villosa*

8. *Quercus semecarpifolia* community

This community has been represented in 1 site of the Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 50 species (Trees: 6; Shrubs: 2; Herbs: 42) were recorded in this community. The total tree density and total basal area were 930.00 Ind ha^{-1} and 38.30m^2 ha^{-1}, respectively. *Quercus semecarpifolia* (Density: 800.00 Ind ha^{-1}, Basal area: 37.80m^2 ha^{-1}, IVI: 234.70) was the dominant tree and *Taxus baccata* subsp*. wallichiana* (Density: 40.00 Ind ha^{-1}, Basal area: 0.05m^2 ha^{-1}, IVI: 19.40) and *Betula utilis* (Density: 40.00 Ind ha^{-1}, Basal area: 0.05m^2 ha^{-1}, IVI: 14.40) were the major tree associates (Table 4.3.2, 3 & 4).

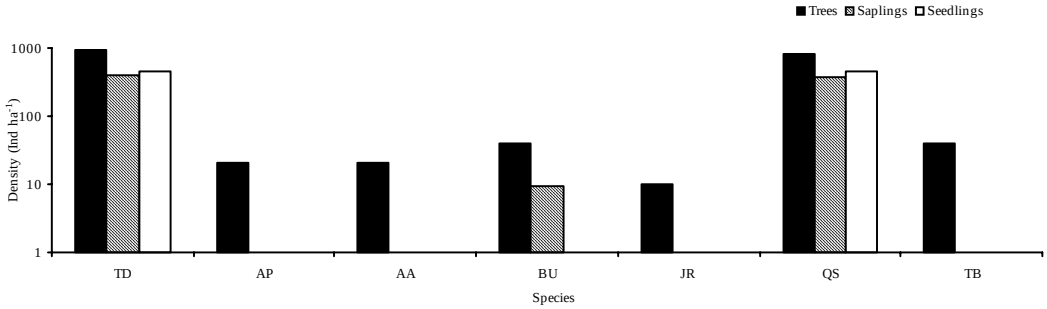
Among the shrubs, highest density was shown by *Viburnum mullaha* (77.78%), followed by *Rosa macrophylla* (22.22%) (Table 4.3.5), and among herbs, highest density was shown by *Lepisorus nudus* (18.92%), followed by *Geranium wallichianum* (7.56%) and *Trifolium pratense* (7.09%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Quercus semecarpifolia* community have been presented in Fig. 4.3.2.8. Total seedlings and saplings densities were 450.00 Ind ha^{-1} and 389.00 Ind ha^{-1}, respectively. Among the

saplings, highest density was shown by *Quercus semecarpifolia* (380.0 Ind ha^{-1}), followed by *Taxus baccata* subsp*. wallichiana* (9.09 Ind ha^{-1}) and among seedlings, only *Quercus semecarpifolia* (335.00 Ind ha^{-1}) showed regeneration. *Betula utilis*, *Acer acuminatum* and *Prunus cornuta* showed poor regeneration in this community.

Fig. 4.3.2.8. Population structure of *Quercus semecarpifolia* community



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum*; BU=*Betula utilis*; JR=*Juglans regia*: QS=*Quercus semecarpifolia*; and TB=*Taxus baccata* subsp. *wallichiana*

9*. Cedrus deodara* community

This community has been represented in 1 site in Hamta catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 44 species (Trees: 3; Shrubs: 8; Herbs: 33) were recorded in this community. The total tree density and total basal area were 230.00 Ind ha^{-1} and 846.89m^2 ha^{-1}, respectively. *Cedrus deodara* (Density: 190.00 Ind ha^{-1}, Basal area: 842.89m^2 ha^{-1}, IVI: 251.50) was the dominant tree and, *Picea smithiana* (Density: 20.00 Ind ha^{-1}, Basal area: 1.45m^2 ha^{-1}, IVI: 24.33) and *Pinus wallichiana* (Density: 20.00 Ind ha^{-1}, Basal area: 1.26 m^2 ha^{-1}, IVI: 24.33) were the major tree associates (Table 4.3.2, 3 & 4).

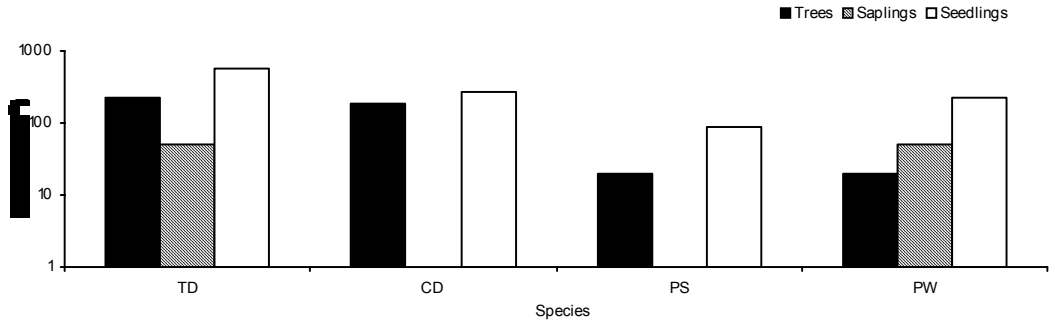
Among the shrubs, highest density was shown by *Indigofera heterantha* (48.50%), followed by *Berberis lycium* (15.50%) and *Rabdosia rugosa* (13.40%) (Table 4.3.5), and among herbs, highest density was shown by *Carex nubigena* (16.30%), followed by *Oxalis corniculata* (8.37%) and *Trifolium pratense* (7.44%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Cedrus deodara* community have been presented in Fig. 4.3.2.9. Total seedlings and saplings densities were 580.00 Ind ha^{-1} and 50.00 Ind ha^{-1}, respectively. In the saplings, only *Abies pindrow* (50.00Ind ha^{-1}) showed regeneration, and among seedlings, highest density was shown by *Cedrus deodara* (270.00 Ind ha^{-1}), followed by *Pinus wallichiana* (220.00 Ind ha^{-1}) and

Picea smithiana (90.00 Ind ha^{-1}).

Fig. 4.3.2.9. Population structure of *Cedrus deodara* community



Abbreviations used: TD=Total density; CD=*Cedrus deodara*; AP=*Abies pindrow*; and PW= *Pinus wallichiana*

10. Betula utilis-Acer acuminatum mixed community

This community has been represented in 1 site of the Jagatsukh catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

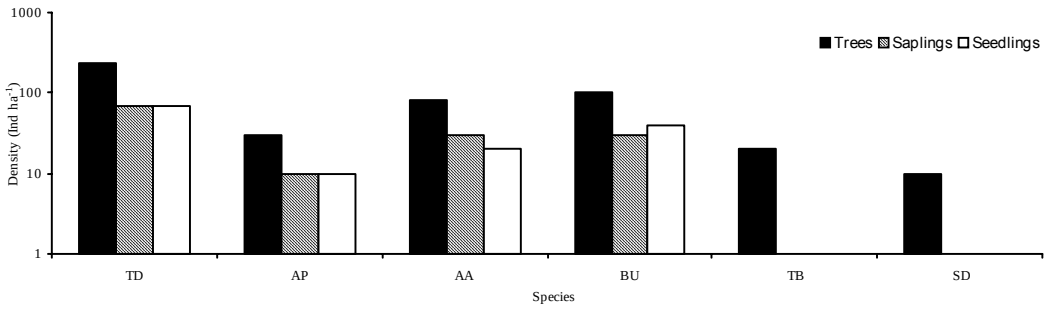
A total of 46 species (Trees: 5; Shrubs: 5; Herbs: 36) were recorded in this community. The total tree density and total basal area were 240.00 Ind ha^{-1} and 223.28m^2 ha^{-1}, respectively. *Betula utilis* (Density: 100.00 Ind ha^{-1}, Basal area: 105.50m^2 ha^{-1}, IVI: 122.20) was the dominant tree and *Acer acuminatum* (Density: 80.00 Ind ha^{-1}, Basal area: 117.20m^2 ha^{-1}, IVI: 115.5) and *Abies pindrow* (Density: 30.00 Ind ha^{-1}, Basal area: 4.48m^2 ha^{-1}, IVI: 34.50), respectively, were the co-dominant species (Table 4.3.2, 3 & 4).

Among the shrubs, highest density was shown by *Viburnum cotonifolium* (37.68%), followed by *Rosa macrophylla* (33.00%) and *Rhododendron campanulatum* (14.49%) (Table 4.3.5.), and among herbs, highest density was shown by *Carex nivaliss* (19.42%), followed by *Podophyllum hexandrum* (9.32%) and *Trifolium pratense* (7.87%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Betula utilis-Acer acuminatum* community have been presented in Fig. 4.3.2.10. Total seedlings and saplings densities were 140.00 Ind ha^{-1} and 140.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Acer acuminatum* and *Betula utilis* (30.00 Ind ha^{-1} each), followed by *Abies pindrow* (10.00 Ind ha^{-1}), and among seedlings, highest density was shown by *Betula utilis* (40.00 Ind ha^{-1}), followed by *Acer acuminatum* (20.00 Ind ha^{-1}) and *Prunus cornuta* (10.00 Ind ha^{-1}). *Salix daphnoides* and *Taxus baccata* subsp. *wallichiana* did not show any regeneration.

Fig. 4.3.2.10. Population structure of *Betula utilis-Acer acuminatum* **mixed community**



Abbreviations used: TD=Total density; AP=*Abies pindrow;* AA=*Acer acuminatum;* BU=*Betula utilis*; TB=*Taxus baccata* subsp. *wallichiana* and SD= *Salix daphnoides*

11. Picea smithiana–Aesculus indica mixed community

This community has been represented in 1 site of the Jagatsukh catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

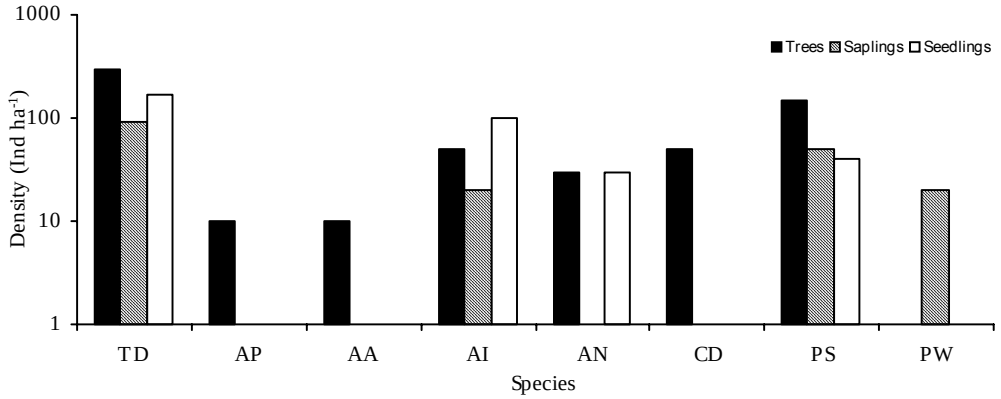
A total of 53 species (Trees: 7; Shrubs: 9; Herbs: 37) were recorded in this community. The total tree density and total basal area were 300.00 Ind ha^{-1} and 10.10m^2 ha^{-1}, respectively. *Picea smithiana* (Density: 150.00 Ind ha^{-1}, Basal area: 8.40m^2 ha^{-1}, IVI: 144.20) was the dominant tree and, *Aesculus indica* (Density: 50.00 Ind ha^{-1}, Basal area: 0.30m^2 ha^{-1}, IVI: 68.40) was co-dominant tree species and *Cedrus deodara* (Density: 50.00 Ind ha^{-1}, Basal area: .30m^2 ha^{-1}, IVI: 42.80) was the major tree associate (Table 4.3.2, 3 & 4).

Among the shrubs, highest density was shown by *Rubus ellipticus* (29.19%), followed by *Indigofera heterantha* (27.03%) and *Desmodium elegans* (14.05%) (Table 4.3.5), and among herbs, highest density was shown by *Carex nubigena* (31.02%), followed by *Polygonum nepalense* (13.90%) and *Carex brevicaulis* (8.70%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Picea smithiana–Aesculus indica* mixed community have been presented in Fig. 4.3.2.11. Total seedlings and saplings densities were 170.00 Ind ha^{-1} and 90.00 Ind ha^{-1}, respectively. Among the saplings, highest density was shown by *Picea smithiana* (50.00 Ind ha^{-1}), followed by *Aesculus indica* and *Pinus wallichiana* (20.00 Ind ha^{-1}, each), and among seedlings, highest density was shown by *Aesculus indica* (100.00 Ind ha^{-1}), followed by *Picea smithiana* (40.00 Ind ha^{-1}) and *Alnus nitida* (30.00 Ind ha^{-1}). *Abies pindrow*, *Cedrus deodara* and *Acer acuminatum* showed no regeneration.

Fig. 4.3.2.11. Population structure of *Picea smithiana–Aesculus indica* **community**



Abbreviations used: TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum;* AI= *Aesculus indica;* AN=*Alnus nitida*; CD=*Cedrus deodara*; PS=*Picea smithiana*; and PW=*Pinus wallichiana*

12. Juglans regia community

This community has been represented in 1 site of the Hamta catchments. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

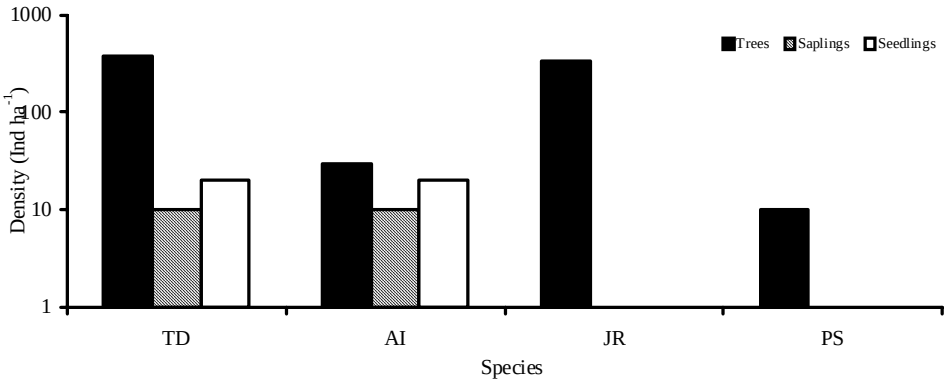
A total of 47 species (Trees: 3; Shrubs: 4; Herbs: 40) were recorded in this community. The total tree density and total basal area were 380.00 Ind ha^{-1} and 69.420m^2 ha^{-1}, respectively. *Juglans regia* (Density: 340.00 Ind ha^{-1}, Basal area: 68.89m^2 ha^{-1}, IVI: 260.40) was the dominant tree and *Aesculus indica* (Density: 30.00 Ind ha^{-1}, Basal area: 0.49m^2 ha^{-1}, IVI: 30.03) and *Picea smithiana* (Density: 10.00 Ind ha^{-1}, Basal area: 0.24m^2 ha^{-1}, IVI: 9.81) were the major tree associates (Table 4.3.2, 3 & 4).

Among the shrubs, highest density was shown by *Prinsepia utilis* (41.70%), followed by *Rosa brunonii* (22.20%) and *Viburnum cotonifolium* (19.40%) (Table 4.3.5), and among herbs highest density was shown by *Pteris cretica* (12.2%), followed by *Eragrostis pilosa* (9.78%) and *Festuca rubra* (9.76%) (Table 4.3.6).

Regeneration pattern

The total density and regeneration pattern of different species in *Juglans regia* community have been presented in Fig. 4.3.2.12. Total seedlings and saplings densities were 10.00 Ind ha^{-1} and 20.00 Ind ha^{-1}, respectively. Among the seedlings and saplings, only *Aesculus indica* (20.00 Ind ha^{-1}), (10.00 Ind ha^{-1}), respectively, showed regeneration. *Picea smithiana* and *Juglans regia* did not show regeneration.

Fig. 4.3.2.12. Population structure of *Juglans regia* **community**



Abbreviations used: TD=Total density; AI=*Aesculus indica;* JR= *Juglans regia*; and PS=*Picea smithiana*

B. Shrub Communities

13. *Indigofera heterantha–Sorbaria tomentosa* mixed community

This community has been represented in 1 site of the Jagatsukh catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 48 species (Shrubs: 6; Herbs: 42) were recorded in this communityThe total shrub density was 520 Ind ha^{-1}. *Sorbaria tomentosa* (34.65%) was the dominant shrub, *Indigofera heterantha* (32.67%) and *Desmodium elegans* (13.86%) were the co-dominant shrub species (Table 4.3.5.) Among herbs highest density was shown by *Oplismenus undulatifolius* (11.20%), followed by *Oxalis corniculata* (9.76%) and *Eragrostris pilosa* (7.26%) (Table 4.3.6).

14. *Rabdosia rugosa-Indigofera heterantha-Spiraea canescens* mixed community

This community has been represented in 1 site of the Jagtsukh catchment. The altitude, latitudes, and longitudes have been presented in Table 4.2.1.

Composition and structure

A total of 47 species (Shrubs: 14 Herbs: 33) were recorded in this community
The total shrub density was 3890 Ind ha^{-1}. *Rabdosia rugosa* (17.80%) was the dominant shrub, *Indigofera heterantha* (16.90%) and *Spiraea canescens* (12.1%) were the co-dominant shrubs (Table 4.3.5). Among herbs highest density was shown by *Impatiens arguta* (12.40%), followed by *Trifolium pratense* (10.92%) and *Pteridium aquilinum* (6.55%) (Table 4.3.6).

Table 4.3.2. Community wise Density (Ind ha^{-1}) of the Trees in High Project Impact Area of the Hamta-Jagatsukh Catchments

Taxa	Community Types											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Abies pindrow		97.5	-	513.3	-	60.0	-	20.0	-	30.0	10.0	-
Acer acuminatum	-	5.0	5.0	13.3	-	190.0	-	20.0	-	80.0	10.0	-
Aesculus indica	-	-	-	3.3	-	5.0	-	-	-	-	50.0	30.0
Alnus nitida	-	-	-	-	-	-	-	-	-	-	30.0	-
Betula utilis	-	-	-	-	-	70.0	-	40.0	-	100.0	-	-
Cedrus deodara	-	-	115.0	-	-	-	-	-	190.0	-	50.0	-
Ilex dipyrena	20.0	-	-	-	-	-	-	-	-	-	-	-
Juglans regia	-	5.0	-	3.3	-	-	-	10.0	-	-	-	340.0
Picea smithiana	-	270.0	10.0	43.3	10.0	-	40.0	-	20.0	-	150.0	10.0
Pinus wallichiana	-	-	575.0	13.3	-	-	-	-	20.0	-	-	-
Prunus cornuta	-	12.5	-	3.3	-	25.0	110.0	-	-	-	-	-
Pyrus pashia	20.0	-	-	-	-	-	-	-	-	-	-	-
Quercus floribunda	-	-	-	-	285.0	-	-	-	-	-	-	-
Q. semecarpifolia	20.0	22.5	-	-	-	30.0	-	800.0	-	-	-	-
Rhus javanica	-	-	5.0	-	-	-	-	-	-	-	-	-
Salix daphnoides	-	-	-	-	-	-	40.0	-	-	10.0	-	-
Taxus baccata subsp. *wallichiana*	-	-	-	6.7	-	15.0	-	40.0	-	20.0	-	-
Ulmus villosa	-	-	-	-	-	-	210.0	-	-	-	-	-

Abbreviations used: 1= *Ilex dipyrena-Pyrus pashia* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Ulmus villosa*; 8=*Quercus semecarpifolia*; 9=*Cedrus deodara*; 10= *Acer acuminatum-Betula utilis* mixed; 11=*Picea smithiana-Aesculus indica* mixed; 12=*Juglans regia*

Table 4.3.3. Community wise Importance Value Index (IVI) of the Trees in High Project Impact Area of the Hamta-Jagatsukh Catchments

	Community Types											
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Abies pindrow	-	54.5	-	240.3	-	41.9	-	13	-	34.5	-	-
Acer acuminatum	-	4.98	9.29	11.1	-	167	-	12.3	-	115.5	19.9	-
Aesculus indica	-	-	-	3.1	-	3.6	-	-	-	-	68.4	30.1
Alnus nitida	-	-	-	-	-	-	-	-	-	-	24.2	-
Betula utilis	-	-	-	-	-	46.01	-	14.4	-	122.2	-	-
Cedrus deodara	-	-	73.2	-	-	-	-	-	251.5	-	42.8	-
Ilex dipyrena	98.1	-	-	-	-	-	-	-	-	-	-	-
Juglans regia	-	2.98	-	2.51	-	-	-	6.1	-	-	-	260.2
Picea smithiana	-	220.5	21.8	26.7	7.5	-	19.3	-	24.3	-	144.2	9.8
Pinus wallichiana	-	-	186.6	8.9	-	-	-	-	24.3	-	-	-
Prunus cornuta	-	8.51	-	2.5	-	19.6	52.8	-	-	-	-	-
Pyrus pashia	118.8	-	-	-	-	-	-	-	-	-	-	-
Quercus floribunda	83.2	-	-	-	292.4	-	-	-	-	-	-	-
Q. semecarpifolia	-	8.49	-	-	-	15.9	-	234.7	-	-	-	-
Rhus javanica	-	-	9.15	-	-	-	-	-	-	-	-	-
Salix daphnoides	-	-	-	-	-	-	27.1	-	-	10.9	-	-
Taxus baccata subsp. *wallichiana*	-	-	-	-	-	6.1	-	19.4	-	15.1	-	-
Ulmus villosa	-	-	-	-	-	-	200.2	-	-	-	-	-

Abbreviations used: 1=*Pyrus pashia-Ilex dipyrena* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Ulmus villosa*; 8=*Quercus semecarpifolia*; 9=*Cedrus deodara*; 10= *Acer acuminatum-Betula utilis* mixed; 11=*Picea smithiana-Aesculus indica* mixed; 12=*Juglans regia*

Table 4.3.4. Community wise Total Basal Area (m^2ha^{-1}) of the Trees in High Project Impact Area of the Hamta-Jagatsukh Catchments

Taxa	Community Types											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Abies pindrow	-	103.7	-	1305.5	-	37.5	-	0.31	-	4.48	-	-
Acer acuminatum	-	0.8	0.05	1.43	-	285.05	-	0.07	-	112.9	0.3	-
Aesculus indica	-	-	-	0.3	-	0.15	-	-	-	-	0.3	4.96
Alnus nitida	-	-	-	-	-	-	-	-	-	-	0.8	-
Betula utilis	-	-	-	-	-	26.8	-	0.05	-	105.5	-	-
Cedrus deodara	-	-	118.7	-	-	-	-	-	842.9	-	0.3	-
Ilex dipyrena	0.18	-	-	-	-	-	-	-	-	-	-	-
Juglans regia	-	0.1	-	0.04	-	-	-	0.02	-	-	-	688.9
Picea smithiana	-	957.2	1.35	22.7	41.8	-	5	-	1.46	-	8.4	0.25
Pinus wallichiana	-	-	196.2	1.53	-	-	-	-	1.26	-	-	-
Prunus cornuta	-	0.5	-	0.03	-	5.87	7.6	-	-	-	-	-
Pyrus pashia	0.34	-	-	-	-	-	-	-	-	-	-	-
Quercus floribunda	0.21	-	-	-	57.5	-	-	-	-	-	-	-
Q.semecarpifolia	-	1.67	-	-	-	4.25	-	37.8	-	-	-	-
Rhus javanica	-	-	19.3	-	-	-	-	-	-	-	-	-
Salix daphnoides	-	-	-	-	-	-	1.8	-	-	0.2	-	-
Taxus baccata subsp. *wallichiana*	-	-	-	1.3	-	0.03	-	0.05	-	0.2	-	-
Ulmus villosa	-	-	-	-	-	-	368.2	-	-	-	-	-

Abbreviations used: 1=*Pyrus pashia-Ilex dipyrena* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Ulmus villosa*; 8=*Quercus semecarpifolia*; 9=*Cedrus deodara*; 10= *Acer acuminatum-Betula utilis* mixed; 11=*Picea smithiana-Aesculus indica* mixed; 12=*Juglans regia*

Table 4.3.5. Community wise Relative Density (%) of the Shrubs in High Project Impact Area of Hamta-Jagatsukh Catchments

Taxa	Community Types													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Asparagus filicinus		-	0.20	-	0.20	-	-	-	-	-	-	-	-	-
Barberis lycium	7.4	6.34	21.66	-	34.20	-	3.13	-	15.46	-	-	-	2.8	2.83
B. jaeschkeana	-	-	-	-	-	-	-	-	-	11.63	-	-	-	-
Boehmeria platyphylla	0.5	-	-	-	-	0.21	-	-	-	-	-	-	-	-
Buddleja crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	8.74
Clematis barbellata	-	-	-	-	-	-	0.52	0.20	-	-	1.62	-	5.32	3.86
C. buchananiana	-	-	0.23	-	-	0.38	-	-	-	-	-	-	-	-
Cotoneaster obtusus	-	5.47	-	7.46	0.42	-	-	-	-	-	-	-	-	-
C. microphylla	0.1	-	-	3.78	0.63	-	-	-	3.09	-	-	-	-	-
C. acuminatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyathula tomentosa	-	-	-	-	-	-	-	-	-	-	-	-	3.35	0.77
Desmodium elegans	9.6	0.73	11.15	5.48	4.79	-	5.21	-	4.12	-	14.05	-	-	8.99
Deutzia corymbosa	-	-	2.87	-	-	8.89	3.13	-	-	-	-	-	-	-
D. staminea	0.7	-	3.50	-	0.63	-	-	-	-	-	-	-	-	-
Elaeagnus conferta	1.4	-	0.96	-	3.79	-	-	-	-	-	-	-	-	2.06
Elsholtzia flava	-	3.65	-	-	2.74	-	3.65	-	-	-	-	-	2.97	2.06
Euonymus echinatus	-	1.64	-	-	3.37	-	-	-	-	-	-	-	-	-
Ficus sarmentosa	-	-	3.50	6.97	1.89	-	-	-	-	-	-	-	-	-
Hedera nepalensis	-	0.18	-	4.48	-	-	-	-	-	-	2.70	-	-	-
Hypericum oblongifolium	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-
Indigofera heterantha	-	-	-	9.45	6.53	-	7.29	-	48.45	-	27.03	16.67	32.67	16.71
I. gerardiana	9.8	1.75	20.38	-	-	-	-	-	-	-	-	-	-	-
Jasminum humile	-	-	4.78	-	0.84	-	2.60	-	-	-	-	-	-	3.86
Leptodermis lanceolata	-	0.18	-	-	-	-	-	-	-	-	-	-	-	-
Lonicera angustifolia	-	-	3.50	-	-	-	-	-	-	-	-	-	-	-
L. quinquelocularis	0.9	0.32	-	-	-	-	-	-	-	-	-	-	-	-

Leycesteria formosa	-	0.10	-	-	-	-	-	-	-	-	-	-	-	-
Myrsine africana	-	-	1.27	-	-	-	-	-	-	-	-	-	-	-
Parthenocissus semicordata	5.1	0.28	-	-	-	-	-	-	-	-	8.65	-	-	-
Prinsepia utilis	8.3	0.91	4.78	-	11.37	-	1.05	-	6.19	-	-	41.67	9.90	4.37
Rhamnus triqueter	-	-	3.50	-	2.74	-	-	-	-	-	-	-	-	3.09
Rhododendron campanulatum	-	-	-	5.48	-	-	-	-	-	23.26	-	-	-	-
Rosa macrophylla	0.3	-	-	8.46	-	62.22	-	-	-	53.49	-	-	-	-
R. brunonii	-	-	1.91	-	2.95	-	0.52	22.22	6.19	-	-	22.22	-	-
Rabdosia rugosa	12.3	1.64	3.50	-	7.16	-	-	-	13.40	-	-	-	5.94	15.97
Rubus lasiocarpus	0.4	1.64	-	-	-	-	-	-	-	-	-	-	-	-
R. ellpticus	-	1.64	3.82	3.99	0.21	-	25.79	-	3.09	-	29.19	-	-	6.68
Salix denticulata	-	-	1.59	4.93	0.21	-	1.56	-	-	11.63	10.27	-	-	-
Sarcococa saligna	20.9	0.73	-	-	-	-	0.52	-	-	-	-	-	2.30	-
Smilax aspera	1.6	-	-	-	-	-	-	-	-	-	-	-	3.20	-
S.vaginata		-	-	-	1.68	-	-	-	-	-	-	-	-	1.29
Sorbaria tomentosa	1.65	48.42	-	6.46	0.42	-	7.81	-	-	-	-	-	34.65	2.06
Spiraea bella	-	-	-	4.93	-	-	-	-	-	-	-	-	-	-
S.canescens	4.60	0.36	0.32	-	11.37	-	-	-	-	-	1.62	-	-	11.08
Viburnum mullaha	-	-	1.59	-	-	-	-	77.78	-	-	-	-	-	-
V. cotonifolium	-	22.81	-	27.87	-	28.89	20.31	-	-	-	4.87	19.44	-	-

Abbreviations used: 1=*Pyrus pashia-Ilex dipyrena* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Ulmus villosa*; 8=*Quercus semecarpifolia*; 9=*Cedrus deodara*; 10= *Acer acuminatum-Betula utilis* mixed; 11=*Picea smithiana-Aesculus indica* mixed; 12=*Juglans regia*; 13=*Indigofera heterantha-Sorbaria tomentosa* mixed; 14=*Indigofera heterantha-Rabdosia rugosa- Spiraea canescens* mixed;

Table 4.3.6. Community wise Relative Density (%) of the Herbs in High Project Impact Area of Hamta-Jagatsukh Catchments

Taxa	Community Types													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Achyranthes bidentata	-	-	-	-	-	-	-	-	-	-	-	0.16	-	19.72
Adenocaulon himalaicum	-	-	-	-	-	-	-	-	-	-	-	0.16	-	-
Adiantum venustum	-	-	2.74	-	-	-	-	-	-	3.62	-	-	-	-
A. capillus-veneris	0.39	3.584	3.24	7.99	-	6.13	1.3	3.78	4.94	-	0.32	2.45	-	0.78
A. pedatum	-	-	-	-	-	1.22	-	-	-	-	-	-	-	-
Agrimonia pilosa	0.79	-	1.17	-	-	-	-	-	-	-	0.47	0.33	-	-
Agrostis munroana	-	1.19	3.05	-	2.37	-	1.3	-	-	-	-	0.62	-	-
A. pilosula	-	-	-	2.5	-	6.08	-	-	-	-	-	-	-	-
Ainsliaea aptera	-	0.164	0.93	-	-	1.33	-	0.14	-	0.77	-	0.25	-	-
A. latifolia	-	-	-	0.56	-	-	-	-	-	-	-	-	-	-
Ajuga bracteosa	-	1.15	0.25	-	-	-	0.62	-	0.82	-	-	0.85	-	-
Amaranthus hybridus	-	-	-	-	-	-	-	0.32	-	-	-	-	-	-
Anaphalis busua	-	-	-	-	-	-	-	1.42	-	-	0.32	-	-	-
A. nepalensis	-	0.09	-	-	-	-	0.36	-	-	-	-	-	-	-
A. triplinervis	-	-	-	0.27	-	-	-	2.98	-	-	-	-	-	-
Anemone rivularis	-	0.3	-	1.58	-	-	-	-	-	5.59	-	-	-	0.23
Angelica glauca	-	-	1.22	-	-	-	-	-	-	-	-	-	-	-
Apluda mutica	-	0.37	-	-	-	-	-	-	-	-	-	-	-	-
Aquilegia pubiflora	-	-	-	-	-	-	-	-	0.51	-	-	-	-	-
Aralia cachemirica	-	-	-	-	-	-	-	-	-	-	0.89	-	-	-
Arenaria festucoides	-	-	-	-	-	-	1.3	-	-	-	-	-	-	-
Arisaema intermedium	-	0.52	-	1.15	-	-	-	1.2	-	-	-	-	-	-
A. jacquemontii	-	0.35	-	1.84	-	-	-	1.4	-	0.12	-	0.88	-	-
Artemisia roxburghiana	-	0.74	0.436	-	0.19	-	-	1.65	-	-	0.66	-	-	0.27
A. vestita	-	-	-	-	-	-	-	-	-	4.14	-	-	-	-
Arundinella setosa	-	-	-	-	-	-	-	-	-	-	-	9.18	-	-

Asplenium anogrannoides	-	-	-	0.14	-	-	-	-	-	-	-	-	-	-
A. dalhousiae	-	-	-	-	-	-	-	-	-	-	-	2.72	-	-
A. variense	-	0.04	0.13	0.5	-	-	0.711	2.8	-	-	-	-	-	-
Aster himalensis	-	-	-	-	-	-	-	-	-	0.83	-	-	1.09	-
A. peduncularis	-	0.46	0.39	-	0.37	-	-	-	-	-	0.66	0.68	-	0.71
Astragallus chlorostachys	-	-	-	0.06	-	-	-	-	-	-	-	-	-	-
Athyrium anisopterum	-	-	-	-	-	1.32	-	-	-	-	-	-	-	-
A. atkinsonii	0.63	0.79	-	-	2.44	-	1.095	-	-	-	-	-	-	0.51
A. attenuatum	1.1	1.17	-	0.45	-	-	-	-	0.2	-	-	-	-	-
Bergenia ligulata	-	-	1.06	-	0.22	-	-	-	-	-	-	-	-	-
Bistorta affinis	-	-	-	-	-	0.35	-	-	-	-	-	-	-	-
B. amplexicaulis	-	-	-	2.28	-	14.43	-	6.62	-	-	-	0.33	-	-
Bromus japonicus	-	0.06	-	2.5	-	-	-	-	-	-	-	-	-	3.07
Bupleurum lanceolatum	-	-	-	-	-	-	-	0.32	-	-	-	-	-	-
B. falcatum	-	-	-	-	0.66	-	-	-	-	-	-	-	-	-
Calamintha umbrosa	0.71	3.04	0.31	-	-	-	-	-	-	-	-	-	-	-
Calanthe tricarinata	-	-	-	0.139	-	-	-	-	-	-	-	-	-	-
Caltha palustris	-	-	-	1.83	-	-	-	-	-	-	-	-	-	-
Campanula colorata	1.18	0.52	-	1.66	0.96	-	-	2.36	-	-	-	-	-	-
Cannabis sativa	-	-	-	-	-	-	-	-	-	-	-	-	1.37	1.183
Capsella bursa-pastoris	1.96	-	0.81	-	0.55	-	-	-	1.13	-	-	-	0.498	0.71
Cardamine impatiens	-	0.26	-	-	0.55	-	2.03	-	-	-	2.02	-	-	-
C. macrophylla	-	-	-	0.45	-	-	-	-	-	-	-	-	-	-
Carduus edelbergii	-	-	-	0.06	-	-	-	-	-	-	-	0.17	-	-
Carex brevicaulis	16.22	4.1	33.3	-	12.67	-	-	-	17.5	-	31.02	9.18	6.85	-
C. folilosa	-	-	-	-	-	-	-	-	-	-	8.70	7.35	-	-
C. nivalis	-	-	-	-	-	3.16	-	-	-	19.41	-	-	-	-
C. setigera	-	-	-	-	-	4.75	-	-	-	-	-	-	-	-
C. nubigena	-	3.16	-	-	-	-	15.75	-	-	-	-	-	-	-

Carpesium pedunculosum	-	-	-	0.104	-	0.51	-	-	-	-	-	-	-	-
Cephalanthera longifolia	-	1.67	-	-	-	-	-	-	-	-	-	-	-	-
Cerastium cerastioides	-	-	-	-	-	-	0.52	0.37	-	-	-	-	-	1.89
C. fontanum	-	0.36	-	-	-	-	-	-	-	-	-	-	-	-
Chaerophyllum reflexum	-	-	-	1.75	0.11	-	-	1.42	-	-	-	1.09	-	-
Chenopodium botrys	0.87	0.49	-	1.66	-	-	-	-	-	-	-	-	0.21	0.94
Chielanthus acrostica	-	0.39	-	-	-	-	-	-	-	-	-	-	-	-
Chrysopogon echinulatus	-	0.71	5.46	-	-	-	-	-	-	-	-	-	-	-
C.gryllus	6.85	0.72	0.24	-	6.148	-	7.718	-	0.3	-	-	-	-	-
Cicerbita macrorhiza	-	0.82	-	-	-	-	-	-	-	-	-	-	-	-
Cirsium wallichii	0.31	0.14	-	0.25	0.74	0.13	0.31	-	0.51	0.517	2.02	0.87	0.62	1.57
Codonopsis rotundifolia	-	-	-	-	-	-	-	-	-	0.32	-	-	-	-
Corydalis diphylla	-	0.02	-	-	-	-	-	-	-	-	-	0.05	-	-
C. govaniana	-	0.12	-	0.18	-	0.38	-	-	-	-	-	-	-	-
Craniotome furcata	-	-	-	-	-	-	-	-	-	-	-	-	-	0.177
Cuscuta reflexa	0.85	-	-	-	0.42	-	-	-	-	-	-	-	-	-
Cyanotis vaga	-	-	-	-	-	-	-	-	-	-	-	-	0.73	-
Cymbopogon martinii	-	-	-	-	0.37	-	-	-	-	-	-	-	-	-
Cyanodon dactylon	1.49	0.56	3.24	-	0.48	-	9.49	-	22.34	-	-	-	-	-
Delphinium denudatum	-	-	-	-	-	-	-	-	-	0.82	-	-	-	-
Dicentra roylei	0.94	0.4	-	-	-	-	0.782	-	-	-	-	-	-	-
Dicliptera roxburghinana	-	-	-	-	1.48	-	-	-	-	-	-	-	-	-
Digitaria cruciata	-	-	-	2.09	-	-	-	-	-	-	-	-	-	-
Dioscorea deltoidea	3.33	0.22	0.42	0.53			3.52							1.20
Diplazium esculentum	0.71	-	-	-	-	-	-	-	-	-	-	-	-	3.16
Dryopteris wallichii	-	-	1.62	-	-	-	-	-	-	-	1.39	-	-	0.12

D. barbigera	-	-	-	-	-	-	-	-	-	0.35	-	0.35	-	-
Duchesnia indica	-	-	-	-	-	-	-	-	-	0.517	-	-	-	2.48
Epilobium latifolium	-	-	-	-	0.148	-	-	1.89	-	-	-	-	-	-
E. cylindricum	-	0.44	-	-	-	-	-	-	-	-	-	-	-	-
E. hirsutum	-	-	-	0.63	-	-	-	-	-	-	-	-	-	-
Eragrostis minor	-	0.49	0.81	-	-	-	1.04	-	5.35	-	-	9.8	-	5.79
E. pilosa	1.34	3.859	-	-	1.33	-	-	-	-	-	-	-	-	-
Erigeron bonareinsis	-	-	0.15	-	0.22	-	-	-	-	-	-	-	0.33	-
E. canadensis	-	0.28	-	-	-	-	-	-	-	-	-	-	-	-
Euphrassia himaliaca	0.39	-	-	-	1.48	-	-	-	-	-	-	-	-	-
Fagopyrum dibotrys	-	0.26	-	-	0.278	-	-	-	-	-	4.05	-	2.16	1.05
Festuca rubra	-	-	-	-	-	-	-	-	-	-	-	9.8	6.28	-
Filipendula vestita	-	-	-	0.33	-	-	-	-	-	-	-	-	-	-
Fragaria nubicola	4.41	2.87	2.99	3.52	1.85	4.75	0.16	2.55	1.75	-	0.94	-	-	2.52
Galinsoga parviflora	-	-	-	-	-	-	-	-	-	-	-	-	0.99	-
Galium acutum	-	0.2	-	-	-	-	-	0.95	-	-	1.52	-	-	-
G. aparine	2.28	6.93	3.68	0.29	4.63	2.59	2.92	-	3.5	-	-	-	3.24	1.933
G. asperifolium	-	-	-	-	-	-	-	-	-	1.24	-	-	-	-
G. rotundifolium	1.65	0.28	0.9	-	0.93	2.27	-	0.48	-	-	-	-	-	-
Gentiana carinata	-	-	-	-	0.23	-	2.14	-	-	-	-	-	-	-
Geranium nepalense	3.78	1.31	-	1.94	4.13	0.88	-	-	-	-	0.19	1.63	5.39	3.03
G. wallichianum	-	0.19	-	-	-	-	1.66	7.57	-	0.78	-	-	-	-
Geum roylei	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-
Girardinia diversifolia	0.16	-	-	-	-	-	-	-	-	-	-	-	1.62	1.26
Goldfusia dalhousiana	-	-	-	-	0.741	-	-	-	-	-	-	-	-	-
Hackelia uncinata	-	-	-	0.49	-	-	-	1.13	-	-	-	-	-	-
Hedychium spicatum	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heracleum candicans	-	0.14	-	0.69	-	-	-	0.85	-	2.07	-	-	-	-
H. wallichii	-	-	-	0.04	-	-	-	-	-	-	-	-	-	-
Herminium monochis	-	0.06	-	-	-	-	-	-	-	0.36	-	-	-	-
Hypericum elodeoides	-	-	-	0.07	-	-	1.72	-	-	-	-	-	-	-

Impatiens arguta	-	-	-	-	0.15	-	-	-	-	-	-	1.83	12.38	-
I. bicolor	-	-	-	1.75	-	1.71	-	-	-	-	3.8	-	-	1.57
I. racemosa	-	1.03	-	-	-	-	-	-	0.31	-	-	-	0.21	-
Iris milesii	2.44	0.7	6.55	-	1.11	-	5.47	-	-	-	-	0.28	-	-
Jaeschkia oligosperma	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Juncus bufonius	-	-	-	-	0.148	-	-	-	0.1	-	3.7	-	-	-
Lepisorus nudus	-	0.72	-	0.11	-	-	-	19.62	-	-	-	0.67	-	-
Lespedeza girardiana	-	-	-	-	-	-	-	4.25	-	-	-	-	-	-
Ligularia amplexicaulis	-	-	-	0.166	-	-	-	-	-	0.77	-	-	-	-
Malva verticillata	-	-	-	-	-	-	-	-	-	-	-	-	-	0.29
Mazus surculosus	-	-	0.19	-	-	-	-	-	-	-	-	-	-	-
Meconopsis aculeata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melothria heterophylla	-	0.32	-	-	-	-	-	-	0.22	-	-	-	-	-
Morina longifolia	-	-	-	-	-	-	-	0.15	-	3.88	-	-	-	-
Myriactis nepalensis	-	0.47	-	0.08	-	-	-	-	-	-	-	-	-	-
Nepeta leucophylla	-	0.91	0.87	0.39	0.52	-	-	-	-	-	-	0.27	2.98	-
N. laevigata	-	2.63	0.65	-	-	1.32	-	3.4	-	2.44	-	-	-	-
Onychium contiguum	-	4.87	0.12	3.05	5.53	-	-	-	-	-	-	5.71	2.67	0.71
Oplismenus undulatifolius	4.25	1.546	4.18	-	5.25	-	0.89	-	2.06	-	6.64	-	2.68	8.97
Oreorchis indica	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-
Origanum vulgare	-	1.37	1.59	-	1.85	-	-	3.47	-	-	1.13	-	2.69	-
Osmunda claytoniana	-	0.02	-	4.71	0.15	0.91	-	3.9	-	3.72	-	-	-	-
O. japonica	-	0.04	-	-	-	-	-	-	-	-	-	-	-	-
Oxalis corymbosa	6.22	-	-	-	-	0.81	-	-	-	-	-	-	-	7.8
O. corniculata	-	0.09	-	-	4.18	-	6.204	-	8.95	-	-	0.899	8.34	-
Oxytropis cachemiriana	-	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Parochetus communis	-	1.69	-	-	-	-	-	-	-	-	-	0.989	-	-
Pedicularis pectinata	-	-	-	0.78	-	-	-	-	-	-	-	-	-	-
P. hoffmeisterii	-	-	-	2.32	-	-	-	-	-	-	-	-	-	-
Pellaea nitidula	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-

Persicaria capitata	-	-	-	-	1.22	-	-	-	-	-	-	-	-	-
Phleum alpinum	-	-	-	0.41	-	-	-	-	-	-	-	-	-	-
Phlomis bracteosa	-	-	-	1.26	-	1.1	-	-	-	0.77	-	-	-	-
Phytolacca acinosa	-	2.65	-	-	-	-	-	-	-	-	-	0.25	-	-
Pimpinella diversifolia	-	-	-	-	-	-	-	-	-	-	-	0.24	-	-
Plantago lanceolata	0.08	0.03	-	-	1.74	-	0.938	0.14	-	1.09	-	-	-	-
P. ovata	-	-	-	-	0.667	-	0.05	0.7	0.52	-	-	-	-	-
Poa annua	-	-	-	-	-	-	-	-	-	6.26	-	-	-	0.29
Podophyllum hexandrum	-	0.59	-	0.139	-	-	-	-	-	9.33	-	-	-	-
Polemonium coeruleum	-	-	-	-	-	-	-	0.38	-	-	-	-	-	-
Polygonatum verticillatum	-	0.28	-	-	-	0.13	-	0.05	-	0.52	-	-	-	-
Polygonum hydropiper	-	-	-	-	-	-	2.92	-	-	-	-	2.82	-	-
P. nepalense	2.519	2.9	2.4	0.069	-	2.22	-	2.34	-	-	13.9	-	0.43	3.3
P.recumbens	-	-	-	-	-	-	-	-	-	0.77	-	-	-	0.3
Polypodioides amoena	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-
Polystichum laciniatum	-	-	-	1	-	-	-	-	-	-	-	-	-	-
P. neolobatum	-	-	-	-	-	-	-	-	-	-	-	0.33	-	-
P. prescottianum	-	-	-	-	-	0.38	-	0.65	-	0.32	-	-	-	-
P. squarrosum	-	1.6	-	2.13	-	3.55	-	0.63	-	-	-	-	-	-
P.wilsonii	-	-	-	0.55	-	-	-	-	-	-	-	-	-	-
Potentilla argyrophylla	-	-	-	2.22	-	-	-	-	-	-	-	1.96	-	-
P. atrosanguinea	-	3.95	-	4.2	-	-	0.63	-	3.99	-	-	-	-	-
P. microphylla	-	-	-	-	-	-	0.26	-	-	-	-	-	-	-
Primula denticulata	-	-	-	-	-	0.44	0.11	-	-	0.87	0.06	-	-	3.5
P. involucrata	-	0.11	-	-	4.04	-	-	-	-	-	-	-	7.47	-
P. rosea	-	0.07	-	-	-	-	-	-	-	-	1.39	-	-	-
Prunella vulgaris	-	0.63	0.32	-	-	-	-	-	-	-	-	0.27	-	-
Pteracanthus alatus	0.79	-	-	-	-	-	-	-	-	-	5.38	-	0.63	-
Pteridium aquilinum	-	0.01	1.81	-	4.22	-	-	-	-	-	-	-	6.53	-

Pteris cretica	1.73	3.51	-	6.35	0.22	7.69	-	-	-	1.23	0.44	12.25	-	0.87
P. vittata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus laetus	-	0.13	-	0.35	1.63	-	0.05	-	-	-	-	-	-	-
Rhodiola bupleuroides	-	-	-	-	-	-	-	0.63	-	1.03	-	-	-	-
Rhynchospermum verticillatum	0.31	0.87	1.41	-	0.91	-	-	-	-	-	0.32	-	-	-
Rosularia rosulata	-	0.26	-	-	1.33	-	-	-	1.54	-	1.6	-	-	-
Rubia cordifolia	1.20	-	0.63	-	0.53	-	1.63	-	-	-	-	-	-	-
Rumex hastatus	-	0.32	-	0.83	1.18	5.97	-	0.75	1.33	-	1.64	-	-	1.1
R. nepalensis	0.23	0.68	-	-	-	-	1.82	-	-	2.49	-	2.17	-	-
Saccharum filifolium	-	-	-	-	-	-	-	-	0.51	-	-	-	-	-
S. spontaneum	2.84	0.28	3.744	-	-	-	-	-	-	-	2.85	-	-	1.47
Salvia lanata	-	-	0.2	-	0.04	-	-	-	-	-	-	-	-	-
S. moorcroftiana	-	-	1.3	0.3	-	-	-	-	-	-	-	-	-	-
Scrophularia decomposita	-	-	-	0.38	-	-	-	-	-	-	-	-	-	-
S. himalensis	-	-	-	-	-	-	-	-	-	-	-	-	-	0.079
Sedum ewersi	-	0.6	-	-	0.04	-	-	-	-	-	-	-	-	-
Selinum tenuifolium	5.9	-	-	2.22	-	0.13	2.61	1.22	-	2.53	-	-	2.28	-
S. vaginatum	-	0.54	-	0.28	-	-	-	0.92	-	-	-	-	-	-
Senecio chrysanthemoides	-	1.78	-	-	-	-	-	-	-	-	-	-	-	-
S. graciliflorus	-	-	-	-	-	2.53	-	-	-	-	-	-	-	-
S. rufinervis	-	-	-	-	-	0.68	-	-	-	2.79	-	-	-	-
Sibbaldia cuneata	-	-	-	0.21	-	-	-	-	-	-	-	-	-	-
Silene conoidea	1.81	-	-	-	-	-	0.21	-	-	-	-	-	-	-
Sisymbrium officinale	1.65	0.46	0.32	-	0.52	-	-	-	2.16	-	-	-	-	-
S. macrophylla	-	-	-	0.08	-	-	-	-	-	-	-	-	-	-
Smilacina pupurea	-	-	0.32	-	-	-	-	-	-	-	-	-	-	-
Stachys sericea	-	-	-	0.69	-	-	-	-	-	-	-	-	-	-
Stellaria media	7.55	0.32	-	-	2.11	-	1.4	-	2.26	-	-	-	0.54	-

S. monosperma	-	0.42	-	0.22	1.04	-	-	0.72	-	-	-	-	-	3.07
Strobilanthus atropurpureus	0.39	1.1	-	0.139	-	1.88	-	-	-	-	0.13	0.81	-	-
S.wallichii	-	0.3	-	4.83	-	3.54	-	-	0.32	-	0.23	-	-	-
Swertia angustifolia	-	-	-	-	-	0.25	-	-	-	1.03	-	-	-	-
Tanacetum dolichophyllum	-	-	-	-	-	-	-	-	-	3.62	-	-	-	-
Taraxacum officinalis	-	-	0.56	0.3	-	-	0.73	-	-	1.44	-	-	-	-
Tegetes minuta	-	-	-	-	-	-	-	-	-	-	-	-	2.54	-
Thalictrum cultratum	0.47	-	-	1.04	1.24	1.77	-	2.23	-	2.27	-	-	-	-
T. foliolosum	3.14	0.05	0.25	-	-	-	-	1.98	-	-	-	-	0.187	-
Thamnocalamus spathiflora	-	-	-	-	-	-	-	-	-	-	-	-	3.73	-
Thlaspi arvense	-	0.7	-	-	0.29	-	6.04	-	-	-	-	-	-	3.47
Thymus linearis	-	0.68	0.96	-	2.48	-	2.08	-	5.66	-	-	-	-	1.33
Trifolium pratense	4.33	1.99	0.56	14.35	6.98	11.02	11.47	7.09	1.95	7.87	1.13	3.81	10.9	5.13
Trillidium govanianum	-	0.16	-	-	-	-	-	0.23	-	0.21	-	-	-	-
Urtica dioica	0.23	0.08	-	-	-	-	0.35	-	-	-	-	1.3	0.332	3.07
U. purpurea	-	0.56	-	-	0.07	-	0.36	-	-	-	-	0.98	0.913	-
Valeriana hardwickii	-	2.28	-	-	-	-	-	-	-	-	-	-	-	-
V. jatamansi	-	0.52	-	0.05	-	0.89	-	0.52	-	-	0.25	0.43	-	-
Verbascum thapsus	-	0.52	0.91	-	1.11	-	0.23	-	0.21	-	-	-	-	-
Viola biflora	-	1.312	-	-	-	-	-	-	1.54	-	-	-	-	-
V.canescens	1.57	4.17	1.68	1.27	1.25	-	1.72	-	2.06	-	-	1.74	-	0.69
Youngia japonica	3.14	0.07	-	-	0.48	-	1.04	-	0.41	-	-	-	-	-

Abbreviations used: 1=*Pyrus pashia-Ilex dipyrena* mixed; 2=*Picea smithiana*; 3=*Pinus wallichiana*; 4=*Abies pindrow*; 5=*Quercus floribunda*; 6=*Acer acuminatum*; 7=*Ulmus villosa*; 8=*Quercus semecarpifolia*; 9=*Cedrus deodara*; 10= *Acer acuminatum-Betula utilis* mixed; 11=*Picea smithiana-Aesculus indica* mixed; 12=*Juglans regia*; 13= *Indigofera heterantha-Sorbaria tomentosa* mixed; 14=*Indigofera heterantha-Rabdosia rugosa- Spiraea canescens* mixed

4.3.3. Species diversity (H')

Community wise diversity of trees, seedlings, saplings, shrubs and herbs has been presented in Table 4.3.7. In general, species diversity (H') for trees ranged from 0.396-1.401, saplings from 0.111-1.241, seedlings from 0.502-1.825, shrubs from 0.530-4.840 and herbs from 2.720-3.914. Highest diversity of trees was reported in *Picea smithiana-Aesculus indica* mixed community (1.401), followed by *Acer acuminatum* (1.371) and *Acer acuminatum-Betula utilis* mixed, communities. It was lowest in *Juglans regia* (0.396) community. Among saplings, highest diversity was reported in *Quercus floribunda* (1.241) community, followed by *Pyrus pashia-Ilex dipyrena* mixed (1.055) and *Acer acuminatum-Betula utilis* mixed (1.004), communities. Lowest diversity was reported in *Quercus floribunda* (0.111) community. Amongst seedlings, highest diversity was reported in *Quercus floribunda* (1.825) community, followed by, *Pinus wallichiana* (1.328) and *Abies pindrow* (1.260) community. Lowest diversity was reported in *Picea smithiana* (1.260) community.

Among shrubs, *Pyrus pashia-Ilex dipyrena* mixed community showed highest diversity (4.85), followed by *Pinus wallichiana* (2.837) and *Quercus floribunda* (2.403) community. It was lowest in *Quercus semecarpifolia* community (0.603). Amongst herbs, highest diversity was shown by *Picea smithiana* community (3.941), followed by *Abies pindrow* (3.485) and *Quercus floribunda* (3.475) communities.

Table 4.3.7. Community wise Total Diversity of Trees, Saplings, Seedlings, Shrubs and Herbs in the High Project Impact Area

Community Types	Trees	Saplings	Seedlings	Shrubs	Herbs
Pyrus pashia-Ilex dipyrena mixed	1.099	1.055	0.917	4.854	3.233
Picea smithiana	0.990	0.621	0.502	1.769	3.941
Pinus wallichiana	0.595	0.771	1.328	2.837	2.774
Abies pindrow	0.629	0.806	1.260	2.355	3.482
Quercus floribunda	0.148	1.241	1.825	2.403	3.475
Acer acuminatum	1.371	-	0.653	0.869	3.060
Ulmus villosa	1.154	-	1.048	2.263	3.059
Quercus semecarpifolia	0.614	0.111	-	0.530	3.174
Cedrus deodara	0.583	-	1.013	1.600	2.720
Acer acuminatum-Betula utilis mixed	1.330	1.004	0.956	1.394	3.022
Picea smithiana-Aesculus indica mixed	1.401	0.995	0.959	1.813	2.476
Juglans regia	0.396	-	-	1.316	3.020
Indigofera heterantha-Rabdosia rugosa-Spiraea canescens mixed	-	-	-	1.508	2.880
Indigofera heterantha -Sorbaria	-	-	-	1.777	3.154

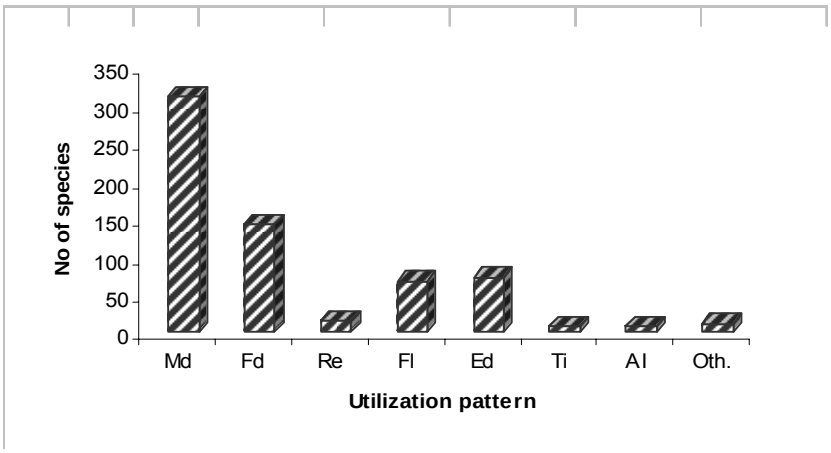
tomentosa mixed					

4.4. Assessment of Economically Important Plants of Hamta and Jagatsukh Catchments

4.4.1. Diversity and Utilization Pattern

A total of 441 species of economically important plants (Angiosperms: 417; Gymnosperms: 8; and Pteridophytes: 11) belonging to 107 families and 282 genera were recorded. Of these, 43 species were trees, 84 species shrubs, 301 species herbs and 11 species ferns. The families, Rosaceae (34), Asteraceae (29 spp.), Poaceae (28 spp.), Polygonaceae (18 spp.), Ranunculaceae, Lamiaceae, and Fabaceae (17 spp., each), Apiaceae (14 spp.), Liliaceae (10 spp.) and Orchidaceae (8 spp.) were species rich. Polygalaceae, Papaveraceae, Linaceae, Podophyllacaeae, Aquifoliaceae, Begoniaceae, Morinaceae, Myrsinaceae, Buxaceae, Cuscutaceae and Smilacaceae were the monotypic families. Among the genera *Carex* (7 spp.), *Impatiens* (6 spp.), *Rubus* and *Prunus* (5 spp.), *Persicaria*, *Rhododendron*, *Lonicera*, *Potentilla*, *Clematis* and *Anemone* (4 spp., each) were species rich. These species are used as **medicine** (309spp.), fuel, (68 spp.) **wild edible/food** (72 spp.), **fodder** (141 spp.), **timber** (7 spp.), **religious** (15 spp.), making **agricultural tools** (7 spp.), and various other purposes (16 spp.) (Fig. 4.4.1).

Fig. 4.4.1. Utilization pattern of the economically important plants



Abbrevations used: Md=medicinal, Fd =fodder, Re= religious, Fl=fuel, Ed= wild edible, Tl=timber, Al=agricultural tools, Oth=other purposes

4.4.2. Altitudinal distribution

The altitudinal distribution of the economically important species has been presented in Fig.4.4.2. The maximum economically important species were distributed between 1800-2800m (temperate zone) (Herbs: 277; Shrubs:30; Trees: 40 and Ferns: 11), followed by the zone, 2800-3800m (Herbs:179; Shrubs: 70; Trees:10 and Ferns: 3).The species was comparatively very low in > 3800m (Herbs:64; Shurbs: 6 and Tree: 1).

Fig.4.4.2. Altitudinal distribution of the economically important plants

Table 4.4.1. Diversity and utilization pattern of economically important plants of Hamta and Jagatsukh catchments

Taxa	Local name	Locality	Altitudinal Range (m)	Life Form	Utilization Pattern
Ranunculaceae					
Aconitum heterophyllum Wall.ex Royle	Patish	I,J,L,M	3000-4200	H	Medicinal
A. violaceum Jacq. ex Stapf	Atish	I,J,L,M	3500-4000	H	Medicinal
Anemone tetrasepala Royle		I,J,L,M, O	2100-3600	H	Medicinal
A. obtusiloba D.Don	Mamiri	A, F, M	2000-4000	H	Medicinal, Fodder
A. rivularis Buch.-Ham.	Jakri	A, D, F, O	2000-3600	H	Medicinal, Fodder
A.rupicola Camb.	Jakri	E, G, K	2000-3600	H	Fodder
A. vitifolia Buch.-Ham. ex DC.	Carbini-Mimiri	A, D, F	1950-3000	H	Fodder
Caltha palustris L.	Shomalap	A,B,F,H, O	2500-2800	H	Medicinal
Clematis barbellata Edgew.	Chabru	A,B,F,H,O	1800-2800	Sh	Medicinal, Fodder
C. buchananiana DC.	Belwala safed	B, C,	1800-3000	Sh	Medicinal
C.connata DC.	Safeda	A,B,F,H	2000-2700	Sh	Fodder
C. grata Wall.	Safeda	B, D, F, L	1900-2500	Sh	Fodder

C. graveolens Lindl.	Safeda	F, D, C	2000-3000	Sh	Fodder
Delphinium denudatum Royle	Laskar	A,B,F,H	2000-2600	H	Medicinal
Ranunculus diffusus DC.		A,B,D, F,H	1800-2000	H	Medicinal
R. hirtellus Royle	Goodi seripetali	A,B,F,H	1800-2500	H	Medicinal
Thalictrum foliolosum DC.	Mamiri	A,B,F,H, O	1800-3300	H	Medicinal, Fodder
T. reniforme Wall.	Mamiri	A,B,F,H,O	2000-3500	H	Medicinal
Berberidaceae					
Berberis chitria Lindl.	Masholi	B,F,H	2000-3000	Sh	Medicinal
B. jaeschkeana Schneid.	Kashambal	E,D,G	2000-2600	Sh	Medicinal, Fodder, fuel
B. lycium Royle	Kashamal	A,B,D, F,H	1800-2700	Sh	Medicinal, Fodder, Fuel
Fumariaceae					
Corydalis cashmeriana Royle	Bhutkeshi	A,B,F,H, L, M, N	2800-3000	H	Medicinal
C. govaniana Wall.	Bhutkashi	A,B,F,H	3000-4000	H	Medicinal
Brassicaceae					
Capsella bursa-pastoris Medic.		A,B,G, F	1900-2800	H	Medicinal
Cardamine impatiens L.		B, D	1900-2600	H	Medicinal
C. macrophylla Willd.		E, G, K	2200-3200	H	Edible
Lepidium apetalum Willd.		C, F, K, L	2000-3000	H	Medicinal
Nasturtium officinale R.Br.		A, B, D, H, F,L,	1900-3000	H	Medicinal
Rorippa indica (L.) Hiern	Petu	A, B, D, H, F	1900-2500	H	Medicinal, Edible
Sisymbrium officinale (L.) Scop.		A, B, D, H, F	1800-2300	H	Fodder
Thlaspi arvense L.		A, B, D, H, F	2000-2600	H	Medicinal
Violaceae					
Viola biflora L.	Banafsha	A, B, D, H, F, O	2400-2600	H	Medicinal
V.canescens Wall. ex Roxb.	Banafsha	A, B, D, H, F, O	1800-2400	H	Medicinal
V. odorata L.	Banafsha	I, J, M	3000-4000	H	Medicinal
V.serpens Wall. ex Roxb.	Banafsha	A, B, D, H, F	1800-2600	H	Medicinal
Polygalaceae					

Polygala sibirica L.		D, E, I, M,	2000-2500	H	Medicinal
Caryophyllaceae					
Arenaria serpyllifolia L.		C, D, E	2000-2500	H	Medicinal
Cerastium fontanum subsp*. membranaceum* Baung.		A, B, H, F	2000- 3000	H	Medicinal
C. fontanum Baung.		A, F, O	1900-2000	H	Medicinal
C. cerastioides (L.) Britt.		A, B, C, F, H, K, N	1800-4700	H	Medicinal
Silene conoidea L.		A, B, H, F	1800-2000	H	Medicinal
Stellaria media (L.) Villars		A, B, H, F	2000-2600	H	Medicinal
Papaveraceae					
Meconopsis aculeata Royle		J, L, M, N	3000-3500	H	Medicinal
Hypericaceae					
Hypericum elodeoides Chiosy	Basanti	H, E	2000-3000	H	Medicinal
H. oblongifolium Choisy		A, E, F,	2000-3000	H	Medicinal
H. uralum Buch.-Ham.		H, E	1800-3000	H	Medicinal
Linaceae					
Reinwardtia indica Dum.		A, H, D	1900-2500	H	Medicinal, Fodder
Geraniaceae					
Erodium cicutarium (L.) L' Herit		A, F	1800-2000	H	Medicinal
Geranium nepalense Sw.		B, E, D,O	2000-3500	H	Medicinal, Fodder
G. pratense L.		E, H, K, M, O	2500-3800	H	Medicinal, Fodder
G. rotundifolium L.		A,B, H, E,F D	1800-2000	H	Fodder
G.wallichianum D.Don ex Sw.	Chowarhi	A,B, H, E,F D	2000-3500	H	Medicinal, Fodder
Oxalidaceae					
Oxalis acetosella L.	Malori	A,B, H, E,F D, O	2000-3000	H	Medicinal, Eddible
O. corymbosa DC.	Malori	A,B, H, E,F D, O	1900-2500	H	Fodder
O. latifolia Kunth	Malori	A,B, H, E,F D,C, O	1900-2800	H	Medicinal, Eddible
Balsaminaceae					
Impatiens amphorata	Tilpara	A,B, H, D, O	2000-3000	H	Edible, Fodder

Edgew.					
I. arguta Hk. f.	Tilpara	A,B, H, D, O	2000-3000	H	Edible, Fodder
I. bicolor Royle	Tilpara	A, B, H, D	2000-2600	H	Edible, Fodder
I. cristata Wall.	Tilpara	A, B, H, D	2000-2600	H	Edible, Fodder
I. racemosa Hk.f.	Tilpara	A,B, H, D, O	2000-2600	H	Edible, Fodder, Medicinal
I .scabrida DC.	Tilpara	A,B, H, D	2000-3500	H	Fodder
Plantaginaceae					
Plantago lanceolata L.	Shokh pocha	A, B, H, D, F, I, L, O	1800-2800	H	Medicinal
P. himalaica Pilg.		A, H, F, I, L	3000-4000	H	Medicinal, Edible
P. ovata Phil.		A, B, C, D, E, G, L, O	1800-2800	H	Medicinal
Podophyllacaeae					
Podophyllum hexandrum Royle	Ban kakri	A, B, H, D, F, I, L, O	1800-4000	H	Medicinal
Rutaceae					
Boenninghausenia albiflora (Hk.f.) Reichenb.ex Meissn	Pessumar	F, G	1800-2800	H	Medicinal
Skimmia laureola Sieb. & Zucc. ex Walp.		A, B, D, F, H	2000-3000	Sh	Medicinal, Religious
Zanthoxylum armatum DC.	Timer	A, F	2000-2500	H	Medicinal, Fuel
Meliaceae					
Toona serrata (Royle) M. Roem.	Toon, Darn	A, F	1800-2400	T	Fodder, Fuel, Timber
Aquifoliaceae					
Ilex dipyrena Wall.	Ghooghee	A, F, G	1800-3000	T	Fodder
Celastraceae					
Euonymus fimbriatus Wall.		A, F, G	2000-2800	Sh	Fuel
E.echinatus		F, G, H	2000-3300	Sh	Medicinal
Rhamnaceae					
Rhamnus purpureus Edgew.	Chaunsha	A, F, H, B	1800-2000	Sh	Medicinal, Fodder, Fuel
R.virgatus Roxb.		A, B, F	1800-2000	Sh	Medicinal, Fuel
Vitaceae					
Parthenocissus semicordata (Wall.) Planch.		A, B, C, D, E	1800-2800	Sh	Fodder, Edible

Aceraceae					
Acer acuminatum Wall. ex D.Don	Mandru	C,D,H	2400-3200	T	Fodder, Fuel
A. caesium Wall. ex Brandis	Mandri	C,D,H, O	2400-3200	T	Fodder, Fuel
Anacardiaceae					
Rhus wallichii Hk. f.	Rikhad	A,F,	1800-2000	T	Fodder
R. javanica L.	Arkhal	A,F, C, D	1800-2500	T	Fodder, Fuel, Edible
Araliaceae					
Hedera nepalensis K. Koch	Gruaru	A, B, C, D, E	1800-2200	Sh	Medicinal
Aralia cachemirica Decne		A, F, G, B	2500-4000	H	Medicinal
Coriariaceae					
Coriaria nepalensis Wall.	Nachhar	A, B, F	1800-2200	T	Medicinal, Edible
Fabaceae					
Astragalus chlorostachys Lindl.		I,J,K,L,M	2600-4000	H	Medicinal
A. himalayanus Klotz.		I, J, M, N	2500-4000	H	Medicinal
Campylotropis eriocarpa (DC.) Schindler		A, F	1900-2500	Sh	Fodder
Desmodium elegans DC.		A,F,D,G,E,C	1800-2800	Sh	Fodder, Fuel
Caragana gerardiana Royle ex Benth.	Kathi	I, J, M, N	2000-2400	Sh	Fodder, Fuel
Indigofera gerardiana Wall. ex Brandis		A, B, C, D, E, G	2200-3500	Sh	Fodder, Fuel
I. heterantha Wall.		A, B, C, D, E, G	1800-2800	Sh	Fodder, Fuel, Medicinal
Lathyrus emodi (Wall. ex Fritsch) Ali		A, B, D, G, H, K	2000-3000	H	Fodder
Lespedeza gerardiana Grah. ex Maxim.		A,H, G,O	1800-2500	H	Fodder
Lotus corniculatus L.		A, F	1800-2800	H	Fodder
Parochetus communis Buch.-Ham. ex D.Don		A,B, H, D	2000-2500	H	Medicinal
Robinia pseudoacacia L.		A, E, B	1900-2500	H	Fodder, Fuel
Thermopsis barbata Royle		I, J, M, N	3000-4000	H	Medicinal
Trifolium repens L.	Malori	A,B, H, D, E, O	1800-2800	H	Medicinal, Fodder
T. pratense L.		A,B, H, D, E, I, L, M, O	1900-2500	H	Fodder

Trigonella emodi Benth.		I, L, M,	2000-3200	H	Medicinal
Vigna vexillata (L.) A.Rich.		A,B, H, D, E	2000-3000	H	Medicinal
Rosaceae					
Agrimonia pilosa Ledeb.		B, H, D, E, I, L	2000-3000	H	Fodder, Medicinal
Aruncus dioicus (Walter) Fernald		G, I, L	3000-3500	H	Medicinal
Cotoneaster obtusus Wall. ex Lindl.	Riunsh	G, H, D	2000-2800	Sh	Fodder, Fuel, Agri. Tools, Medicinal
C. microphyllus Wall. ex Lindl.	Kalashada	B, H, D, E, I, L	2400-3500	Sh	Medicinal
Duchesnea indica (Andrew.) Focke		B, H, D, E,	2000-3000	H	Edible, Medicinal
Fragaria nubicola L.	Bumbra	A,B, H, D, E, O	2000-3000	H	Edible
Geum elatum Wall. ex G. Don		I, L, K, M,	2000-3900	H	Medicinal
G.roylei Bolle		I, M, N	2500-3500	H	Medicinal
Potentilla argrophylla Wall. ex Lehm.	Dori	A,B, H, D, E	2500-3800	H	Medicinal
P. atrosanguinea Lodd.	Dori	A,B, H, D, E	2800-4200	H	Medicinal
P. supina L.	Dori	A,B, H, D, E	2000-2600	H	Medicinal
P. fruticosa L		I, J, M	3000-4000	Sh	Medicinal
Prunus avium L.	Cherry	A,B, F	1800-2000	T	Edible, Fuel, Medicinal
P. domestica L.	Palum	A, B, F	1800-2200	T	Edible, Fuel, Medicinal
P. persica (L.) Batsch	Aru	A,B, F	1800-2200	T	Edible, Fuel, Medicinal
P. armeniaca L.	Khumani, Shada	A,B, F	1800-2200	T	Edible, Fuel, Medicinal
P. cornuta (Wall.ex Royle) Steud.	Jammun	A,B, E, D	1800-2600	T	Edible, Fuel, Medicinal
Prinsepia utilis Royle	Bhekhal	A,B, H, D, E	1800-2900	Sh	Medicinal
Pyrus malus Royle	Seb	A, B	1800-2400	T	Edible, Fuel
P. communis L.	Nashpati	A,B, F	1800-2400	T	Edible, Fuel
P. pashia Buch.-Ham.ex D.Don	Shegal	A,B, F	1800-2600	T	Edible, Fuel, Fodder, Medicinal
Rosa brunonii Lindl.	Kuja	A,B, H, D, E	1800-2500	Sh	Fuel , Fodder, Medicinal

R. macrophylla Lindl.	Kuja	A,B, H, D, E, O	2100-3200	Sh	Fuel , Fodder, Medicinal
R. sericea Lindl.		I, J ,L, N	2500-3500	Sh	Medicinal, Edible
Rubus biflorus Buch.-Ham. ex Sm.	Aakha	A,B, H, D, E	2000-2700	Sh	Edible
R. lasiocarpus Sm.	Aanchha, Aakha	A,B, H, D, E	1800-2500	Sh	Edible
R. ellipticus Sm.	Kala Aanchha	A,B, H, D, E	1800-2500	Sh	Edible, Medicinal
R. paniculatus Sm.	Lal Aachha, Aakha	A,B, H, D, E, F	1800-2500	Sh	Edible, Medicinal
R. nivues Thunb.	Aachha, Aakha	A,B, H, D, E, F	2000-3500	Sh	Edible, Medicinal
Sibbaldia cuneata Hornemm ex O. Ktze.		A,B, H, D, E	2000-2500	H	Fodder
Sorbaria tomentosa (Lindl.) Rehder		A,B, H, D, E	1800-2900	Sh	Fuel
Sorbus foliolosa (Wall.) Spach		A,B,F	2000-2500	T	Fuel
Spiraea bella Sims.	Chakhu	A,B, F	2500-3500	Sh	Agri. Tools , Fuel
S.canescens D.Don	Chakhu	A,B,C,,F	1800-2500	Sh	Agri. Tools , Fuel
Saxifragaceae					
Astilbe rivularis Buch.-Ham. ex D.Don		A, F	2400-4000	H	Medicinal
Bergenia ciliata (Haw.) Sternb.	Pashan ved	A, B, H, D, E	2000-3000	H	Medicinal, Edible
B. stracheyi (Hk. f. & Th.) Engl.	Pashan ved	B, D, H, I, L, M	2800-4000	H	Medicinal, Edible
Parnassiaceae					
Parnassia nubicola Hk. f.		D, H, I, J	3000-4000	H	Medicinal
Philadelphiaceae					
Deutzia staminea R.Br. ex Wall.	Chruru	A, B, H, D, E	2500-3500	Sh	Medicinal, Fodder, Fuel
D. corymbosa (Schneid) Airy-Shaw	Churu	A, F, H	2400-2700	Sh	Medicinal, Fodder, Fuel
Grossulariaceae					
Ribes glaciale Decne	Chalendhar	A, H, D, E	2400-2700	Sh	Edible
R. emodense Rehd.	Chalendhar	A, H, D, E	2400-2700	Sh	Edible
Crassulaceae					

Sedum ewersii Ledeb.	Moshu ghas	D,E, H	2500-4000	H	Medicinal
S. multicaule Wall. ex Lindl.		A, H, D, E	2500-3500	H	Medicinal
Rosularia rosulata (Edgew.) H. Ohba	Moshu ghas	A, F, H	1800-2600	H	Medicinal
Onagraceae					
Epilobium royleanum Haussk.		A, F, G, H	2000-2500	H	Medicinal
E. latifolium L.		A, F, J, K, M	2800-3500	H	Medicinal
E. hirsutum L.		I, K, M, N	2000-3000	H	Medicinal
Cucurbitaceae					
Melothria heterophylla (Lour.) Cogn.	Balakakri	A, B, F, H	2000-2500	H	Medicinal, Edible, Fodder
Begoniaceae					
Begonia picta Sm.	Khatnaru	A,B, F, H	1800-2500	H	Medicinal
Apiaceae					
Angelica glauca Edgew.	Chora	A, B, F, O	2100-2800	H	Medicinal, Edible
Bupleurum falcatum L.	Nimla	A, B, F	2000-4000	H	Medicinal
B. lanceolatum Wall. ex DC.	Nimla	A, B, F	2000-2600	H	Medicinal
Chaerophyllum villosum Wall. ex DC.	Bahe	I, E, K, L, M	2500-3500	H	Medicinal, Edible
Pleurospermum candollii (DC.) Cl.		J, M, N	3500-4000	H	Medicinal
P. densiflorum Hk.f.	Losar	H,J, M, N	3000-4000	H	Medicinal, Edible
P.angelicoides (DC.) Cl.		I, J, M, N	3000-4000	H	Medicinal
Cortia depressa (Don) Norm.			3200-4000	H	Medicinal
Heracleum candicans Wall. ex DC.	Padiyala	A,B, F, O	2000-4000	H	Medicinal, Edible
Pimpinella acuminata (Edgew.) Cl.		A, B, G, H	2000-3000	H	Medicinal
P. diversifolia DC.		A, C, E, F, G	2100-3000	H	Medicinal
Selinum candolii DC.	Matoshal	A,B, F,O	2000-4000	H	Medicinal
S. tenuifolium Wall.	Bhae	A,B, F	2000-4000	H	Medicinal, Religious
S. vaginatum Cl.	Butkesh	F, H, G, I, L, M, N,O	2500-4000	H	Medicinal

Cornaceae					
Cornus capitata Wall.	Kirchhan	A, F, H	2000-2500	T	Fuel, Edible
C. macrophylla Wall.	Kirchhan	A, F, H	2000-2500	T	Fuel
Caprifoliaceae					
Leycesteria formosa Wall.		A, F	2000-2800	Sh	Fodder
Lonicera angustifolia Wall. ex DC.	Plaas	A, B, F, H, G	1900-3000	Sh	Fodder, Medicinal
L. obovata Royle ex Hk. f. & Th.		A, B, C, H, F, L, N	3000-4000	Sh	Fodder
L. purpurascens (Decne) Walp.	Changari	A, F, E, L	2400-3000	Sh	Fodder
L. quinquelocularis Hardw.		A, C, F	1900-2500	Sh	Fodder
Viburnum cotinifolium D.Don	Thallana	A, B, C, F	2000-2600	Sh	Edible, Fuel Fodder, Medicinal,
V. mullaha Buch.-Ham. ex D. Don	Thallana	A, B,F, H,G	2000-2500	Sh	Edible, Fodder
V.grandiflorum Wall. ex DC.	Thallana	A, F, H,G,K, O	2600-3600	Sh	Fuel
Rubiaceae					
Galium acutum L.	Looth	A, B,F, H,G	2000-3000	H	Medicinal
G.asperifolia Wall.		A, B,F, H,G, E	2000-3000	H	Medicinal
G. rotundifolium L.		A, B, C, D, F	1800-2400	H	Medicinal
Leptodermis lanceolata Wall.		E, G, H,D	2800-3000	Sh	Medicinal
Rubia cordifolia L.		A, B,C,F, H,G	1800-2600	H	Medicinal, Fodder
Valerianaceae					
Valeriana hardwickii Wall.	Nihanu	A, B,F, H,G	2000-3000	H	Medicinal, Religious
V. jatamansi Jones	Nihanu	A, B,F, H,G	2000-3000	H	Medicinal, Religious
Dipsacaceae					
Dipsacus inermis Wall.		A, B, F	2500-3500	H	Medicinal
Morinaceae					
Morina longifolia Wall. ex DC.		I, M, N, K,O	2500-4000	H	Medicinal
Asteraceae					
Achillea millefolium L.		I, M, K	2500-3800	H	Medicinal

Ainsliaea aptera DC.	Sath-jalari		2000-3000	H	Medicinal
A. latifolia D. Don		A, B,F, H,G	2000-3000	H	Medicinal
Anaphalis busua (Buch. – Ham. ex D. Don) DC.	Bacha	A, B,F, H,G, O	2000-3500	H	Fibre
A. triplinervis (Sims.) Cl. var. *intermedia* (DC.) Airy Shaw	Bacha	B, C, G, I, J, M,	2400-3500	H	Fumitory
Arctium lappa L.	Nakli kunth	D, C, F	2500-3500	H	Medicinal
Artemisia roxburghiana Bess.	Jonkhar	C, E, D,O	2200-3500	H	Medicinal, Fodder
A. parviflora Roxb.	Jhau	A, B, F, H,G	1800-2800	H	Medicinal, Fodder
Bidens bipinnata L.		A, B,F, H, G	1900-2500	H	Medicinal, Fodder
Cicerbita macrorhiza (Royle) Beauv.		A, F	2000-4000	H	Medicinal
Conyza stricta Willd.		A, F, H	2000-2500	H	Medicinal, Fodder
Erigeron bellidioides Benth.		A, F, H,	2000-2500	H	Medicinal
E. bonariensis L.		A, F, H,	1900-2100	H	Fodder
E. multiradiatus Benth.		B, D, G, E	2000-2800	H	Fodder
Galinsoga parviflora Cav.		B, D, G, E	2000-3000	H	Medicinal, Fodder
Gerbera gossypina (Royle) Beauv.		B, D, G, E	2000-2400	H	Medicinal
Gnaphalium hypoleucum DC.		B, D, G, E	1900-2500	H	Religious
Inula cappa DC.		B, D, G, E	1800-2000	H	Medicinal, Fodder
Jurinella macrocephala (Benth. ex Hk. f.) Aswal & Malhotra	Dhoop	L, K, M, N	3000-4000	H	Religious, Medicinal
Lactuca dissecta D. Don		B, D, G, E	1900-2500	H	Medicinal, Edible
Saussurea costus (Falk.) Lipsch.	Kuth	D	2500-3500	H	Medicinal
S. heteromella (D.Don) Hand.-Mazz.	Kuth	A, B, F	1900-3000	H	Medicinal
S. obvallata (DC.) Edgew.	Brahm camal	I, M, K	3500-4000	H	Medicinal, Religious
Siegesbeckia orientalis L.		A, B, F	2000-2500	H	Medicinal
Sonchus oleraceus L.		A, B, F	2000-2500	H	Medicinal,

					Fodder
Senecio chrysanthemoides DC.		J, I, M, N	2500-3500	H	Medicinal
Tanacetum dolichophyllum Kitam.		B, D, ,N, I, M, K	3000-4000	H	Medicinal
Taraxacum officinale Weber		A, B,C,D, F, O	1900-4000	H	Medicinal
Youngia japonica (L.) DC.		A, B, F	1900-2500	H	Medicinal
Campanulaceae					
Campanula colorata Wall.		A, B, F,O	2200-3500	H	Medicinal
Cyananthus lobatus Wall.		L, N, I, G, J	3000-4000	H	Medicinal
Ericaceae					
Cassiope fastigiata Wall.		J, K,	3200-4000	Sh	Medicinal
Gaultheria trichophylla Royle		B,C,D	2000-3500	Sh	Medicinal, Edible
Lyonia ovalifolia (Wall.) Drude	Ayar	A, B, F	1800-2800	T	Medicinal, Fuel
Rhododendron arboreum Sm.	Brass	G	2500-2700	T	Fuel, Edible, Medicinal
R. campanulatum D.Don	Shargal	L, I, J, K, M,	3000-4000	Sh	Medicinal, Fuel
R. anthopogon D.Don&		J, K, N	3000-4000	Sh	Medicinal
R. lepidotum Wall.	Shargal	J, M, N	2500-3500	Sh	Medicinal
Primulaceae					
Anagallis arvensis L.		A, C, F	1900-2100	H	Medicinal
Primula denticulata Sm.	Jaibeez	C, L, I, K, M,	2500-4000	H	Medicinal
P. rosea Royle		L, I, K, M	2500-4000	H	Medicinal
Myrsinaceae					
Myrsine africana L.		A, F,	2000-2500	Sh	Medicinal
Asclepiadaceae					
Vincetoxicum hirudinaria Medik.		A, H	2000-2600	H	Medicinal
Marsdenia roylei With.		A, F, C, D,	1800-2200	Sh	Medicinal
Buxaceae					
Sarcococca saligna (D.Don) Muell.	Chirbeeri	C, D, E	2100-3600	Sh	Medicinal
Cannabaceae					
Cannabis sativa L.	Bhang	C, D, F, A	1900-2500	H	Medicinal
Gentianaceae					

Gentiana kurrooa Royle		K, M, N	2400-4000	H	Medicinal
G. carinata (D.Don) Griseb.		A, D, C, G, I, K, M, N	2000-4000	H	Medicinal
Gentianella tenella (Rottb.) Borner		I, K, M, N	3000-4000	H	Medicinal
Jaeschkea oligosperma (Griseb.) Knobl.		J, M	2900-4200	H	Medicinal
Swertia angustifolia Ham. ex D.Don	Chirayata	I, K, M, N	2000-4000	H	Medicinal
S. paniculata Wall.	Chirayata	A, F	2000-3500	H	Medicinal
Boraginaceae					
Arnebia benthamii (Wall. *ex G.*Don) Johnst.	Rattan jot	I, K, M, N	3300-4000	H	Medicinal
Cynoglossum lanceolatum Farssk.		A, F	2000-2600	H	Medicinal
C. zeylanicum Vahl ex Harnem		A, F	1900-2500	H	Medicinal
C. glochidiatum Wall. ex Benth.		A, F	2200-3800	H	Medicinal
Lindelofia longiflora (Benth.) Baill.		J, M, N	3000-4200	H	Medicinal
Hippocastanaceae					
Aesculus indica Coleb. ex Wall.	Khanor	A, B, H, D, C	1900-2800	T	Fodder, Fuel, Medicinal, Edible
Convolvulaceae					
Convolvulus arvensis L.		A, F	1900-2400	H	Medicinal
Ipomoea purpurea L.		A, F, B,	1800-2300	H	Medicinal
Cuscutaceae					
Cuscuta reflexa Roxb.	Amar bel	A, C, F	1800-2400	H	Medicinal
Solanaceae					
Datura stramonium L.	Datura	A, F	1800-2000	H	Medicinal
Nicotiana tabacum L.	Tambakhu	A,C, F	1900-2700	H	Medicinal
Physalis minima L.		A,, F	1800-2000	H	Medicinal
Physochlaina praealta (Decne) Miess.	Bajar bang	A,C, F	2000-3000	H	Medicinal
Solanum pseudocapsicum L.		A,C, F	1800-2000	Sh	Medicinal
S. nigrum L.	Makoi	A,C, F	1900-2500	H	Medicinal
Scrophulariaceae					

Euphrasia himalaica Wettst.		M, N	3200-4200	H	Medicinal
Lindenbergia indica (L.) Vatke		A, B, C	1800-2000	H	Medicinal
Lindernia anagallis (Burm.f.) Penn.		A, C, D	1800-1800	H	Medicinal
Pedicularis bicornuta Klotz.		L, M, N, I, O	3000-4000	H	Medicinal
P. pectinata Wall. ex Benth.		L, M, N, I,	2500-3500	H	Medicinal
Picrorhiza kurrooa Royle	Karroo	L, M, N, I,	3000-4200	H	Medicinal
Verbascum thapsus L.	Ban tambaku	A, F	1900-2500	H	Medicinal
Acanthaceae					
Barlaria cristata L.		A, F	1800-2000	H	Medicinal, Fodder
Dicliptera roxburghiana Nees		A, F	1800-2300	H	Medicinal, Fodder
Goldfussia dalhousiana Nees		A, F	1800-2000	H	Fodder
Pteracanthus alatus Wall. ex Nees	Kunda	A, F	2000-2800	H	Fodder
Strobilanthus atropurpureus Nees	Dhuda	A,B,D, F, H	2000-2800	H	Fodder
S. wallichii Nees	Dhuda	A,B,D, F, H	2000-2800	H	Fodder
Smilacaceae					
Smilax aspera L.		A,B,D, F, H	1800-2500	Sh	Medicinal, Fodder
Lamiaceae					
Ajuga parviflora Benth.	Neel kanthi	A,B,D, F, H	1800-2000	H	Medicinal
A. bracteosa Wall. ex Benth.	Neel kanthi	A,B,D, F, H	1800-2000	H	Medicinal
Elsholtzia ciliata (Thunb.) Hyland.	Foran	A, C, F, H	1800-3400	H	Medicinal, Edible
E. fruticosa (D.Don) Rehder	Foran	A, C, D, F, H	2000-2700	Sh	Medicinal, Edible
E.flava Benth.		A, F , D, H, J, L	1800-2400	Sh	Medicinal
Lamium amplexicaule L.		F, H	1800-2500	H	Edible
Leucas lanata Benth.		A, B, C	1800-4500	H	Medicinal, Fodder
Mentha longifolia (L.) Hudson	Jungli pudina	A, B, C	1800-2400	H	Medicinal

Micromeria biflora Benth.		A, B, C, L, J	2000-4000	H	Medicinal
Nepeta campestris Benth.		A, C, D, F, H, O	2500-3500	H	Medicinal
Origanum vulgare L.	Ban tulsi	A, C, D, F, H, O	1800-2800	H	Medicinal, Religious
Phlomis bracteosa Royle		L, K, M, I, N	2000-4000	H	Medicinal
Plectranthus rugosus Wall.	Shian	A, B, C, D	1800-2500	Sh	Medicinal
Prunella vulgaris L.		B, C, D, E	1900-2800	H	Medicinal
Salvia lanata Roxb.	Gawandru	A, C, D, F, H	1900-2500	H	Medicinal
S. moorcroftiana Wall.		A, C, H, F, E, O	1900-2500	H	Medicinal
Thymus linearis Benth.	Ban ajwain	A, C, D, F, H	2000-3000	H	Medicinal
Amaranthaceae					
Amaranthus hybridus L.		A, C, F, H	1900-2500	H	Medicinal
A.paniculatus L.		A, F,	1800-2000	H	Medicinal
Cyathula capitata Moq.		A, C, D, F, H, O	1800-2800	Sh	Medicinal, Fodder
C. tomentosa Roth		A, C, D, F, H	1800-2500	Sh	Medicinal, Fodder
Chenopodiaceae					
Chenopodium album L.	Bathua	A, F	1800-2000	H	Medicinal, Edible
C. botrys L.		A, F	1800-2200	H	Medicinal
Achyranthaceae					
Achyranthes bidentata Bl.		A, F,D, H	1900-2500	H	Medicinal
A.aspera L.		A, F	1800-2000	H	Medicinal
Phytolaccaceae					
Phytolacca acinosa Roxb.	Jharka	A, B, H, D, E, O	2000-3000	H	Medicinal, Edible
Polygonaceae					
Bistorta amplexicaulis (D.Don) Greene	Dori ghass	A, C, D, F,O	2000-2800	H	Medicinal, Fodder
B. affinis (D.Don) Greene	Roti muhin	J, L, K, M, N,	3000-4000	H	Medicinal
B. vaccinifolia (Wall. ex Meissn.) Greene		J, L, K, M, N	3000-4000	Sh	Medicinal
Fagopyrum debotrys (D.Don) Hara	Paphra	A, C, D, F	1800-2800	H	Medicinal, Edible
F. esculentum Moench	Ghangri	C, D	2000-3000	H	Medicinal, Edible
F. tataricum (L.) Graertn.	Bhesa	C, D	1900-3000	H	Medicinal,

					Edible
Oxyria digyna (L.) Hill		A, F, G	2500-4000	H	Medicinal, Edible
Persicaria nepalensis (Meisn.) Gross	Trod	A, F, G, O	2000-3500	H	Medicinal, Edible
P. capitata Gross	Kalovar	A, F, G	1800-2500	H	Medicinal
P. polystachya Gross	Kalovar	A, F, G	2000-3000	H	Edible
P. recumbens Royle	Kalovar	A, C, D, F, H	2000-3300	H	Medicinal
Polygonum plebeium R.Br.		A, F, G, H	1800-2400	H	Medicinal
P. hydropiper L. subsp. *microcarpum* Danger	Pipiri	A, F	1800-2000	H	Medicinal
Rheum australe D.Don	Chuchi	J, M, N	3000-4200	H	Medicinal, Edible
R. webbianum Royle	Chuchi	I, K, L, M, N	3000-4200	H	Medicinal, Edible
Rumex acetosa L.	Jungli palak	A, C, D, F, H	2000-3500	H	Medicinal, Edible
R. nepalensis Spreng.	Malora	A, C, D, F, H, O	1800-3500	H	Medicinal, Fodder
R.hastatus D.Don	Malora	A, C, D, F, H, O	1800-2500	H	Medicinal, Edible
Thymelaeaceae					
Daphne papyracea Wall. ex Steud.		A, F	1800-2500	Sh	Medicinal
Wikstroemia canescens Meissn.		A, C, D, F, H	2000-2700	Sh	Fuel
Elaeagnaceae					
Elaeagnus conferta Wall. ex Royle	Ghiayeen	A, F,	1800-2600	Sh	Medicinal, Edible
Hippophae salicifolia D. Don	Chhaku	G	2400-2900	Sh	Medicinal, Edible
Loranthaceae					
Viscum album L.	Rinni	A, F, C	1800-3000	Sh	Medicinal
Euphorbiaceae					
Euphorbia hirta L.		A, F,	1800-2000	H	Medicinal
E. stracheyi Boiss.		L, K, M, I	2500-3500	H	Medicinal
E. pilosa L.		L, K, M, I	2000-3300	H	Medicinal
Urticaceae					
Debregeasia longifolia (Forssk) Heppetr. & Wood	Sariyahu	A, F	1800-1900	Sh	Fodder
Parietaria micrantha		A, F	1900-2500	H	Medicinal

Ledeb.					
Pilea scripta (Buch.-Ham. ex D.Don) Wedd.		A, F	1900-2200	H	Fodder
P.umbrosa Bl.		A,F C, G, O	2000-3000	H	Medicinal
Pouzolzia zeylanica L.		A, F	1800-2500	H	Medicinal
Urtica dioica L.	Aan	A, F, D, C,O	1800-2800	H	Medicinal
U. hyperborea Jacq. ex Wedd.		A, F, G, D	3000-4200	H	Medicinal
Girardinia diversifolia (Link) Friis	Jharan	A, F, D, C, O	1800-3000	H	Medicinal, Fibre
Ulmaceae					
Ulmus wallichiana Planch.	Mahun	A, F	1800-2000	T	Religious, Medicinal Fuel, Fodder
U. villosa Brandis ex Gamble	Chor	C, D, F	2200-2800	T	Fuel, Fodder
Celtis australis L.	Kharik	A, F	1800-2500	T	Fuel, Fodder
Moraceae					
Ficus nemoralis Wall. ex Miq.	Fagda	A, F	1800-2000	T	Fodder, Edible
F. sarmentosa Wall.		A, B, F	1800-2400	Sh	Fodder, Edible
Juglandaceae					
Juglans regia L.	Akhrot	A, B, D, F, O	1800-2600	T	Edible, Fuel, Medicinal, Timber
Betulaceae					
Alnus nepalensis D. Don	Kosh	A, F	1800-3000	T	Fuel, Fodder, Medicinal
A. nitida (Spach) Endl.	Kosh	A, B, F	1800-3000	T	Fuel, Fodder, Medicinal
Betula alnoides Buch.-Ham. ex D.Don	Kolsh	F	2000-2500	T	Fuel, Fodder
B. utilis D.Don	Bhojpatra	G, J, L, M, F, O	3000-4500	T	Fuel, Medicinal, Religious
Corylaceae					
Corylus jacquemontii Decne	Jamgli-Badam	H	1900-2700	T	Fuel, Fodder, Edible
Fagaceae					
Quercus floribunda Lindl.	Mohru	A, B, F,	1800-2400	T	Fuel, Fodder, Agri. Tool

Q. semecarpifolia J.E.Sm.	Kharshu	C, D, L, O	2600-2700	T	Fuel, Fodder, Agri. Tool
Q. leucotrichophora A.Camus	Ban	F	1900-2200	T	Fuel, Fodder, Agri. Tool, Timber, Medicinal
Salicaceae					
Salix denticulata (Anders.) Svensk	Belli	A, F, C	2000-2600	Sh	Fuel, Fodder
S. acutifolia Willd.	Beuns	A, F, I, E	1800-3000	T	Fuel, Fodder
S.daphnoides L.		A, C, F, E	1900-2800	Sh	Fuel, Fodder
S. lindleyana Wall. ex Anders.	Basil	J, N	3000-4000	Sh	Fuel, Fodder
Populus ciliata Wall.	Popular	A, F, C	1800-2200	T	Fuel, Fodder, Medicinal
Orchidaceae					
Calanthe tricarinata Lindl.		A, F, C, O	2000-3000	H	Medicinal
Cephalanthera longifolia (L.) Fritsch		A, F, C	2000-3000	H	Medicinal
Dactylorhiza hatagirea (Don) Soo		L, J, M	3000-4000	H	Medicinal, Edible
Epipactis gigantea Dougl. ex Hk.		A, F, C	1800-3500	H	Medicinal
Goodyera repens (L.) R.Br.		A, F, C	1900-3000	H	Medicinal
Habenaria edgeworthii Hk. f. ex Collett		A, F, C	2000-3500	H	Medicinal
Herminium lanceum (Thunb. ex Sw.) Veujk.		A, F, C	1800-3000	H	Medicinal
Spiranthes sinensis (Pers.) Ames.	Bakersinghi	A, F, C	1800-3000	H	Medicinal
Zingiberaceae					
Hedychium spicatum J. E. Sm.	Ban haldi	A, F, C	1800-2500	H	Medicinal, Fodder
Roscoea purpurea J.E. Sm.		A, F, C	2000-3000	H	Medicinal
R. alpina Royle		I, J M, N	2500-4000	H	Medicinal
Haemodoraceae					
Mondo intermedius D. Don		A, F, D, F	1800-2000	H	Medicinal
Iridaceae					
Iris milesii Foster	Chirichi	A, B, C, F,G, O	2100-2700	H	Religious

I. kumaonensis Wall. ex D.Don		A, B, C, F,G	2000-3500	H	Medicinal
Dioscoreaceae					
Dioscorea deltoidea Wall.		A, B, C, F,G	1800-2500	H	Medicinal
Alliaceae					
Allium humile Kunth	Farn	J, M, N	1800-3500	H	Medicinal
A. wallichii Kunth		J, M	2800-4000	H	Medicinal
Asparagaceae					
Asparagus filicinus Buch.-Ham.	Shatavari	A,B,D, F, H	2000-2700	Sh	Medicinal
Liliaceae					
Eremurus himalaicus Baker		A, F	2000-3000	H	Medicinal
Fritillaria roylei Hk.		F	2100-2700	H	Medicinal
Narcissus tezatte L.		A, F	1800-2200	H	Religious
Paris polyphylla Sm.		F, D	2000-3000	H	Medicinal
Polygonatum cirrhifolium (Wall.) Royle	Salam misri	A,B,D, F, H	1900-3000	H	Medicinal, Edible
P. verticillatum (L.) All.	Salam misri	A,B,D, F, H, O	1900-3500	H	Medicinal, Edible
P. multiflorum (L.) All.	Salam misri	A,B,D, F, H	1900-3000	H	Medicinal, Edible
Smilacina purpurea Wadle		A,B,D, F, H	2100-2700	H	Medicinal
Trillidium govanianum (Wall. ex D. Don) Kunth		A,B,D, F, H	2300-2700	H	Medicinal
Tulipa stellata Hk.f.		A, F	1800-3200	H	Edible
Loganiaceae					
Buddleja crispa Benth.		A,B,D, F, H	1900-2800	Sh	Fuel
Malvaceae					
Malva verticillata L.	Siddu	A,B,D, F, H	1800-2600	H	Medicinal, Edible
Moraceae					
Morus serrata Roxb.	Toot	A, B, F	1800-2500	T	Fodder, Fuel, Edible, Agri. Tools
Oleaceae					
Jasminum humile L.		A,B,D, F, H	1800-2800	Sh	Fodder, Medicinal, Religious
Commelinaceae					

Commelina paludosa Bl.		B, F, G	1800-3000	H	Fodder
Cyanotis vaga (Lour.) J.A. & J.H. Schult.		A,B,D, F, H	1800-2500	H	Edible
Juncaceae					
Juncus articulatus L.		A, G, F, O	2000-4000	H	Fodder, Broom making
Araceae					
Arisaema flavum (Forssk.) Schott	Kida alu	A, B, C, F, H,O	2000-3500	H	Medicinal
A. tortuosum (Wall.) Schott	Kida alu	A, B, C, F, H	1800-3000	H	Medicinal
A. jacquemontii Bl.		A, B, C, F, H, O	2500-4000	H	Medicinal
Cyperaceae					
Carex breviculmis R. Br.	Krash	A, B, C, F, H, O	2000-3000	H	Fodder
C. filicina Nees		A, B, C, F, H, O	1900-3000	H	Fodder, Medicinal
C. foliosa D. Don		A, B, C, F, H	1800-3000	H	Fodder
C. nivalis Boott.		L, M, N, I, O	3000-4000	H	Fodder
C. cruciata Wahlenb.		A, F, G, H	2200-3500	H	Fodder
C.setigera D. Don		A, B, C, F, H	2000-3000	H	Fodder
C.nubigena D. Don		A, B, C, F, H	1800-3500	H	Fodder
Cyperus squarrosus L.		A, B, C, F, H	1800-2500	H	Fodder
Eleocharis palustris (L.) R. Br.		A, B, C, F, H	2000-4000	H	Fodder
Eriophorum comosum Wall. ex Nees		A, B, C, F, H	1900-3500	H	Fodder
Poaceae					
Agrostis pilosula Trin.		A, B, C, F, H	2000-4000	H	Fodder
Apluda mutica L.		A, B, C, F, H	1800-2500	H	Fodder
Bromus japonicus Thunb. ex Murr.		A, B, C, F, H	2000-4000	H	Fodder
B. racemosus Hudson		B, CG, H,K	2000-3500	H	Fodder
Chrysopogon gryllus (L.) Trin.		A, B, C, F, H	2000-2800	H	Fodder
C. echinulatus (Nees) W. Wats.		A, F, B, C, D, H K	1800-3500	H	Fodder
C. serrulatus Trin.		A, B, C, F,	1800-2500	H	Fodder
Cymbopogon martinii (Roxb.) Wats.		A, F	1800-2000	H	Fodder, Medicinal

Cynodon dactylon L.	Doob	A, B, C, O	1800-2200	H	Fodder
Dactylis glomerata L.		A, B, C, F,	2000-3500	H	Fodder
Digitaria cruciata (Nees ex Steud.) Canus		A, B, C, F,	1800-3000	H	Fodder
Eragrostis pilosa P.Beauv.		A, B, C, F, H,O	1800-2000	H	Fodder
E. minor Host.		A, F, B	1800-2200	H	Fodder
Festuca rubra L.		A, B, C, F, H	1800-2500	H	Fodder
Imperata cylindrica (L.) Raeuschel		A, B, C, F	1800- 2000	H	Fodder
Isachne himalaica Hk. f.		B, C, F,	1800-2000	H	Fodder
Koeleria micrantha (Ledeb.) Schult.		C, D	1900-4000	H	Fodder
Lolium temulentum L.		A, B, C, F, H	1800-2000	H	Fodder
Oplismenus compositus (L.) Beauv.		E, G	2000-3000	H	Fodder
Poa annua L.		A, B, C, F, H	1800-3000	H	Fodder
P. alpina L.		L, M, K,O	2500-4000	H	Fodder
Saccharum spontaneum L.	Philoo	A, B, C	1800-2400	H	Fodder
S. rufipillum Steud	Philoo	A, B, C	1800-2500	H	Fodder
S. filifolium Nees & Steud	Philoo	A, B, C, F, H	1800-2500	H	Fodder
Setaria pumila (Poir.) Roem. & Schult.		B, C, D	1800-2500	H	Fodder
Stipa sibirica (L.) Lam.		D, E, F	2000-3000	H	Fodder
Themeda anathera (Nees) Hack.		A, B, C, F, H,O	2000-2800	H	Fodder
Thamnocalamus spathiflora (Trin.) Munro	Rangad	F, H	2500-3000	Sh	Fodder, Basket making
Gymnosperms					
Cupreassaceae					
Juniperus recurva Buch.-Ham. ex D.Don	Baittori	I, L, M, N, K,	3000-4500	Sh	Fuel, Religious
J. indica Bertol.	Baittor	I, L, M, N, K,	3000-4500	Sh	Fuel, Religious
J. communis L.	Bithal	J, M,L	2500-3500	Sh	Medicinal, Fuel, Religious
Pinaceae					
*Picea smithiana (*Wall.) Boiss	Rai	A, B, C, F, H,O	1800-3300	T	Timber, Fuel, Minor forest products
Pinus wallichiana A.B.Jack	Kail	A, B, C, F, H	1800-2500	T	Timber, Fuel,

					Minor forest products
Cedrus deodara G.Don	Dyar	A, B, C, F, H	1800-2500	T	Medicinal, Timber, Fuel, Minor forest products
Abies pindrow Royle	Tosh	A, B, C, F, H,O	2200-3600	T	Timber, Fuel, Minor forest products
Taxaceae					
Taxus baccata subsp. *wallichiana* (Zucc.) Pilger	Rakhal	A, B, C, F, H,O	2500-3500	T	Medicinal, Fuel
Pteridophytes					
Pteridaceae					
Pteris cretica L.	Baran	A, B, D, E, F, O	2200-2500	F	Medicinal
Pteridium aquilinum (L.) Kuhn.	Baran	B, C, D	1900-2500	F	Minor forest products, Medicinal
Equisetaceae					
Equisetum arvense L.		A, B, C, D, E, F	1800-2500	F	Medicinal
Athyriaceae					
Diplazium esculentum (Retz.) Sw.	Lingar	A, B, D, E, F	1800-2600	F	Edible
Ophioglossaceae					
Ophioglossum petiolatum Hk.		A, E, F	1900-2100	F	Medicinal
Dryopteridaceae					
Dryopteris barbigera (T.Moore ex Hk.) O.Ktze.		A, C, G, H, I,	2200-3300	F	Medicinal
Aspleniaceae					
Asplenium trichomanes Cl.		A, B, C, E, G, I, M	1800-3000	F	Medicinal
Sinopteridaceae					
Cheilanthus albomarginata Cl.		B, D, E, F	1800-2500	F	Medicinal
Adiantaceae					
Adiantum capillus-veneris L.		A, B, C, D, E, F, G,O	1800-3000	F	Medicinal
A. venustum D.Don		B, D, E, F	1800-2700	F	Medicinal
Hemionitidaceae					

Gymnopteris vestita (Wall. ex Moore) Underwood		A, F, G, D, E	1800-2500	F	Medicinal

Abbreviations used: H=Herb; Sh=Shrub; T=Tress; F=Fern; A=Prini Nallah; B=Hamta; C=Hamta potato farm; D=Sethan; E=Pandu Ropa; F=Jagatsukh nallah; G=Khanoor; H=Brun Dhar; I=Chhika; J=Seri; K= Banshiru; L=Bujh Dhar; M= Jabri Nallah; N=Marasu Nallah; O= Dam site

4.5. Assessment and identification of Rare Endangerd Species

4.5.1.Diversity and categorization

A total of 49 species have been identified as rare- endangered (Table 4.5.1). However, using current criteria of International Union for Conservation of Nature and Natural Resources (IUCN), **5** species have been categorized as **Critically Endangered** (*Saussurea obvallata*, *Gentiana kurroo*, *Arnebia benthamii*, *Dactylorhiza hatagirea* and *Saussurea costus*); **12** species as **Endangered** (*Aconitum heterophyllum, Angelica glauca, Betula utilis, Bergenia stracheyi, Dioscorea deltoidea, Meconopsis aculeata, Paris polyphylla, Podophyllum hexandrum Polygonatum cirrhifolium, Picrorhiza kurrooa, Taxus baccata* subsp*. wallichiana* and *Zanthoxylum armatum,*); **8** species as **Vulnerable** (*Aconitum violaceum, Polygonatum verticillatum, P.multiflorum, Rheum australe, R. webbianum, Rhododendron campanulatum, R. anthopogon* and *Valeriana jatamansi*); **1** species as **Near Threatened** (*Hippophae salicifolia*); **1** species as **Extinct in Wild** (*Saussurea costus***)** (Samant & Pal, 2003; Ved et al.,2003)**.** In general, *Saussurea costus* has been placed under Critically Endangered cartegory, however, in Himachal Pradesh this species has been placed under the category, Extinct in Wild. Twenty two (**22)** species were identified as **Rare.** Similarly, other species which have not been categorized but facing habitat degradation and over exploitation may be considered under vulnerable category whereas species presently not facing such problems may be considered under Near Threatened or leas concerned categories.

Table 4.5.1. Diversity and Distribution Pattern of Rare Endangered Plants of Hamta Jagatsukh Catchments in Himachal Pradesh

Taxa	Locality	Altitudinal range (m)	Life Form	Status in H.P./ Global
Ranunculaceae				
Aconitum heterophyllum Wall.ex Royle	I,J,L,M	3000-4200	H	CR (CR)
A. violaceum Jacq. ex Stapf`	I,J,L,M	3500-4000	H	VU (VU)
Delphinium denudatum Royle	A,B,F,H	2000-2600	H	R
Violaceae				
Viola biflora L.	A, B, D, H, F, O	2400-2600	H	R
Papaveraceae				
Meconopsis aculeata Royle	J, L, M, N	3000-3500	H	EN(EN)
Podophyllacaeae				
Podophyllum hexandrum Royle	A, B, H, D,	1800-4000	H	EN

	F, I, L, O			
Rutaceae				
Zanthoxylum armatum DC.	A, F	2000-2500	H	EN
Aquifoliaceae				
Ilex dipyrena Wall.	A, F, G	1800-3000	T	R
Aceraceae				
Acer caesium Wall. ex Brandis	C,D,H, O	2400-3200	T	R
Fabaceae				
Caragana gerardiana Royle ex Benth.	I, J, M, N	2000-2400	Sh	R
Saxifragaceae				
Bergenia stracheyi (Hk. f. & Th.) Engl.	B, D, H, I, L, M	2800-4000	H	EN
Apiaceae				
Angelica glauca Edgew.	A, B, F, O	2100-2800	H	EN (EN)
Chaerophyllum villosum Wall. ex DC.	I, E, K, L, M	2500-3500	H	R
Heracleum candicans Wall. ex DC.	A,B, F, O	2000-4000	H	R
Valerianaceae				
Valeriana jatamansi Jones	A, B,F, H,G	2000-3000	H	VU
Asteraceae				
Saussurea costus (Falk.) Lipsch.	D	2500-3500	H	EW (CR)
S. obvallata (DC.) Edgew.	I, M, K	3500-4000	H	CR
Campanulaceae				
Codonopsis rotundifolia Benth.	N, I	3000-4000	H	R
C. viridis (DC.) Roxb.	I,M	2500-3300	H	R
Ericaceae				
Rhododendron arboreum Sm.	G	2500-2700	T	R
R. campanulatum D.Don	L, I, J, K, M,	3000-4000	Sh	VU
R. anthopogon D.Don	J, K, N	3000-4000	Sh	VU
Gentianaceae				
Gentiana kurrooa Royle	K, M, N	2400-4000	H	CR (CR)
Boraginaceae				
Arnebia benthamii (Wall. *ex G.*Don) Johnst.	I, K, M, N	3300-4000	H	CR (CR)
Cynoglossum zeylanicum Vahl ex Harnem	A, F	1900-2500	H	R

Scrophulariaceae				
Picrorhiza kurrooa Royle	L, M, N, I,	3000-4200	H	EN
Polygonaceae				
Rheum australe D.Don	J, M, N	3000-4200	H	VU
R. webbianum Royle	I, K, L, M, N	3000-4200	H	VU (VU)
Elaeagnaceae				
Hippophae salicifolia D. Don	G	2400-2900	Sh	NT
Betulaceae				
Betula alnoides Buch.-Ham. ex D.Don	F	2000-2500	T	R
B. utilis D.Don	G, J, L, M, F, O	3000-4500	T	EN
Corylaceae				
Corylus jacquemontii Decne	H	1900-2700	T	R
Orchidaceae				
Dactylorhiza hatagirea (Don) Soo	L, J, M	3000-4000	H	CR
Oreorchis indica Hk. f.	H, F, G, E	2500-2800	H	R
Dioscoreaceae				
Dioscorea deltoidea Wall.	A, B, C, F,G	1800-2500	H	EN (EN)
D. melanophyma Burkill & Prain	A, B, C	1800-2500	H	R
Liliaceae				
Fritillaria roylei Hk.	F	2100-2700	H	EN (EN)
Paris polyphylla Sm.	F, D	2000-3000	H	EN
Polygonatum cirrhifolium (Wall.) Royle	A,B,D, F, H	1900-3000	H	EN
P. verticillatum (L.) All.	A,B,D, F, H, O	1900-3500	H	VU
P. multiflorum (L.) All.	A,B,D, F, H	1900-3000	H	VU
Gymnosperms				
Cupreassaceae				
Juniperus communis L.	J, M,L	2500-3500	Sh	R
Taxaceae				
Taxus baccata subsp. w*allichiana* (Zucc.) Pilger	A, B, C, F, H,O	2500-3500	T	EN
Pteridophytes				
Botrychiaceae				
Botrychium ternatum (Thunb.) Stz.	D, E, H,	2500-3000	F	R

Osmundaceae				
Osmunda japonica Thunb.	A, B, F	1900-2500	F	R
Dryopteridaceae				
Polystichum nepalense (Spreng.) C.Chr.	B, D, E, F, O	1900-2500	F	R
Aspleniaceae				
Asplenium septentrionale (L.) Hoffm.	E	1900-2500	F	R
Phymatopteris stracheyi (Ching) P. Sermolli	I, M, D	2500-3300	F	R
Hemionitidaceae				
Gymnopteris vestita (Wall. ex Moore) Underwood	A, F, G, D, E	1800-2500	F	R

Abbreviations used: H=Herb; Sh=Shrub; T=Tress; F=Fern; R=Rare; EW=Extinct in wild; EN= Endangered; VU= Vulnerable; and LC= Least Concern. NT= Near Threatened; A=Prini Nallah; B=Hamta; C=Hamta potato farm; D=Sethan; E=Pandu Ropa; F=Jagatsukh nallah; G=Khanoor; H=Brun Dhar; I=Chhika; J=Seri; K= Banshiru; L=Bujh Dhar; M= Jabri Nallah; N=Marasu Nallah; and O=Dam site

*****CR, EN, VU, EW and NT is based on IUCN; ( ) =category in parenthesis global status

5. Discussion

5.1. Comparison of the plant communities of the Hamta Jagatsukh catchments with the plant communities of the High Project Impact Areas

5.1.1. Species Composition

Over all, 324 species (Trees: 23; Shrubs: 53; Herbs: 249) were recorded from the Hamta- Jagatsukh catchments whereas 284 species (Trees: 18; Shrubs: 46; Herbs: 220) were recorded from High Project Impact area. Amongst the communities, *Picea smithiana* showed maximum number of species i.e., 192 species (Trees: 14; Shrubs: 29; Herbs: 149) in Hamta-Jagatsukh catchments and 137 species (Trees: 8; Shrubs: 29; Herbs: 100) from high project impact area, followed by *Abies pindrow*, 136 species (Trees: 11; Shrubs: 21; Herbs: 104) in the Hamta-Jagatsukh catchments and 94 species (Trees: 8; Shrubs: 14; Herbs: 72) from high project impact area. Minimum number of species (41) were recorded in *Quercus semecarpifolia* community (Trees: 5; Shrubs: 2; Herbs: 34) in the Hamta-Jagatsukh catchments whereas *Cedrus deodara* 44 species (Trees: 3; Shrubs: 8; Herbs: 33) from high impact area.

Tree species of the forests communities notably *Quercus floribunda, Q. semecarpifolia, Acer acuminatum, Ulmus villosa, Juglans regia, Prunus cornuta, Aesculus indica, Pinus wallichiana, Abies pindrow, Picea smithiana, Betula utilis and Taxus baccata* subsp. *wallichiana* may be affected by the project.

5.1.2. Site representation

Over all, total 54 sites have been sampled for the study in the Hamta and Jagatsukh catchments of these 22 sites fall under the high project impact area. Shady Moist habitat represented maximum sites (15 sites) in both the Hamta and Jagatsukh catchments, followed by riverine habitat (10 sites), degraded and bouldary habitats (6 sites, each) and Alpine meadows (4 sites), but in high project impact area maximum sites were represented by riverine, shady moist and degraded (4 sites, each).

Maximum sites (17 sites) were represented in North West aspect, followed by West (12 sites) and South (7 sites) aspects in the Hamta-Jagatsukh catchments whereas West aspect (9) represented maximum sites in High project impact area.

Maximum sites represented by *Picea smithiana* community both in high project impact area & the Hamta-Jagatsukh catchments, 4 &12 sites, respectively, followed by *Abies pindrow*, 3 & 8 sites, respectively. However, *Quercus floribunda* (2 sites), *Cedrus deodara, Pyrus pashia-Ilex dipyrena* and *Juglans regia* (1 site, each) represented only in high project impact area

5.1.3. Community types

A total of 23 communities reported in the Hamta and Jagatsukh catchments (i.e. Forests: 14; Shrubs: 02; Alpine Scrubs: 4; & Alpine Herbs: 03 communities) have been identified. Of these, only 14 communities (Forests: 12 and shrubs: 2) were represented in high project impact area. The main forests communities of the high project impact area are *Picea smithiana, Quercus floribunda, Q. semecarpifolia, Abies pindrow,* and *Betula utilis-Acer acuminatum* mixed.

Overall total tree density ranged from 50.00-1280.00 Ind ha^{-1} and total basal area from 0.74-1964.20m^2 ha^{-1} whereas in high project impact area, density ranged from 60.00-1280.0 Ind ha^{-1} and total basal area from 0.74-1964.20m^2 ha^{-1}. The values are almost similar for both *Pinus wallichiana* showed highest density (i.e. 160.00-1280.00 & 120.00-1280.00 Ind. ha^{-1}) for both *Abies pindrow* (470.00-720.00 Ind ha^{-1}) in high project impact area and *Acer acuminatum-Betula utilis* mixed (240.00-1020.00 Ind ha^{-1}) in Hamta –Jagatsukh catchments. *Pyrus pashia –Ilex dipyrena* community showed minimum tree density 60.00 Ind ha^{-1} both in high project impact area & Hamta – Jagatsukh catchments.

5.1.4. Regeneration

In Hamta Jagatsukh catchments showed maximum total density of seedlings (1040 Ind ha^{-1}) was shown by *Quercus semecarpifolia–Abies pindrow* mixed community, and saplings (259 Indha^{-1}) by *Quercus semecarpifolia* community. However, in high project impact area, *Quercus semecarpifolia* community showed maximum density for saplings (389 Ind. ha^{-1}), followed by *Pinus wallichiana* community (245 Ind. ha^{-1}), and *Pinus wallichiana* community for seedlings (890 Ind. ha^{-1}), followed by *Cedus deodara*

community (580 Ind. ha^{-1}).

5.1.5. Species diversity

Over all, species diversity (H') for trees ranged from 0.15-1.51, seedlings from 0.70-1.83, saplings from 0.18-1.47, shrubs from 0.33-2.30 and herbs from 2.73-4.20 in the Hamta-Jagatsukh catchment whereas in high project impact area trees diversity ranged from 0.396-1.401, saplings from 0.111-1.241, seedlings from 0.502-1.825, shrubs from 0.530-4.840 and herbs from 2.720-3.914. Highest diversity of trees, shrubs and herbs wasreported in *Acer acuminatum* community (1.508), *Ilex dipyrena-Pyrus pashia* mixed community (4.85) and *Picea smithiana* community (4.20), respectively, whereas in high project impact area trees, shrubs and herbs diversity was maximum in *Picea smithiana-Aesculus indica* mixed community (1.401), *Pyrus pashia-Ilex dipyrena* mixed (4.85) and *Picea smithiana* community (3.941), respectively.

5.2. Current impact of local communities on floristic diversity

5.2.1. Human dependence

Over all, 441 economically important species (43 trees; 84 shrubs; 301 herbs and 11 ferns) were recorded from the Hamta Jagatsukh catchments, of these 181 species (24 trees; 44 shrubs; 111 herbs and 2 ferns) occur in the high project impact area.. Inhabitants of the seven villages i.e., Prini, Hamta, Chhaleth, Sethan, Jagatsukh, Shuru and Bhanara are mostly dependent on vegetation of the catchments for house building, fodder, fuel wood, medicine, edible/food etc. Evergreen broad leaved trees such as *Quercus semecarpifolia* and *Q. floribunda* are the chief sources of fodder and *Pinus wallichiana*, *Cedrus deodara*, and *Abies pindrow* are the sources main of the timber and *Valeriana jatamansi, Viola biflora*, *Podophyllum hexandrum* and *Angelica glauca,* etc. are exploited for the medicine.

5.2.2. Loss of floristic diversity by construction of Tunnels and Roads

During the construction of tunnels high labour pressure may cause the damage to ground layer (herbs) of the vegetation by trampling and using woody species as fuel wood. Construction of the tunnels may also cause damage to rootstock of the tree species. A total of 1352 trees (882 trees in Allain site and 470 in Duhangan site) are to be affected by the project. Maximum number of individuals are of *Quercus semecarpifolia* (270), followed by *Abies pindrow* (268 individuals) and *Quercus floribunda* (232 individuals) (Table 5.2.1). These tree species are being affected by the construction of tunnels, reservoir and roads.

Table 5.2.1. Number of different tree species affected in the High Project Impact Area

S. No.	Trees species	Number	S. No.	Trees species	Number
1	*Quercus floribunda*	232	2	*Quercus semecarpifolia*	270
3	*Acer acuminatum*	88	4	*Aesculus indica*	4
5	*Juglans regia*	10	6	*Cedrus deodara*	78
7	*Prunus cornuta*	48	8	*Pinus wallichiana*	133
9	*Abies pindrow*	268	10	*Picea smithiana*	195
11	*Taxus baccata* subsp. *wallichiana*	6	12	*Betula utilis*	8
13	*Ulmus villosa*	7	14	*Salix daphnoides*	3

5.2.3. Loss of floristic diversity in Dam submergence area

A total of 58 species (Trees: 5; Shrubs: 5; Herbs: 42: Ferns: 6) were reported from the Dam Submergence Area (Table 5.2.2).

Table 5.2.2. List of plant species reported from the Dam Submergence Area

Taxa	Local name	Altitudinal Range (m)	Life Form	Status	Utilization Pattern
Abies pindrow Royle	Tosh	2200-3600	T	Co	Timber, Fuel, Minor forest products
Adiantum capillus-veneris L.		1800-3000	F	Co	-
Aesculus indica Coleb. ex Wall.	Khanor	1900-2800	T	Co	Fodder, Fuel, Medicinal, Edible
Anemone rupicola Camb.		2000-3600	H	Co	Fodder
Angelica glauca Edgew.	Chora	2100-2800	H	EN	Medicinal, Edible
Arctium lappa L.	Nakli kunth	2500-3500	H	Oc	Medicinal
Arisaema intermedium Bl.	Kida alu	2000-25000	H	Co	
A. jacquemontii Bl.	Kida alu	2500-4000	H	Co	Medicinal
Anemone rupicola Camb.		2000-3600	H	Co	Fodder
Anaphalis busua (Buch. – Ham. ex D. Don) DC.	Bacha	2000-3500	H	Co	Fibre
A. triplinervis (Sims.) Cl. var. *intermedia* (DC.) Airy Shaw	Bacha	2400-3500	H	Co	Fumitory
Bistorta amplexicaulis (D.Don) Greene	Dori ghass	2000-2800	H	Co	Medicinal, Fodder
Boehmeria platyphylla Jacq.		1800-2500	Sh	Co	-
Caltha palustris L.	Shomalap	2500-2800	H	Co	Medicinal
Calanthe tricarinata Lindl.		2000-3000	H	Co	-
Campanula colorata		2200-3500	H	Co	Medicinal

Wall.					
Carex foliosa D. Don		1800-3000	H	Oc	Fodder
Corydalis diphylla Wall.		2500-3000	H	Co	-
Cirsium wallichii DC.	Bhoosh	1900-2500	H	Co	-
Clematis buchananiana DC.	Belwala safed	1800-3000	Sh		Medicinal
Epilobium latifolium L.		2800-3500	H	Oc	-
Fragaria nubicola L.	Bumbra	2000-3000	H	Co	Edible
Galium asperifolium Wall.		2000-3000	H	Co	
Geranium wallichianum D.Don ex Sw.	Chowarhi	2000-3500	H	Co	Medicinal, Fodder
Hackelia uncinata (Benth.) Fisher		2000-3500	H	Co	-
Heracleum candicans Wall. ex DC.	Padiyala	2000-4000	H	R	Medicinal, Edible
Impatiens arguta Hk. f.	Tilpara	2000-3000	H	Oc	Edible, Fodder
Indigofera heterantha Wall.		1800-2800	Sh	Co	Fodder, Fuel, Medicinal
Lepisorus nudus (Hk.) Ching		1900-2900	F	Co	
Malva verticillata L.	Siddu	1800-2600	H	Co	Medicinal, Edible
Nepeta leavigata (D.Don) Hand.-Mazz.		2500-4000	H	Co	-
Onychium contiguum Wall. ex Hope		1900-2500	F	Co	-
Origanum vulgare L.	Ban tulsi	1800-2800	H	Co	Medicinal
Osmunda claytoniana L.		1900-2500	F	Co	-
Oxalis corymbosa DC.	Malori	1900-2500	H	Co	Fodder
Persicaria capitata Gross	Kalovar	1800-2500	H	Co	Medicinal
P. nepalensis (Meisn.) Gross	Trod	2000-3500	H	Co	Medicinal, Edible
Pilea scripta (Buch.-Ham. ex D.Don) Wedd.		1900-2200	H	Co	Fodder
Plantago ovata Phil.		1800-2800	H	Co	Medicinal
Podophyllum hexandrum Royle	Ban kakri	1800-4000	H	EN	Medicinal
Polygonatum verticillatum (L.) All.	Salam misri	1900-3500	H	VU	Medicinal, Edible
Polysticum.prescottianum (Wall. ex Mett.) T.Moore		2200-2800	F	Co	-
Prunus cornuta (Wall.ex Royle) Steud.	Jammun	1800-2600	T	Co	Edible, Fuel, Medicinal
Pteris cretica L.	Baran	2200-2500	F	Co	Medicinal
Quercus semecarpifolia	Kharshu	2600-2700	T	Co	Fuel, Fodder, Agri.

J.E.Sm.					Tool
Rumex hastatus D.Don	Malora	1800-2500	H	Co	Medicinal, Edible
Salix denticulata (Anders.) Svensk	Belli	2000-2600	Sh	Co	Fuel, Fodder
S. daphnoides L.		1900-2800	Sh	Co	Fuel, Fodder
Sedum ewersii Ledeb.	Moshu ghas	2500-4000	H	Co	Medicinal
Spiraea canescens D.Don	Chakhu	1800-2500	Sh	Co	Agri. Tools , Fuel
Selinum. tenuifolium Wall.	Bhae	2000-4000	H	Co	Medicinal
S. vaginatum Cl.	Butkesh	2500-4000	H	Co	Medicinal
Sibbaldia cuneata Hornemm ex O. Ktze.		2000-2500	H		Fodder
Skimmia laureola Sieb. & Zucc. ex Walp.		2000-3000	Sh	Co	Medicinal, Religious
Stellaria monosperma Buch.-Ham.		2000-3500	H	Co	-
Taraxacum officinale Weber		1900-4000	H	Co	Medicinal
Taxus baccata subsp. *wallichiana* (Zucc.) Pilger	Rakhal	2500-3500	T	EN	Medicinal, Fuel
Thalictrum foliolosum DC.	Mamiri	1800-3300	H	Oc	Medicinal, Fodder
Trifolium pratense L.		1900-2500	H	Co	Fodder
Viburnum cotonifolium D.Don	Thallana	2000-2600	Sh	Co	Edible, Fuel Fodder, Medicinal,
Viola biflora L.		2400-2600	H	R	Medicinal

Abbreviations used: T= Tree; Sh= Shrub; H= Herbs; F= Fern; Co= Common; Oc= Occasional; R= Rare; EN= Endangered; and VU= Vulnerable

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Appendix: Diversity and Distribution Pattern of the Vascular Plants of Hamta and Jagatsukh Catchments

Taxa	Local name	Locality	Altitudinal Range (m)	Life Form	Status
Ranunculaceae					
Aconitum heterophyllum Wall.ex Royle	Patish	I,J,L,M	3000-4200	H	CR
A. violaceum Jacq. ex Stapf	Atish	I,J,L,M	3500-4000	H	VU
Actaea spicata L.	Mamira	A, F	1900-3600	H	Co
Anemone tetrasepala Royle		I,J,L,M, O	2100-3600	H	Co
A. obtusiloba D.Don	Mamiri	A, F, M	2000-4000	H	Co
A. rivularis Buch.-Ham.	Jakri	A, D, F, O	2000-3600	H	Co
A.rupicola Camb.		E, G, K	2000-3600	H	Co
A. vitifolia Buch.-Ham. ex DC.	Carbini-Mimiri	A, D, F	1950-3000	H	Co
Aquilegia pubiflora Wall. ex Royle		A,B,F,H	2000-2600	H	Co
Caltha palustris L.	Shomalap	A,B,F,H, O	2500-2800	H	Co
Clematis barbellata Edgew.	Chabru	A,B,F,H,O	1800-2800	Sh	Co
C. buchananiana DC.	Belwala safed	B, C,	1800-3000	Sh	Oc
C.connata DC.	Safeda	A,B,F,H	2000-2700	Sh	Co
C. grata Wall.		B, D, F, L	1900-2500	Sh	Co
C. graveolens Lindl.		F, D, C	2000-3000	Sh	Co
Delphinium denudatum Royle	Laskar	A,B,F,H	2000-2600	H	R
Ranunculus diffusus DC.		A,B,D, F,H	1800-2000	H	Oc
R. hirtellus Royle	Goodi seripetali	A,B,F,H	1800-2500	H	Oc
R. laetus Wall. ex D.Don		F, H, K, L, M	2500-4000	H	Co
Thalictrum foliolosum DC.	Mamiri	A,B,F,H, O	1800-3300	H	Oc
T. reniforme Wall.	Mamiri	A,B,F,H,O	2000-3500	H	Co
T. alpinum L.		I, J, M	2800-3800	H	Oc
T. pauciflorum Royle		F, H, K, L	2000-3500	H	Co
T. secundum Edgew.	Mamiri	A,B,F,H	2000-2600	H	R

Berberidaceae					
Berberis chitria Lindl.	Masholi	B,F,H	2000-3000	Sh	Co
B. jaeschkeana Schneid.	Kashambal	E,D,G	2000-2600	Sh	Co
B. lycium Royle	Kashamal	A,B,D, F,H	1800-2700	Sh	Co
Fumariaceae					
Corydalis cashmeriana Royle	Bhutkeshi	A,B,F,H, L, M, N	2800-3000	H	Co
C. govaniana Wall.	Bhutkashi	A,B,F,H	3000-4000	H	Co
C.diphylla Wall.		I, J, M	2500-3000	H	Co
Brassicaceae					
Arabis thaliana L.		A, B, D, G, H	1800-3000	H	Co
A. tenuirostris O.E.Schulz		E, I, M	2500-3500	H	Co
A. pterosperma Edgew.		I, J, M	3000-4000	H	Oc
Capsella bursa-pastoris Medic.		A,B,G, F	1900-2800	H	Co
Cardamine impatiens L.		B, D	1900-2600	H	Co
C. macrophylla Willd.		E, G, K	2200-3200	H	Co
Erysimum hieraciifolium L.		D, E, G	2000-2800	H	Co
Lepidium apetalum Willd.		C, F, K, L	2000-3000	H	Co
L. pinnatifidum L.		A, C, F, G, N	2000-2500	H	Co
Nasturtium officinale R.Br.		A, B, D, H, F,L,	1900-3000	H	Co
Rorippa indica (L.) Hiern	Petu	A, B, D, H, F	1900-2500	H	Co
Sisymbrium officinale (L.) Scop.		A, B, D, H, F	1800-2300	H	R
S. wallichii Hk. f. & Th.		C, E, F, G	2000-2700	H	Oc
Thlaspi arvense L.		A, B, D, H, F	2000-2600	H	Co
T. andersonii (Hk. f. & Th.) O.E. Schulz		A, G, H	3000-4000	H	Co
T. cochleariforme DC.		B, C, E, M	2000-3000	H	Oc
Turritis glabra L.		A, G, F	1800-2500	H	Oc
Violaceae					
Viola biflora L.	Banafsha	A, B, D, H, F, O	2400-2600	H	R
V.canescens Wall. ex Roxb.	Banafsha	A, B, D, H, F, O	1800-2400	H	Co
V. odorata L.	Banafsha	I, J, M	3000-4000	H	Oc

V.serpens Wall. ex Roxb.	Banafsha	A, B, D, H, F	1800-2600	H	Co
Polygalaceae					
Polygala abyssinica R.Br. ex Fresen		B, C D	1800-2500	H	Co
P.sibirica L.		D, E, I, M,	2000-2500	H	Oc
Caryophyllaceae					
Arenaria festucoides Benth.		B, C, D, E	3000-4000	H	Co
A. neelgherrensis Wt. ex Arn.		C, D, E	2200-2500	H	Oc
A.serpyllifolia L.		C, D, E	2000-2500	H	Co
Gypsophila cerastioides D.Don		A, B, H, F	2000-2800	H	Oc
Cerastium fontanum subsp. *membranaceum* Baung.		A, B, H, F	2000-3000	H	Co
C. fontanum Baumg.		A, F, O	1900-2000	H	Co
C. cerastioides (L.) Britt.		A, B, C, F, H, K, N	1800-4700	H	Oc
Lychnis indica Benth.		B, D, F, G	2200-3500	H	Oc
Minuartia kashmirica (Edgew.) Matt.		E, F, G	2000-3000	H	R
Myosoton aquaticum (L.) Moench.		D, E	1800-2500	H	Co
Silene conoidea L.		A, B, H, F	1800-2000	H	Co
S. edgeworthii Bocquept		I, J, M	2500-4000	H	Oc
S. vulgaris (Moench) Garcke		A, B, H, F	1800-3000	H	Co
Stellaria himalayensis Majumdar		A, B, H, F	2000-2800	H	Co
S.media (L.) Villars		A, B, H, F	2000-2600	H	Co
S. monosperma var. *paniculata* Buch.-Ham.		A, B, H, F	2000-3500	H	Co
S. patens D.Don		A, C, D, F, H	2000-3500	H	Co
Papaveraceae					
Meconopsis aculeata Royle		J, L, M, N	3000-3500	H	EN
Hypericaceae					
Hypericum elodeoides Chiosy	Basanti	H, E	2000-3000	H	Co
H. oblongifolium Choisy		A, E, F,	2000-3000	H	Oc
H. uralum Buch.-Ham.		H, E	1800-3000	H	Co
Tiliaceae					

Tilia cordata Mill.		A, H, D	2000-2500	T	Co
Linaceae					
Reinwardtia indica Dum.		A, H, D	1900-2500	H	Co
Geraniaceae					
Erodium cicutarium (L.) L' Herit		A, F	1800-2000	H	Co
Geranium nepalense Sw.		B, E, D,O	2000-3500	H	Co
G. pratense L.		E, H, K, M, O	2500-3800	H	Co
G. rotundifolium L.		A,B, H, E,F D	1800-2000	H	Co
G.wallichianum D.Don ex Sw.	Chowarhi	A,B, H, E,F D	2000-3500	H	Co
Oxalidaceae					
Oxalis acetosella L.	Malori	A,B, H, E,F D, O	2000-3000	H	Oc
O. corymbosa DC.	Malori	A,B, H, E,F D, O	1900-2500	H	Co
O. latifolia Kunth	Malori	A,B, H, E,F D,C, O	1900-2800	H	Co
Balsaminaceae					
Impatiens amphorata Edgew.	Tilpara	A,B, H, D, O	2000-3000	H	Co
I. arguta Hk. f.	Tilpara	A,B, H, D, O	2000-3000	H	Oc
I. bicolor Royle	Tilpara	A, B, H, D	2000-2600	H	Co
I. cristata Wall.	Tilpara	A, B, H, D	2000-2600	H	Co
I. racemosa Hk.f.	Tilpara	A,B, H, D, O	2000-2600	H	Co
I .scabrida DC.	Tilpara	A,B, H, D	2000-3500	H	Co
Plantaginaceae					
Plantago lanceolata L.		A, B, H, D, F, I, L, O	1800-2800	H	Co
P. himalaica Pilg.		A, H, F, I, L	3000-4000	H	Oc
P. ovata Phil.		A, B, C, D, E, G, L, O	1800-2800	H	Co
Podophyllacaeae					
Podophyllum hexandrum Royle	Ban kakri	A, B, H, D, F, I, L, O	1800-4000	H	EN
Rutaceae					
Boenninghausenia albiflora (Hk.f.) Reichenb.ex Meissn	Pessumar	F, G	1800-2800	H	Co

Skimmia laureola Sieb. & Zucc. ex Walp.		A, B, D, F, H	2000-3000	Sh	Co
Zanthoxylum armatum DC.		A, F	2000-2500	H	EN
Meliaceae					
Toona serrata (Royle) M. Roem.	Toon, Darn	A, F	1800-2400	T	Co
Aquifoliaceae					
Ilex dipyrena Wall.	Ghooghee	A, F, G	1800-3000	T	R
Celastraceae					
***Gymnosporia royleana* M.Laws.**		A, F, H	1800-2500	Sh	Oc
Euonymus fimbriatus Wall.		A, F, G	2000-2800	Sh	Oc
E.echinatus		F, G, H	2000-3300	Sh	Oc
Rhamnaceae					
Rhamnus purpureus Edgew.	Chaunsha	A, F, H, B	1800-2000	Sh	Co
R.virgatus Roxb.		A, B, F	1800-2000	Sh	Co
Vitaceae					
Parthenocissus semicordata (Wall.) Planch.		A, B, C, D, E	1800-2800	Sh	Co
Aceraceae					
Acer acuminatum Wall. ex D.Don	Mandru	C,D,H	2400-3200	T	Co
A. caesium Wall. ex Brandis	Mandri	C,D,H, O	2400-3200	T	R
Anacardiaceae					
Rhus wallichii Hk. f.	Rikhad	A,F,	1800-2000	T	Oc
R. javanica L.	Arkhal	A,F, C, D	1800-2500	T	Oc
Araliaceae					
Hedera nepalensis K. Koch	Gruaru	A, B, C, D, E	1800-2200	Sh	Co
Aralia cachemirica Decne		A, F, G, B	2500-4000	H	Co
Coriariaceae					
Coriaria nepalensis Wall.	Nachhar	A, B, F	1800-2200	T	Co
Fabaceae					
Astragalus chlorostachys Lindl.		I,J,K,L,M	2600-4000	H	Oc
A. himalayanus Klotz.		I, J, M, N	2500-4000	H	Oc
Campylotropis eriocarpa (DC.) Schindler		A, F	1900-2500	Sh	Co

Desmodium elegans DC.		A,F,D,G,E,C	1800-2800	Sh	Co
Caragana gerardiana Royle ex Benth.	Kathi	I, J, M, N	2000-2400	Sh	R
Indigofera gerardiana Wall. ex Brandis		A, B, C, D, E, G	2200-3500	Sh	Co
I. heterantha Wall.		A, B, C, D, E, G	1800-2800	Sh	Co
Lathyrus emodi (Wall. ex Fritsch) Ali		A, B, D, G, H, K	2000-3000	H	Oc
Lespedeza gerardiana Grah. ex Maxim.		A,H, G,O	1800-2500	H	Co
Lotus corniculatus L.		A, F	1800-2800	H	Co
Medicago lupulina L.		A, F	1800-2200	H	Co
Oxytropis cachemiriana DC.		A, F	1800-2000	H	Oc
Parochetus communis Buch.-Ham. ex D.Don		A,B, H, D	2000-2500	H	Oc
Robinia pseudoacacia L.		A, E, B	1900-2500	H	Co
Thermopsis barbata Royle		I, J, M, N	3000-4000	H	Co
Trifolium repens L.	Malori	A,B, H, D, E, O	1800-2800	H	Co
T. pratense L.		A,B, H, D, E, I, L, M, O	1900-2500	H	Co
Trigonella emodi Benth.		I, L, M,	2000-3200	H	Co
Vicia hirsuta (L.) S.F. Gray		A,B, D	2000-3000	H	Co
Vigna vexillata (L.) A.Rich.		A,B, H, D, E	2000-3000	H	Oc
Rosaceae					
Agrimonia pilosa Ledeb.		B, H, D, E, I, L	2000-3000	H	Co
Aruncus dioicus (Walter) Fernald		G, I, L	3000-3500	H	Co
Cotoneaster obtusus Wall. ex Lindl.	Riunsh	G, H, D	2000-2800	Sh	Co
C. microphyllus Wall. ex Lindl.	Kalashada	B, H, D, E, I, L	2400-3500	Sh	Co
C. acuminata Lindl.			2000-3000	Sh	co
Duchesnea indica (Andrew.) Focke		B, H, D, E,	2000-3000	H	Co
Fragaria nubicola L.	Bumbra	A,B, H, D, E, O	2000-3000	H	Co
Filipendula vestita (Wall. ex G. Don) Maxim.		A,B, H, D, E	2000-2500	H	Co
Geum elatum Wall. ex G.		I, L, K, M,	2000-3900	H	Co

Don					
G.roylei Bolle		I, M, N	2500-3500	H	Co
Potentilla argrophylla Wall. ex Lehm.	Dori	A,B, H, D, E	2500-3800	H	Co
P. atrosanguinea Lodd.	Dori	A,B, H, D, E	2800-4200	H	Co
P. supina L.	Dori	A,B, H, D, E	2000-2600	H	Co
P. peduncularis D.Don		I, E, M, L	3000-4200	H	Co
P. microphylla D.Don		M, L, I	2600-4000	H	Co
P. fruticosa L		I, J, M	3000-4000	Sh	Co
Prunus avium L.	Cherry	A,B, F	1800-2000	T	Cult
P. domestica L.	Palum	A, B, F	1800-2200	T	Cult
P. persica (L.) Batsch	Aru	A,B, F	1800-2200	T	Cult
P. armeniaca L.	Khumani, Shada	A,B, F	1800-2200	T	Co
P. cornuta (Wall.ex Royle) Steud.	Jammun	A,B, E, D	1800-2600	T	Co
Prinsepia utilis Royle	Bhekhal	A,B, H, D, E	1800-2900	Sh	Co
Pyrus malus Royle	Seb	A, B	1800-2400	T	Cult
P. communis L.	Nashpati	A,B, F	1800-2400	T	Cult
P. pashia Buch.-Ham.ex D.Don	Shegal	A,B, F	1800-2600	T	Co
Rosa brunonii Lindl.	Kuja	A,B, H, D, E	1800-2500	Sh	Co
R. macrophylla Lindl.	Kuja	A,B, H, D, E, O	2100-3200	Sh	Co
R. sericea Lindl.		I, J ,L, N	2500-3500	Sh	Co
Rubus biflorus Buch.-Ham. ex Sm.	Aakha	A,B, H, D, E	2000-2700	Sh	Co
R. lasiocarpus Sm.	Aanchha, Aakha	A,B, H, D, E	1800-2500	Sh	Co
R. ellipticus Sm.	Kala Aanchha	A,B, H, D, E	1800-2500	Sh	Co
R. paniculatus Sm.	Lal Aachha, Aakha	A,B, H, D, E, F	1800-2500	Sh	Oc
R. nivues Thunb.	Aachha, Aakha	A,B, H, D, E, F	2000-3500	Sh	Co
Sibbaldia cuneata Hornemm ex O. Ktze.		A,B, H, D, E	2000-2500	H	Co
Sorbaria tomentosa (Lindl.) Rehder		A,B, H, D, E	1800-2900	Sh	Co

Sorbus foliolosa (Wall.) Spach		A,B,F	2000-2500	T	Co
Spiraea bella Sims.	Chakhu	A,B, F	2500-3500	Sh	Oc
S.canescens D.Don	Chakhu	A,B,C,,F	1800-2500	Sh	Co
Saxifragaceae					
Astilbe rivularis Buch.-Ham. ex D.Don		A, F	2400-4000	H	Co
Bergenia ciliata (Haw.) Sternb.	Pashan ved	A, B, H, D, E	2000-3000	H	Co
B. stracheyi (Hk. f. & Th.) Engl.	Pashan ved	B, D, H, I, L, M	2800-4000	H	EN
Saxifraga brunonis Wall. ex Seringe		B, D, H, I	2500-3500	H	Co
S. diversifolia Wall. ex Seringe		E, I, J, N, M	2500-4000	H	Co
Parnassiaceae					
Parnassia nubicola Hk. f.		D, H, I, J	3000-4000	H	Co
Philadelphiaceae					
Deutzia staminea R.Br. ex Wall.	Chruru	A, B, H, D, E	2500-3500	Sh	Co
D. corymbosa (Schneid) Airy-Shaw	Churu	A, F, H	2400-2700	Sh	Co
Grossulariaceae					
Ribes glaciale Decne	Chalendhar	A, H, D, E	2400-2700	Sh	Oc
R. emodense Rehd.	Chalendhar	A, H, D, E	2400-2700	Sh	Oc
Crassulaceae					
Crassula indica Decne		I, M, N, F, A, O	2500-3200	H	Co
Sedum adenotricum Wall. ex Edgew.	Moshu ghas	A, F, H	2000-3000	H	Oc
S. ewersii Ledeb.	Moshu ghas	D,E, H	2500-4000	H	Co
S. multicaule Wall. ex Lindl.		A, H, D, E	2500-3500	H	Co
S. rosulatum Edgew.		A, H, D, E	2000-3000	H	Co
Tillaea pentandra Royle ex Edgew.		A, F, H	1800-2500	H	Co
Rosularia rosulata (Edgew.) H. Ohba	Moshu ghas	A, F, H	1800-2600	H	Co
Onagraceae					
Circaea alpina L.		I, J, N, M	3000-4000	H	Oc

Epilobium cylindricum D.Don		A, F, G, H	1900-2500	H	Co
E. laxum Royle		C, D, F,	2000-3000	H	Co
E. royleanum Haussk.		A, F, G, H	2000-2500	H	Co
E. latifolium L.		A, F, J, K, M	2800-3500	H	Oc
E. hirsutum L.		I, K, M, N	2000-3000	H	Co
Oenothera rosea L`Her.ex Ait.		A, F,G, H	1900-2200	H	Co
Cucurbitaceae					
Melothria heterophylla (Lour.) Cogn.	Balakakri	A, B, F, H	2000-2500	H	Co
Begoniaceae					
Begonia picta Sm.	Khatnaru	A,B, F, H	1800-2500	H	Co
Apiaceae					
Angelica glauca Edgew.	Chora	A, B, F, O	2100-2800	H	EN
Bupleurum falcatum L.	Nimla	A, B, F	2000-4000	H	Co
B. atroviolaceum (Schulz) Nasir in Nasir & Ali		I, L, N, M, J	2500-3500	H	Oc
B. lanceolatum Wall. ex DC.	Nimla	A, B, F	2000-2600	H	Co
B. aitchisonii (Boiss.) Wolff		A, B, D, F, L, J	2500-3500	H	R
B. candollii Wall.ex DC.		E, G, H, J, M	2400-3600	H	Oc
Chaerophyllum reflexum Lindl.	Bhae	A, F, C, H	2500-3000	H	Co
C. villosum Wall. ex DC.	Bahe	I, E, K, L, M	2500-3500	H	R
Pleurospermum candollii (DC.) Cl.		J, M, N	3500-4000	H	Oc
P. densiflorum Hk.f.	Losar	H,J, M, N	3000-4000	H	Oc
P.angelicoides (DC.) Cl.		I, J, M, N	3000-4000	H	Oc
Cortia depressa (Don) Norm.		I, J, L, M, N	3200-4000	H	R
Heracleum candicans Wall. ex DC.	Padiyala	A,B, F, O	2000-4000	H	R
Pimpinella acuminata (Edgew.) Cl.		A, B, G, H	2000-3000	H	Oc
P. cuspudata (Edgew.) Cl.		A, C, E, F, G	2000-3000	H	Co
P. diversifolia DC.		A, C, E, F, G	2100-3000	H	Co

Sanicula alata Buch.-Ham. ex D. Don		A,B, F	2400-2600	H	Co
Selinum candolii DC.	Matoshal	A,B, F,O	2000-4000	H	Oc
S. tenuifolium Wall.	Bhae	A,B, F	2000-4000	H	Co
S. vaginatum Cl.	Butkesh	F, H, G, I, L, M, N,O	2500-4000	H	Co
Cornaceae					
Cornus capitata Wall.	Kirchhan	A, F, H	2000-2500	T	Oc
C. macrophylla Wall.	Kirchhan	A, F, H	2000-2500	T	Co
Caprifoliaceae					
Leycesteria formosa Wall.		A, F	2000-2800	Sh	Oc
Lonicera angustifolia Wall. ex DC.	Plaas	A, B, F, H, G	1900-3000	Sh	Co
L. obovata Royle ex Hk. f. & Th.		A, B, C, H, F, L, N	3000-4000	Sh	Co
L. purpurascens (Decne) Walp.	Changari	A, F, E, L	2400-3000	Sh	Co
L. quinquelocularis Hardw.		A, C, F	1900-2500	Sh	Oc
Viburnum cotinifolium D.Don	Thallana	A, B, C, F	2000-2600	Sh	Co
V. mullaha Buch.-Ham. ex D. Don	Thallana	A, B,F, H,G	2000-2500	Sh	R
V.grandiflorum Wall. ex DC.	Thallana	A, F, H,G,K, O	2600-3600	Sh	Co
Rubiaceae					
Galium acutum L.		A, B,F, H,G	2000-3000	H	Oc
G. aparine L.		A, B, F, H, G	2000-2500	H	Co
G.asperifolia Wall.		A, B,F, H,G, E	2000-3000	H	Co
G. rotundifolium L.		A, B, C, D, F	1800-2400	H	Co
Leptodermis lanceolata Wall.		E, G, H,D	2800-3000	Sh	Co
Rubia cordifolia L.		A, B,C,F, H,G	1800-2600	H	Co
Valerianaceae					
Valeriana hardwickii Wall.	Nihanu	A, B,F, H,G	2000-3000	H	Oc
V. jatamansi Jones	Nihanu	A, B,F, H,G	2000-3000	H	VU
Dipsacaceae					
Dipsacus inermis Wall.		A, B, F	2500-3500	H	Oc

Morinaceae					
Morina longifolia Wall. ex DC.		I, M, N, K,O	2500-4000	H	Co
Asteraceae					
Achillea millefolium L.		I, M, K	2500-3800	H	Co
Adenocaulon himalaicum Edgew.		A, C, G, K	2000-3000	H	Oc
Ainsliaea aptera DC.	Sath-jalari		2000-3000	H	Oc
A. latifolia D. Don		A, B,F, H,G	2000-3000	H	Co
Anaphalis busua (Buch. – Ham. ex D. Don) DC.	Bacha	A, B,F, H,G, O	2000-3500	H	Co
A. contorta (D. Don) Hk.	Bacha	A, B, F, H, G, O	2000-3500	H	Co
A. triplinervis (Sims.) Cl. var. *intermedia* (DC.) Airy Shaw	Bacha	B, C, G, I, J, M,	2400-3500	H	Oc
A. royleana DC.		B, C, D, E, I, J	1800-3500	H	Co
A. nepalensis (Sperng.) Hand.-Mazz.		A, I, J, L, M	2800-4000	H	Oc
Arctium lappa L.	Nakli kunth	D, C, F	2500-3500	H	Oc
Artemisia roxburghiana Bess.	Jonkhar	C, E, D,O	2200-3500	H	Oc
A. parviflora Roxb.	Jhau	A, B, F, H,G	1800-2800	H	Co
A. vestita Wall. ex DC.		A, C, F, G,O	2200-3200	H	Co
Aster himalaicus Cl.		A, H, G	2400-4000	H	Co
A. peduncularis Wall. ex Nees		B, F, G, H, L	2000-3000	H	
Bidens bipinnata L.		A, B,F, H, G	1900-2500	H	Co
Carpesium peduculosum Wall. ex DC.		L, M, H	2000-3000	H	Oc
Carduus edelbergii Rech.f.		A, E, F, I, M, N	1800-4000	H	Co
Cicerbita macrorhiza (Royle) Beauv.		A, F	2000-4000	H	Oc
Cirsium wallichii DC.	Bhoosh	A, F, H	1900-2500	H	Co
Conyza stricta Willd.		A, F, H	2000-2500	H	Co
Cremanthodium arnicoides DC. ex Royle		I, M, K	3000-4000	H	Co
Erigeron bellidioides Benth.		A, F, H,	2000-2500	H	Co
E. bonariensis L.		A, F, H,	1900-2100	H	Co

E. canadensis L.		A, F, E, I, M	2500-3500	H	Co
E. multiradiatus Benth.		B, D, G, E	2000-2800	H	Co
Galinsoga parviflora Cav.		B, D, G, E	2000-3000	H	Co
Gerbera gossypina (Royle) Beauv.		B, D, G, E	2000-2400	H	Co
Gnaphalium affine D. Don		B, D, G, E	1900-2500	H	Co
G. hypoleucum DC.		B, D, G, E	1900-2500	H	Co
Inula cappa DC.		B, D, G, E	1800-2000	H	Co
I. cuspidata (DC.) Cl.		A,B, D, G, E	1800-2000	H	Co
I. grandiflora Willd.		B, D, G, E	2000-3300	H	Co
Jurinella macrocephala (Benth. ex Hk. f.) Aswal & Malhotra	Dhoop	L, K, M, N	3000-4000	H	Co
Lactuca dissecta D. Don		B, D, G, E	1900-2500	H	Co
L. lassertiana (DC.) Cl.		A, F, I, M, L	2800-3800	H	Oc
L. macrorhiza (Royle) Hk.		B, D, G, E	2000-2500	H	Co
Launaea obtusus (DC.) Mundhe & Almeida		A, B, F	1900-2200	H	Co
L. secunda (Cl.) Hk.		A, B, F	1900-2600	H	Co
Leontopodium himalayanum DC.		L, K, M, N, J	3000-4000	H	Co
Ligularia amplexicaulis DC.		L, I, M, K	3000-4000	H	Co
L. fischeri (Ledeb.) Turcz.		I, K, N, L, J	3000-4000	H	Co
Myriactis nepalensis Less.		A, B, F	2000-2500	H	Co
Rhynchospermum verticillatum Reinw.		A, F	1800-2500	H	Oc
Prenanthes brunoniana Wall. ex DC.		L, K, M, N, J	2500-3500	H	Co
Saussurea costus (Falk.) Lipsch.	Kuth	D	2500-3500	H	Cult
S. heteromella (D.Don) Hand.-Mazz.	Kuth	A, B, F	1900-3000	H	Co
S. obvallata (DC.) Edgew.	Brahm camal	I, M, K	3500-4000	H	CR
S. hypoleuca Spreng. ex DC.		I, L, H, K, M	3000-3500	H	Oc
S. piptathera Edgew.		I, J, K, L, M	3000-4000	H	Oc
Siegesbeckia orientalis L.		A, B, F	2000-2500	H	Co
Sonchus oleraceus L.		A, B, F	2000-2500	H	Co

Senecio chrysanthemoides DC.		J, I, M, N	2500-3500	H	Co
S. graciliflorus DC.		I, M, K	2500-4000	H	Co
S. rufinervis DC.		I, M, K	2500-3500	H	Co
Solidago virga-aurea L.		A, B, F	2500-3500	H	Co
Tanacetum dolichophyllum Kitam.		B, D, ,N, I, M, K	3000-4000	H	Co
Taraxacum officinale Weber		A, B,C,D, F, O	1900-4000	H	Co
Youngia japonica (L.) DC.		A, B, F	1900-2500	H	Co
Campanulaceae					
Campanula colorata Wall.		A, B, F,O	2200-3500	H	Co
Codonopsis rotundifolia Benth.		N, I	3000-4000	H	R
C. viridis (DC.) Roxb.		I,M	2500-3300	H	R
Cyananthus lobatus Wall.		L, N, I, G, J	3000-4000	H	Co
Ericaceae					
Cassiope fastigiata Wall.		J, K,	3200-4000	Sh	Oc
Gaultheria trichophylla Royle		B,C,D	2000-3500	Sh	Co
Lyonia ovalifolia (Wall.) Drude	Ayar	A, B, F	1800-2800	T	Co
Rhododendron arboreum Sm.	Brass	G	2500-2700	T	R
R. campanulatum D.Don	Shargal	L, I, J, K, M,	3000-4000	Sh	VU
R. anthopogon D.Don&		J, K, N	3000-4000	Sh	VU
R. lepidotum Wall.	Shargal	J, M, N	2500-3500	Sh	Co
Primulaceae					
Anagallis arvensis L.		A, C, F	1900-2100	H	Oc
Androsace rotundifolia Hardw.		A, C, F	2000-2600	H	Oc
A. sarmentosa Wall.		A, C, F	2000-2700	H	Co
Primula denticulata Sm.	Jaibeez	C, L, I, K, M,	2500-4000	H	Co
P. involucrata Wall. ex Duby		J, K, N, M	3000-4000	H	Co
P. rosea Royle		L, I, K, M	2500-4000	H	Co
Rammannia drummondii H.		A, C, F	1800-2500	H	Co
Myrsinaceae					
Myrsine africana L.		A, F,	2000-2500	Sh	Oc

Asclepiadaceae					
Vincetoxicum hirudinaria Medik.		A, H	2000-2600	H	Co
Marsdenia roylei With.		A, F, C, D,	1800-2200	Sh	Oc
Buxaceae					
Sarcococca saligna (D.Don) Muell.	Chirbeeri	C, D, E	2100-3600	Sh	Oc
Cannabaceae					
Cannabis sativa L.	Bhang	C, D, F, A	1900-2500	H	Co
Gentianaceae					
Gentiana argentea Royle ex D.Don		A, B, C, D, F	1900-3500	H	Co
G. kurrooa Royle		K, M, N	2400-4000	H	CR
G. pedicellata (D.Don) Griseb.		I, K, M, N	3000-3800	H	Co
G. venusta (D.Don) Griseb.		I, K, M, N	3000-4000	H	Co
G. carinata (D.Don) Griseb.		A, D, C, G, I, K, M, N	2000-4000	H	Co
Gentianella tenella (Rottb.) Borner		I, K, M, N	3000-4000	H	Co
Jaeschkea oligosperma (Griseb.) Knobl.		J, M	2900-4200	H	Co
Swertia angustifolia Ham. ex D.Don	Chirayata	I, K, M, N	2000-4000	H	Oc
S. alternifolia Royle		A, F, C, L	2500-3500	H	Oc
S. paniculata Wall.	Chirayata	A, F	2000-3500	H	Co
Polemoniaceae					
Polemonium caeruleum var. *himalaicum* Bak.		J, N	3000-3700	H	R
Boraginaceae					
Arnebia benthamii (Wall. *ex G.*Don) Johnst.	Rattan jot	I, K, M, N	3300-4000	H	CR
Cynoglossum lanceolatum Farssk.		A, F	2000-2600	H	Co
C. zeylanicum Vahl ex Harnem		A, F	1900-2500	H	R
C. glochidiatum Wall. ex Benth.		A, F	2200-3800	H	Co
Hackelia uncinata (Benth.) Fisher		A, F	2000-3500	H	Co
Lindelofia longiflora (Benth.) Baill.		J, M, N	3000-4200	H	R

Hippocastanaceae					
Aesculus indica Coleb. ex Wall.	Khanor	A, B, H, D, C	1900-2800	T	Co
Convolvulaceae					
Convolvulus arvensis L.		A, F	1900-2400	H	Co
Ipomoea purpurea L.		A, F, B,	1800-2300	H	Co
Cuscutaceae					
Cuscuta reflexa Roxb.	Amar bel	A, C, F	1800-2400	H	Co
Solanaceae					
Datura stramonium L.	Datura	A, F	1800-2000	H	Oc
Nicotiana tabacum L.	Tambakhu	A,C, F	1900-2700	H	Co
Physalis minima L.		A,, F	1800-2000	H	Co
Physochlaina praealta (Decne) Miess.	Bajar bang	A,C, F	2000-3000	H	Oc
Solanum pseudocapsicum L.		A,C, F	1800-2000	Sh	Co
S. nigrum L.	Makoi	A,C, F	1900-2500	H	Co
Scrophulariaceae					
Euphrasia himalaica Wettst.		M, N	3200-4200	H	Oc
Lindenbergia indica (L.) Vatke		A, B, C	1800-2000	H	Co
L. macrostachya Benth.		B, C, D	1800-2000	H	Co
Lindernia anagallis (Burm.f.) Penn.		A, C, D	1800-1800	H	Oc
Mazus pumilus (Burm.f.) Steen.		A, C,	1900-2500	H	Oc
M. surculosus D.Don		A, F	1800-2000	H	Co
Pedicularis albida Penn.		L, M, N, I,	3000-4000	H	Co
P. bicornuta Klotz.		L, M, N, I, O	3000-4000	H	Co
P. gracilis Wall. ex Benth.		A, F	1900-2100	H	Co
P. hoffmeisteri Klotz		L, M, N, I,O	2500-4000	H	Co
P. mollis Wall. ex Benth.		L, M, N, I,	2500-4000	H	Co
P. pectinata Wall. ex Benth.		L, M, N, I,	2500-3500	H	Co
P. punctata Decne		L, M, N, I,	3000-4000	H	Co
Picrorhiza kurrooa Royle	Karroo	L, M, N, I,	3000-4200	H	EN
Scrophularia decomposita Royle		I, J, M, K, N	2500-3500	H	Oc
S. himalensis Royle		A, F	2000-2700	H	Co

Verbascum thapsus L.	Ban tambaku	A, F	1900-2500	H	Co
Veronica biloba L.		A, F	2000-2700	H	Co
Wulfenia amherstiana Wall.		A, F	1800-2700	H	Co
Acanthaceae					
Barlaria cristata L.		A, F	1800-2000	H	Co
Dicliptera roxburghiana Nees		A, F	1800-2300	H	Co
Goldfussia dalhousiana Nees		A, F	1800-2000	H	Co
Pteracanthus alatus Wall. ex Nees	Kunda	A, F	2000-2800	H	Co
Strobilanthus atropurpureus Nees	Dhuda	A,B,D, F, H	2000-2800	H	Co
S. wallichii Nees	Dhuda	A,B,D, F, H	2000-2800	H	Oc
Verbenaceae					
Caryopteris bicolor (Hardw.) Mabbarley		A, F	1800-2000	Sh	Oc
Smilacaceae					
Smilax aspera L.		A,B,D, F, H	1800-2500	Sh	Co
S. vaginata Decne		A, B, C,D, F, H	2000-2800	Sh	Co
Lamiaceae					
Ajuga parviflora Benth.	Neel kanthi	A,B,D, F, H	1800-2000	H	Co
A. bracteosa Wall. ex Benth.	Neel kanthi	A,B,D, F, H	1800-2000	H	Oc
Craniotome furcata Kuntze		F, G, H	1900-2600	H	Co
Clinopodium umbrosum Koch		A, F	1800-3000	H	Co
Elsholtzia ciliata (Thunb.) Hyland.	Foran	A, C, F, H	1800-3400	H	Co
E. fruticosa (D.Don) Rehder	Foran	A, C, D, F, H	2000-2700	Sh	Co
E.flava Benth.		A, F , D, H, J, L	1800-2400	Sh	Oc
Lamium amplexicaule L.		F, H	1800-2500	H	Co
Leucas lanata Benth.		A, B, C	1800-4500	H	Co
Mentha longifolia (L.) Hudson	Jungli pudina	A, B, C	1800-2400	H	Co
Micromeria biflora Benth.		A, B, C, L, J	2000-4000	H	Co
Nepeta leucophylla Benth.		A, C, D, F, H	1800-2500	H	Co

N. leavigata (D.Don) Hand.-Mazz.		H, K, I, M, O	2500-4000	H	Co
N. hindostana (Roth) Haines		A, F	1800-2200	H	Co
N. campestris Benth.		A, C, D, F, H, O	2500-3500	H	Oc
N. erecta Royle ex Benth.		A, C, D, F, H	2500-4000	H	Oc
Origanum vulgare L.	Ban tulsi	A, C, D, F, H, O	1800-2800	H	Co
Phlomis bracteosa Royle		L, K, M, I, N	2000-4000	H	Co
Plectranthus japonicus Koidz.	Chchri	C, D, E	1800-3300	H	Co
P. rugosus Wall.	Shian	A, B, C, D	1800-2500	Sh	Co
Prunella vulgaris L.		B, C, D, E	1900-2800	H	Co
Salvia lanata Roxb.	Gawandru	A, C, D, F, H	1900-2500	H	R
S. moorcroftiana Wall.		A, C, H, F, E, O	1900-2500	H	Co
Stachys sericea Wall.		L, K, M, I, N	2000-3000	H	Oc
Thymus linearis Benth.	Ban ajwain	A, C, D, F, H	2000-3000	H	Co
Teucrium royleanum Wall. ex Benth.		A, C, F, H	1800-2000	H	Co
Amaranthaceae					
Amaranthus hybridus L.		A, C, F, H	1900-2500	H	Co
A.paniculatus L.		A, F,	1800-2000	H	
Cyathula capitata Moq.		A, C, D, F, H, O	1800-2800	Sh	Co
C. tomentosa Roth		A, C, D, F, H	1800-2500	Sh	Co
Chenopodiaceae					
Chenopodium album L.	Bathua	A, F	1800-2000	H	Co
C. botrys L.		A, F	1800-2200	H	Co
Achyranthaceae					
Achyranthes bidentata Bl.		A, F,D, H	1900-2500	H	Co
A.aspera L.		A, F	1800-2000	H	Co
Phytolaccaceae					
Phytolacca acinosa Roxb.	Jharka	A, B, H, D, E, O	2000-3000	H	Oc
Polygonaceae					
Bistorta amplexicaulis (D.Don) Greene	Dori ghass	A, C, D, F,O	2000-2800	H	Co

B. affinis (D.Don) Greene	Roti muhin	J, L, K, M, N,	3000-4000	H	Co
B. vaccinifolia (Wall. ex Meissn.) Greene		J, L, K, M, N	3000-4000	Sh	Co
Fagopyrum debotrys (D.Don) Hara	Paphra	A, C, D, F	1800-2800	H	Co
F. esculentum Moench	Ghangri	C, D	2000-3000	H	Cult
F. tataricum (L.) Graertn.	Bhesa	C, D	1900-3000	H	Cult
Oxyria digyna (L.) Hill		A, F, G	2500-4000	H	Co
Persicaria nepalensis (Meisn.) Gross	Trod	A, F, G, O	2000-3500	H	Co
P. capitata Gross	Kalovar	A, F, G	1800-2500	H	Co
P. polystachya Gross	Kalovar	A, F, G	2000-3000	H	Co
P. recumbens Royle	Kalovar	A, C, D, F, H	2000-3300	H	Co
Polygonum plebeium R.Br.		A, F, G, H	1800-2400	H	Co
P. hydropiper L. subsp. *microcarpum* Danger		A, F	1800-2000	H	Co
Rheum australe D.Don	Chuchi	J, M, N	3000-4200	H	VU
R. webbianum Royle	Chuchi	I, K, L, M, N	3000-4200	H	VU
Rumex acetosa L.	Jungli palak	A, C, D, F, H	2000-3500	H	Co
R. nepalensis Spreng.	Malora	A, C, D, F, H, O	1800-3500	H	Co
R.hastatus D.Don	Malora	A, C, D, F, H, O	1800-2500	H	Co
Thymelaeaceae					
Daphne papyracea Wall. ex Steud.		A, F	1800-2500	Sh	Co
Wikstroemia canescens Meissn.		A, C, D, F, H	2000-2700	Sh	Co
Elaeagnaceae					
Elaeagnus conferta Wall. ex Royle	Ghiayeen	A, F,	1800-2600	Sh	Co
Hippophae salicifolia D. Don		B	2400-2900	Sh	NT
Loranthaceae					
Viscum album L.	Rinni	A, F, C	1800-3000	Sh	Co
Euphorbiaceae					
Euphorbia hirta L.		A, F,	1800-2000	H	Co
E. stracheyi Boiss.		L, K, M, I	2500-3500	H	Co
E. pilosa L.		L, K, M, I	2000-3300	H	Co

Urticaceae					
Boehmeria platyphylla Jacq.		A, B, G, F, O	1800-2500	Sh	Co
Debregeasia longifolia (Forssk) Heppetr. & Wood	Sariyahu	A, F	1800-1900	Sh	Co
Lecanthus peduncularis (Royle) Wedd.		A, F	1800-3000	H	Co
Parietaria micrantha Ledeb.		A, F	1900-2500	H	Co
Pilea scripta (Buch.-Ham. ex D.Don) Wedd.		A, F	1900-2200	H	Co
P.umbrosa Bl.		A,F C, G, O	2000-3000	H	Co
Pouzolzia zeylanica L.		A, F	1800-2500	H	Co
Urtica dioica L.	Aan	A, F, D, C,O	1800-2800	H	Co
U. mairei Lev.		A, F, G	2500-3500	H	Oc
U. hyperborea Jacq. ex Wedd.		A, F, G, D	3000-4200	H	Co
Girardinia diversifolia (Link) Friis	Jharan	A, F, D, C, O	1800-3000	H	Co
Ulmaceae					
Ulmus wallichiana Planch.	Mahun	A, F	1800-2000	T	Oc
U. villosa Brandis ex Gamble	Chor	C, D, F	2200-2800	T	Oc
Celtis australis L.	Kharik	A, F	1800-2500	T	Co
Moraceae					
Ficus nemoralis Wall. ex Miq.	Fagda	A, F	1800-2000	T	Oc
F. sarmentosa Wall.		A, B, F	1800-2400	Sh	Co
Juglandaceae					
Juglans regia L.	Akhrot	A, B, D, F, O	1800-2600	T	Co
Betulaceae					
Alnus nepalensis D. Don	Kosh	A, F	1800-3000	T	Oc
A. nitida (Spach) Endl.	Kosh	A, B, F	1800-3000	T	Co
Betula alnoides Buch.-Ham. ex D.Don	Kolsh	F	2000-2500	T	R
B. utilis D.Don	Bhojpatra	G, J, L, M, F, O	3000-4500	T	EN
Corylaceae					
Corylus jacquemontii Decne	Jamgli-Badam	H	1900-2700	T	R

Fagaceae					
Quercus floribunda Lindl.	Mohru	A, B, F,	1800-2400	T	Co
Q. semecarpifolia J.E.Sm.	Kharshu	C, D, L, O	2600-2700	T	Co
Q. leucotrichophora A.Camus	Ban	F	1900-2200	T	Oc
Salicaceae					
Salix denticulata (Anders.) Svensk	Belli	A, F, C	2000-2600	Sh	Co
S. acutifolia Willd.	Beuns	A, F, I, E	1800-3000	T	Co
S.daphnoides		A, C, F, E	1900-2800	Sh	
S. lindeleyana Wall. ex Anders.	Basil	J, N	3000-4000	Sh	Co
Populus ciliata Wall.	Popular	A, F, C	1800-2200	T	Co
Orchidaceae					
Calanthe tricarinata Lindl.		A, F, C, O	2000-3000	H	Co
Cephalanthera longifolia (L.) Fritsch		A, F, C	2000-3000	H	Oc
Dactylorhiza hatagirea (Don) Soo		L, J, M	3000-4000	H	CR
Epipactis gigantea Dougl. ex Hk.		A, F, C	1800-3500	H	Oc
E. latifolia (L.) All.		A	2500-3000	H	Oc
Goodyera repens (L.) R.Br.		A, F, C	1900-3000	H	Co
Habenaria edgeworthii Hk. f. ex Collett		A, F, C	2000-3500	H	Oc
Herminium lanceum (Thunb. ex Sw.) Veujk.		A, F, C	1800-3000	H	Co
H. monorchis (L.) R. Br.		A, F, C	2000-3300	H	Oc
Oreorchis indica Hk. f.		H, F, G, E	2500-2800	H	R
Spiranthes sinensis (Pers.) Ames.	Bakersinghi	A, F, C	1800-3000	H	Oc
Zingiberaceae					
Hedychium spicatum J. E. Sm.	Ban haldi	A, F, C	1800-2500	H	Oc
Roscoea purpurea J.E. Sm.		A, F, C	2000-3000	H	Co
R. alpina Royle		I, J M, N	2500-4000	H	
Haemodoraceae					
Mondo intermedius D. Don		A, F, D, F	1800-2000	H	Co
Iridaceae					

Iris milesii Foster	Chirichi	A, B, C, F,G, O	2100-2700	H	Co
I. kumaonensis Wall. ex D.Don		A, B, C, F,G	2000-3500	H	Co
Dioscoreaceae					
Dioscorea deltoidea Wall.		A, B, C, F,G	1800-2500	H	EN
D. melanophyma Burkill & Prain		A, B, C	1800-2500	H	R
Alliaceae					
Allium humile Kunth	Farn	J, M, N	1800-3500	H	Oc
A. wallichii Kunth		J, M	2800-4000	H	Co
Asparagaceae					
Asparagus filicinus Buch.-Ham.	Shatavari	A,B,D, F, H	2000-2700	Sh	Co
Liliaceae					
Cardiocrinum giganteum (Wall.) Makino		A, D, F,	1800-3000	H	Co
Eremurus himalaicus Baker		A, F	2000-3000	H	LC
Fritillaria roylei Hk.		F	2100-2700	H	EN
Gagea elegans Wall. ex D. Don		A,B,D, F, H	2000-4000	H	Co
Lloydia serotina (L.) Reichb.		A,B,D, F, H	3300-4300	H	Co
Narcissus tezatte L.		A, F	1800-2200	H	Co
Paris polyphylla Sm.		F, D	2000-3000	H	EN
Polygonatum cirrhifolium (Wall.) Royle	Salam misri	A,B,D, F, H	1900-3000	H	EN
P. verticillatum (L.) All.	Salam misri	A,B,D, F, H, O	1900-3500	H	VU
P. multiflorum (L.) All.	Salam misri	A,B,D, F, H	1900-3000	H	VU
Smilacina purpurea Wadle		A,B,D, F, H	2100-2700	H	Co
Trillidium govanianum (Wall. ex D. Don) Kunth		A,B,D, F, H	2300-2700	H	Oc
Tulipa stellata Hk.f.		A, F	1800-3200	H	Oc
Loganiaceae					
Buddleja crispa Benth.		A,B,D, F, H	1900-2800	Sh	Co
Malvaceae					
Malva verticillata L.	Siddu	A,B,D, F, H	1800-2600	H	Co
Moraceae					
Morus serrata Roxb.	Toot	A, B, F	1800-2500	T	Oc

Oleaceae					
Jasminum humile L.		A,B,D, F, H	1800-2800	Sh	Co
Ligustrum compactum (Wall. ex DC.) Hk. f &Th. ex Brandis		G, D, E	2300-2800	Sh	Co
Commelinaceae					
Commelina paludosa Bl.		B, F, G	1800-3000	H	Co
Cyanotis vaga (Lour.) J.A. & J.H. Schult.		A,B,D, F, H	1800-2500	H	Co
Juncaceae					
Juncus articulatus L.		A, G, F, O	2000-4000	H	Co
J .bufonius L.		B, C, D	1800-2700	H	Co
J. concinnus D. Don		E, F, G	2000-4000	H	Co
J. glaucus Ehrh.		B, C, D	2000-2700	H	Co
J. membranaceus Royle ex D.Don		B, C, D, L, M	2200-3500	H	Oc
Araceae					
Arisaema flavum (Forssk.) Schott	Kida alu	A, B, C, F, H,O	2000-3500	H	Oc
A. tortuosum (Wall.) Schott	Kida alu	A, B, C, F, H	1800-3000	H	Oc
A. intermedium Bl.		A, B, C, F, H	2000-2500	H	Co
A. jacquemontii Bl.		A, B, C, F, H, O	2500-4000	H	Co
Cyperaceae					
Carex breviculmis R. Br.	Krash	A, B, C, F, H, O	2000-3000	H	Co
C. filicina Nees		A, B, C, F, H, O	1900-3000	H	Oc
C. foliosa D. Don		A, B, C, F, H	1800-3000	H	Oc
C. nivalis Boott.		L, M, N, I, O	3000-4000	H	Co
C. cruciata Wahlenb.		A, F, G, H	2200-3500	H	Oc
C. haematostoma Nees		I, J, K, L	3000-4200	H	Co
C. ligulata Nees		A, F, B	1900-2200	H	Co
C.setigera D. Don		A, B, C, F, H	2000-3000	H	Co
C.nubigena D. Don		A, B, C, F, H	1800-3500	H	Co
Cyperus squarrosus L.		A, B, C, F, H	1800-2500	H	Co
C. difformis L.		A, H, G, F	1800-2800	H	Co
Eleocharis palustris (L.) R.		A, B, C, F, H	2000-4000	H	Co

Br.					
Eriophorum comosum Wall. ex Nees		A, B, C, F, H	1900-3500	H	Co
Poaceae					
Agrostis pilosula Trin.		A, B, C, F, H	2000-4000	H	Co
Apluda mutica L.		A, B, C, F, H	1800-2500	H	Co
Bromus japonicus Thunb. ex Murr.		A, B, C, F, H	2000-4000	H	Co
B. racemosus Hudson		B, CG, H,K	2000-3500	H	Co
Chrysopogon gryllus (L.) Trin.		A, B, C, F, H	2000-2800	H	Co
C. echinulatus (Nees) W. Wats.		A, F, B, C, D, H K	1800-3500	H	Co
C. serrulatus Trin.		A, B, C, F,	1800-2500	H	Co
Cymbopogon martinii (Roxb.) Wats.		A, F	1800-2000	H	Oc
Cynodon dactylon L.	Doob	A, B, C, O	1800-2200	H	Co
Dactylis glomerata L.		A, B, C, F,	2000-3500	H	Co
Digitaria cruciata (Nees ex Steud.) Canus		A, B, C, F,	1800-3000	H	Co
Eragrostis pilosa P.Beauv.		A, B, C, F, H,O	1800-2000	H	Co
E. minor Host.		A, F, B	1800-2200	H	Co
Festuca rubra L.		A, B, C, F, H	1800-2500	H	Co
Imperata cylindrical (L.) Raeuschel		A, B, C, F	1800-2000	H	Co
Isachne himalaica Hk. f.		B, C, F,	1800-2000	H	Co
Koeleria micrantha (Ledeb.) Schult.		C, D	1900-4000	H	Co
Lolium temulentum L.		A, B, C, F, H	1800-2000	H	Co
Oplismenus compositus (L.) Beauv.		E, G	2000-3000	H	Co
O. undulatifolius (Ard.) Roem. & Schult.		A, F, G	1800-2500	H	Co
Phleum alpinum L.		J, M, L	3000-4000	H	Co
P. paniculatum Hudson		A, F	1800-2000	H	Co
Poa annua L.		A, B, C, F, H	1800-3000	H	Co
P. alpina L.		L, M, K,O	2500-4000	H	Co
Saccharum spontaneum L.	Philoo	A, B, C	1800-2400	H	Co
S. rufipillum Steud	Philoo	A, B, C	1800-2500	H	Co

S. filifolium Nees & Steud	Philoo	A, B, C, F, H	1800-2500	H	Co
Setaria pumila (Poir.) Roem. & Schult.		B, C, D	1800-2500	H	Co
Stipa sibirica (L.) Lam.		D, E, F	2000-3000	H	Co
Themeda anathera (Nees) Hack.		A, B, C, F, H,O	2000-2800	H	Co
Thamnocalamus spathiflora (Trin.) Munro	Rangad	F, H	2500-3000	Sh	Oc
Gymnosperms					
Cupreassaceae					
Juniperus recurva Buch.-Ham. ex D.Don	Baittori	I, L, M, N, K,	3000-4500	Sh	Oc
J. indica Bertol.	Baittor	I, L, M, N, K,	3000-4500	Sh	Co
J. communis L.	Bithal	J, M,L	2500-3500	Sh	R
Pinaceae					
*Picea smithiana (*Wall.) Boiss	Rai	A, B, C, F, H,O	1800-3300	T	Co
Pinus wallichiana A.B.Jack	Kail	A, B, C, F, H	1800-2500	T	Co
Cedrus deodara G.Don	Dyar	A, B, C, F, H	1800-2500	T	Co
Abies pindrow Royle	Tosh	A, B, C, F, H,O	2200-3600	T	Co
Taxaceae					
Taxus baccata subsp. *wallichiana* (Zucc.) Pilger	Rakhal	A, B, C, F, H,O	2500-3500	T	EN
Pteridophytes					
Pteridaceae					
Pteris cretica L.	Baran	A, B, D, E, F, O	2200-2500	F	Co
P.vittata L.	Baran	A, B, C, O	1900-2500	F	Co
P. pseudoquadriaurita Khullar		A, F, B, G	1800-2400	F	Co
Pteridium aquilinum (L.) Kuhn.	Baran	B, C, D	1900-2500	F	Co
Botrychiaceae					
Botrychium ternatum (Thunb.) Stz.		D, E, H,	2500-3000	F	R
Equisetaceae					
Equisetum arvense L.		A, B, C, D, E, F	1800-2500	F	Co

Selaginaceae					
Selaginella chrysocaulos (Hk. & D.Don) Spring		A, B, C, D, F	1800-2800	F	Co
Athyriaceae					
Athyrium anisopterum Christ.		A, F	1800-2200	F	Oc
A. attenuatum (Wall. ex Cl.) Tagawa		A, H, F	2200-3000	F	Co
A. pectinatum (Wall. ex. Mett.) T.Moore		A, F, G	1800-2200	F	Oc
A. atkinsonii Bedd.		K, H, I, G	2400-3000	F	Co
Cystopteris fragilis (L.) Bernh.		G, H, K	2100-3000	F	Co
Diplazium esculentum (Retz.) Sw.	Lingar	A, B, D, E, F	1800-2600	F	Co
Cryptogrammaceae					
Onychium contiguum Wall. ex Hope		B, D, E, F, O	1900-2500	F	Co
O.lucidum (D,Don) Spr.		A, B, C, D, G, F,O	1800-2000	F	Oc
Cryptogramma brunoniana Wall. ex. Hk.		G, L, K	2700-3200	F	Oc
C.stellari (Gmel.) Prantl		I, N	2700-4000	F	Oc
Osmundaceae					
Osmunda claytoniana L.		A, B, D, E, F, O	1900-2500	F	Co
O. japonica Thunb.		A, B, F	1900-2500	F	R
Ophioglossaceae					
Ophioglossum petiolatum Hk.		A, E, F	1900-2100	F	Oc
Dryopteridaceae					
Dryopteris panda (Cl.) Christ.		B, D, E, F	1800-2500	F	Co
D.barbigera (T.Moore ex Hk.) O.Ktze.		A, C, G, H, I,	2200-3300	F	Co
D. wallichiana (Spreng.) Hylander		A, B, C, D, E, G, I, F,	2000-2800	F	Co
Polystichum nepalense (Spreng.) C.Chr.		B, D, E, F, O	1900-2500	F	R
P.prescottianum var. prescottianum (Wall. ex Mett.) T.Moore		A, F, D, G, C	2200-2800	F	Co

P.discretum (D.Don) Sm.		A, F	1800-2000	F	Co
P. neolobatum Nakai		I, K, N, M	2700-3000	F	Oc
P. squarrosum (D.Don) Fee		I, F, H, G	2700-3000	F	Co
P. wilsonii Christ.		G, F, L, O	2500-3200	F	Co
P. lachenense (Hk.) Bedd.		I, J, L, N, M	3000-3500	F	Oc
Aspleniaceae					
Asplenium anogrammoides Christ.		A, , B, G, H, F	1800-2500	F	Oc
A. dalhousiae Hk.		B,C, D, E, F	2200-2800	F	Co
A. septentrionale (L.) Hoffm.		E	1900-2500	F	R
A. trichomanes Cl.		A, B, C, E, G, I, M	1800-3000	F	Co
A. yunnanense Franch		A, F	1800-2400	F	Co
Polypodiaceae					
Polypodioides amoena (Wall. ex Mett.) Ching		B, A, G	1800-2400	F	Co
Lepisorus nudus (Hk.) Ching		B, E, F, O	1900-2900	F	Co
L. amaurolepidus (Sledge) Bir		A, F, G	2000-2800	F	Oc
L. morrisonensis (Hayata) Ito		A, F, D	2000-2500	F	Oc
Phymatopteris stracheyi (Ching) P. Sermolli		I, M, D	2500-3300	F	R
Sinopteridaceae					
Cheilanthus albomarginata Cl.		B, D, E, F	1800-2500	F	Co
C. acrostica (Baibis) Tod		B, D, E, F	1900-2600	F	Co
Pellaea nitidula (Wall. ex Hk.) Hk.		A, F, L	1800-2400	F	Co
Adiantaceae					
Adiantum capillus-veneris L.		A, B, C, D, E, F, G,O	1800-3000	F	Co
A. edgeworthii Hk.		A, C, D, G, O	1800-2000	F	Co
A. pedatum L.		F	1900-2500	F	Oc
A. venustum D.Don		B, D, E, F	1800-2700	F	Co
Hemionitidaceae					
Conniogramme intermedia Hieron. *var. glabra* Ching		A, F, D, K,	2000-3000	F	Co

Gymnopteris vestita (Wall. ex Moore) Underwood		A, F, G, D, E	1800-2500	F	R
Thelypteridaceae					
Pseudophegopteris levingei (Cl.) Ching		D, C, K	1800-3000	F	Oc
Davalliaceae					
Araiostegia beddomei (Hope) Ching		I, J, N,L, M	2700-3600	F	Co

Abbreviations used: H=Herb; Sh=Shrub; T=Trees; F=Fern; Oc=Occasional; Co=Common; R=Rare; EW=Extinct in wild; EN= Endangered; VU= Vulnerable; and LC= Least Concern. NT= Near Threatened; A=Prini Nallah; B=Hamta; C=Hamta potato farm; D=Sethan; E=Pandu Ropa;F=Jagatsukh nallah; G=Khanoor; H=Brun Dhar; I=Chhika; J=Seri; K= Banshiru; L=Bujh Dhar; M= Jabri Nallh; N=Marasu Nallah and O= Dam site