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Ecological Assessment and Conservation Implications for *Ulmus wallichiana* (Planch.) in Kullu Forest Division, Himachal Pradesh

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***Abstract*:** The present investigation to assess the phytosociological and natural regeneration status of *Ulmus wallichiana* (Planch.) from three ranges i.e., Kullu, Patlikuhl, and Naggar of the Kullu forest division, Himachal Pradesh were selected. From each range, three sites were chosen randomly. The overall highest (145.74) IVI (Important Value Index) of tree species was for *U. wallichiana* and the overall highest (178.68) IVI of shrub species was for *Rosa moschata* in the Babeli site in the Kullu range. The maximum Shannon index and species richness i.e., 2.427, and 2.589 was observed in the Badagram population of Ulmus for tree species whereas for shrub species maximum Shannon index (1.988) and species richness (1.791) was observed in the Dhobi population. The natural regeneration of *U. wallichiana* was maximum (7.5%) at the lower altitudinal range (1100-1500m) and minimum (3.75%) at the higher altitudinal range (1800-2100m). *U. wallichiana* has been identified as a vulnerable species, therefore, the major species is essential from an immediate in-situ and ex-situ conservation point of view.

***Keywords*:** Conservation, Diversity, Phytosociological, Population, Regeneration

Elms are deciduous and semi-deciduous trees of the genus *Ulmus* of the family Ulmaceae with roughly 30 to 40 different species (Zhang et al 2022) that grow between 800 to 3000 meters above sea level. It is found in Afghanistan, Pakistan, Northern India and Western Nepal (Nazima Batool et al 2014). This species is found in India in the states of Jammu and Kashmir, Uttarakhand, and Himachal Pradesh. The Himalayan elm may grow to a height of 30 meters and has a broad canopy with ascending branches. The bark on the trunk is greyish-brown and wrinkled lengthwise. The leaves are elliptic-acuminate, with a length of less than 13 cm and a breadth of less than 6 cm. The blooms have a diameter of less than 13 mm and are known as samara. They grow in clusters of branches and blossom between March and April (Arya et al 2013). Elm leaves provide good feed, and the bark produces a strong fiber that can be used to make cordage and rope. The bark of *Ulmus wallichiana* is widely used in Himalayan traditional medicine to treat shattered bones in both animals and humans (Arya and Agarwal 2008). According to the IUCN Red List, *U. wallichiana* is vulnerable (IUCN 2016). Heavy lopping for fodder and fuelwood, as well as the removal of fibrous bark for rope making, decimated the tree and rendered it incapable of reproducing naturally through seeds. The high proportion of empty seeds hinders the natural regeneration of the species. Cuttings are also difficult to root making vegetative propagation problematic (Mughal and Mugloo 2016).

Regeneration is the most critical mechanism for maintaining a community's stable age structure of plant species, which is influenced directly or indirectly by numerous climatic and edaphic conditions. In forest management, a regeneration study illustrates not only the current state of the forest but also hints at future forest composition changes (Sharma et al 2014, Malik and Bhatt 2016). In the Indian Himalayan Region (IHR) changes in the structure, composition, and regeneration of natural forests are being caused by climate change and environmental disturbances. The Himalayan forests are vulnerable to significant climate change effects because they are frequently dominated by low-temperature conditions (Wester et al 2019). Poor regeneration due to habitat loss, land degradation, deforestation, forest fires, overgrazing, lopping, etc. is the major problem of mountain forests (Parveen et al 2017, Pant and Samant 2012). The conservation status of *Ulmus wallichiana* in the western Himalayas (Nazim Batool et al 2014), in Pakistan (Khan et al 2021) and the analysis of the phytosociology and regeneration status of the Elm tree were earlier studied by Kumar and Sharma 2014. In the current investigation, the ecological status and regeneration potential of *U. wallichiana* Planch was carried out in the Kullu forest division of Himachal Pradesh.

MATERIAL AND METHODS

Study area: The study was conducted in the Kullu Forest Division of Himachal Pradesh, India. The climate is typical of the temperate zone at higher altitudes, above 1000 meters and subtropical at lower elevations. The Kullu district forms a transitional zone between the Lesser and Greater

Himalayas. It is characterized by high NW-SE trending ridges and deep river valleys, several of which in their upper reaches bear imprints of glacial activity in the near past. The area generally represents young, immature topography, controlled by the underlying rocks' structure and lithology. The study was carried out from 2020 to 2022 at three ranges i.e., Kullu, Patlikuhl, and Naggar of the upper Beas valley of district Kullu. Three sites were further selected from each range for the survey (Table 1).

Experimental methodology: The study on the phytosociology of forests was carried out after laying out sample plots in each of the selected sites. The observations for trees and shrubs were recorded by laying quadrats of size (30m × 10m). In each site, 5 quadrats were laid out and the Importance value index (IVI), similarity/dissimilarity index, diversity indices, Simpson index, Shannon index, equitability, and species richness index were recorded. The survey was carried out from the rainy season onwards to study the regeneration status of major species. Observations on regeneration were made in a recording unit (quadrat) size by the species-area curve method. The recruits, un-established and established regeneration was computed using the following:

$$\text{Recruit (r) / ha} = \frac{2500 \times \text{total number of recruits}}{\text{Total number of recording units}}$$

$$\text{Unestablished (u) / ha} = \frac{2500 \times \text{total number of unestablished plants in sampling units}}{\text{Total number of recording units}}$$

$$\text{Established (e) /ha} = \frac{2500 \times \text{total number of established plants in sampling units}}{\text{Total number of recording units}}$$

RESULTS AND DISCUSSION

Phytosociological study: The phytosociological studies revealed the floristic composition of trees and shrubs in the natural population of *Ulmus wallichiana* growing. The maximum number of trees was in Badagram (11) followed, by Dhobi, Seonidhar, Pulang and Rumsu (10), Mohal and Babeli (9), Shamshi and Naggar (8) (Table 2). The maximum number of shrubs was found in Dhobi (11), followed by Badagram and Seonidhar (9), Naggar, Pulang and Rumsu (6), Babeli (5), and the minimum in Shamshi and Mohal (4).

Importance value index (IVI) : The most dominating species was *Ulmus wallichiana* with a maximum (145.74) IVI value in the Babeli site followed by *Robinia pseudocasia* (74.94), *Populus deltoides* (70.74) in the Mohal site whereas, the least dominating species was *Morus serrata* (10.40) in Babeli site, in the Kullu range (Table 3). The most dominating shrub species was *Rosa moschata* with a maximum (178.68) IVI value followed by *Prinsepia utilis* in the Mohal site whereas, the least dominating species was *Indigofera heterantha* in the Shamshi site, in the Kullu range.

Diversity Indices

Similarity and dissimilarity indices: The similarity index in *Ulmus* growing population of fourteen species ranged from 0.09 to 0.95 (Table 4) maximum in Pulang and Naggar (0.95), and minimum in Rumsu and Naggar (0.09). The dissimilarity index for trees ranged from 0.05 to 0.89. The maximum was recorded in Pulang and Mohal, Rumsu and Mohal (0.89) whereas a minimum (0.05) was in Pulang and Naggar. The species present in sites Pulang and Naggar depicted the highest similarity because these two populations were under the same range. Rumsu and Naggar are so far apart from each other, hence there are fewer similarities in trees and shrubs.

The Similarity index for the shrubs in *Ulmus*-bearing populations ranged from 0.16-0.75 maximum in Seonidhar and Shamshi (0.75) populations and a minimum in Dhobi and Seonidhar (0.16) populations. The dissimilarity index for shrubs ranged from 0.25 to 0.84 and was maximum in Seonidhar and Dhobi (0.84) populations, whereas a minimum (0.25) was in Seonidhar and Shamshi.

Simpson index (D): The Simpson index for tree species in the *Ulmus* growing population was a maximum (0.881) for Pulang and a minimum (0.667) for Mohal (Table 5). In the

Table 1. Selected sites in Kullu forest division of Kullu district (HP)

Ranges	Sites	Latitude (°N)	Longitude (°E)	Altitude (m)
Kullu	Shamshi	31.89	77.13	1100-1250
	Mohal	31.91	77.11	1250-1350
	Babeli	32.00	77.12	1350-1500
Patlikuhl	Badagram	34.77	73.13	1500-1600
	Seonidhar	31.95	77.15	1600-1700
	Dhobi	32.08	77.12	1700-1800
Naggar	Naggar	32.11	77.16	1800-1900
	Pulang	32.03	77.23	1900-2000
	Rumsu	32.11	77.17	2000-2100

Table 2. Floristic composition of trees and shrubs in the natural population of *Ulmus wallichiana*

Species	Trees								
	Kullu			Patlikuhl			Naggar		
	Shamshi	Mohal	Babeli	Badagram	Seonidhar	Dhobi	Naggar	Pulang	Rumsu
Abies pindrow	-	-	-	-	-	-	-	-	-
Aesculus indica	-	-	-	-	-	-	-	-	-
Ailanthus altissima	-	-	-	-	-	+	-	-	-
Alnus nepalensis	-	-	-	+	+	+	-	+	+
Betula alnoides	-	-	-	-	-	-	-	-	-
Cedrus deodara	-	+	-	+	+	+	-	+	+
Celtis australis	+	+	+	-	-	-	+	-	-
Eucalyptus globulus	-	-	+	-	-	-	-	-	-
Ficus palmata	+	+	+	+	+	-	+	+	+
Jacaranda mimosifolia	-	-	-	-	-	-	-	-	-
Juglans regia	-	+	-	+	+	+	+	+	+
Melia azedarach	+	+	+	-	-	-	-	-	-
Melia composita	-	-	-	+	+	+	-	+	+
Morus alba	+	-	-	-	-	-	-	-	-
Morus serrata	+	-	+	+	+	+	-	+	+
Piceasmithiana	-	-	-	+	+	+	-	+	+
Pinus wallichiana	-	-	-	+	+	+	+	+	+
Pistacia integerrima	+	-	+	-	-	-	-	-	-
Platanus orientalis	-	+	-	-	-	-	-	-	-
Populus ciliata	-	-	-	-	-	-	-	-	-
Populus deltoides	-	+	-	+	-	-	-	-	-
Populus nigra	-	-	-	-	-	-	-	-	-
Pyrus pashia	+	-	-	-	-	-	-	-	-
Robinia pseudocacia	-	+	+	-	-	-	+	-	-
Sapindus mukorosii	-	-	-	-	-	-	-	-	-
Sterculia urens	-	-	-	-	-	-	+	-	-
Toona serrata	-	-	+	+	+	+	+	+	+
Ulmus wallichiana	+	+	+	+	+	+	+	+	+
Total	8	9	9	11	10	10	8	10	10
Shrubs									
Berberis lycium	-	+	+	+	-	+	-	-	-
Bochmeria mivea	-	-	-	+	+	+	-	-	-
Daphne cannabina	-	-	-	+	-	+	+	+	+
Debregeasia hypoleuca	-	-	+	-	-	-	-	-	-
Indigofera heterantha	+	-	-	+	+	+	+	+	+
Prinsepia utilis	+	+	+	+	+	+	+	+	+
Rosa macrophylla	-	-	-	-	-	-	-	-	-
Rosa moschata	+	+	+	+	+	+	+	+	+
Rubus ellipticus	+	+	+	+	+	+	+	+	+
Rubus niveus	-	-	-	-	+	+	-	-	-
Sarcococca saligna	-	-	-	-	-	-	-	-	-
Skimmia laureola	-	-	-	+	+	+	-	-	-
Strobilanthes glutinosus	-	-	-	+	+	+	-	-	-
Zanthoxylum armatum	-	-	-	-	-	-	+	+	+
Zizyphus jujuba	-	-	-	-	+	+	-	-	-
Total	4	4	5	9	9	11	6	6	6

case of shrubs, the maximum was for Seonidhar (0.827) and a minimum for Naggar (0.676).

Shannon index (H): The Shannon index for trees in the *Ulmus* growing population was maximum (2.427) for Badagram indicating that more than two tree species displayed codominance. The minimum (1.488) was for Mohal depicting that (90%) of the dominance was contributed by a single species. In the case of shrubs, the maximum was (1.988) for Dhobi and a minimum (0.342) for Babeli in *Ulmus* growing population (Table 5).

Equitability (e): Equitability for trees in *Ulmus* growing population was highest (0.962) for Pulang and lowest (0.646) for Mohal. In the case of shrubs, the maximum was for Seonidhar (0.866), and the minimum (0.728) for Naggar in the *Ulmus* growing population (Table 5).

Species richness index (Dmg): Species richness for trees in the *Ulmus* growing population was (2.589) for Badagram (Table 5), whereas a minimum (1.789) for Shamshi. In the case of shrubs, the maximum (1.791) was seen for Dhobi, while the minimum (0.488) for Babeli in *Ulmus* growing

Table 3. Importance value index (IVI) of tree and shrub species

Species	Trees								
	Kullu			Patlikuhl			Naggar		
	Shamshi	Mohal	Babeli	Badagram	Seonidhar	Dhobi	Naggar	Pulang	Rumsu
Alnus nepalensis	-	-	-	15.81	15.69	16.89	-	17.16	21.84
Cedrus deodara	-	10.36	-	23.66	23.16	42.52	-	50.24	50.9
Celtis australis	11.24	26.86	27.43	-	-	-	19.7	-	-
Eucalyptus globulus	-	-	18.05	-	-	-	-	-	-
Ficus palmata	20.62	22.43	21.01	26.91	28.91	-	16.53	24.33	21.77
Juglans regia	-	11.37	-	23.93	24.14	36.37	41.39	33.03	41.87
Melia azedarach	37.51	9.61	22.33	-	-	-	-	-	-
Melia composita	-	-	-	16.07	19.94	25.95		20.91	19.53
Morus serrata	72.38	-	10.4	21.08	21.25	10.87		22.48	18.28
Picea smithiana	-	-	-	13	16.77	16.9		19.54	22.63
Pinus wallichiana	-	-	-	40.09	43.58	56.75	38.97	39.86	32.48
Pistacia integerrima	18.82	-	10.96	-	-	-	-	-	-
Populus ciliata	-	-	-	15.36	-	-	-	-	-
Populus deltoides	-	70.74	-	-	-	-	-	-	-
Pyrus pashia	50.35	-	-	-	-	-	-	-	-
Robinia pseudocasia	-	74.94	33.62	29.76	30.21	21.84	66.95	-	-
Toona serrata	-	-	10.46	18.41	21.68	23.02	27.32	27.15	22.91
Ulmus wallichiana	89.08	73.69	145.74	55.92	54.67	48.89	89.14	45.3	47.79
Shrubs									
Berberis lycium	-	19.87	33.97	12.69	-	12.24	-	-	-
Bochmeria mivea	-	-	-	14.38	26.37	20.64	-	-	-
Daphne cannabina	-	-	-	12.25	-	13.74	39.45	54.38	54.17
Debregeasia hypoleuca	-	-	69.7	-	-	-	-	-	-
Indigofera heterantha	17.59	-	-	19.81	53.01	11.64	86.75	62.38	62.38
Prinsepia utilis	82.63	66.27	17.65	73.63	62.97	91.76	118.66	117.17	108.64
Rosa moschata	105.24	174.33	178.68	49.29	55.14	57.84	20.39	14.88	17.33
Rubus ellipticus	57.79	39.53	-	66.73	59.55	30.04	9.26	23.15	31.46
Skimmia laureola	-	-	-	34.26	17.57	25.07	-	-	
Strobilanthes glutinosus	-	-	-	16.92	10.64	25.48	-	-	-
Zanthoxylum armatum	-	-	-	-	-		25.45	21.48	26
Zizyphus jujuba	36.75	-	-	-	14.71	11.5	-	-	-

population. Recent studies have investigated the similarity and dissimilarity indices of vegetation in forest ecosystems, revealing consistent patterns in growth forms and species composition among nearby forests (Kumar and Thakur 2008; Suyal et al 2010). High similarity indices indicate the proximity and grouping of forests based on vegetation (Suyal et al 2010). Variable diversity indices (Simpson, Shannon and equitability) among tree and shrub species were also studied by Chauhan (2021), Shafi et al(2018) and Sharma et al (2020). Compared to previous studies in the Himalayas and surrounding regions have reported similar patterns. Gairola et al (2009) and Raturi (2012) stated that the species richness and diversity vary with elevation and environmental conditions. Khan et al *(*2020) indicated varied degrees of species evenness by equitability indices.

Regeneration potential: The regeneration studies were conducted for recruits (R), un-established (Un), and established (E) seedlings in the different forests of Kullu,

Table 4. Similarity and dissimilarity index of trees and shrubs in natural *Ulmus wallichiana*

S/D	Shamshi	Mohal	Babeli	Badagram	Seonidhar	Dhobi	Naggar	Pulang	Rumsu
Trees									
Shamshi	1	0.44	0.7	0.42	0.33	0.31	0.37	0.33	0.33
Mohal	0.55	1	0.37	0.22	0.11	0.22	0.13	0.11	0.11
Babeli	0.3	0.62	1	0.47	0.4	0.28	0.55	0.4	0.3
Badagram	0.57	0.77	0.52	1	0.13	0.25	0.46	0.13	0.13
Seonidhar	0.66	0.88	0.6	0.86	1	0.4	0.55	0.42	0.42
Dhobi	0.68	0.77	0.71	0.75	0.6	1	0.31	0.28	0.28
Naggar	0.63	0.87	0.45	0.54	0.45	0.69	1	0.95	0.09
Pulang	0.67	0.89	0.6	0.87	0.58	0.72	0.05	1	0.28
Rumsu	0.67	0.89	0.7	0.87	0.58	0.72	0.91	0.72	1
Shrubs									
Shamshi	1	0.5	0.28	0.5	0.75	0.62	0.66	0.33	0.33
Mohal	0.5	1	0.4	0.42	0.42	0.4	0.6	0.6	0.6
Babeli	0.72	0.6	1	0.33	0.33	0.3	0.5	0.5	0.5
Badagram	0.5	0.58	0.67	1	0.33	0.3	0.5	0.5	0.5
Seonidhar	0.25	0.58	0.67	0.67	1	0.16	0.28	0.28	0.28
Dhobi	0.38	0.6	0.7	0.7	0.84	1	0.28	0.28	0.28
Naggar	0.34	0.4	0.5	0.5	0.72	0.72	1	0.62	0.62
Pulang	0.67	0.4	0.5	0.5	0.72	0.72	0.38	1	0.45
Rumsu	0.67	0.4	0.5	0.5	0.72	0.72	0.38	0.55	1

Table 5. Diversity indices of tree and shrub species in the natural population of *Ulmus wallichiana*

Population	Diversity indices							
	Trees				Shrubs			
	Simpson	Shannon	Equitability	Species richness	Simpson	Shannon	Equitability	Species richness
Shamshi	0.722	1.585	0.762	1.789	0.736	1.793	0.799	1.227
Mohal	0.667	1.488	0.646	1.907	0.742	1.793	0.812	1.227
Babeli	0.713	1.689	0.768	2.352	0.773	0.342	0.843	0.488
Badagram	0.863	2.427	0.887	2.589	0.826	1.909	0.868	1.383
Seonidhar	0.874	2.349	0.94	2.37	0.827	1.904	0.866	1.412
Dhobi	0.872	2.184	0.915	2.245	0.805	1.988	0.829	1.791
Naggar	0.804	1.811	0.871	1.885	0.676	1.305	0.728	1.05
Pulang	0.881	2.216	0.962	2.01	0.724	1.447	0.807	1.022
Rumsu	0.87	2.208	0.941	2.118	0.751	1.549	0.864	1.079

Table 6. Regeneration status of *Ulmus wallichiana* in Kullu district of Himachal Pradesh

Sites	Populations	Recruits/ha	Unestablished regeneration/ha	Establishment regeneration/ha	Regeneration success %
Kullu	Shamshi	250	250	0	2.5
	Mohal	125	125	0	1.25
	Babeli	750	375	0	3.75
	Total	1125	750	0	7.5
Patlikuhl	Badagran	375	250	0	2.5
	Seonidhar	125	125	0	1.25
	Dhobi	250	125	0	1.25
	Total	750	500	0	5.0
Naggar	Naggar	250	128	0	1.28
	Pulang	125	125	0	1.25
	Rumsu	125	122	0	1.22
	Total	500	375	0	3.75

Patlikuhl, and Naggar Ranges of Kullu Forest division of Himachal Pradesh (Table 6). The un-established regeneration/ha of Kullu, Patlikuhl, and Naggar ranges were 750, 500, and 375 respectively. In the Kullu range, the maximum (375) number of unestablished regenerations was in Babeli and a minimum (125) in Mohal, In the Patlikuhl range, the maximum (250) number of unestablished regenerations was in Badagram and a minimum (125) in Seonidhar and Dhobi whereas in the Naggar range maximum (128) number of unestablished regenerations in Naggar and minimum (122) in Rumsu.

The regeneration success percentages of Kullu, Patlikuhl, and Naggar ranges were 7.50, 5.00, and 3.75 respectively. In Kullu range the maximum (3.75%) of regeneration success was in Babeli and the minimum (1.25%) in Mohal, In the Patlikuhl range maximum (2.50%) of regeneration success was in Badagram and the minimum (1.25%) in Seonidhar and Dhobi and Naggar range maximum (1.28%) of regeneration success in Naggar and minimum (1.22%) in Rumsu. In all the populations, the established regeneration recorded was nil. The overall number of recruits/ha in Kullu, Patlikuhl, and Naggar was 1125,750, and 500 respectively (Table 6). In the Kullu range the maximum (750) number of recruits were in Babeli and a minimum (125) of recruits were found in Mohal followed by Patlikuhl and the Naggar range.

The *Ulmus* forest exhibited a decreasing trend of regeneration success with altitudinal ranges: Kullu>Patlikuhl> Naggar. The Kullu range (1100-1500) had the highest regeneration success of *Ulmus wallichiana* (7.5), whereas the Naggar range (1800-2100) had the lowest regeneration success of *U. wallichiana* (3.75). Maximum regeneration was recorded at lower altitudes.

CONCLUSIONS

The phytosociological analysis of *Ulmus wallichiana* in the Kullu range revealed significant findings regarding its floristic composition and diversity patterns. The study identified Badagram and Dhobi sites in the Patlikuhl range as hotspots for tree and shrub diversity, with *U. wallichiana* emerging as the dominating species at Babeli site, followed by *Robinia pseudocasia* and *Populus deltoides* at Mohal site. Conversely, *Morus serrata* exhibited the lowest dominance at the Babeli site. The species richness declined with increasing elevation, while natural regeneration of *U. wallichiana* peaked (7.5%) at lower altitudes (1100-1500m) and dwindled at higher altitudes (1800-2100). Given *U. wallichiana's* vulnerable status, these findings underscore the imperative for immediate in-situ and ex-situ conservation efforts to protect this species and its habitats, particularly in lower elevation ranges where regeneration is optimal.

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