Indian Journal of Ecology (2023) 50(4): 1002-1007
DOI: https://doi.org/10.55362/IJE/2023/4004

Manuscript Number: 4004
NAAS Rating: 5.79

Ecotype Diversity Assessment of Autumn Olive (*Elaeagnus umbellata* Thunb.) in Himachal Pradesh

Shreya Chauhan, Anita Kumari*, Pratiksha Saini, Suman Kumar Jha[1] and G.B. Rawale

Department of Tree Improvement and Genetic Resources, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, India
[1]Department of Forest Biology and Tree Improvement, College of Forestry Navsari Agricultural University, Gujarat-396 450, India
**E-mail: anita_78@ymail.com*

***Abstract*:** *Elaeagnus umbellata* Thunb. commonly known as autumn olive (Elaeagnaceae) is a multipurpose actinorhizal shrub of the Western Himalayas. It is distinctly distributed at a range of about 1200 m to 2100 m, withstanding the eroded areas owing to renowned nitrogen fixing ability. The shrub was recorded at the three altitudinal ranges, at two locations from each range. *Elaeagnus* invasively outcompetes *Myrisine africana, Lantana camara, Coraria nepalensis* in chirpine forest and *Sambuca nigra, Ruscus, Indigofera, Lonicera* in kail forest. *E. umbellata* enhanced the levels of soil nitrogen in forest land, due to the presence of nodules on its roots that houses nitrogen fixing actinomycetes. This wild shrub is acclaimed for plantation to revamp soil fertility in a forest for hosting numerous herbs and shrubs in its vicinity.

***Keywords*:** Wild species, Diversity, Distribution, Phytosociology, Nodules

Globally, forests cover nearly one third of the land area and contain over 80% of terrestrial biodiversity. Forests play a significant role in offering a multitudinal range of habitats for plants, animals, as well as micro-organisms (Jendresen and Rasmussen 2022). As a result of changing climatic patterns and altering human behavior, forests serve as a reserve for future needs (Devi et al 2018, Pichura et al 2017). More than 2/3rd (1.6 billion) people throughout the world, living in low and middle-income nations, reside within 5 kilometers of a forest periphery (Newton et al 2020). Further around 40% of the world's extremely poor population, rely on products and services that forest provide (IUFRO 2020). Forest aids in benefitting the humans by providing firewood, housing materials, high value forest products and food. The Himalayas are lavished with the rich flora, flourishing across vast range of habitats in distinct altitudinal ranges. Himalayan region, geographically covers 18% and accounts for more than 50% of India's forest cover. 30-40% species are endemic from the total, circumscribed under the Himalayan region many wild species of economic importance suffer from obscurity and of being ascertained. In natural or semi-natural habitats, the term "wild plant species" refers to those that develop spontaneously in self-maintaining populations and are unaffected by human activity. Wild resources in general are frequently disregarded and receive little or no appreciation. Lack of knowledge about their scope of use and significance, economic worth, global markets and a lack of quality standards are the major causes of this neglect.

Among the wild species, *Elaeagnus* is the largest shrub genus of Elaeagnaceae family (Paudel et al 2020). Around 90 species, have been reported in *Elaeagnus,* inclusive of which *E. umbellata* Thunb (Ahmad et al 2006)*, E. angustifolia* Thunb.*, E. multiflora* Thunb. and *E. pungens*, are used as medicinal plants (Paudel et al 2020). *Elaeagnus umbellata* Thunb. commonly known as autumn olive, autumn *elaeagnus* and Japanese silverberry (Gamba et al. 2020) belonging to family Elaeagnaceae is a multipurpose actinorhizal shrub of the Western Himalayas. *E. umbellata* Thunb. is widely distributed in Shimla, Solan, Sirmour, Chamba, Kangra, and Kinnaur districts in Himachal Pradesh at an altitudinal range of 1000-3000m. It is spiny-branched, deciduous shrub that grows upto 3.5 to 5.5m tall and wide along with light green foliage. The leaves are alternate with size ranging from 1 to 4 cm and are petiolated in lateral clusters on twigs (Ahmad et al 2005). *E. umbellata* Thunb. develops root nodules as a result of symbiotic association with actinomycetes (*Frankia*) in the soil that enables fixation and utilization of atmospheric nitrogen (Kim et al 1993). It is planted in eroded areas of mountainous zones to re-establish and develop vegetation cover. The fixation of atmospheric nitrogen by actinorhizal plants represented a contribution to global nitrogen cycle (Baker et al 1979).

There is a meager information on the diversity status of wild species. The appraisal of diversity and phytosociological studies constituting a forest could prove essential for exploration of certain unexplored wild species that may prove

beneficial for several future purposes. Phytosociology is a study of vegetation of a plant community, certainly focused on assemblage of plants in forest stands. It emphasizes on characterizing vegetation types on basis of floristic composition of stands. There are various topographic and climatic factors that affect the plant species diversity (Malik and Bhatt 2015). The diversity of species in a forest differs throughout the altitudinal range depending upon the set of factors characterizing the habitat of particular species (Gairola et al 2011, Joshi et al 2021). In the hill slopes, the physiographic factors widely influence the plant microhabitats (Sharma et al 2010, Slobodkin and Sanders 1969). These studies frame an outlining for the wild species for establishing their status and distribution patterns.

MATERIAL AND METHODS

The present study was confined to three altitudinal ranges *i.e.,* <1200 m, 1200-1800 and >1800 m, containing *Elaeagnus umbellata* Thunb. in three districts of Himachal Pradesh (Fig. 1). From each altitudinal range two locations were selected comprising of five shrubs. At altitudinal range less than 1200 m, two sites *viz.,* Dilman (1157 m) (30º48´39"N, 77º08´36"E) and Kujji (1046 m) (30º49´02"N, 77º09´41"E) in Sirmaur district, between 1200-1800 m, two sites *viz.,* Kalaghat (1320 m) (30º51´57"N, 77º11´03"E) and Nauni (1252 m) (30º51´39"N, 77º10´09"E) in Solan district, at an elevation range greater than 1800 m sites *viz.,* Dhar (2141 m) (31º06´11"N, 77º41´37"E) and Shari (2010 m) (31º06´27"N, 77º41´11"E) in Shimla district were appraised.

The vegetation analysis was carried out by randomly placed 20 quadrats of 5×5 m for shrubs and 1×1 m for herbaceous growth in the six locations bearing shrubs along with one control site (*E. umbellata* absent). Quadrates were laid out randomly by species area curve method (Mishra 1968). The vegetation data was analyzed quantitatively for phytosociological parameters *viz.,* basal area, density and frequency (Curtis and McIntosh 1950). The Importance Value Index (IVI), (Philips 1959), species diversity indices and dominance indices were determined as per the methods outlined by Magurran (1988), Shannon-Wiener (1963) and Simpson (1949). The soil parameters (pH, electrical conductivity, N, P, K) were evaluated at three depths *i.e.,* 0-10 cm, 11-20 cm and 21-30 cm.

RESULTS AND DISCUSSION

Around 32 species of shrubs and 50 herbaceous species were recorded during the sampling of the three habitats. The species diversity observed in the chir pine and kail forest, was comparable with the previous studies (Sharma 2006, Gupta et al 2009, Attri et al 2017). Variations in the phytosociological attributes, among the different habitats in Himachal Pradesh, are primarily due to the changing environmental, geographic and edaphic conditions. *E. umbellata* dominated the three habitats, ranging at different altitudes (Table 1). Due to its invasive nature, outcompetes species *viz., Myrisine africana, Lantana camara, Coraria nepalensis, Zanthoxylum aratum, Bidens pilosa* and *Setaria glauca* in chir pine forest, *Sambuca nigra, Ruscus, Indigofera, Lonicera*, *Eunymus europaeus, Urena lobata, Viola* and *Liparis* in kail forest (Table 2). These species dominated in its absence. During the early phases of regeneration, it replaces the forest with invasive thickets and limits the light reaching forest ground (Chittka and Schurkens 2001). As being a vigorous individual with sufficient light in open grasslands habitat, it provides a large source of seeds to understory, where probability of successful recruitment increases with increased propagule pressure (Brym et al 2011).

The diversity indices (Shannon, Simpson, equitability and species richness) were highest in the habitat bearing *E. umbellata* (Table 3). The luxuriant richness of species was present at an altitudinal range below 1200 m, whereas at a higher altitudinal range greater than 1800 (Dhar and Shari), the species were scattered and equally distributed. Our findings were supported by earlier investigations that

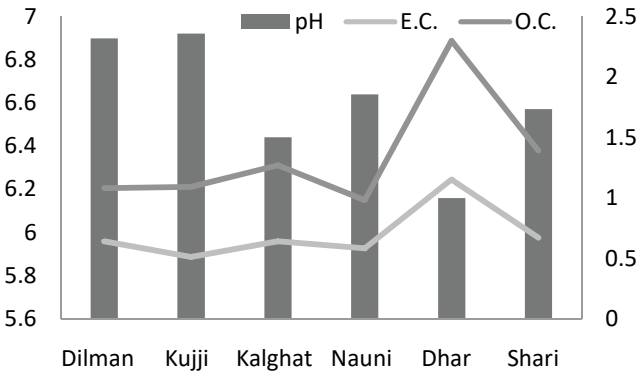

Fig. 1. Soil parameters (pH, EC, O.C.)

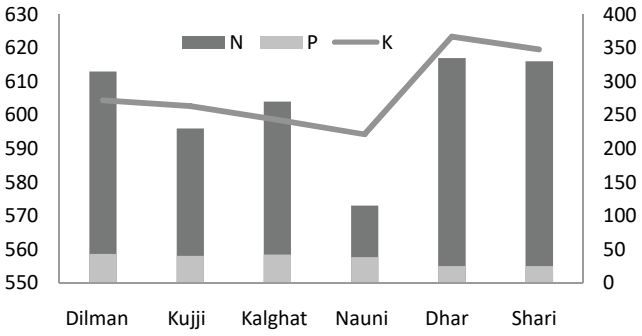

Fig. 2. Soil parameters (N, P, K)

demonstrated species richness increasing from the higher elevation towards the lower elevation (Kumar and Thakur 2008, Sharma et al 2009, Raturi 2012, Singh 2013).

E. umbellata alters the soil chemistry owing to the presence of root nodules that house nitrogen fixing actinomycetes (Baer et al 2006). The nodules favor pH above 5 and no nodulation is observed below pH 4 (Mohebbi and Mahler 1989). Electrical conductivity in the soils depicted significantly higher values ($P<0.05$) at a range of >1800 m, it is linked with the high nutrient pumping and deposition of organic matter on soil surface. *E. umbellata* Thunb. is a source of nitrate overload in both terrestrial and aquatic ecosystems, thus increasing levels of nitrogen in forest soils (Goldstein et al 2009) (Fig. 1). Significantly higher nitrogen levels ($P<0.05$) were observed at a range of >1800 m (Fig. 2). A single plant of *E. umbellata* Thunb. is sufficient to induce a change in composition of soil microbial communities. It releases higher than normal nitrate in surrounding soil environment that is a form of nitrogen used by plants for their growth (Brym et al 2011).

Table 1. Shrub species diversity in all the six locations and their IVI values

Species	Dilman		Kujji		Kalaghat		Nauni		Dhar		Shari	
	EP	EA	EP	EA	EP	EA	EP	EA	EP	EA	EP	EA
Berberis aristata	-		-	-	-	-	-	-	102.59	72.43	27.54	44.87
Berberis lycium	38.67	40.79	43.59	-	70.07	45.95	65.39	84.14	-	-	-	-
Carissa spinarum	24.48	20.22	21.48	33.49	12.50	-	-	-	-	-	-	-
Cassia floribunda	-	15.34	17.90	28.12	-	-	-	-	-	-	-	-
Coriaria nepalensis	-	16.43	-	-	-	-	-	-	-	-	-	-
Caryopteris wallichiana	15.22	20.93	10.16		16.44	-	-	-	-	-	-	-
Daphne spp.	-	-	-	-	-	-	-	-	-	28.59	15.40	19.66
Elaeagnus umbellata	76.87	-	63.22	-	41.96	-	74.98	-	135.91	-	59.06	-
Euonymus europaeus	-	-	-	-	-	-	-	-	-	94.91	-	-
Hypericum oblongifolium	15.23	-	31.68	-	13.81	26.67	29.50	15.21	-	-	-	-
Indigofera spp.	-	-	-	-	-	-	-	-	-	35.24	24.07	-
Lantana camara	-	40.29	-	60.30	-	34.90	-	31.72	-	-	-	-
Lonicera angustifolia	-	-	-	-	-	-	-	-	-	88.43	19.13	29.32
Lonicera interrupta	-	-	-	-	-	-	-	-	-	-	8.64	-
Murraya koenigii	-	-	-	-	-	-	24.71	-	-	-	-	-
Myrsine africana	-	46.33	-	61.90	-	-	29.33	-	-	-	-	-
Peritoma arborea	-	-	-	-	-	-	9.89	-	-	-	-	-
Plectranthus rugosus	-	-	-	-	-	-		-	-	-	18.60	-
Prinsepia utilis	-	-	18.50	-	18.26	22.36	31.36	50.06	43.12	48.31	34.60	30.53
Pseudocaryopteris bicolor	-	-	-	-	27.39	15.87	5.99	-	-	-	-	-
Rhamnus spp.	-	-	-	-	20.56	10.68	-	-	-	-	-	-
Rosa moschata	55.23	44.34	24.49	43.29	45.22	50.32	35.92	58.73	23.33	28.39	26.64	39.37
Rosa mulliganii	-	-	7.77	-	-	-		-	75.02	33.28	-	-
Rubus leucodermis	-	-	-	-	-	-	-	-	62.23	-	-	-
Rubus ellipticus	47.92	33.02	43.58	53.22	33.46	53.43	32.15	33.56	-	72.68	29.31	41.41
Rubus niveus	-	-	-	-	-	-	-	-	52.05	-	-	-
Ruscus aculeatus	-	-	-	-	-	-	-	-	30.91	-	-	30.66
Sambuca nigra	-	-	-	-	-	-	-	-	-	38.10	-	15.38
Sarcococca saligna	-	-	-	-	-	-	-	-	-	-	16.26	-
Symphoricarpos orbiculatus	-	-	-	-	-	-	-	-	-	79.25	-	-
Viburnum prunifolium	-	-	-	-	-	-	-	-	13.33	-	20.75	38.27
Zanthoxylum armatum	26.38	22.31	17.65	19.68	-	-	-	26.58	-	-	-	-

Here EP represents *E. umbellata* present, EA represents *E. umbellata* absent

Table 2. Herb species diversity in all the six locations and their IVI

Species	Dilman		Kujji		Kalaghat		Nauni		Dhar		Shari	
	EP	EA	EP	EA	EP	EA	EP	EA	EP	EA	EP	EA
Alternanthera pungens	-	-	-	-	-	-	-	-	-	-	27.51	-
Apluda mutica	14.09	20.56	11.94	11.39	-	13.11	-	16.49	-	-	-	-
Ageratum conyzoides	-	-	-	-	-	-	-	-	15.47	-	-	-
Artemisia	44.68	19.79	37.38	-	29.11	73.94	60.05	24.40	-	-	-	-
Arundinella	9.85	-	-	-	-	-	-	-	-	-	-	-
Athyrium attenuatum	5.64	6.09	10.48	27.43	-	-	-	-	21.91	18.08	-	-
Atriplex glauca	-	-	-	-	-	-	-	-	32.19	-	-	-
Avena	-	-	-	-	-	-	6.68	-	-	-	-	-
Barleria cristata	34.79	6.89	42.73	-	14.47	-	-	-	-	-	-	
Bidens Pilosa	-	58.61	-	32.19	77.72	51.19	44.20	82.28	-	-	-	-
Brixly oxtongue	17.09	29.29	+21.91	108.99	16.85	6.41	29.80	-	12.22	19.31	-	-
Cenchrus	-	-	-	-	-	-	-	-	13.51	-	-	-
Chrysopogon montanus	5.14	13.72	13.44	-	7.89	3.40	5.12	-	-	-	-	-
Clematis	-	-	-	16.04	10.63	4.88	5.03	6.30	-	-	-	17.92
Climber	-	-	-	-		-	-	-	-	-	7.63	
Convolvulus arvensis	-	-	-	-	-	-	-	-	10.40	-	-	-Contd.
Crepidium acuminatum	-	-	-	-	-	-	-	-	11.16	40.07	-	-
Crepis tectorum	-	-	-	-	-	-	-	-	-	-	12.01	-
Cirsium horridulum	-	-	-	-	10.21	-	9.17	-	-	-	-	-
Deutzia gracilis	-	-	-		25.22	-	-	-	-	-	-	-
Eleusine indica	-	-	39.81	21.46	-	-	-	-	19.10	9.38	37.52	39.28
Erigeron canadensis	61.31	18.85	25.02	19.88	-	33.45	25.33	49.69	23.17	-	16.67	62.83
Euphorbia hirta	-	-	-	-	-	-	-	-	-	18.31	-	-
Galinsoga parviflora	14.74	-	21.78	-	9.18	-	-	-	-	-	-	-
Habenaria intermedia	-	-	-	-	-	-	-	-	-	46.80	-	-
Hedera helix	-	-	-	-	-	-	-	-	11.24	26.51	8.61	-
Heteropogon contortus	14.62	8.23	4.23	-	-	17.05	3.34	25.52	-	-	-	8.35
Jasminum humile	-	-	-	-	-	-	14.40	-	-	-	-	-
Justicia simplex	-	-	-	-	8.31	-	-	-	-	-	-	-
Koeleria macrantha	-	-	-	-	10.65	-	6.71	-	-	-	-	-
Liparis nervosa	-	-	-	-	-	-	-	-	-	36.45	-	-
Oxalis corniculate	-	-	-	-	-	-	-	-	5.62	-	5.39	-
Panicum maximum	-	-	-	-	8.41	6.71	-	-	-	-	-	-
Parthenium hysterophorus	-	-	-	-	-	43.77	-	-	-	-	-	-
Paspalum notatum	15.48	-	-	-	-	-	3.35	-	-	-	-	-
Pennisetum purpureum	-	-	-	-	-	-	-	-	8.52	-	-	-
Pteris cretica	-	-	-	-	-	-	-	-	-	30.57	48.24	18.36
Rhynchosia minima	-	-	-	-	-	-	-	-	-	-	14.94	-
Rumex nepalensis	-	-	-	-	-	-	9.31	34.45	17.49	-	18.95	35.57
Saccharum filifolium	-	-	-	-	8.16	3.65	-	-	-	-	-	-
Setaria glauca	-	12.84	-	16.04	18.97	13.41	6.69	-	-	-	-	-
Smilax aspera	21.63	17.99	16.17	-	12.85	17.01	18.43	8.99	-	-	10.07	16.44
Spartina patens	-	-	-	-	-	-	-	-	-	-	13.77	-
Thalictrum foliolosum	10.56	-	12.16	-	4.69	-	11.65	-	-	-	-	-
Themeda anathera	12.69	42.83	-	-	11.61	10.34	24.36	18.90	-	-	-	-
Trifolium repens	-	-	15.67	21.24	-	-	18.11	27.87	23.20	26.34	26.84	35.16
Urena lobata	-	-	-	-	-	-	-	-	-	8.15	16.10	47.46
Urtica dioca	17.67	44.31	27.28	25.33	-	-	-	-	28.28	12.09	20.83	-
Vicia hirsuta	-	-	-	-	14.08	6.08	+	-	-	-	-	-
Viola	-	-	-	-	-	-	-	-	-	7.93	14.89	18.63

Here EP represents *E. umbellata* present, EA represents *E. umbellata* absent

Table 3. Vegetation indices in all the six locations

Population	Plant category	Vegetation indices							
		Simpson index (S)		Shannon Weiner (H)		Equitability index (E)		Species richness index	
		EP	EA	EP	EA	EP	EA	EP	EA
Dilman	Shrubs	0.902	0.85	2.32	2.009	1.008	0.9663	2.53	1.68
	Herbs	0.930	0.934	2.64	2.757	1.003	0.9906	3.12	3.45
Kujji	Shrubs	0.856	0.885	1.939	2.27	0.996	0.947	1.38	2.03
	Herbs	0.924	0.92	2.31	2.6	1.006	0.988	1.93	2.60
Kalaghat	Shrubs	0.890	0.8693	2.19	2.21	1.001	0.922	2.06	2.26
	Herbs	0.93	0.946	2.65	2.86	1.005	1.012	3.05	3.69
Nauni	Shrubs	0.811	0.864	1.802	2.084	0.9258	0.9485	1.49	1.87
	Herbs	0.904	0.9225	2.399	2.68	0.9653	0.9459	2.51	3.71
Dhar	Shrubs	0.900	0.882	2.358	2.22	0.9835	0.9658	2.19	1.97
	Herbs	0.900	0.923	2.38	2.61	0.96	0.9892	2.54	2.70
Shari	Shrubs	0.8828	0.882	2.106	2.242	1.013	0.9351	1.74	2.11
	Herbs	0.9185	0.865	2.57	2.052	0.9768	0.9868	1.57	2.91

Here EP represents *E. umbellata* present, EA represents *E. umbellata* absent

CONCLUSION

Several worthwhile wild species face obscurities due to dearth of study and anonymity. The present study has illustrated the significance of *E. umbellata* in distinct habitats, at three altitudinal gradients in north-west Himalayas. The shrub occupies various forests, hosting numerous shrubs, herbaceous vegetation and soil microbes underneath its canopy. Juxtaposing habitats bearing *Elaeagnus* with the non-bearing ones, edaphic and phytosociological attributes were more inclined towards the *Elaeagnus* bearing habitats. *E. umbellata* Thunb. is renowned for its soil binding and nitrogen fixing characteristics simultaneously. Therefore, we recommend *E. umbellata* for plantation in degraded landscapes and reforesting mountainous regions. The wild shrub provides anchorage to multitudinal species, that are unable to establish themselves in stress conditions in a particular habitat.

REFERENCES

Ahmad SD, Sabir MS, Juma M and Asad HS 2005. Morphological and biochemical variations in *Elaeagnus umbellata* Thunb. from mountains of Pakistan. *Acta Botanica Croatica* **64**: 121-128.

Ahmad SD, Sabir SM and Zubair M 2006. Ecotypes diversity in autumn olive (*Elaeagnus umbellata* Thunb.): A single plant with multiple micronutrient genes. *Chemistry and Ecology* **22**: 509-521.

Attri V, Sharma DP and Dhiman R 2017. Floristic diversity and natural regeneration status of chir pine (*Pinus roxburghii* Sargent) forest: A case study of Rajgarh forest division of Himachal Pradesh. *Bulletin of Environment Pharmacology and Life Sciences* **6:** 1-6.

Baer SG, Church JM, Williard KW and Groninger JW 2006. Changes in intra-system N cycling from N_2-fixing shrub encroachment in grassland: multiple positive feedbacks. *Agriculture, Ecosystems and Environment* **115**: 174-182.

Baker D, Torrey JG and Kidd GH 1979. Isolation by sucrose-density fractionation and cultivation *in vitro* of actinomycetes from nitrogen-fixing root nodules. *Nature* **281**: 76-78.

Brym ZT, Lake JK, Allen D and Ostling A 2011. Plant functional traits suggest novel ecological strategy for an invasive shrub in an understorey woody plant community. *Journal of Applied Ecology* **48**: 1098-1106.

Chittka L and Schurkens S 2001. Successful invasion of a floral market: An exotic Asian plant has moved in on Europe's river-banks by bribing pollinators. *Nature* **411**: 653-653.

Curtis JT and McIntosh RP 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology* **31**: 434-455.

Devi NL, Singha D and Tripathi SK 2018. Tree species composition and diversity in tropical moist forests of Mizoram, Northeast India. *Indian Journal of Ecology* **45**: 454-461.

Gairola S, Sharma CM, Suyal S and Ghildiyal SK 2011. Species composition and diversity in mid-altitudinal moist temperate forests of the western Himalaya. *Journal of Forest Sciences* **27**: 1-15.

Gamba G, Donno D, Mellano MG, Riondato I, De BM, Randriamampionona D and Beccaro GL 2020. Phytochemical characterization and bioactivity evaluation of autumn olive (*Elaeagnus umbellata* Thunb.) pseudodrupes as potential sources of health-promoting compounds. *Applied Sciences* **10**: 4354-4355.

Goldstein CL, Williard KW and Schoonover JE 2009. Impact of an invasive exotic species on stream nitrogen levels in southern Illinois. *Journal of the American Water Resources Association* **45**: 664-672.

Gupta B, Mehta R and Mishra VK 2009. Fire ecology of ground vegetation in *Pinus roxburghii* Sargent plantations in north-west Himalaya-floristic composition and species diversity. *Caspian Journal of Environmental Sciences* **7**: 71-78.

IUFRO 2020. *Forests, Trees and the Eradication of Poverty: Potential and Limitations - A Global Assessment Report*. International Union of Forest Research Organizations, Vienna, Austria.

Jendresen MN and Rasmussen LV 2022. The importance of forest foods for diet quality: A case study from Sangthong District, Laos. *Trees, Forests and People* **7:** 100166.

Joshi VC, Sundriyal RC and Arya D 2021. Forest floor diversity, distribution and biomass pattern of oak and chir-pine forest in the

Indian Western Himalaya. *Indian Journal of Ecology* **48**: 232-237.

Kim SC, Kim CH, An CS, Ku CD, Park MC and Song SD 1993. Isolation of symbiotic *Frankia* Eulk1 strain from root nodule of *Elaeagnus umbellata*. *Korean Journal of Botany* **36**: 177-182.

Kumar R and Thakur V 2008. Effect of forest fire on trees, shrubs and regeneration behavior in chir pine forest in northern aspects under Solan forest division, Himachal Pradesh. *Indian Journal of Forestry* **31**: 19-27.

Magurran RA 1988. *Ecological Diversity and its Measurement*, University Press, Cambridge, p 179.

Malik ZA and Bhatt AB 2015. Regeneration status of tree species and survival of their seedlings in Kedarnath wildlife sanctuary and its adjoining areas in western Himalaya, India. *Tropical Ecology* **25**: 677-690.

Mishra R 1968. *Ecology workbook*, Oxford and IBH Publishing Company, Calcutta, 244p.

Mohebbi S and Mahler RL 1989. The Effect of soil ph on wheat and lentils grown on an agriculturally acidified northern Idaho soil under greenhouse conditions. *Communications in Soil Science and Plant Analysis* **20:** 359-381.

Newton P, Kinzer AT, Miller DC, Oldekop JA and Agrawal A 2020. The number and spatial distribution of forest-proximate people globally. *One Earth* **3**: 363-370.

Paudel SB, Han AR, Choi H and Nam JW 2020. Phytochemical constituents of leaves and twigs of *Elaeagnus umbellata*. *Biochemical Systematics and Ecology* **93**: 104-178.

Philips BA 1959. *Methods of Vegetation Study*, Henry Holt & Co., Inc., USA, p 450.

Received 10 February, 2023; Accepted 15 July, 2023

Pichura VI, Domaratsky YA, Yaremko YI, Volochnyuk YG and Rybak VV 2017. Strategic ecological assessment of the state of the transboundary catchment basin of the Dnieper river under extensive agricultural load. *Indian Journal of Ecology* **44**: 442-450.

Raturi GP 2012. Forest community structure along an altitudinal gradient of district Rudraprayag of Garhwal Himalaya, India. *Ecologia* **2**: 76-84.

Shannon CE and Wiener W 1963. *The Mathematical Theory of Communication.* University Illinois Press, Urbana, USA, p 117.

Sharma CM, Suyal S, Gairola S and Ghildiyal SK 2009. Species richness and diversity along an altitudinal gradient in moist temperate forest of Garhwal Himalaya. *Journal of American Science* **5**: 119-128.

Sharma CM, Suyal S, Gairola S and Ghildiyal SK 2010. Role of physiographic factors in distribution of *Abies pindrow* (silver fir) along an altitudinal gradient in Himalayan temperate forests. *The Environmentalist* **30**:76-84.

Sharma Y 2006. *Studies on stand parameters and natural regeneration status of silver fir and spruce in Himachal Pradesh*. M.Sc. Thesis, Department of Silviculture and Agroforestry, YSP University of Horticulture & Forestry, Solan.

Simpson EH 1949. Measurement of diversity. *Nature* **163:** 680-688.

Singh D 2013. *Forest structure, diversity, growing stock variation and regeneration status of different forest cover types in Dudatoli area of Garhwal Himalaya*. Ph.D. Thesis, HNB Garhwal University Srinagar Garhwal, India.

Slobodkin LB and Sanders HL 1969. On the contribution of environmental predictability to species diversity. *Brookhaven Symposia in Biology* **22**: 82-95.