https://doi.org/10.30799/jespr.225.22080301 J. Environ. Sci. Pollut. Res. - Volume 8 Issue 3 (2022) 475–478

Share Your Innovations through JACS Directory

Journal of Environmental Science and Pollution Research

Visit Journal at https://www.jacsdirectory.com/jespr

ISSN: 2455-0272

Proliferation of Invasive Alien Species in Different Forest Types of Western Himalaya

Anita Mehra[1,*], Lalit M. Tewari[1], Ranbeer S. Rawal[2], Hema Joshi[1]

[1]*Department of Botany, DSB, Campus, Kumaun University, Nainital – 263 001, Uttarakhand, India.*
[2]*Department, G.B. Pant National Institute of Himalayan Environment & Sustainable Development, Kosi-Katarmal, Almora – 263 643, Uttarakhand, India*

ARTICLE DETAILS

Article history:
Received 21 September 2022
Accepted 17 October 2022
Available online 07 November 2022

Keywords:
Invasive Alien Species
Proliferation
Forest Types

ABSTRACT

Present study was carried out to understand the proliferation status of invasive alien species (IAS) along altitudinal gradient (650-2150 m) in different forest types (Sal, Pine, Oak and Deodar) of western Himalaya. To understand the trend of proliferation of invasive species repeat vegetation survey and quantitative analysis method used in same plots after two years. Major invasive species in the region were *Lantana camara, Ageratina adenophora, Ageratum conyzoides* and *Parthenium hysterophorus. Ageratina adenophora* was highly spreading invasive species present in all forest type of the study area. Maximum density (8394 ind/ha.) and frequency (64.15%) was recorded in Pine forest. Important value index (IVI) of *Ageratina adenophora* increase from 23.4 to 25.71 in Pine forest followed by in Sal forest (6.32 to 8.21) and Deodar forest (11 to 12.53). Maximum density (246 ind/ha.) and frequency (41%) of *Lantana camara* recorded in Sal forest and IVI increase from 29.9 to 30.78. Oak forest allowed less rate of invasion of alien species. In study area with increase elevation number of invasive species decrease. However, high proliferation rate of *Ageratina adenophora* recorded at an elevation 2150 m asl in moist Deodar forest.

1. Introduction

The Himalaya has been recognized as one of the 36 global biodiversity hotspots for its unique and rich biodiversity that is under severe threats [1-2]. Human disturbances, particularly from the overexploitation of biological resources, generally have negative impacts on species diversity at a global scale [3]. In India, habitat destruction, over exploitation, pollution and alien species introduction were identified as major causes of biodiversity loss. After the habitat loss, the invasion of alien plant species has become the second-highest threat to plant diversity [4]. Biological invasions are widespread and significant component of global environmental change, which lead to the loss of biodiversity and ecosystem services through altering native biodiversity, community structure, composition and functions [5-7]. Climate is one of the important determinants of vegetation patterns globally and has significant influence on the ecology of forests [8]. Global climate change has been reported to favour the proliferation of invasive alien species [9]. Climate change may increase the chances for introduction and spread of alien invasive plants [10]. The first inventory on invasive alien plant species of India was compiled by Reddy [11]. In Indian Himalaya region (IHR), specifically in west Himalaya, *Ageratina adenophora* was recorded an aggressive alien species [12]. While considering the diversity of invasive species in IHR regions, a total of 190 species were reported as invasive alien species [13]. Present study was carried out in four different forest type of western Himalaya to know the proliferation status of invasive and alien species along altitude gradient. Proliferation of invasive species were analysed by repeat vegetation survey and calculated density, frequency, abundance and dominance in the same area after two years.

2. Experimental Methods

2.1 Study Area

The Western Himalaya comprises of Garhwal and Kumaun region covering an area of about 30,000 sq km abounds forests, meadows, marshes and swamps with their characteristic plant composition. Present study was carried out in Elevation ranges from 650m – 2150 m asl from bank of river Ramganga to Chandak area known as Chandak-Aunla Ghat watershed (Fig. 1). The Latitude (N) and Longitude (E) of the study area are $29^0 37'0.36''$ and $80^0 09'42.05''$ respectively. The study site supports a variety of forest vegetation. The river (Ramganga) valleys were dominated by Sal forests, while the mid portion dominated by Pine forest and increasing elevation Banj oak replace the Pine forest and Deodar forest were located in the upper ridges of the study area. Major part (66%) of the study site was under forest, 30.39% used for agriculture and 2.80% for settlement.

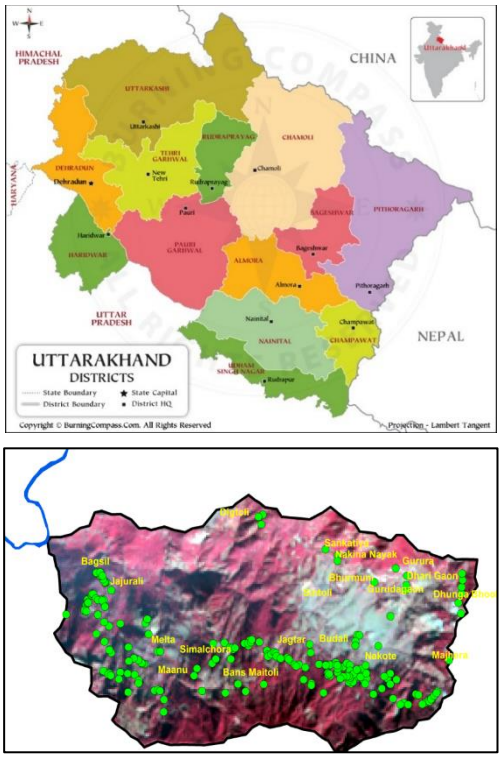

Fig. 1 Geographical location of the study area with sampling location of invasive alien species

*Corresponding Author:annumehra414@gmail.com(Anita Mehra)

https://doi.org/10.30799/jespr.225.22080301

Cite this Article as: Anita Mehra, Lalit M. Tewari, Ranbeer S. Rawal, Hema Joshi, Proliferation of invasive alien species in different forest types of Western Himalaya, J. Env. Sci. Pollut. Res. 8(3) (2022) 475–478.

2.2 Methods

Vegetation data was gathered by quadrat method [14]. For vegetation assessment 3 (50 x 50 m) permanent plot was marked in Sal, Pine, Oak and Deodar forest. GPS point of four corners was recorded and proper marked with tag. After two-year again vegetation data was collected. Inside the larger plot, ten (10 ×10 m) quadrats were laid for assessment of tree species. Inside the 10 ×10m quadrat, 2 (5 x 5 m) quadrats for shrubs and 4 (1 x 1 m) quadrats for herbs were laid. The vegetational data were quantitatively analyzed for density, frequency, abundance and dominance following [14-15]. The Importance Value Index (IVI) was computed for all the tree and shrub species by adding the relative values of frequency, density and dominance (basal area) [16-17]. For herb importance value index (IVI) was calculated by adding relative frequency (RF), relative density (RD) and relative abundance (RA) of the species [18]. Proliferation of invasive species were analysed by repeat vegetation survey in each season, and calculate density, frequency, abundance and dominance in same plots after two-year gap.

3. Results and Discussion

Sal, Chir pine, Deodar and Banj oak are among the most dominated forest types in the western Himalaya. These forests serve the lifeline for local communities for their daily sustenance. However, very recently these forests were invaded by various invasive alien species with different intensities. It was observed that Sal and Pine forest were highly invaded by invasive species. Major invasive plants in study area were *Lantana camara L.* (Verbenaceae), *Ageratina adenophora* (Spreng.) R. M. King and H. Rob. (Asteraceae), *Ageratum conyzoides L.* (Asteraceae) and *Parthenium hysterophorus L.* (Asteraceae).

Table 1 Density (D, ind/ha), frequency(F), abundance (A), relative density (RD), relative frequency (RF) and Important value index (IVI) of different invasive species across diverse forest types

Species	First year						Third Year					
Sal forest	D	RD	F	RF	A	IVI	D	RD	F	RF	A	IVI
Ageratum conyzoides	1150	2.05	7	2.42	3.65	8.12	1210	2.12	7	2.34	1.93	8.47
Lantana camara	246	10.1	41	9.15	1.49	30	269	11.02	42	9.23	1.6	30.7
Ageratina adenophora	560	1.03	3	1.04	1.8	6.3	730	1.67	4.5	1.5	1.46	8.21
Parthenium hysterophorus	510	0.93	3	1.04	1.6	5.9	550	1.01	3	1	1.67	6.13
Pine forest												
Ageratina adenophora	8394	10.29	64.1	10.3	1.3	23.4	9725	11.64	67.5	11.4	1.43	25.7
Oak forest												
Ageratina adenophora	667	1.05	4.17	0.98	1.6	5.1	833	1.31	4.58	1.07	1.82	5.84
Deodar forest												
Ageratina adenophora	162	2.69	5	1.35	3.25	11	2450	4.12	10	2.7	2.38	12.5

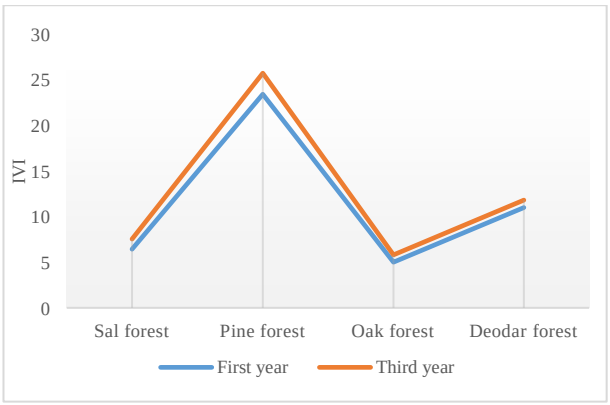

Fig. 2 Proliferation rate *Ageratina adenophora* in different forest types

To understand the trend of proliferation we assessed the rate of invasion at two years interval across various forest types. *Ageratina adenophora* was highly spreading invasive species present in all forest type of watershed. Maximum density (8394 ind/ ha.) and frequency (64.15%) recorded in Pine forest, IVI of *Ageratina adenophora* increase from 23.4 to 25.71 in pine forest (Fig. 2) followed by in Sal (6.32 to 8.2) and Deodar forest (10 to 11.78). *Ageratum conyzoides, Lantana camara* and *Parthenium hysterophorus* was recorded in Sal dominating forest of study area. *Lantana camara* (density (246 ind/ha., frequency 41%) proliferate highly in Sal forest, IVI increase from 29.9 to 30.8 followed by *Ageratum conyzoides* (density 1150/ha IVI increased 8.12 to 8.47). *Lantana camara* and *Parthenium hysterophorus* were frequently observed along road sides while *Ageratina adenophora* mostly observed near river bank. Oak forest allow less invasion (density 667 ind/ ha. and frequency 4.67) among all forest (Table 1). The proliferation rate of *Lantana camara* in Sal Forest was 0.51% (Fig. 3). *Ageratina adenophora* proliferate rapidly (0.65%) in deodar forest however maximum area under invasion recoded in Pine forest (Fig. 4). *Ageratum conyzoides* and *Parthenium hysterophorus* proliferate slowly in forest as compare to *Lantana camara* and *Ageratina adenophora*.

In pine forest high dominance of *Ageratina adenophora* due to the high canopy opening and grazing in the region. Low canopy cover (30%), high lopped tree individuals and heavy grazing signs were found in highly disturbed areas in the village forests, supporting high dominance of *Ageratina adenophora* among other herb species. Most of oak forest in the region were under van panchayat and they were well managed by communities, allowed less invasion by alien species. In general, *Ageratina adenophora* had wide distribution from villages forests, fringes of agriculture lands, forests, along road sides and water streams courses covering about 70- 74% of the cover. *Parthenium hysterophorus* mostly recorded in degraded and near community forest.

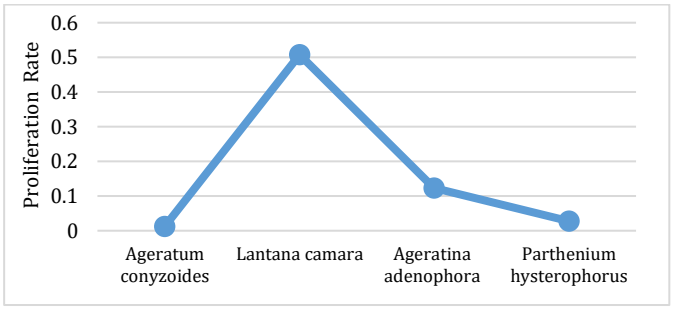

Fig. 3 Proliferation rate of invasive alien species in Sal forest

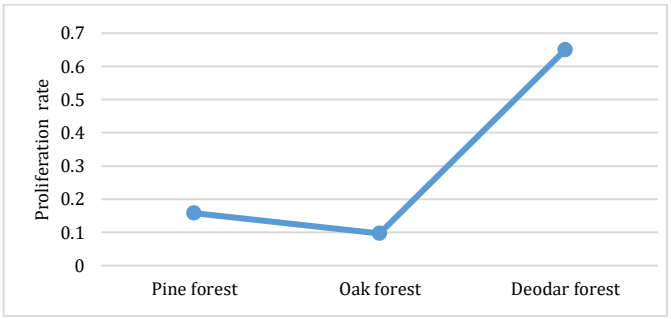

Fig. 4 Proliferation rate of *Ageratina adenophora* in Pine, Oak and Deodar forest

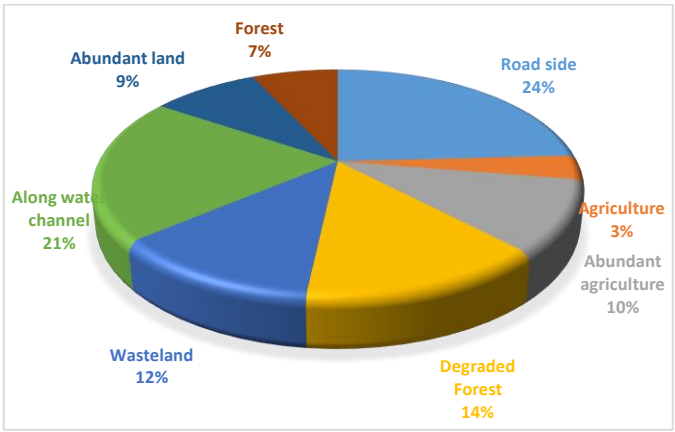

Fig. 5 Distribution of invasive alien species in different habitat

Fig. 5 illustrated the habitat of invasive species in study area. Maximum distribution of invasive alien species was recorded near road sides and along water bodies. *Ageratum conyzoides* maximum observed in abundant agriculture land. *Lantana camara* maximum recorded in wasteland and *Parthenium hysterophorus* maximum recorded in road side. However *Ageratina adenophora* was recorded in all habitat in in study area.

https://doi.org/10.30799/jespr.225.22080301

Cite this Article as: Anita Mehra, Lalit M. Tewari, Ranbeer S. Rawal, Hema Joshi, Proliferation of invasive alien species in different forest types of Western Himalaya, J. Env. Sci. Pollut. Res. 8(3) (2022) 475–478.

Climatic and habitat conditions are known to affect the altitudinal distribution of alien species in mountainous regions [19]. Among various invasive species, *Lantana camara*, *Ageratina adenophora*, *Parthenium hysterophorus* and *Ageratum conyzoides* were reported from most of the states of IHR and proliferated over larger area [20]. These species also recorded in present study. *Ageratina adenophora* proliferate in all forest types of study area. A total of 297 naturalized alien plant species belongs to 65 families in the IHR are reported. Of the total 297 naturalized alien plant species in IHR, maximum species occur in Himachal Pradesh (232; 78.1%) followed by Jammu & Kashmir (192; 64.6%) and Uttarakhand (181; 60.90%) [20]. Studies showed *Lantana camara* affect Poor forest regeneration and crop production; significant loss of species richness and diversity in invaded localities. *Ageratina adenophora* reduced crop production by reducing seed germination, also reported allergy from seeds to humans; replacement of native species. *Parthenium hysterophorus* change physico-chemical properties of soil; adversely affect the germination and the seedling growth of native plants; reduction in species richness in infested areas [21-22]. Roads, waterways and anthropogenic activity were the main modes of transmission of invasive species from one place to another place in the study area. Bhattarai et al., [23] also reported that road construction was major cause of plant invasion in mountainous regions of India and Nepal. Chaudhary et al. [24] reported altitude; soil texture, distance from disturbance site such as road and village/settlement as well as a water source as the distance from nearest drainage play a major role in the invasion of *Ageratina adenophora*. In Present study it was observed that anthropogenic disturbance, water channel and roads were play a major role in proliferation of invasive species.

3.1 Trend of Proliferation

A elevation regulates the microclimate of an area; therefore, it also regulates the patterns of vegetation [25]. It was observed that the highest *Ageratina adenophora* invasion (density 8394ind/ha frequency 64.15%) was in between 1400 – 1700m elevation gradient in Pine forest and the lowest presence (density 510 ind/ha frequency 1.1%) detected between 650 – 750m in Sal forest. *Lantana camara* showed high proliferation rate (0.51%) in Sal forest. Oak forest showed less invasion because managed by community where low human interference observed. In study site recent invasion in Deodar forest (2100 m) recorded. Shady and moist climate of Deodar forest makes favourable climate for proliferation of *Ageratina adenophora* (frequency increase from 5 to 10%). *Lantana camara*, *Ageratum conyzoides* and *Parthenium hysterophorus* recorded from 600 to 1000 m elevation in study area. However, there was no corelation found between elevation and density of *Ageratina adenophora* (Fig. 6).

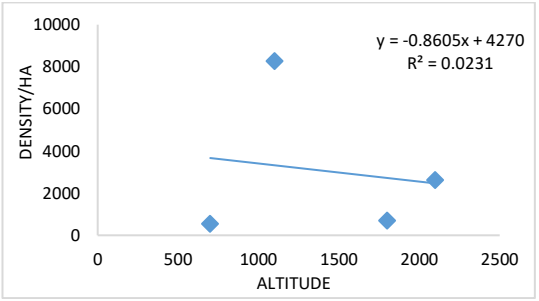

Fig. 6 Correlation between density of invasive species and altitude

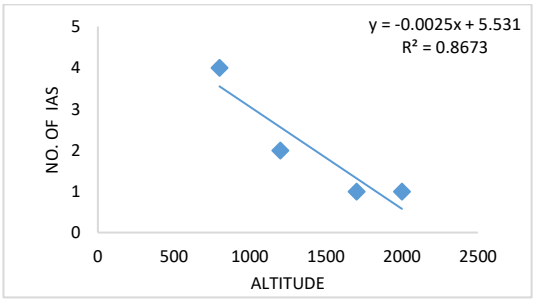

Fig. 7 Correlation between number of invasive species and altitude

This depicted elevation did not affect the density of *Ageratina adenophora*, only need favourable climatic condition. A strong negative correlation exhibited between elevation and number of invasive alien species means with increase elevation number of invasive species decrease (Fig. 7). Community managed forest showed less density and abundance of *Ageratina adenophora*. Natural and direct anthropogenic disturbances are known to promote invasion of exotic species [26]. Hence it could be concluded that the water channel, disturbance or anthropogenic activities are favourable for the distribution of alien species.

3.2 Management

Roads and waterways seem to be the main channels for the spread of *Ageratina adenophora.* Management to control this exotic should focus on habitats along roads and streams. It was found that several invasive species were used for different purposes [13]. In study area people use *Ageratina adenophora* ethnobotanically in cut and wound healing. *Parthenium hysterophorus* mostly reported in road side in lower altitude area of study area also reported in abundant agriculture land. Plantation of native species in degraded site and plantation of grass species, bamboo in abundant land could help in further distribution. The best form of invasive species management is prevention. Infestation when they are small and manual eradication considered to be the most effective approach to its long-term control. *Lantana camara* is a major weed along roadsides, riparian zones (river banks), fence-lines, forest, pastures and waste areas. Invasive alien plants have an advantage over the natives because of the escape from their natural enemies of their native ranges [27]. So biological control is low-cost environment friendly approach. Invasive plants degrade ecosystem in many ways community participation and awareness in necessary for proper management. It was observed that most of oak forest in watershed under van panchayat and they were well managed by people they showed less invasion by invasive species. In study area asthmatic allergy and Respiratory irritation were observed among the local people due to high exposure to *Parthenium hysterophorus and Lantana camara.* While *Ageratina adenophora* and *Lantana camara* was poisonous to cattle and human being.

4. Conclusion

Lantana camara, *Ageratum conyzoides*, *Parthenium hysterophorus* and *Ageratina Adenophora* was major invasive species present 650-2150 m asl elevation range in different forest types (Sal, Pine, Oak and Deodar) of western Himalaya. *Ageratina Adenophora* proliferate rapidly in all forest type of watershed maximum density and frequency was recorded in Pine forest at altitude 1300-1700 m asl. At lower altitude, *Lantana camara* proliferate highly. It was observed *Ageratina Adenophora* replace the grass cover in pine forest where invasion of *Lantana camara* affect the growth of other plant. Manual eradication, eradication at early stage, using the species in compost and awareness among people will be helpful for management of these invasive alien species. The increased incidence of invasion in high altitudinal ecosystems possesses a major threat to the indigenous biological diversity of the region. In present study high proliferation rate of *Ageratina adenophora* recorded at an elevation 2150 m asl. The further distribution of this alien species in the Himalayan region is alarming sign for biodiversity and ecosystem services.

References

[1] L.M.S. Palni, R.S. Rawal, The himalayan biodiversity: richness, representativeness, uniqueness and life-support values, G.B. Pant Institute of Himalayan Environment and Development (GBPIHED), Almora, 2013.
[2] E. Sharma, D. Molden, P. Wester, R.M. Shrestha, The Hindu Kush Himalayan monitoring and assessment programme: action to sustain a global asset, Mt. Res. Dev. 36(2) (2016) 236-239.
[3] J.C. Abadie, N. Machon, A. Muratet, E. Porcher, Landscape disturbance causes small-scale functional homogenization, but limited taxonomic homogenization, in plant communities, J. Ecol. 99(5) (2011) 1134-1142.
[4] R. Hobbs, S. Humphries, An integrated approach to the ecology and management of plant invasions, Conservational Bio. 9 (1995) 761-770.
[5] D. Tilman, The ecological consequences of changes in biodiversity: a search for general principals, Ecology 80(5) (1999) 1455-1474.
[6] J.G. Ehrenfeld, Effects of exotic plant invasions on soil nutrient cycling processes, Ecosystems 6(6) (2003) 503-523.
[7] K.A. Yurkonis, S.J. Meiners, B.E. Wachholder, Invasion impacts diversity through altered community dynamics, J. Ecol. 93(6) (2005) 1053–1061.
[8] M.U. Kirschbaum, Forest growth and species distribution in a changing climate, Tree Physiol. 20(5–6) (2000) 309-322.
[9] G.R. Walther, A. Roques, P.E. Hulme, M.T. Sykes, P. Pyšek, et al., Alien species in a warmer world: risks and opportunities, Trends Ecol. Evol. 24(12) (2009) 686–693.
[10] IUCN, Invasive alien species and climate change, 2017. Retrieved from https://www.iucn.org/sites/dev/files/ias_and_climate_change_issues_brief_final.pdf (Accessed on: 14.04.2021)
[11] C.S. Reddy, Catalogue of invasive alien fora of India, Life Sci. J. 5(2) (2008) 84-89.

https://doi.org/10.30799/jespr.225.22080301

[12] Y.L. Zheng, Y.L. Feng, W.X. Liu, Z.Y. Liao, Growth, biomass allocation, morphology, and photosynthesis of invasive *Ageratina adenophora* and its native congeners grown at four irradiances, Plant Ecol. 203(2) (2009) 263–271.
[13] K. Chandra Sekar, Invasive Alien plants of Indian Himalayan region- diversity and implication, Amer. J. Plant Sci. 3 (2012) 177-184.
[14] R. Misra, Ecology Work Book, Oxford and IBS Publishing Company, Calcutta, 1968.
[15] D. Mueller-Dombois, H. Ellenberg, Aims and methods of vegetation ecology, Wiley, New York, 1974.
[16] J.T. Curtis, R.P. McIntosh, The interrelations of certain analytic and synthetic phytosociological characters, Ecol. 31 (1950) 438-455.
[17] W.H. Brown, J.T. Curtis, The upland conifer-hardwood forests of northern Wisconsin, Ecol. Monogr. 22 (1952) 217-234.
[18] E.A. Philips, Methods of vegetation study, Henery Halt and Co. Inc., USA, 1959.
[19] S. Haider, J. Alexander, H. Dietz, L. Trepl, P.J. Edwards, C. Kuefer, The role of bioclimatic origin, residence time and habitat context in shaping non-native plant distributions along an altitudinal gradient, Biol Invasions 12(12) (2010) 4003–4018.
[20] R. Pathak, V.S. Negi, R.S. Rawal, I.D. Bhatt, Alien plant invasion in the Indian-Himalayan Region: state of knowledge and research priorities, Biodivers. Conserv. 28 (2019) 3073–3102.
[21] R.K. Kohli, K.S. Dogra, D.R. Batish, H.P. Singh, Impact of invasive plants on the structure and composition of natural vegetation of north western Indian Himalayas, Weed Technol. 18 (2004) 1296–1300.
[22] K.S. Dogra, R.K. Kohli, S.K. Sood, An assessment and impact of three invasive species in the Shivalik hills of Himachal Pradesh, India, Int. J. Biodivers. Conserv. 1(1) (2009) 4–10.
[23] K.R. Bhattarai, I.E. Maren, S.C. Subedi, Biodiversity and invasibility: Distribution patterns of invasive plant species in the Himalaya, Nepal J. Mt. Sci. 11 (2014) 688-696.
[24] A. Chaudhary, B.S. Adhikari, N.C. Joshi, G.S. Rawat, Patterns of invasion by crofton weed (*Ageratina adenophora*) in Kailash sacred landscape region of western Himalaya (India), Envi. Cons. J. 20(3) (2019) 9-17.
[25] R. Busing, P.S. White, M. Mac Kende, Gradient analysis of old spruce-fir forest of the Great Smokey Mountains circa 1935, Canad. J. Bot. 71 (1992) 951-958.
[26] R. Hobbs, L.F. Huenneke, Disturbance, diversity and invasion: implications for conservation, Conserv. Biol. 6 (1992) 324-337.
[27] R.H. Messing, M.G. Wright, Biological control of invasive species: solution or pollution?, Front. Ecol. Environ. 4(3) (2006) 132-140.

https://doi.org/10.30799/jespr.225.22080301

Cite this Article as: Anita Mehra, Lalit M. Tewari, Ranbeer S. Rawal, Hema Joshi, Proliferation of invasive alien species in different forest types of Western Himalaya, J. Env. Sci. Pollut. Res. 8(3) (2022) 475–478.