Impact of Invasive Alien Plant Species (IAPS) on Native Flora in Barandabhar Forest Corridor, Nepal

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Abstract

Chitwan National Park is currently under invasion by different Invasive Alien Plant Species (IAPS) thereby increasing threat to native flora and fauna. This study was conducted in southern part of Barandabhar Forest Corridor to list out IAPS, identify the occurrence of IAPS, and calculate various ecological indices of flora and also to explore local IAPS control practices. Nine Buffer Zone Community Forests (BZCFs) of Chitwan National Park were selected for transect walk to list out IAPS. Vegetation sampling and key informant survey were conducted in two community forests that were highly influenced by invasion (realized during transect walk). A total of 14 IAPS were found invading the habitat. Highest occurrence was recorded for *Chromolaena odorata* which was dominant in *Shorea robusta* forest with open canopy cover. Vegetation analysis reveals high invasion in Milijuli BZCF than Tikauli BZCF. Simpson's diversity Index and Shannon-Wiener diversity Index for Milijuli were 0.32 and 1.51 respectively; and for Tikauli it was 0.26 and 1.75 respectively. Various local control measures were practised by each community forests such as cutting, uprooting and fire to resist the IAPS but were not effective. Early detection and uprooting of IAPS before flowering was recommended for controlling in initial stage of its invasion.

Keywords: Barandabhar corridor, BZCFs, Diversity index, IAPS, Native flora, Occurrence

Introduction

Challenging era of “invasion” has already started in globe following human activities. Nepal is also suffering from the introduction of Invasive Alien Plant Species (IAPS). As many as 179 species of these plants are naturalized (Shrestha et al., 2018) in different ecosystems with higher invasion in eastern and central parts of the country than the western region (Bhattarai et al., 2014) with majority of concentration lying in Terai and Siwalik regions (Poudel, 2016). Most of these invasive species are natives of the Americas. For Asia Pacific region, top invasive species include *Ageratina adenophora, Ageratum conyzoides, Chromolaena odorata, Eichhornia crassipes, Lantana camara, Mikania micrantha and Parthenium hysterophorus* (Sankaran et al., 2005). Nepal has a long history of introduction of such species and pioneer contributors were the British who brought economically important plants from almost all continents to the Indian sub-continent and later introduced in Nepal (Nurul Islam, 1991). Moreover, gardeners, horticulturists, foresters and the retired British Gorkha soldiers have also facilitated introduction of IAPS in Nepal (Kunwar, 2003). IAPS have potentiality to rapidly colonize range of habitats, which in turn modify plant community and ecological processes like nutrient cycling, energy flow or hydro-dynamic properties of the native ecosystem (Huston, 2004). Numerous natural or agri-ecosystems are damaged by forest invasive species which includes native forests and biodiversity (Srivastava & Singh, 2009). Not only loss of biodiversity but commercial value of biodiversity also deplete due to invasion. There are great concerns to production forestry because IAPS are associated with economic impacts (Padmanaba & Corlett, 2014). Many researchers have raised concerns of IAPS colonization at the boundary between protected areas and human-dominated areas (Alston & Richardson, 2006). Although IAPS are exerting serious pressures in conservation of native ecosystems in CNP and its Buffer Zone, these problems are not being taken seriously (Sapkota, 2007). Considering the importance of CNP as a protected area coupled with its importance as globally renowned conservation of biological richness, this study on biological invasion was conducted at its buffer zones as the latter have management implications as entry point to extend in entire areas.

Materials and Methods

Study Area

The study was conducted in Barandabhar forest which is a trans-boundary corridor that connects two important protected areas to Mahabharat range namely the Chitwan National Park (CNP), Nepal; and the Valmiki Tiger Reserve, India in the south and is intersected by east-west Mahendra Highway. The corridor is surrounded by Bharatpur sub-metropolitan city in the west and Ratnanagar and Kalika municipality in the east.

Barandabhar forest comprises of vegetation dominated by *Shorea robusta* and partly by tall and short grassland. Winter, summer and monsoon are the notable seasons. Temperature can vary from minimum at 8° C during January to maximum of 37°C during April (DNPWC, 2015). Nine Buffer Zone Community Forests namely Ban Devi Barandabhar (254.25 ha), Nawa Jyoti (62.05 ha), Dakshinkali (165 ha), Batuli Pokhari (67.07 ha), Belsahar (204.40 ha), Tikauli (79.35 ha), Milijuli (45.66 ha), Chitrasen (185.01 ha) and Baghmara (215 ha) were selected as study area and among the nine Buffer Zone Community Forests, Tikauli and Milijuli were selected for vegetation analysis and key informants survey.

Vegetation Sampling

Systematic sampling was carried out in Tikauli and Milijuli BZCFs. 25*20 m^2 quadrates were allocated in front and left side of the sample plot for trees and nested plots of 5*5 m^2 and 1*1 m^2 quadrates were allocated within the big quadrants for shrubs and herbs respectively (Figure 1). One percent sampling intensity was used for the study. All the species in the plot were counted for the analysis.

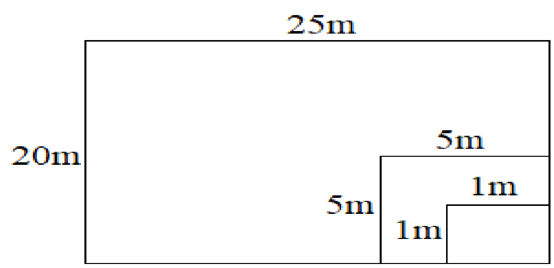


Figure 1 *Layout of sample plot*

Transect walk was started from 100m inside the forest boundary and at every 200m interval, IAPS, canopy cover, and habitat type were observed and recorded in the data sheet. The level of IAPS was measured using a simple ranking of cover within the area through ocular estimation as: 0- absence; 1 - present but coverage < 50%; 2 - High coverage i.e. >50% (Lamichhane et al., 2014). Manual on invasive alien plant species (Bisht et al., 2016) and unpublished field guides were followed along with taxonomic expert's consultation to identify the invasive species. A total of 115 transect segments were intercepted during this study.

Key Informant Survey

Nine key informants were interviewed using set checklists to document local management practices for IAPS control and history of invasion of IAPS in particular forests. Presidents, members and forest guard were key informants and one of these informants in each Buffer Zone Community Forests was interviewed to deduce information.

Data Analysis

The collected data were tabulated, processed and analyzed using Microsoft Excel 2015. The following quantitative characteristics of the vegetation were determined using following formulae.

Frequency= $J/I \times 100$, J = No. of quadrates in which the species occurred, I = Total quadrates studied.

Density= $\frac{H/I}{A}$, H= Total no. of individual of a species in all the quadrates, I = Total quadrates studies, A= Area of the quadrates.

Abundance= H/J , H = Total no. of individual of a species in all the quadrates, J= No. of quadrates in which the species occurred.

Simpson's index (D) = $\frac{\sum n(n-1)}{N(N-1)}$, n = the total number of organisms of a particular species, N = the total number of organisms of all species (Simpson, 1949).

Shannon-Wiener index or α diversity (H′) = $-\sum$ pi ln pi**,** H′ = Shannon's diversity index, pi= proportion of total sample belonging to the i^{th} species, ln= log of natural numbers (Shannon's & Weaver, 1963).

Results and Discussion

Altogether 14 IAPS belonging to nine Families were recorded. This requires urgency in management focus for such diverse number of alien plants. *Asteraceae* was the largest family with six species; remaining eight Families namely *Verbenaceae, Mimosaceae, Pontederiaceae, Araceaesaceae, Papaveraceae, Caesalpiniaceae, Convolvulace* and *Lamiaceae* were represented by only one species each (Table 1).

Table 1 *List of IAPS and their local names*

S.N.	Scientific Name	Local Name	Family
1.	*Chromolaena odorata*	Seto Banmara	Asteraceae
2.	*Ageratum houstonianum*	Nilo Gandey	Asteraceae
3.	*Ageratum conyzoides*	Seto Gandey	Asteraceae
4.	*Ageratina adenophora*	Kalo Banmara	Asteraceae
5.	*Mikania micrantha*	Lahare Banmara	Asteraceae
6.	*Lantana camara*	Kande Banmara	Verbenaceae
7.	*Parthenium hysterophorus*	Pati Jhar	Asteraceae
8.	*Mimosa pudica*	Lajjawati Jhar	Mimosaceae
9.	*Eichhornia crassipes*	Jalkumbi	Pontederiaceae
10.	*Pistia stratiotes*	Kumbhika	Araceaesaceae
11.	*Argemone mexicana*	Gaida Kanda	Papaveraceae
12.	*Senna ocidentalis*	Panwar	Caesalpiniaceae
13.	*Ipomea carnea*	Besaram	Convolvulace
14.	*Hyptis suaveolens*	Tulsi Jhar	Lamiaceae

Out of the total segments (n=115) under transect walk, highest occurrence was of *Chromolaena* (in 97 segments), followed by *Ageratum houstoniaum* (in 82 segments), *Mikania* (in 64 segments) and *Ageratum conyzoides* (in 37 segemnts). Maximum observed species with above 50% occurrence was *Mikania* (15) followed by *Chromolaena* (13) (Figure 2). Grassland, wetland and mixed forest were lowest intercepted habitat types. Table 2 shows the occurrence of IAPS and their frequency in different canopy cover. Table 3 shows the occurrence of IAPS and their frequency in different habitats. Occurrence of *Mikania*, *Chromolaena*, *A conyzoides*, *A houstonianum* and *Parthenium* prevailed in both grades of canopy cover density Presence of *L camara* in the study area is in contradiction to previous study (Dangol & Maharjan, 2012) which indicated its presence in the forested area along the Narayani river of CNP. Severe management implications have been always stressed upon *Mikania micrantha* as the most problematic weed for immediate measures to control the species in CNP (Sapkota, 2007). This study has shown *C odorata* and *A houstonianum* need equal management focus for immediate control measures which also agrees with the findings of Shrestha et al (2019) in Chitwan-Annapurna Landscape. Heavy infestation of *C odorata* and *A houstonianum* was observed in both open and closed canopy covers of *Shorea robusta* forest during the transect walk. Barandabhar corridor is invaded by *Lantana* and *Parthenium* at very low extent in comparison to that of *Mikania*, *Chromolaena* and *A conyzoides* under several habitat types and both grades of canopy cover and their presence indicate that they may be possible threat in the future. *Mikania* can occur in wetlands in seepage areas of both perennial and seasonal types (Siwakoti, 2007) and it was found to be dominant in the wetlands of study area. It has been realized that at the moment *Mikania*, *Chromolaena*, *A houstonianum* and *A conyzoides* need intensive management focus for control. In general, forest with open canopy covers have maximum occurrence of IAPS. Most alien plant species are open-habitat species, probably because most introductions have occurred through agriculture and gardening (Rubino et al., 2002). Many authors have stressed that open forest canopy favours alien species where they germinate and develop more rapidly in such micro-sites than in closed canopy (Brothers & Spingarn, 1992; Forrest Meekins & McCarthy, 2001; Meiners et al., 2002). This is due to two mechanisms operated at two scales. At localized scale, germination and growth of IAPS is favourable whereas at landscape scale, open canopy increases seeding rate resulting in rapid colonization in such sites (Charbonneau & Fahrig, 2004).

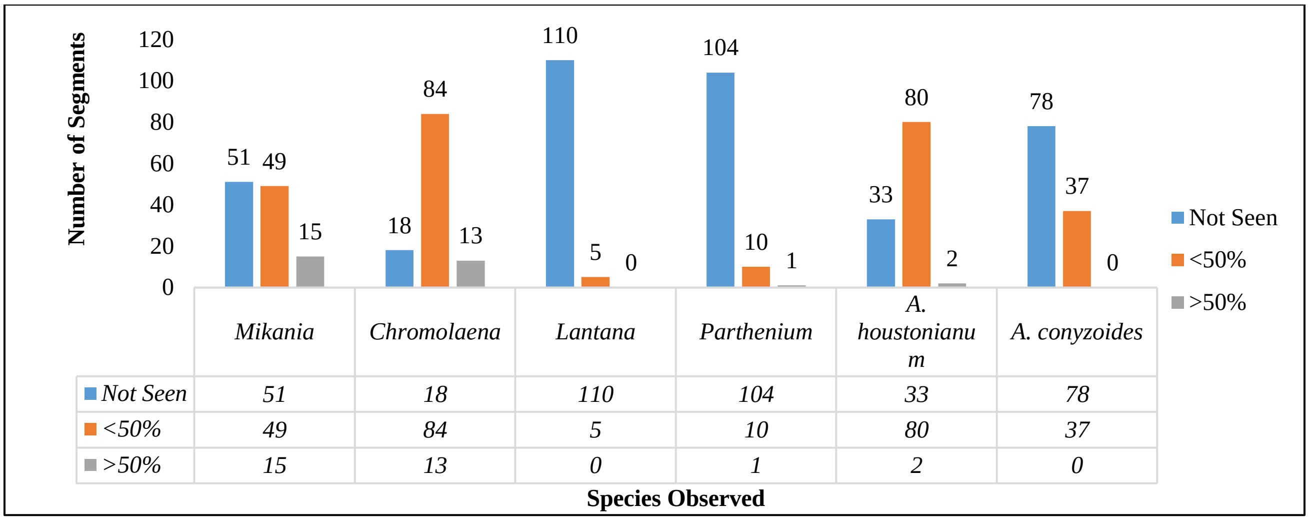


Figure 2 *Occurrence of IAPS in number of segments*.

Table 2 *Occurrence of IAPS and canopy Cover.*

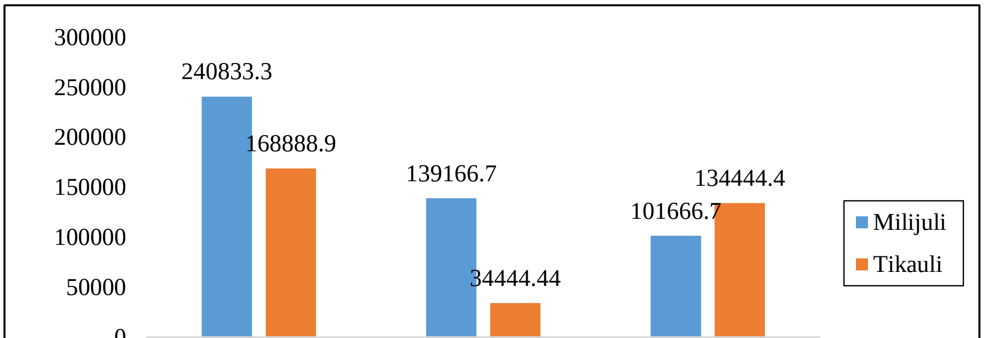
Species	Canopy Cover	Not seen	<50%	>50%
Mikania micrantha	Closed	30	23	6
	Open	21	26	9
Chromolaena odorata	Closed	11	30	3
	Open	7	54	10
Lantana camara	Closed	59	0	0
	Open	51	5	0
Parthenium hysterophorus	Closed	54	4	0
	Open	50	7	0
Ageratum houstonianum	Closed	23	36	0
	Open	10	44	2
Ageratum conyzoides	Closed	42	17	0
	Open	36	20	0

Table 3 *Occurrence of IAPS vs Habitat Types.*

Species	Habitat type	Not seen	<50%	>50%
Mikania micrantha	Grassland	1	3	0
	Mixed	1	1	0
	Riverine	0	9	13
	Wetland	5	12	2
	Sal	44	24	0
Chromolaena odorata	Grassland	1	3	0
	Mixed	1	1	0
	Riverine	5	17	0
	Wetland	1	3	0
	Sal	10	60	13
Lantana camara	Grassland	4	0	0
	Mixed	2	0	0
	Riverine	22	0	0
	Wetland	2	1	0
	Sal	80	4	0
Parthenium hysterophorus	Grassland	2	2	0
	Mixed	2	0	0
	Riverine	13	8	1
	Wetland	5	0	0
	Sal	82	0	0
Ageratum houstonianum	Grassland	2	2	0
	Mixed	0	2	0
	Riverine	15	7	0
	Wetland	0	10	2
	Sal	15	59	1
Ageratum conyzoides	Grassland	4	0	0
	Mixed	2	0	0
	Riverine	18	4	0
	Wetland	3	10	0
	Sal	51	23	0

Vegetation analysis data shows that high density of flora in Milijuli than that of Tikauli. However the density of invasive species is high in Milijuli than non-invasive species Total density of flora was higher in Milijuli than in Tikauli BZCF (Figure 3; Table 4). In *Shorea* dominated forests, *C odorata* and *A conyzoides* were found to be most invasive plants invading Milijuli and Tikauli forests in general (however only record of *C odorata* in Tikauli). Both these forests are close to each other under similar management regime i.e. under hands of community. However, in Tikauli BZCF, both Simpsons and Shannon-Wiener diversity index is higher to that of Milijuli (Table5). This is due to low infestation of invasive species and greater number of non-invasive species in the forest than Milijuli BZCF.

It is clearly shown that under similar management status how invasive species are varying in infestation at spatial scale in forest. There is urgent requirement of suitable control methods to be adopted in Milijuli BZCF to minimize invasive species and enhance native flora of the forest in intensive scale to that of Tikauli.



	Total Density/ha	Invasive Density/ha	Non-Invasive density/ha
Milijuli	240833.3	139166.7	101666.7
Tikauli	168888.9	34444.44	134444.4

Figure 3 *Comparison of density of flora of both community forests*

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Table 2 *Ecological indices of Milijuli and Tikauli Buffer Zone Community Forest.*

Milijuli Buffer Zone Community Forest					Tikauli Buffer Zone Community Forest				
Species	**Numbers**	**Density**	**Frequency**	**Abundance**	**Species**	**Numbers**	**Density**	**Frequency**	**Abundance**
Chromolaena odorata	112	93333.33	75	12.44	*Chromolaena odorata*	7	7777.78	33.33	2.33
Mikania micrantha	15	12500	8.33	15	*Shorea robusta*	93	103333.33	100	10.33
Hyptis suaveolens	12	10000	8.33	12	*Clerodendron infortunatum*	23	25555.56	55.56	4.6
Ageratum conyzoides	20	16666.67	8.33	20	*Flemingia spp*	19	21111.11	33.33	6.33
Shorea robusta	81	67500	91.67	7.364	*Maesa chisia*	1	1111.11	11.11	1
Terminalia tomentosa	3	2500	8.33	3	*Myrsine semiserrata*	1	1111.11	11.11	1
Clerodendron infortunatum	35	29166.67	33.33	8.75	*Argemone mexicana*	2	2222.22	11.11	2
Hymenodictyon exelsum	4	3333.33	8.33	4	*Pogostemon benghalensis*	2	2222.22	11.11	2
Maesa chisia	6	5000	8.33	6	*Lallea coromegelica*	4	4444.44	11.11	4
koenigii	1	833.33	8.33	1					

Table 3 *Diversity Index*

Diversity index	Tikauli BZCF	Milijuli BZCF
Simpson's Diversity Index (D)	0.26	0.32
Shannon-Wiener Diversity index (H')	1.75	1.51

Control measures

Various control measures such as cutting, uprooting and fire were practised by the users in both but most of these measures seem to have failed in controlling the invasive species. Figure 4 and 5 respectively show the existing applied control measures and suggested control measures in the study area.

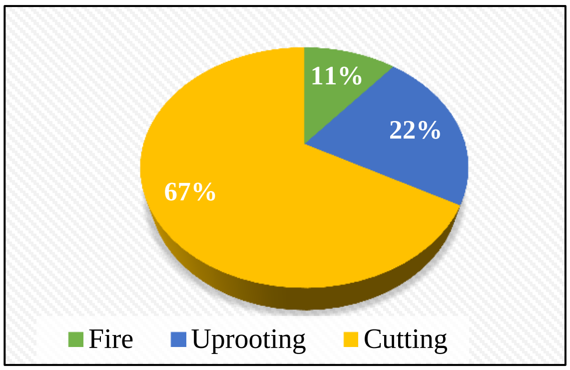

Figure 4 *Existing applied control measures*.

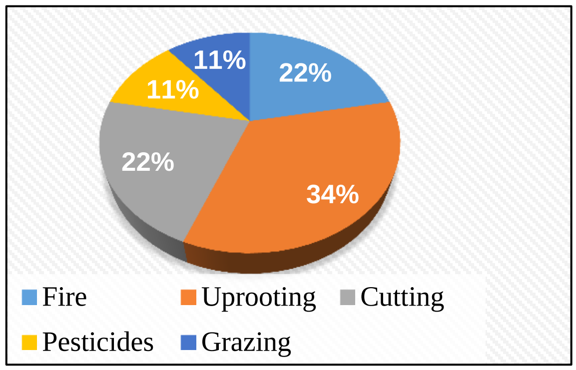

Figure 5 *Suggested control measures.*

Uprooting has been suggested to be most effective method by respondents and it should be exercised at regular interval particularly before flowering and fruiting season. Some of the respondents shared that invasive species were not found in large scale like present days before the introduction of community forestry. This may be because of the trampling effects which restrict the species to grow by making the soil compact. They also believe that transportation or road access may have brought the weed in their localities while some of them shared that weeds originates after the flood of 2050 BS (1993 AD).

Conclusion

Altogether 14 species of IAPS were recorded in the study site. The occurrence of *C odorata* is the highest. Diversity of Tikauli is higher to that of Milijuli BZCF. *Shorea* forest with open canopy has maximum hold of two species; *Chromolaena* and *A houstonianum*. High invasion was seen in Milijuli to that of Tikauli BZCF but the density of regeneration of native species was higher in Tikauli BZCF. This study shows that invasive plants reduce the regeneration which was evident by low density of non-invasive plants in highly infested area. Most of the control measures are not effective. Regular assessment and monitoring of the IAPS is necessary to understand the problem and their impacts. Early detection of IAPS by user groups of BZCFs in order to apply best control practices and prevent the further invasion is crucial. Permanent experimental plots can be established at different sites invaded by highly problematic IAPS to assess the effectiveness of restoring native species after removal of the IAPS. Identification and awareness program by CNP authority to local community about impacts and their control measures are recommended with this study.

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