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Botanica Pacifica
Botanical Garden-Institute FEB RAS
Makovskii Str. 142
Vladivostok 690024 RUSSIA

http://www.geobotanica.ru/bp

botanica.pacifica@icloud.com
krestov@biosoil.ru
vabakalin@gmail.com

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Phytogeography and Invasion Spread of *Chromolaena odorata* (L.) R.M. King et H. Rob. in the Western Himalaya, India

Gautam Mandal*, Shambhu P. Joshi

Gautam Mandal*
e-mail: gautam231@gmail.com
Shambhu P. Joshi
e-mail: spjbotdav03@yahoo.co.in

Ecology Research Laboratory, Department of Botany, DAV (PG) College, Dehradun, Uttarakhand, India

* corresponding author

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ABSTRACT

Habitat suitability assessment of *Chromolaena odorata* (L.) R.M. King et H. Rob. from Himalayan forests reveals that both native and exotic species were frequently growing as associates with this invasive species. Annuals were found to be outnumbered by the perennials in all the study sites. *C. odorata* and *Lantana camara* L. were the only invasive species to be found common in all the sites with high values of Importance Value Index giving wide amplitude to the growth of *C. odorata* in broad variety of habitats as it was found growing well in all types of climatic conditions including moist, mesic, dry and cold. The pH was found acidic in all the invaded sites further arguing that *C. odorata* is more adapted in acidic soil than non acidic soil. *C. odorata* population was found increasing the soil fertility by enhancing the soil nutrient content such as K, P, Mg, Ca, N, SOM and reducing the bulk density. This further provided the possible corridor to the invasion of other noxious weeds such as *Lantana camara* L., *Parthenium hysterophorus* L. and *Ageratum conyzoides* L.

Keywords
invasive alien species, habitat suitability, Importance Value Index, soil analysis

РЕЗЮМЕ

Мандал Г., Джоши Ш. Фитогеография и инвазионное распространение *Chromolaena odorata* (L.) R.M. King et H. Rob. в Западных Гималаях, Индия

Оценка пригодности местообитаний *Chromolaena odorata* (L.) R.M. King et H. Rob. из гималайских лесов показывает, что и местные и заносные виды часто формируют сообщества с этим инвазивным видом. Было обнаружено, что однолетние виды превосходили многолетники в сообществах *C. odorata* на всех исследованных участках. *C. odorata* и *Lantana camara* L. были единственными инвазивными видами с высокими показателями индекса ценотической значимости, встречающимися на всех исследованных участках в широком спектре экологических и климатических условий, включая влажные, мезофильные, сухие и холодные местообитания. Почвы обследованных участков характеризовались низкими значениями pH, что дает основания полагать высокую приспособленность *C. odorata* к кислым почвам. Популяции *C. odorata* повышали численность на плодородных почвах с высокими концентрациями K, P, Mg, Ca, N, SOM, характеризующихся низкой объемной плотностью. Таким образом, расселение *C. odorata* создает дополнительные благоприятные условия для вторжения других видов с высокой инвазионной активностью, таких как *Lantana camara* L., *Parthenium hysterophorus* L. и *Ageratum conyzoides* L. [Переведено редколлегией].

Ключевые слова
инвазионный вид, пригодность местообитания, индекс ценотической значимости, почвенный анализ

INTRODUCTION

Plant invasions into natural ecosystems are one of the major threats to the conservation of biological diversity across all biogeographical regions on Earth. It is likely that the invasion of weeds into natural areas has been associated with human movements throughout our evolutionary development, but as is now widely recognised, the rate of this process has accelerated considerably recently. A combination of factors, including developments in transport technology, changes in life style patterns (particularly in the «western» world), tourism, human movement from one area to another and a seemingly cosmopolitan interest in the introduction and utilisation of foreign plant species, have all been powerful forces in shaping the changing flora of natural areas world-wide.

The invasion of natural communities by such introduced species constitutes a major threat to biodiversity globally (Lodge 1993, Adair & Groves 1998). The general trend of an increase in introduced components of natural vegetation accompanied by a decrease in native components has also been greatly assisted by the increasingly extensive exploitation of natural areas, which can alter natural disturbance regimes and thereby provide enhanced opportunities for the colonisation and establishment of introduced plants. Invasive plants have been found to affect ecosystem structure and function adversely in habitats throughout the world by reducing native species richness, altering water or fire regimes, changing soil nutrient status and altering geomorphological processes (Macdonald et al. 1989, Cronk & Fuller 1995, Rose 1997). A major challenge for invasive plant research is to develop the ability to predict the invasiveness of species and invasibility of habitats (Kareiva 1996). Human activities have resulted in the transport of plants worldwide, yet only around 10 % of introduced species become established, and 10 % of these become invasive (Groves 1991). Several generalizations for predicting invasiveness have been proposed, including the degree of similarity of the new compared with the native climate (Cronk & Fuller 1995, Crawley et al. 1997) and invasiveness in other new habitats (Scott & Panetta 1993, Reichard & Hamilton 1997). Many studies have focused on identifying plant traits that confer invasiveness. Early work by (Baker 1974) identified the attributes of an ideal weed, including fast vegetative growth to flowering, production of large quantities of seed, vegetative propagation and non specialized pollination system and germination requirements. Although this approach is useful as a checklist of potential warning signs, it is too broad to be of much predictive value (Noble 1989). Some studies have been too broad in their scope, using too wide a range of habitats e.g. worldwide (Binggeli 1996) or North America (Reichard & Hamilton 1997) or combining agricultural with environmental weeds (Newsome & Noble 1986, Williamson & Fitter 1996 a). The lack of clear patterns has led to the suggestion that prediction of invasiveness is not possible (Williamson & Fitter 1996 b).

Alternative hypothesis to explain the success of exotic species involve release from their coevolved natural pests and predators in the new environment. Exotic plants arrive in their new habitat unaccompanied by their co evolved predators and pathogens. Release from natural pests may increase plant fitness by several potential mechanisms. These are (a) a direct effect, the so called 'predator-release effect' (Newsome & Noble 1986), (b) reallocation of resources from defense to growth (Crawley et al. 1997) or (c) as a result of selection of genotypes with increase allocation to growth and decrease allocation to defense, the evolution of increased competitive ability hypothesis (Blossey & Notzold 1995). Landscape transformation by humans has been rapid, widespread, and extraordinarily thorough in many cases (Whitney 1994). It is no coincidence, therefore, that anthropogenic disturbances resulting in habitat destruction and fragmentation are viewed as the leading threats to biodiversity, followed by the threat posed by invasive species (Wilcove et al. 1998). Fragmentation is characterized as 'landscape level' disturbance and disturbance is almost unanimously acknowledged to influence invasive spread (Fox & Fox 1986). Thus, habitat loss and fragmentation may facilitate the spread of invasive species. Other studies (Burgess et al. 1991, Dukes & Mooney 1999) have shown that in dry regions, increase of water supply (whether by natural rainfall or by experimental additions) increase the invasibility of vegetation, either as a direct effect of water supply or through improved access to mineral nutrients.

Mountain systems provide a variety of often very pronounced environmental gradients and may therefore be particularly suitable study areas for a limiting conditions approach to investigating the mechanisms of plant invasions. They also represent valuable yet endangered ecosystems that have not been sufficiently studied from the point of view of biological invasions. Furthermore, since there are many different factors that could, singly or in combination, limit the ability of an alien plant to invade, it would be desirable to study plant invasions along environmental gradients that include changes in most potential limiting factors at different degrees of independence. The present study is therefore assessing the habitat suitability of a noxious weed *Chromolaena odorata* (L.) R.M.King et H.Rob., (henceforth *C. odorata*) a species of Asteraceae family, also known as Christmas bush, bitter bush, Siam weed, which by nature is a scrambling shrub (Howard 1989, Liogier 1997) that may reach up to 1 m or more as a free standing shrub and 4 m or more when climbing into trees or shrubs (Fig. 1).

This weed is reported as one of the world's most invasive, and considered to be a serious weed in central and western Africa, India, Australia, Pacific Islands, and Southeast Asia (McFadyen 2003). This species has a wide tolerance to various climates, having already invaded five continents including Asia, North and South America as well as North and South Africa (Kriticos et al. 2005). It can quickly establish and smother plant crops, forestry and native vegetation (McFadyen & Skarratt 1996). It is unpalatable and noxious and may cause death if ingested by domesticated animals (Aterrado & Bachiller 2002). *C. odorata* distribution can be roughly divided into three types (Fig. 2) namely (a) areas where *Chromolaena* is not reprted yet, (b) *Chromolaena* introduced and (c) *Chromolaena* native (Zachariades et al. 1999). The geographical distribution of *C. odorata* is known to be limited to regions within 30°N and 30°S latitudes in areas with a rainfall of 200 cm and above and where air temperature ranges from 20°C to 37°C (Timbilla & Braimah 2002). Christmas bush grows from near sea level to over 1000 m in elevation (Binggeli 1999).

In this study, it is hypothesized that the time since Doon valley has become the capital of the state Uttarakhand there has been a considerable change in economic possibilities available to the local and outside people, hence there is a significant increase in migration of people from in state and outside the state in order to gain maximum benefit. This increasing human population of the state has led to the possible changes such as forest canopy gaps, reduced understory biomass and soil nutrient alteration, thus building up the pressure on remaining forest areas and further intensifying the invasion of introduced species like *C. odorata*, *Lantana camara* L. and *Parthenium hysterophorus* L. In any natural ecosystems, a fundamental issue on which management decisions need to be based is the impact (potential or actual) that a particular weed or a group of weeds has on the long term conservation of biological diversity. Its distribution and abundance is least studied in the Doon valley. Hence, this study has two main aims: the first is to determine the distribution and estimate the abundance of the species in the

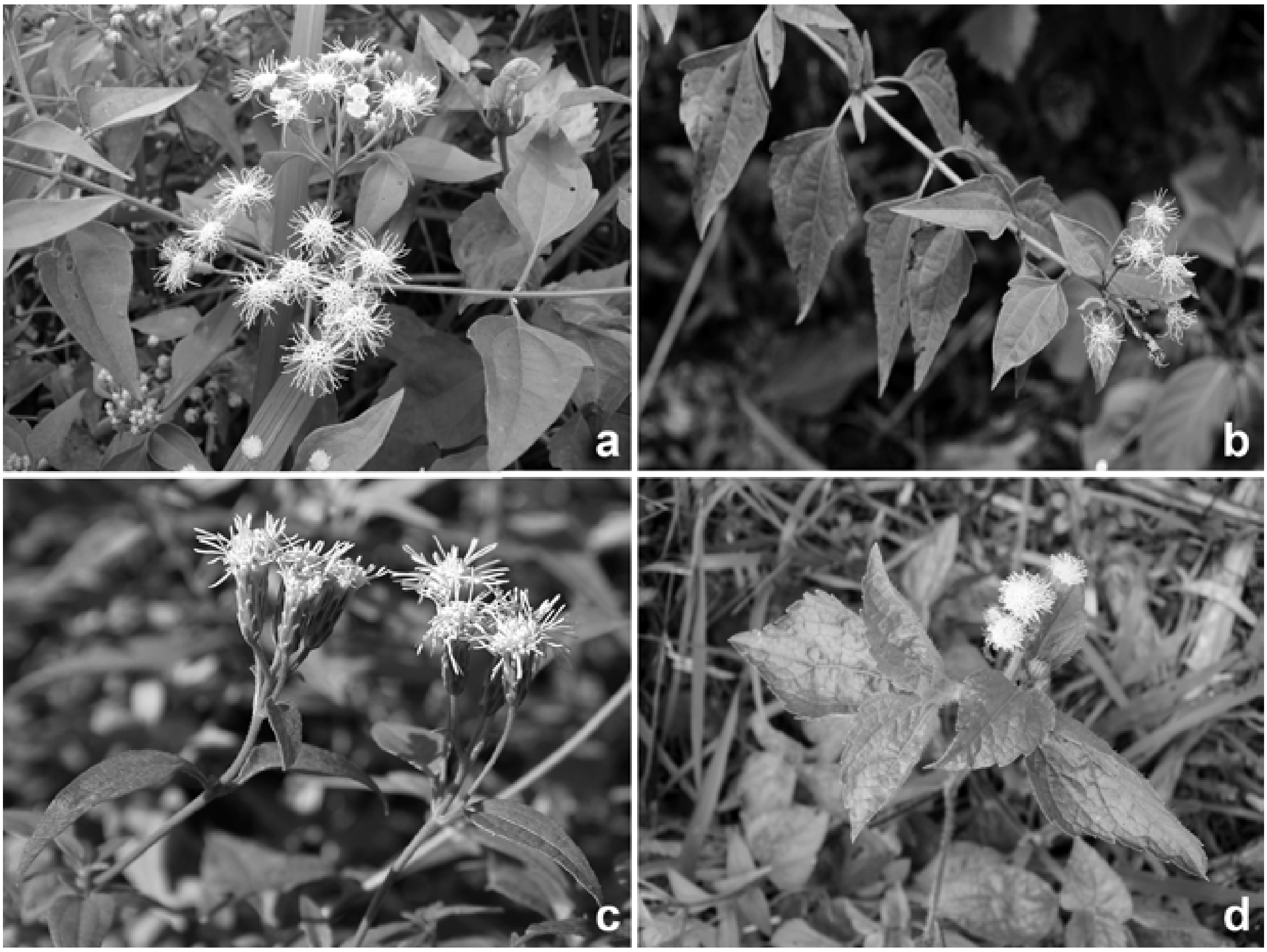

Figure 1 Photos of *Chromolaena odorata* as seen in different study sites: (a) site 1; (b) site 2; (c) site 3; (d) site 4

valley by using Importance Value Index calculation, (a simple yet powerful tool for biodiversity assessment) in order to come up with a baseline information about its level of invasion in the area; and the second is to determine the difference between soil parameters in both non invaded and invaded areas also to determine possible relationship between selected soil parameters and other plant species with the abundance of *C. odorata*. In particular, we tried to disentangle the factors influencing the establishment of invasive exotic species in different altitudes and disturbance types.

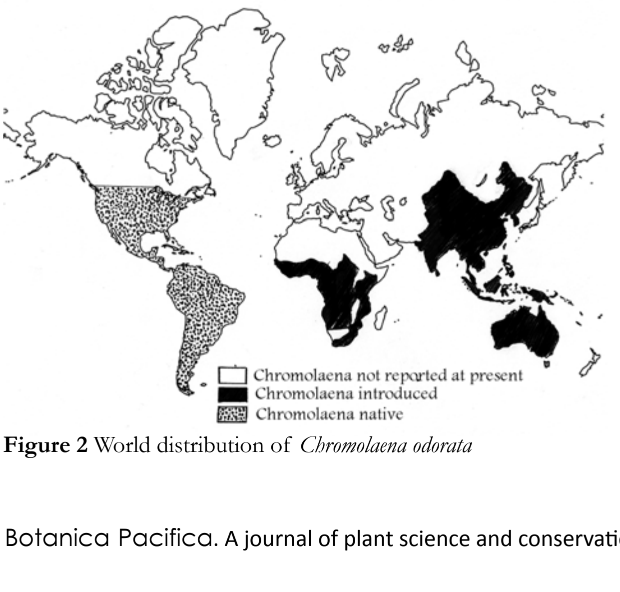

Figure 2 World distribution of *Chromolaena odorata*

MATERIAL AND METHODS

Study sites and experimental design

The present study site was Doon valley which is situated in western Himalaya and a major part of Uttarakhand, India. The state of Uttarakhand is in the northern part of India and shares an international boundary with China in the north and Nepal in the east. It has an area of 53,483 km^2 and lies between latitude 28°43' and 31°28'N and longitude 77°34' and 81°03'E. The state has a temperate climate except in the plain areas, where the climate is tropical (Fig. 3). The average annual rainfall of the state is 1550 mm and temperatures range from zero to 43°C (FSI, 2013). Of the total geographical area of the state, about 19 % is under permanent snow cover, glaciers and steep slopes where tree growth is not possible due to climatic and physical limitations (FSI, 2013). As per the 2013, FSI assessment, total forest cover of the country is 697,898 km^2 which amounts to 21.23 % of the country's total geographic area. The recorded forest area of the state is 24,508 km^2, which constitutes 45.82 % of Uttarakhand's geographical area (FSI, 2013). It may be presumed that, whole of the valley has been at one time or other in the condition of single bed, but a large proportion of the area is now covered with *Shorea robusta* Roxb. ex Gaertner f. or sal forest. The sal is a tree of an exacting nature, requiring good fertile moist soil, with good drainage, and is a species severely damaged

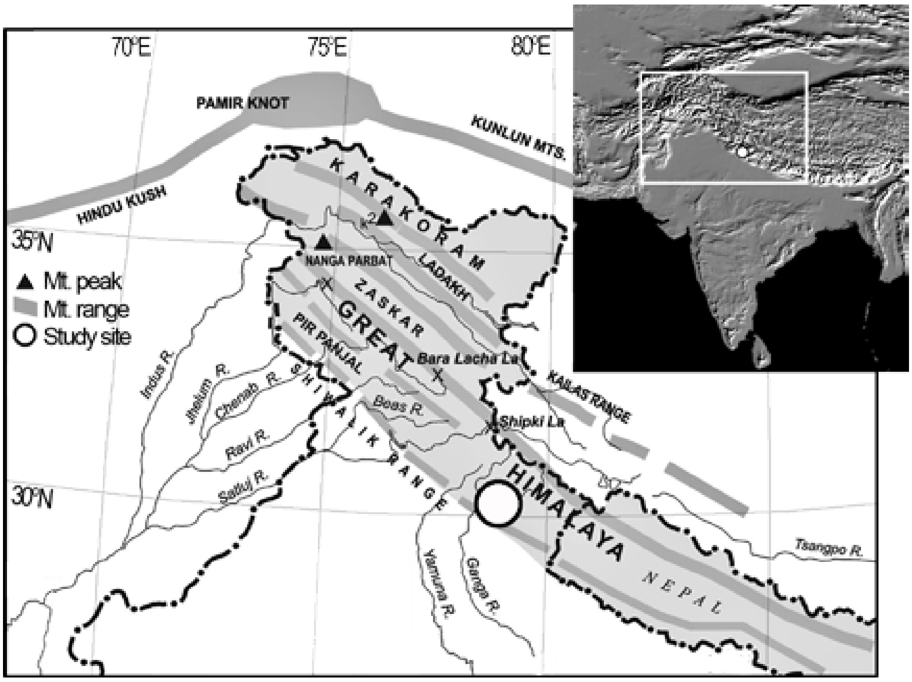

Figure 3 Map of Doon valley, western Himalayan part of India

by frost when young, so much that it cannot come up in open places except under the protection of other trees. The sal forests cannot, therefore, have come directly into existence on open exposed alluvial single soils. Although it is not possible to actually observe the successive stages in the development of the sal forests in the same area, as the changes are gradual and may occupy a long period, yet an examination of the existing types of forests and of what is now taking place leaves little doubt as to the stages through which the sal forests is ultimately developed.

Phytosociological studies of the selected sites were conducted constantly during rainy seasons for herbaceous vegetation and once for trees and shrubs in the years 2011-2013. The vegetation was analyzed by means of random sampling to give most representative composition of vegetation. The vegetation survey was carried out by nested quadrat method. Twenty quadrats each of 10 × 10 m and 5 × 5 m size were laid on each site for studying the trees and shrubs respectively while thirty quadrats of 1 × 1 m size were laid for the herbaceous vegetation. Percentage abundance of all plant species, including *C. odorata*, was computed as the length (in meters) intercepted by each species within a transect line. Above ground and fine root biomass (Mg ha^{-1}) of large colonies of *C. odorata* was recorded for which plant roots were carefully collected using a 25 × 25 × 40 cm soil monolith within the 1 m^2 quadrat. Plant materials such as green material (leaves), dead residues (mulch), and roots collected were oven dried at 60°C for 72 h and weighted. The location of each site was recorded using a Garmin 72 GPS. Fresh samples and photographs of each plant species were taken and herbarium was made for identification purposes. Plants were identified following standard protocol and with the help of the experts from the Archives of Forest Research Institute (FRI), Dehradun, India. Detailed description of study sites is shown in Table 1.

Site 1. These sites are found growing as understory vegetation or forest periphery vegetation at an altitude above 1000 m. The forest canopy is dense and dominated by *Quercus leucotrichophora* A. Camus. The area is mountainous with well developed soil.

Site 2. These sites are typically found in the swampy localities of Doon valley in some of the areas the dominant tree taxa including *Shorea robusta* Roxb. ex Gaertner f., *Diospyros malabarica* (Desrousseaux) Kosteletsky, *Toona ciliata* Roemer, and *Trewia nudiflora* L. The area has well developed soil with wet to moist conditions.

Site 3. This study site is located at an altitude 750 m on north facing slopes in the northern part of Doon valley. The soil was found dry and temperature was relatively cool. The dominant tree taxon was *Shorea robusta* Roxb. ex Gaertner f. and *Syzygium cumini* (L.) Skeels. There is relatively little biotic interference in these sites as they are away from the human settlement.

Site 4. The site is heavily disturbed due to thick tourist influx round the year. Basis of selection of the sites was to create variation in the habitat, aspects, average top soil depth and biotic interference level. The major plant species are *Adhatoda vesica* Nees., *Carex nubigena* D. Don ex Tilloch et Taylor, *Barleria cristata* L., *Ageratum conyzoides* L., *Berberis aristata* DC. *Bidens pilosa* L., *Boehmeria platyphylla* D. Don.

The dominance of the plant species was determined by the Importance Value Index (IVI). Vegetation composition was evaluated by analyzing the frequency, density, abun-

Table 1. Site characteristics of Doon valley, western Himalaya

Site	Elevation (m)	Aspects	Location in Doon Valley	Average depth of top soil (cm)	Relative soil moisture and temperature condition	Dominant tree and shrub taxa	Biotic interference
1	1200	South	North (Kolhu Khet)	0-30	Moist & Cool	*Quercus leucotrichophora, Lantana camara*	Grazing, Lopping
2	550	Open/ North	South (Mothronwala)	0-30	Wet & Warm	*Shorea robusta, Lantana camara*	Heavy Grazing, camping & Lopping
3	750	North	North (Rajpur forest peripheries)	0-30	Dry & Cool	*Shorea robusta, Lantana camara*	Moderate biotic interference
4	700	North East	North (Sahastradhara)	0-30	Dry & Cool	*Mangifera indica, Lantana camara*	High tourist activity zone, gravelly substratum

dance and IVI according to Mishra (1968) and Curtis and McIntosh (1951) as given below:

$$\text{Frequency} = \frac{\text{Total no. of quadrats in which the species occurred}}{\text{Total no. of quadrats studied}} \times 100$$

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \times 100$$

$$\text{Density} = \frac{\text{Total no. of individuals of a species}}{\text{Total no. of quadrats studied}}$$

$$\text{Relative Density (\%)} = \frac{\text{Number of individuals of a species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Abundance} = \frac{\text{Total no. of individuals of a species}}{\text{Total No. of quadrats in which the species occurred}}$$

$$\text{Relative Dominance (\%)} = \frac{\text{Basal area of a species}}{\text{Basal area of all the species}} \times 100$$

$$\text{Importance Value Index} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Dominance}$$

Basal cover is considered as the portion of ground surface occupied by a species (Greig-Smith 1983). Basal area measurement was based on the following formula:

$$\text{Total Basal Cover} = \text{Mean basal area of a species} \times \text{Density of that species}$$

Mean Basal Area (MBA) = πr^2 (sq. cm.),
or (since, r = C/2 × 3.14):

$$\text{MBA} = \frac{C^2}{4 \times \pi^2}$$

where *C* = average circumference of one individual of that species and MBA is expressed as cm^{-2} $plant^{-1}$ (Mishra 1968).

Diversity indices and Evenness

The Shannon-Wiener diversity index (H') (Shannon & Wiener 1963) was calculated from the IVI values using the formula as given by Magurran (1988):

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

where, s = the number of species,
p_i = the proportion of individuals or abundance of the i^{th} species expressed as a proportion of total cover,
ln = log base n.

The beta diversity (β) was computed to measure the rate of species change across the sites (Whittaker 1975) using the following formula:

$$\text{Beta diversity } (\beta) = \frac{\text{Sc}}{\text{S}}$$

Equitability (J) or evenness was calculated by as given by Pielou (1969):

$$\text{Equitability (J)} = \frac{H'}{H'_{max}} = \frac{\sum_{i=1}^{s} p_i \ln p_i}{\ln s}$$

where, s = the number of species,
p_i = the proportion of individuals or abundance of the i^{th} species expressed as a proportion of total cover,
ln = log base n.

Soil chemical analysis

Soil samples were taken from sixteen 3 × 3 m plots in each study sites. Eight plots were invaded by *C. odorata* while 8 adjacent plots were not invaded. Invaded plots contained dense *C. odorata* thickets, while non-invaded plots did not containe *C. odorata* and were in close proximity to the corresponding invaded plots. The non invaded plots served as control because they provided a baseline for functional diversity of the non-invaded soil physicochemical properties. The soil was sieved through a 2 mm mesh and stored at 4°C until analysis. Total N was determined by micro Kjeldahl approach and available P was determined by molybdenum blue colorimetry. Exchangeable K, Ca and Mg were extracted using ammonium acetate, K was determined on flame photometer while Ca and Mg by atomic absorption spectrophotometer (Okalebo et al. 1993), pH and electrical conductivity of the soil (soil: water, 1:5) was determined by the help of water analysis Kit (Systronics). The organic carbon of the soil was determined by Walkley & Black (1934) rapid titration method as given by Piper (1944). Tukey's Honestly Significant Difference (HSD) test was used to compare means between soil parameters. Statistical analysis was done using XLSTAT *V*. 2011 for Microsoft Windows.

RESULTS

C. odorata was found not only in the open well drained ground like dry and exposed slopes, abandoned fields and pastures but also in the peripheries and deep forests throughout the study sites. Fundamentally all sites have already been heavily invaded by *C. odorata*. The above ground biomass estimates ranged from 11.05 Mg ha^{-1} to 12.99 Mg ha^{-1} and fine root biomass ranged from 1.84 Mg ha^{-1} to 1.99 Mg ha^{-1} for large colonies of the species. Seventy one plant species were recorded as associates of *C. odorata* (Table 2). This value does not include all the species present on these sites, since many species did not occur within the quadrat sampled. Out of the total 71 species 29 were exotic with 21 genera and 8 families. Indigenous species accounted for 59 % of total species (Fig. 4). A major number were dicots as compared to monocots and perennials were found outnumbered in all the sites. *C. odorata* and *Lantana camara* were the only common species in all four sites. 7 species occurred in two sites while the remaining species were found exclusive to the particular site.

Our studies have shown that the vegetation of various sites was well dominated by a number of families. *C. odorata* density was found highest in all the sites amongst other plant species growing with it. In general, standard errors of plant numbers were high, indicating a patchy distribution over the plots. The soil cover was found patchy, partly because *C. odorata* seedlings were numerous while also being vigorous around the stumps of the same species. *C. odorata* was found to be the dominant species in sites 1 and 3 with maximum IVI (81.04 and 52.62 respectively). The co-dominants include *Lantana camara*, *Boenninghausenia albiflora* (Hook.) Reichb. ex Meissn., *Myrsine africana* L., *Randia tetrasperma* (Wall. ex Roxb.) Benth. et Hook. f. ex Brandis, *Daphne cannabina* Wall. and *Lonicera quinquelocularis* Hard. The sites 1 and 3) were represented by 22 commonly growing plant species out of which 10 plant species alone contributed 2/3 of the IVI values (Table 2). Canopy cover of the understory vegetation was 69 % in site 1 and 56 % in site 3 for the dominant invasive species *C. odorata*. In site 2 *Adenostemma lavenia* (L.) O. Kuntze was the dominant species with maximum IVI (74.21). The co-dominants included *Lantana camara* (IVI, 25.33) *Rorippa nasturtium-aquaticum* (L.) Hayek (IVI, 45.21), *Perilla frutescens* (L.) Britton (IVI, 32.96) and *Ageratum conyzoides*. (IVI, 32.40). In this site, the invasive species *C. odorata* had surprisingly shown its strong presence (IVI, 21.54) despite the fact that warm temperature conditions persist in these areas.

The site 4 was found to be heavily disturbed due to the thick tourist influx round the year. This site was dominated by three invasive species viz., *Lantana camara* (IVI, 30.12), *C. odorata* (IVI, 22.70) and *Parthenium hysterophorus* (IVI, 17.60). The site had 32 species, yet *C. odorata* had the maximum canopy cover in the area. This area had no dominant tree taxon however sporadic distribution of *Azadirachta* spp. and *Mangifera* spp. was found apparent.

It was observed that *C. odorata* contributed highest IVI values (81.04 and 52.62 in sites 1 and 3 respectively). *Adenostemma lavenia* contributed highest IVI value (74.21) in site 2 whereas *Lantana camara* and *C. odorata* were dominant in site 4 with IVI values of 30.12 and 22.70 respectively (Table 2). *Parthenium hysterophorus* was major co-dominant species in this site. *Lantana camara* was the only species found with *C. odorata* in all four study sites making them equally dominant species in Doon valley. No significant difference was observed in the above ground biomass and the fine root biomass of *C. odorata* from all the sites. The minimum root biomass (1.84±0.33) was recorded from site 2 and the maximum was from site 3 (Table 3). The largest proportion of height class (2.5–3.0) was recorded from most of the study sites while the lowest was from the height class (0–1.0).

The rooting system of *C. odorata* was superficial on all the plots, about 80 % of the roots were found in the upper 15–20 cm. Most roots spread laterally with only a few roots penetrating into deeper soil. Soil characteristics varied between sampling areas (Table 4). Mean soil pH was found acidic in all the *C. odorata* invaded sites which ranged from 5.88 to 6.33 while as the non invaded sites recorded mean pH ranged from 6.11 to 7.23. The range of mean organic matter was quite low in all the invaded sites (2.66 to 3.01 %) yet these values were higher when compared with the non invaded sites. Total nitrogen level was found elevated in all the invaded sites when compared with the non-invaded sites and was within the range of 0.31 to 0.54 %. The total phosphorus was found lowest in the infested site 4 and highest in site 1. The total potassium was also lowest in the *C. odorata* infested site 4 and maximum in site 1 though when the level of P and K was compared with the non invaded areas of all study sites, it was found elevated. The mean magnesium, moisture content and total porosity levels were also found elevated in all the invaded sites when compared from the non invaded sites. The above results argue that probably the heavy infestation of *C. odorata* in all four sites of Doon valley was found to be favoured by its acidic soil, high nitrogen, high calcium, high magnesium, high potassium and phosphorus content and low bulk density. Soil pH though was not found to be a limiting factor in the germination and growth of *C. odorata* as it can grow in a wide ranges of pH (4 to 8) also it was found adapting to a wide range of soil condition. The moisture content was high in all the invaded sites thus giving an indication that high moisture content also favours the growth of this invasive species.

Diversity Indices

The values of alpha diversity ranged between 9 and 32. It was recorded the least for site 2 and the maximum for site 4. In sites 1 and 3, richness was recorded as 22 and 19 respectively. Shannon Wiener Diversity Index or Species Diversity Index did not vary significantly between sites 1 and 4 and site 2 and 3. It was least for site 2 *i.e.,* 2.27 and maximum for site 4 being 3.21. Species turnover was high in the site 4. The values of Evenness varied between the sites. It was 4.56, 2.09, 4.21 and 5.84 respectively in the site 1, 2, 3 and 4. Pielou's Evenness values (Table 5) clearly show that Evenness was approximately similar in all the sites within a range of 0.92 (site 4) and 0.98 (site 2).

DISCUSSION

The IVI calculation is very essential to demonstrate resource apportionment and niche space among species over the span of time, therefore it is always considered as a simple yet strong and powerful tool for biodiversity assessment. Many alien species are introduced deliberately for intentional purposes. A lot of risk is associated with the introduction of these new species. Introduction of *C. odorata*, *Lantana camara*, *Parthenium hysterophorus, Cassia tora* and *Datura stramonium* has become problematic due to their invasion on natural areas and urban ecosystem such as Doon valley. Biological invasions now operate on a global scale and will undergo rapid increase in this century due to interaction with other changes such as increasing globalization of markets, rise in global trade, travel and tourism. For effective management of invasive species, knowledge about their ecology, morphology, phenology, reproductive biology, physiology and phytochemistry is essential (Raghubanshi et al. 2005). Keeping these facts in mind the present study attempts to assess the habitat suitability of an invasive species *C. odorata* from the Himalayan foothill, Doon valley. We used Importance Value Index (IVI) as the main tool to assess the habitat suitability of *C. odorata* in different

Table 2. Importance Value Index (IVI) of various plant species in different sites

No.	Plant Species	Importance Value Index (IVI)			
		Site 1	Site 2	Site 3	Site 4
1.	*Chromolaena odorata* (L.) R.M.King et H.Rob.	81.04	21.54	52.62	22.70
2.	*Lantana camara* L.	17.34	25.33	17.99	30.12
3.	*Lepidagathis cuspidata* Nees	-	-	28.34	11.20
4.	*Ageratum conyzoides* (L.) L.	-	32.40	-	5.30
5.	*Randia tetrasperma* (Wall. ex Roxb.) Benth. et Hook.f. ex Brandis	18.16	-	13.41	-
6.	*Reinwardtia indica* Dumort.	7.76	-	5.54	-
7.	*Cassia tora* L.	-	-	5.62	4.90
8.	*Rubus ellipticus* Sm.	1.31	-	-	8.90
9.	*Phyllanthus parvifolius* Buch.-Ham. ex D. Don	3.61	-	-	2.40
10.	*Adenostemma lavenia* (L.) Kuntze	-	74.21	-	-
11.	*Rorippa nasturtium-aquaticum* (L.) Hayek	-	45.21	-	-
12.	*Perilla frutescens* (L.) Britton	-	32.96	-	-
13.	*Murraya koenigii* (L.) Spreng.	-	-	30.59	-
14.	*Polygonum hydropiper* L.	-	25.31	-	-
15.	*Mallotus philippensis* (Lam.) Müll. Arg.	-	-	25.51	-
16.	*Leea alata* Edgew.	-	-	24.38	-
17.	*Floscopa scandens* Lour.	-	23.60	-	-
18.	*Boenninghausenia albiflora* (Hook.) Reichb ex Meissn.	22.70	-	-	-
19.	*Myrsine africana* L.	20.40	-	-	-
20.	*Desmodium podocarpum* Hook. et Arn.	-	-	17.78	-
21.	*Parthenium hysterophorus* L.	-	-	-	17.60
22.	*Daphne cannabina* Wall.	17.31	-	-	-
23.	*Oplismenus compositus* (L.) P. Beauv.	-	-	-	16.70
24.	*Urtica dioica* L.	-	-	-	16.60
25.	*Clerodendrum infortunatum* L.	-	-	16.22	-
26.	*Lonicera quinquelocularis* Hard.	15.90	-	-	-
27.	*Debregeasia hypoleuca* (Hochst. ex A. Rich.) Wedd.	-	-	-	15
28.	*Rhamnus virgata* Roxb.	15.42	-	-	-
29.	*Carissa opaca* Stapf. ex Haines	-	-	14.99	-
30.	*Amaranthus spinosus* L.	-	-	-	14.70
31.	*Bidens pilosa* L.	-	-	-	14.60
32.	*Sarcococca pruniformis* Lindl.	13.91	-	-	-
33.	*Carex nubigena* D. Don ex Tilloch et Taylor	-	-	-	13.80
34.	*Adhatoda vasica* Nees	-	-	-	12.90
35.	*Boehmeria platyphylla* D. Don.	-	-	-	9.34
36.	*Quercus leucotrichophora* A. Camus	10.50	-	-	-
37.	*Berberis asiatica* Roxb. ex DC.	10.21	-	-	-
38.	*Pouzolzia pentandra* (Roxb.) Benn.	-	10	-	-
39.	*Shorea robusta* Gaertn.	-	-	9.75	-
40.	*Mahonia acanthifolia* Wall. ex G. Don	9.64	-	-	-
41.	*Pycreus sanguinolentus* (Vahl) Nees	-	9.64	-	-
42.	*Acer oblongum* Wall. ex DC.	8.88	-	-	-
43.	*Eleusine indica* (L.) Gaertn.	-	-	-	8.50
44.	*Berberis aristata* DC.	-	-	-	8.20
45.	*Xylosma longifolia* Clos	-	-	8.11	-
46.	*Pyrus foliolosa* Wall.	-	-	8.08	-
47.	*Colebrookea oppositifolia* Sm.	-	-	-	8
48.	*Cestrum aurantiacum* Lindl.	7.03	-	-	-
49.	*Ilex dipyrena* Wall.	6.11	-	-	-
50.	*Solanum hispidum* Pers.	-	-	-	7.10
51.	*Hypericum oblongifolium* Choisy	-	-	-	7
52.	*Rumex hastatus* D. Don	-	-	-	6.80
53.	*Machilus odoratissimus* Nees	5.12	-	-	-
54.	*Mangifera indica* L.	-	-	-	5.90
55.	*Eriophorum comosum* (Wall.) Nees	-	-	-	4.81
56.	*Cocculus laurifolius* DC.	-	-	5.53	-
57.	*Millettia auriculata* Bak. ex Brandis	-	-	5.38	-
58.	*Ficus heterophylla* L. f.	-	-	-	4.70
59.	*Woodfordia floribunda* Salisb.	-	-	-	4.50
60.	*Cyanotis cristata* (L.) D. Don	-	-	-	4.30
61.	*Syzygium cumini* (L.) Skeels	-	-	4.08	-
62.	*Oxalis corniculata* L.	-	-	-	4
63.	*Smilax aspera* L.	3.95	-	-	-
64.	*Discorea alata* L.	-	-	-	3.20
65.	*Barleria cristata* L.	-	-	-	3.20
66.	*Geniosporum coloratum*(D. Don) Kuntze	-	-	3.17	-
67.	*Viburnum cotinifolium* D. Don	3.10	-	-	-
68.	*Tabernaemontana coronaria* (Jacq.) Willd.	-	-	3.04	-
69.	*Sida cordifolia* L.	-	-	-	2.60
70.	*Thalictrum foliolosum* DC.	-	-	-	1.20
71.	*Carpinus faginea* Lindl.	1.05	-	-	-

locations of Doon valley. The use of IVI for biodiversity assessment of plant species is well advocated by many workers (Hazarika et al. 2006, Sahu et al. 2010, Surendra et al. 2013, Awodoyin et al. 2013, Biswas et al. 2014, Mandal 2014, Sarma & Deka 2014).

In the present study, 71 plant species from 20 families were recorded. Indigenous species accounted for 59 % of the total species represented by 26 genera and 11 families (Fig. 4). The above mentioned result shows that both native and exotic species were managed well to grow with *C. odorata* in all types of climatic conditions including mesic, dry, moist and cold. The plant species of a place are largely determined by moisture and length of the growing season. The present results are in line with many previous works such as Bliss (1963), Douglas & Bliss (1977) and Billings (1979), where they have reported that vegetation of any area is the result of interaction of many factors; the meso-topographic gradient, the elevation, soil, slope, nearness to existing glaciers, species composition and biotic interferences.

The present study reflects from the site characteristics that disturbance, topography, land use types and soil nutrients are the major factors in deciding the community structure of the area specially the invasive species; however the microclimatic conditions have also played a significant role in study sites 1 and 2. *C. odorata* individuals invade various sites when their seeds are readily available. Physical disturbance of the habitat due to various biotic stresses make the factors in a particular site favorable before the invasion occur. In the present study available soil resources for site 4 and moist to mesic condition in sites 1 and 2 appear to be most suitable for invasion of *C. odorata*. These findings are in agreement with Tilman (1977), Belnap & Phillips (2001), Safford & Harrison (2001), Williamson & Harrison (2006), Kandwal et al. (2007). The present work was well supported by IVI as discussed above and canopy cover of the *C. odorata* in all four sites. According to the present results sites 1 and 3 were found to be the most suitable sites for this invasive species on the basis of IVI value. However, in site 4 which was the most disturbed site, due to round the year heavy human activity, the dominance of *C. odorata* was shared by two other invasive species *Lantana camara* and *Parthenium hysterophorus*. Elevation by itself may not have strong direct effects on the distribution of species, but most likely a complex gradient comprised of a number of different variables including temperature, light, moisture and nutrients this fact was well supported by the findings of Stevens (1992) where these factors had some direct effects in species distribution. Although exotic alien plants in the valley occurred sporadically at higher elevations, most were found <1500 m except *C. odorata* and with far greater cover estimates than in higher elevation areas.

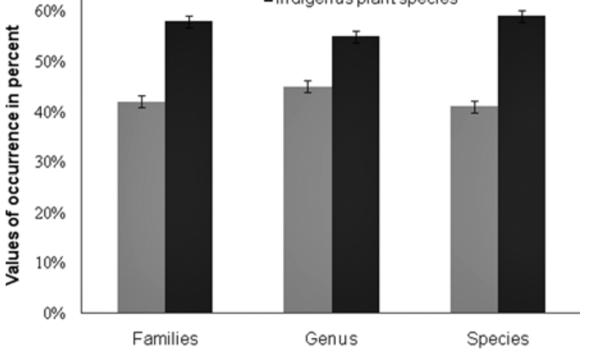

Figure 4 Status of the exotic and indigenous plant species in all the study sites of Doon valley

In the Old World, *C. odorata* was an invasive transformer species (Richardson et al. 2000), at least partly because it lacks natural enemies. It grows rapidly and often forms a dense scrambling thicket that grows through and over the existing vegetation. It most readily invades areas of natural or human induced disturbance, but can invade undisturbed land. *C. odorata* affects subsistence and commercial agriculture, including crops and plantations, grazing lands, and silviculture. The site 1 had significantly greater density of *C. odorata* than the other study sites. This may be due to high altitude, high rate of grazing, high lopping and past management of the area. The normal range of plant height is upto 3 m in open and fallow lands but a large proportion of plant height class (3.5–4.0) was recorded from site 1 and site 3 (Table 3). This may be explained due to its high competing nature with trees to avail the resources and light. These findings are in line with the previous findings of Goodall & Erasmus (1996), Prasad et al. (1996) where *C. odorata* was found invading a wide range of natural vegetation types, from grassland through savanna, bush, open woodland, forest margins and gaps and showing high competition with indigenous species.

Natural forests are not usually invaded by *C. odorata* due to its high light requirements, but forest degradation generally allows this weed to establish itself by suppressing the recruitment of trees. Forest gaps that naturally develop through tree fall are colonized rapidly by *C. odorata* (Epp 1987, Goodall & Erasmus 1996). The plant scrambles up through the surrounding trees and emerges on top of the canopy, eventually causing its collapse (Goodall & Erasmus 1996). However, removal of *C. odorata* allows rapid regeneration of indigenous forest (Honu & Dang 2000). Thus our findings conclude that suitability of *C. odorata* depends not only on physical disturbance of site but also on overall site characteristics. The present study reveals that the peripheries of forests and fallow lands are fully occupied by *C. odorata,* findings were also supported by Ambika (2007). However the dense forests are still intact and unaffected by the invasion. The observation of this study partly supports the statement of Awanyo et al. (2011) where it was mentioned that highly invasive *C. odorata* grows aggressively and suppress other vegetation by easily forming a thick cover at a very short span of time. In another study by Sahid & Sugau (1993) it was found that high allelopathic properties of this weed supported in gaining dominance in vegetation, and in replacing other aggressive invaders such as *Lantana camara* and *Imperata cylindrica* (L.) Beauv. of Poaceae, this was well supported by the findings of Eussen & de Groot (1974) and Ivens (1974) in Asia and Africa. The present study shows that *C. odorata* forms extensive infestation in slightly moist frost free areas but it has started registering

Table 3. Density of *Chromolaena odorata* (mean shrub per ha) from all four study sites

Name of the sites	Above ground biomass (Mg ha^{-1})	Fine root biomass (Mg ha^{-1})	Plant height class (m) (%)							Soil Type
			0–1.0	1.0–1.5	1.5–2.0	2.0–2.5	2.5–3.0	3.0–3.5	3.5–4.0	
North (Kolhu Khet)	12.67 ± 2.58^{b}	1.98 ± 0.56^{a}	3.18	3	10.11	12.01	25.88	17.94	27.88	Silt gravel
South (Mothronwala)	11.99 ± 2.44^{a}	1.84 ± 0.33^{b}	4.87	9.55	13.01	12.66	33.01	23.86	3.04	Silt clay
North (Rajpur Forest Peripheries)	12.99 ± 1.89^{a}	1.99 ± 0.41^{b}	2.01	3.77	5.39	10.98	14.33	18.57	44.95	Coarse grained
North (Sahastradhara)	11.05 ± 2.13^{b}	1.94 ± 0.34^{a}	4.33	8.48	16.24	15	38.99	12.97	3.99	Organic mix soil

SE: Standard Error, Biomass value with different superscripts are statistically different ($p<0.05$)

Table 4. Soil Parameters ± SD, n=15 and soil type at four sampling sites in the Doon valley (values with same superscript letters are not significantly different, Tukey's test; $P>0.05$)

Soil Factors (depth 0-30cm)	Site 1		Site 2		Site 3		Site 4	
	Control	Invaded	Control	Invaded	Control	Invaded	Control	Invaded
pH	7.23^{a} (±0.21)	5.88^{b} (±0.17)	6.98^{a} (±0.31)	6.11^{b} (±0.11)	6.78^{a} (±0.45)	5.98^{b} (±0.10)	7.02^{a} (±0.31)	6.33^{c} (±0.07)
Avail. Potassium (cmol/kg)	0.39^{a} (±0.08)	0.44^{b} (±0.01)	0.40^{a} (±0.11)	0.42^{b} (±0.17)	0.30^{a} (±0.31)	0.32^{b} (±0.09)	0.22^{a} (±0.54)	0.29^{b} (±0.10)
Total Nitrogen (%)	0.44^{b} (±0.34)	0.55^{c} (±0.20)	0.50^{a} (±0.23)	0.54^{c} (±0.91)	0.41^{a} (±0.33)	0.49^{b} (±0.16)	0.29^{a} (±0.39)	0.31^{a} (±0.09)
Soil organic matter (%)	2.11^{c} (±0.12)	2.66^{b} (±0.14)	2.01^{b} (±0.29)	2.99^{a} (±0.15)	1.98^{c} (±0.38)	2.78^{b} (±0.05)	2.33^{b} (±0.18)	3.01^{a} (±0.13)
Avail. Phosphorus (mg/kg)	8.2^{a} (±0.33)	9.1^{b} (±0.14)	7.9^{a} (±0.32)	8.5^{c} (±0.07)	7.0^{a} (±0.44)	7.5^{c} (±0.19)	6.2^{b} (±1.12)	6.7^{c} (±0.61)
Calcium (cmol/kg)	3.9^{b} (±0.88)	4.3^{a} (±0.32)	3.6^{a} (±0.54)	3.8^{c} (±0.63)	3.0^{b} (±0.11)	3.5^{c} (±0.08)	3.9^{c} (±0.81)	4.1^{a} (±0.19)
Magnesium (cmol/kg)	1.22^{a} (±0.13)	1.39^{c} (±0.03)	0.68^{a} (±0.44)	0.98^{b} (±0.19)	1.00^{b} (±0.51)	1.25^{c} (±0.08)	1.01^{a} (±0.23)	1.22^{c} (±0.37)
Bulk density (g/cm^3)	1.6 (±0.55)	1.4 (±0.27)	1.48 (±0.12)	1.2 (±0.17)	1.94 (±0.44)	1.8 (±0.29)	1.76 (±0.66)	1.2 (±0.23)
Moisture content (%)	25.3^{b} (±0.34)	29.1^{a} (±0.41)	26.5^{c} (±0.44)	28.5^{a} (±0.31)	22.5^{b} (±0.59)	28.4^{a} (±0.34)	24.9^{a} (±0.29)	27.9 (±0.32)
Total porosity (%)	50^{b} (±0.41)	55^{a} (±0.33)	54^{c} (±0.61)	57^{a} (±0.02)	59^{a} (±0.11)	61^{b} (±0.09)	56^{a} (±0.39)	58^{c} (±0.27)

Table 5. Diversity indices of various sites

Sites	Alpha Diversity	Beta Diversity	Shannon Weiner Index	Pielou's Index
Site 1	22	4.56	3.01	0.97
Site 2	09	2.09	2.27	0.98
Site 3	19	4.21	2.85	0.96
Site 4	32	5.84	3.21	0.92

its presence in warm places also and will become invasive in medium to arid land use types that are not water stressed during summer season this is in line with the findings of Goodall & Erasmus (1996).

It is evident from the past and foregoing discussions that soils, their texture, quality and nature are vital for the germination and growth of not only native but exotic species also. Soils are considered living systems, and like any other organism, they too develop and decay, get degraded, respond to proper treatment if administered in time. These have serious repercussions on other components of the system of which they themselves are important parts. In our research we aim at understanding how this invasive alien species influence soil processes, to see this we collected soil samples from plots where *C. odorata* invasion was high and also from adjacent plots not invaded by this weed. In some studies the significant increases of SOC and total N was recorded under the fallow within the 0–10 cm layer further revealing the potential of *C. odorata* from all the fallow lands (Tondoh et al. 2013) this was well supported by the findings of Goyal et al. (1999) and Manjaiah et al. (2000) where increased SOC and N was recognized as a key attribute of soil quality and a deciding factor for *C. odorata* invasion. The present study also supports the above mentioned findings by recording an elevated level of the soil nutrients including SOM and N in all the invaded sites from the non invaded sites, but contrary to the previous studies mentioned above, the current study overtly suggest that *C. odorata* has high fertilizing and sound potentials for building soil organic matter (SOM) to adequate levels that will surely meet nutritional needs of different herbs and shrub species and will surely improve the nutrient element status of Doon valley forests. This further advocates the fact that when such organic resources are made available to understory shrub bushes like *Lantana camara* due to the invasion of *C. odorata*, instead of being suppressed, these noxious woody shrubs and their growth in the fallow fields and forest peripheries will further prosper.

In a similar study it was found that the soil nutrient of the fallow land was increased by *C. odorata* further favouring the invasion of other opportunistic species (Ojeniyi et al. 2012). Due to the ability of the weeds to shield the soil, propagate surface soil with their roots, increase biomass and organic matter; the fallow lands were able to improve soil construction and porosity, reduce bulk density, and increase soil fertility and growth of other invasive plants. Our study shows that not only the SOM but other soil properties such as N, P, K, also the acidity of the soil increased in all the invaded sites, the similar elevated level of these nutrients were also reported by Ehrenfeld (2003) in her review. This could be explained and argued further that the invasion intensity of *C. odorata* can be more in already fertile soil or perhaps after its invasion to a particular place. The pH was found more acidic in all the invaded sites when compared to the non invaded sites, this explains that *C. odorata* is well managed in growing at low pH soil then high pH soil of non invaded areas (Table 4). Different theories and concepts have given in plant invasion process but the most likely reason why the search for has largely failed is that invasiveness depends more upon the interaction between the characteristics of non native species and their potential new habitats than upon the characteristics of species alone. It is probably no accident that the best general predictors of invasiveness across habitats, native range and rapid dispersal, are both traits likely to affect the probability of initial introduction of a species, the phase of invasion which is most independent of habitat (Tondoh et al. 2013). Species that occur more widely and produce more propagules should have a better chance of being picked up and transported. However, the reason these traits appear to explain only a small part of the variation between species in invasiveness may be because the second phase of invasion, spread in new habitats, is habitat specific. Habitat specificity of invasiveness is consistent with the observation that different growth forms tend to be invasive in different habitats. It may therefore be necessary to predict invasiveness separately for different habitat types.

CONCLUSIONS

The study of gradual changes in population patterns at the landscape scale, as might occur near to a hypothetical invasion front, could help to elucidate the processes underlying an invasion. In most cases, however, there is no clearly defined invasion front or the scales over which gradual changes may occur are too large to be manageable. Hence, it is often difficult to find gradients in the population structure of an invasive plant at the landscape scale that reveals the conditions limiting the invasion. Furthermore, since there are many different factors that could, singly or in combination, limit the ability of an alien plant to invade, it would be desirable to study plant invasions along environmental gradients that include changes in most potential limiting factors at different degrees of independence. This might allow the researcher to disentangle the various factors influencing the plant invasion. The following are the conclusion of the present study.

Site 1 and site 3 which are attitudinally on more height with moist to mesic and cold climatic condition were found to be the most suitable habitat of *C. odorata* but the presence of this species in all four study sites with significant IVI values show that it can now very well grow not only in the cold, moist and unconstrained areas but also in the mesic, humid, warm and human disturbed areas as well. This property is giving wide amplitude to the growth of *C. odorata* in a wide variety of habitats.

Success of *C. odorata* can therefore be considered to be dependent on the degradation of sal forests where large canopy gaps created due to heavy human activities and availability of light facilitate the invasion establishment of *C. odorata* populations.

C. odorata population increases the soil fertility by enhancing the soil nutrient content such as K, P, Mg, N, SOM and reducing the bulk density. This further provided corridor to the invasion of other noxious weeds such as *Lantana camara*, *Parthenium hysterophorus* and *Ageratum conyzoides*.

The soil nutrient was found high in all the study sites where *C. odorata* had grown, this soil suitability can support optimal growth of different opportunistic and exotic species like *Lantana camara* and *Parthenium hysterophorus*, which can again be a serious threat to the biodiversity.

The pH was found acidic in all the study sites, this argues that *C. odorata* is more adapted in acidic soil than non acidic soil, but this factor was not found to be the limiting factor in deciding the adaptation of *C. odorata* to a particular acidic nature of soil.

C. odorata was found aggressively growing on fallow lands and therefore it can be considered that *C. odorata* is a 'good' fellow plant. Due to its fast growth and development not only during the cropping phase but also from abandoned forest peripheries where light availability is more, it can provide a protective cover and allow better weed suppression than fallow lands not dominated by *C. odorata*. The results of the present study show that only *Lantana camara* managed to grow alongside *C. odorata* in all four study sites and other species were present only in selected sites. However, we cannot fully neglect the possibility of further plant invasion due to increase in the nutrient value of the soil. An important concept to consider when measuring the soil composition and processes associated in sites with *C. odorata* is whether the invasive has caused the changes or simply grows preferentially where soil composition is ideal.

In this respect the immediate benefit of this research has been in contributing to the knowledge base of land managers by providing improved information on the phytogeography and habitat suitability of *C. odorata*, from similar climatic and topographical conditions which will support efficient habitat ranking to restore invaded areas and protect non-invaded ecosystems.

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News, Books, Events

MEETINGS RELATED TO BOTANY AND VEGETATION SCIENCE FOR 2015

July 19–24, 2015 – Brno, Czech Republic

58th Annual Symposium of the International Association for Vegetation Science "Understanding Broad-Scale Vegetation Patterns"

Scientific topics: Patterns and drivers of alpha and beta diversity in plant communities: an old, but still insufficiently understood topic; Plant community assembly: niche-based vs. neutral processes and the role of species pools; Plant traits: towards an understanding of the functional diversity of plant communities; Phylogenetic community structure: merging vegetation ecology with phylogenetic research; Vegetation survey: towards the broad-scale synthesis of local vegetation classifications; Large time scales: past vegetation change, effects of historical processes on current vegetation and modern analogues of past ecosystems; Patterns of vegetation change across landscapes: which drivers are important in which contexts?; Community invasibility: plant invasions as broad-scale biogeographical experiments Data sources for broad-scale vegetation studies: can we use composite sets of data originally sampled for other purposes on fine scales?; Vegetation in macroecological modelling: what insights can be obtained from models if broad-scale experiments are not feasible?; Vegetation science serving nature conservationr.

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BOOK

Probatova, N.S. 2014 Chromosome numbers in vascular plants of the Primorskii Krai (the Russian Far East). Dal'nauka, Vladivostok, 343 pp. (in Russian, with English summary)

This book presents the first generalization of the chromosome number data on vascular flora of the Primorskii Krai, for the period of time of chromosome studies (from 1966 up to now). Since 1966, chromosome numbers in 1318 vascular plant species from 604 genera and 128 families were revealed in Primorskii Krai. The chromosome number were the most extensively studied in families Asteraceae – 207 species of 91 genera and in Poaceae – 166 species of 60 genera. Adventive (alien) species in the flora of the Primorskii Krai were marked. References and brief information on the origin of specimens studied were given. The analysis of chromosome number data as a source of information on the flora was given on examples of caryotaxonomic situation in some families and genera. Caryological studies on vascular plants permit to consider these data in the context of special features of the forming of the flora in the south of the Russian Far East, including human impact.

The book is available from the author:

Nina S. Probatova, Institute of Biology and Soil Science FEB RAS
Vladivostok 690022 Russia; e-mail: probatova@ibss.dvo.ru

BOOK SERIES

Kozhevnikov A.E. (ed.) 2014 V.L. Komarov Memorial Lectures: Issue 62. Dalnauka, Vladivostok, 316 pp. ISSN 1997-1869 (in Russian, with English summary)

The issue 62 contains reports presented at the 67th annual V.L. Komarov Memorial Lectures held by the Institute of Biology and Soil Science FEB RAS in cooperation with the Primorskii Branch of the Russian Botanical Society. The series cover a wide range of problems of the structure , diversity, distribution, ecology, functioning, evolution and use of plants and publishes experimental, theoretical and review articles in the following areas: Contemporary problems of theoretical botany; Vegetation and its organization; Structure and functioning of plant ecosystems; Problems of taxonomy and systematics of plants; Morphology and anatomy of plants; History of botany and botanical education; Protection and use of vegetation. The issue includes the following papers: Kozhevnikov, A.E. & Z.V. Kozhevnikova Taxonomic composition and special features of the natural flora in the Primorskii Krai; Antonova, L.A. Adventive component in the coastal flora jf the Khabarovskii Krai; Prokopenko, S.V. Vascular flora of the Trudnyi Peninsula (Nakhodka City and its vicinity); Yakubov, V.V. The genera *Pentactina* and *Geum* (Rosaceae) in the Russian Far East; Kholod, S.S. Vegetation and permafrost terrain in Wlangel Island

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