LANTANA CAMARA L. INVASION AND IMPACT ON HERB LAYER DIVERSITY AND SOIL PROPERTIES IN A DRY DECIDUOUS FOREST OF INDIA

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Abstract. Invasion of lantana (*Lantana camara* L.) in dry deciduous forest is capable of causing changes in micro sites (soil properties and species composition) in which they invade. As lantana is most conspicuous invader in the Vindhyan dry deciduous forests of India. We analyzed the effect of this invasive species on the composition of herbaceous layer and on soil properties. Habitats with different level of canopy cover were analyzed. And the canopy cover was significantly related to the lantana cover. Results indicate that different levels of lantana cover affect soil properties and herbaceous species composition. We found as the lantana cover increases some of the species get locally extinct and some are favored by lantana invasion. Principal Component Analysis (PCA) ordination indicated that the quadrates with nil and differently covered lantana were unique with herb species composition, especially the sites with no lantana cover had native species which were not present in site with differently covered lantana. The distinctness of herb species composition is indicative of marked spatial dynamics with regard to nil and differently covered lantana. Concentration of organic carbon (OC) and total nitrogen (TN) were significantly higher in habitats having large lantana cover. Thus we may conclude that lantana modifies the spatial pattern of herbaceous plant species and the nutrient levels of soil.
Keywords: *Lantana camara, local extinction, soil properties, species composition*

Introduction

Exotic species invasion is amongst the most important global scale problems experienced by natural ecosystems and is also considered as the second largest threat to global biodiversity (Drake et al., 1989). In India, dry tropical accounts for 38.2% of the total forest cover (MoEF, 1999). These forests are under immense anthropogenic pressure in form of rapid industrialization and related land-use change in the past few decades. With increase in human population forests are also exposed to illegal sporadic tree felling, widespread lopping of trees for timber resources and shrubs for fuel wood or leaf fodder (Singh and Singh 1989; Jha and Singh, 1990). All these have lead to forest fragmentation, which is prone to subsequent invasion by exotic species (Tripathi, 2003). Invasion of species may lead to local declines (Islam, 2001) and even extinction of native species (Pimm, 1986) thus altering species richness in the forest fragment (Carey et al., 1996). We studied Lantana (*Lantana camara* L.) as it has spread in almost all the fragmented areas in the Vindhyan dry deciduous forest, and has been ranked as the highest impacting invasive species (Batianoff and Butler, 2003), and is among the 100 worlds worst invasive alien species (GISP, 2003), because it posses great potential to escape cultivation and have deleterious effect on species richness (Islam, 2001). In India it was introduced in early nineteenth century as an ornamental plant (Sharma, 1988), but now it is growing densely throughout India (Sharma et al., 2005a,b).

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However, small-scale environmental changes caused by lantana invasion have not been addressed in dry tropical forest areas. The objective of the present study was to analyze the effect of lantana invasion on the composition of the herbaceous layer and on the soil properties of the dry deciduous forest.

Materials and methods

Study area

The study area (*Fig 1*) lies on the Vindhyan plateau in the Sonebhadra district of Uttar Pradesh (24º 6' to 24º21' N; 82º59' to 83º14'). The elevation above the mean sea level ranges between 315 and 485 m (Singh and Singh, 1992).

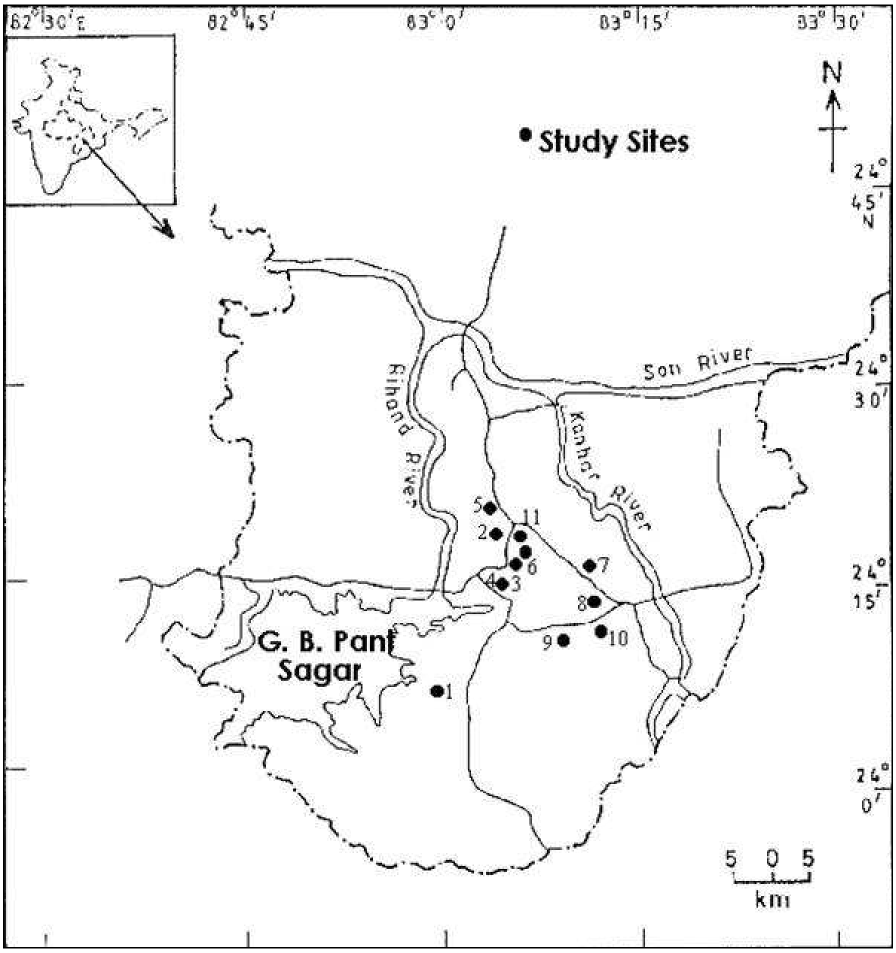

Figure 1. *Location of study sites within Vindhyan highlands, India. 1- Khatabaran; 2- Hathwani I; 3- Hathwani II; 4- Kadhpathar; 5- Majhauli; 6-Hathinala I;7- Bhaheradol; 8- Rajkhar; 9- Manbasa; 10- Runtola; 11- Hathinala II*

The climate is tropical with three seasons in a year, i.e. summer (from March to mid June), rainy (mid June to September) and winter (October to February). October and March constitute the transition months between the rainy and winter seasons, and between winter and summer seasons, respectively. The average rainfall varies between 850 and 1300 mm. About 85% of the annual rainfall occurs during the rainy season from the southwest monsoon. The maximum monthly temperature varies between 20ºC

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in January to 46ºC in June, and the mean minimum monthly temperature between 12ºC in January to 31ºC in May.

Red coloured and fine textured sandstone (Dhandraul orthoquartzite) is the most important rock of the area. Sandstone is generally underlain by shale and limestone. The soils derived from these rocks are residual ultisoils and are sandy-loam in texture (Raghubanshi, 1992). These soils are part of the hyperthermic formation of typical plinthustults with ustorthents according to VII approximation of the USDA soil nomenclature (Singh et al., 2002).

The potential natural vegetation of the region is tropical dry deciduous forest, which is locally dominated by species such as *Acacia catechu, Anogeissus latifolia, Boswellia serrata, Buchanania lanzan, Diospyros melanoxylon, Hardwickia binata, Lagerstroemia parviflora, Madhuca longifolia* and *Terminalia tomentosa*. Height of the locally dominant canopy tree species varies from 6 m to 14 m (Troup, 1921) across the sites and the height of the herb layer varies from 2 cm to 75 cm.

Lantana is a perennial woody shrub and in its naturalized range, lantana forms dense mono-specific thickets 1-4 m high and ≈ 1-4 m in diameter (Sharma et al., 2005b), although some of the clumps smother near by trees and reach up-to the height of 8-15 m (Sharma et al., 2005b). Eleven sites were selected at random in the region, within a radius of approximately 10 km. These sites had visually different levels of invasion of lantana, with one as control site i.e. having no lantana. In Vindhyans micro-distribution pattern of lantana occurs in patches as homogenous clumps.

Data collection

A total of 11 sites were sampled and at each site, three large quadrats (10m x10m) were sampled randomly for vegetation and soil features in the year 2003, i.e. a total of 33 quadrats were sampled in the entire study area. Tree canopy cover in each quadrat was measured by estimating the area, shaded directly by the overhead tree canopy. The values were then transformed into percentage area. All the measurements were taken during mid-day when the sun was approximately perpendicular to the surface.

Lantana cover was estimated using the Domin Krajina scale and was transformed into percentage cover for final analysis (Mueller-Dumbois and Ellenberg, 1974).

The light intensity was measured by LCA-2 battery portable infrared carbon dioxide analyser having PAR (Photosynthetic Active Radiation) sensors (filtered selenium photocell) (ADC Scinokem International, U.K.); the 70-100% sunlight (measured as PAR at 11.00 am on a cloud-free day) corresponded to 1,600-1,720 μmol m^{-2} s^{-1}. Light intensity was measured above and below the lantana bushes of the total light received (values reported are in percent). Percentage light attenuation below lantana was calculated using formula:

$$\%\text{ light attenuation} = \frac{\text{Light above lantana - Light beneath lantana}}{\text{Light above lantana}} \times 100$$

Within each large quadrate, four (0.5 X 0.5 m) mini plots were randomly sampled and density, frequency and cover of herbaceous species were estimated. For density individual plants were counted while frequency of species in each large quadrate was calculated using the ratio of total number of mini plots in which the species occurred to the total number of mini plots studied (i.e. 4) in each quadrate and cover was estimated

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using the ground percentage cover of Domin Krajina scale and transformed into percentage cover in the final analysis (Mueller-Dumbois and Ellenberg, 1974).

Importance values were calculated as the sum of the mean values of relative cover, relative density and relative frequency (Phillips, 1959). Soil samples from the upper10 cm soil layer were collected randomly from three places in each quadrat. Each sample was mixed thoroughly, air dried and sieved through a 2mm mesh screen. Fine roots were hand picked. Soil pH (1:2.5; Soil:Water) was determined by digital pH meter (model 7025M Titrino, Metrohm ion analysis, Metrohm Ltd. Switzerland), organic carbon was measured by Walkey and Black rapid titration method (Jackson, 1958) and total nitrogen by Gerhardt Kjeldal analyzer (Gerhardt Gmbh, Germany). Soil moisture was measured in the field condition using the Theta probe (Delta-T devices Ltd., England). Sampling was carried out during October, when luxuriant mature herbaceous vegetation is present in the area.

Data analysis

Diversity was measured by Shannon-Weiner index (H'):

$$H' = -\sum pi * \ln pi$$

where pi is the importance value contributed by the i^{th} species.

Relationship between tree canopy cover, lantana cover and soil parameters was analyzed by using SPSS Version 10.0 (SPSS, 1997) software and Shannon-Weiner diversity and Principle Component Analysis was calculated using Biodiversity Pro Version 2.0 (McAleece, 1997). Quadrats were segregated into nil, low, medium and high lantana cover, on the basis of PCA ordination.

Results

Lantana cover varied between sites and with tree canopy cover (*Table 1*). For example, when tree canopy cover was >30% (Hathwani I, Hathwani II, Hathinala, Baheradol, Rajkhar, Runtola sites), then the lantana cover varied from 27 to 60% and when the tree canopy cover was <30% (Khatabaran, Kadhpather, Majhauli, Manbasa sites) then there was a considerable increase in lantana cover and it varied from 62 to 84%. Lantana cover was negatively related to tree canopy cover (*Table 2*). At Hathinala II site where the canopy cover was 63% no lantana was reported.

Mean vales of light intensity above the lantana bushes was 20 ± 1.73, 25.4 ± 1.94, 39 ± 2.17 and 63 ± 3.08 for nil, low, medium and high lantana cover respectively, on the other, light intensity recorded beneath the lantana bush was 15.4 ± 1.50, 18.3 ± 2.69 and 8.0 ± 2.73 for low, medium and high lantana cover respectively, of the total light received. The percentage attenuation of light beneath the lantana increased with increasing lantana cover i.e. 40, 53 and 87 % for low, medium and high lantana cover respectively.

Although the lantana cover varied with changes in soil moisture and pH (*Table 1*), it was not significantly related to these soil parameters. There was a strong positive linear relation of lantana cover with soil carbon (*Table 2*). At the maximum (Manbasa site) and minimum (Hathinala II site) lantana cover, organic carbon varied from 3.38 to 1.46% (*Table 1*). The lantana cover also had a strong positive linear relation with soil nitrogen (*Table 2*) which varied from 0.29 to 0.11% among the sites (*Table 1*).

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Table 1. *Vegetation and soil characteristics at different sites (Values in parenthesis are ± SE). Sites are arranged in order of increasing tree canopy cover.*

Sites	Tree canopy cover (%)	Lantana cover (%)	Total herb cover (%)	Shannon diversity (H')	Soil moisture (%)	pH	C (%)	N (%)	Light Intensity (μmol m^{-2} s^{-1})
Khatabaran	15.00 (5.00)	75.00 (10.41)	33.33 (10.26)	0.24 (0.04)	12.50 (1.59)	7.32 (0.07)	2.18 (0.26)	0.14 (0.02)	1706.6 (8.8)
Manbasa	20.67 (9.68)	83.33 (14.24)	32.33 (8.76)	0.55 (0.19)	14.50 (2.01)	7.48 (0.07)	3.38 (0.40)	0.29 (0.04)	1688.3 (6.0)
Majhauli	26.67 (7.26)	68.33 (21.86)	17.66 (9.27)	0.52 (0.18)	20.33 (0.43)	7.42 (0.08)	2.42 (0.49)	0.18 (0.04)	1656.6 (14.5)
Kadhpathar	28.33 (10.93)	61.67 (18.56)	51.66 (17.81)	0.65 (0.13)	19.43 (1.22)	7.44 (0.08)	3.26 (0.44)	0.26 (0.05)	1616.7 (4.4)
Bhaheradol	33.33 (18.33)	60 (21.79)	31.66 (11.09)	0.98 (0.48)	17.23 (1.37)	7.24 (0.08)	2.48 (0.64)	0.20 (0.06)	1536.6 (32.4)
Hathwani I	36.67 (11.67)	48.33 (19.22)	70.66 (16.80)	0.73 (0.07)	15.47 (1.39)	7.26 (0.07)	1.78 (0.23)	0.13 (0.01)	1375.0 (22.5)
Runtola	36.67 (16.91)	58.33 (21.67)	47.00 (23.50)	0.45 (0.25)	13.43 (0.88)	7.46 (0.05)	2.26 (0.35)	0.15 (0.02)	1295.0 (35.1)
Rajkhar	45.00 (16.07)	56.67 (20.28)	36.66 (11.66)	0.66 (0.04)	18.30 (2.89)	7.13 (0.02)	2.36 (0.47)	0.17 (0.03)	956.7 (15.8)
Hathwani II	51.67 (12.02)	56.67 (17.40)	21.33 (5.04)	0.55 (0.09)	17.60 (0.85)	7.29 (0.07)	2.64 (0.30)	0.19 (0.03)	859.3 (11.0)
Hathinala I	56.67 (8.33)	26.67 (10.14)	73.66 (21.34)	0.86 (0.02)	18.53 (1.06)	7.33 (0.06)	1.66 (0.30)	0.13 (0.01)	784.3 (4.7)
Hathinala II	63.33 (1.66)	0.00 (0.00)	94.66 (0.88)	1.16 (0.01)	18.70 (1.22)	7.35 (0.11)	1.46 (0.20)	0.11 (0.008)	707.6 (17.1)

Table 2. *Correlation matrix of vegetation and soil parameters in a lantana invaded forest.*

	Canopy cover (%)	Herb layer diversity	Herb cover (%)	Lantana cover (%)	Carbon (%)	Nitrogen (%)	pH	Moisture (%)
Canopy cover (%)	1							
Herb layer diversity	0.662**	1						
Herb cover (%)	0.503**	0.612**	1					
Lantana cover (%)	-0.853**	-0.749**	-0.544**	1				
Carbon (%)	-0.688**	-0.514**	-0.256	0.824**	1			
Nitrogen (%)	-0.627**	-0.409*	-0.202	0.743**	0.966**	1		
pH	-0.199	-0.143	0.129	0.100	0.192	0.245	1	
Moisture (%)	0.202	0.276	0.136	-0.159	0.060	0.052	-0.094	1

** significant at level 0.01, * significant at level 0.05 (Values are Pearson's correlation coefficients)

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The analysis of variance (ANOVA) revealed that the sites differed significantly in terms of canopy, lantana cover, carbon, nitrogen, diversity and herb cover (*Table 3*).

Maximum herb layer diversity occurred at the Hathinala II site which had no lantana cover followed by Hathinala I site which had 27% lantana cover, and the minimum occurred at the Khatabaran site where lantana cover was 75% (*Table 1*). Lantana cover showed a strong linear negative relationship with Shannon-Weiner diversity index of herbaceous layer (*Table 2*) and herbaceous cover (*Table 2*).

Table 3. *Summary of ANOVA of different sites for vegetation and soil parameters*

Vegetation		**df**	**Mean Square**	**F**	**P**
Canopy cover (%)	Between groups	3	3649.7	22.50	0.000
	Within groups	29	162.2		
	Total	32			
Herb layer Diversity	Between groups	3	0.536	14.54	0.000
	Within groups	29	0.036		
	Total	32			
Herb cover (%)	Between groups	3	4000.5	6.29	0.002
	Within groups	29	636.0		
	Total	32			
Lantana Cover (%)	Between groups	3	11195.23	214.2	0.000
	Within groups	29	52.27		
	Total	32			
Light intensity	Between groups	3	1526668.6	321.9	0.000
	Within groups	29	4742.4		
	Total	32			
Soil parameters					
Carbon (%)	Between groups	3	4.288	17.88	0.000
	Within groups	29	0.240		
	Total	32			
Nitrogen (%)	Between groups	3	0.027	11.92	0.000
	Within groups	29	0.002		
	Total	32			

The Principal Component Analysis (PCA) ordination of 33 quadrates on the basis of IVI of herb species is present in *Fig 2*. The PCA 1 and PCA 2 axis accounted for 14 and 12 % variation respectively. PCA 1 represented the lantana cover (r^2 = 0.36, p = 0.05) cover and the PCA 2 axis was related to tree canopy (r^2 = -0.45, p = 0.009). *Fig 2* indicated that the quadrates segregated on the basis of different lantana cover. Revealing that the nil, low, medium and high lantana cover quadrates are behaving differently in terms of herb species composition.

The dominance spectrum of the herbaceous species changed with the increasing level of lantana cover. *Alysicarpus vaginalis* dominated the herbaceous vegetation at lantana nil sites on the other, *Evolvulus alsinoides* L. dominated the herbaceous vegetation at low, *Oplismenus compositus* Beaub. at medium and *Corchorus trilocularis* L. at high lantana cover (*Table 4*). Species that occurred at high lantana cover with proportionally greater IVI could be considered lantana tolerant species (*Cassia tora* L., *Corchorus trilocularis* L, *Echinochloa colona* Link., *Ichnocarpus frutescens* (L.) R. Br., *Ludwigia perennis* L.) and species that were more predominant at low lantana cover may be considered lantana intolerant (*Dichanthium annulatum* Stapf., *Evolvulus alsinoides* L.,

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Leucas aspera Spr., *Sida acuta* Burm. F., *S. cordifolia* L., *S. rhombifolia* L., *Tephrosia purpurea* Pers.).

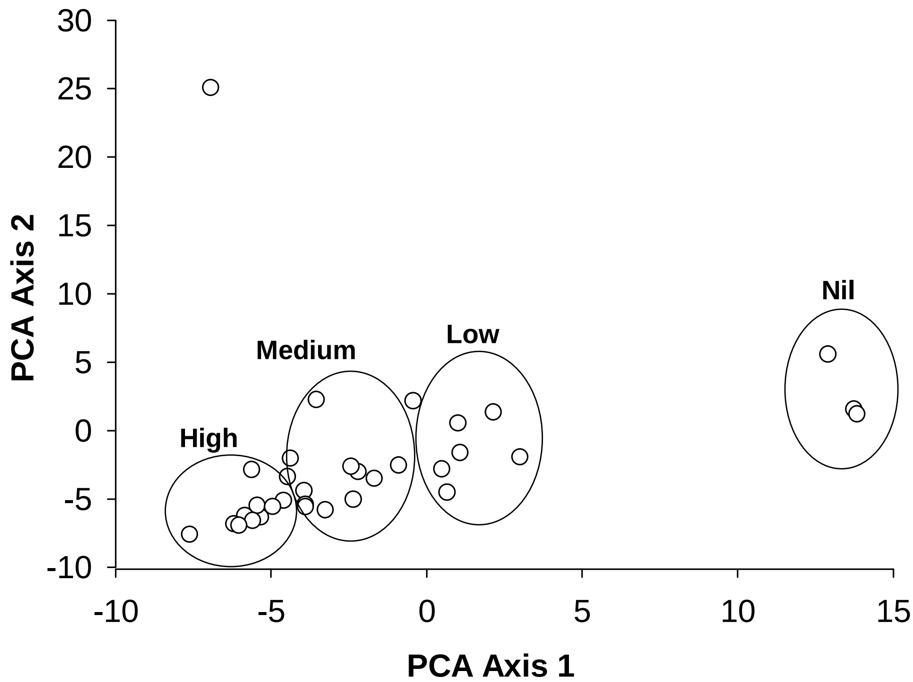

Figure 2. *PCA ordination of herbaceous species showing segregation of quadrats at different level of lantana cover (nil, low, medium and high). The PCA 1 and PCA 2 axis accounted for 14 and 12 % variation respectively.*

Species which are unique to the no lantana site may be considered as highly sensitive species to lantana and proportionality of these unique species increased on the nil lantana cover site with respect to differently covered lantana sites. Species that occurred ubiquitously, irrespective of lantana cover may be considered as species insensitive to lantana cover (*Table 4*).

Table 4. *Importance value indices of herbaceous species under nil, low, medium and high lantana cover and species information*

Species	Family	Life form	A/P	N/NN	Lantana cover (%)			
					Nil (0%)	LOW (0-30%)	MEDIUM (31-60%)	HIGH (61-100%)
Alysicarpus vaginalis (L.) DC	Fabaceae	Th	A	N	8.76	0.00	0.00	0.00
Andrographis echioides Nees.	Acanthaceae	Th	A	N	5.29	0.00	0.00	0.00
Anagallis arvensis L.	Primulaceae	Th	A	NN	0.00	0.00	1.17	0.00
Barleria cristata L.	Acanthaceae	H	P	N	0.00	0.00	0.65	0.00
Begonia picta Sm**.**	Begnoniaceae	H	A	N	3.96	0.00	0.00	0.00
Cassia tora L.	Caesalpiniacae	Th	A	NN	3.02	1.01	2.79	3.75
Ceropegia bulbosa L.	Asclepediaceae	G	P	N	2.83	0.00	0.00	0.00
Chloris dolichostachya Lag.	Poaceae	H	P	N	0.00	0.53	0.00	0.74

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***Table 4.** cont.*

Species	Family	Life form	A/P	N/NN	Lantana cover (%)			
					Nil (0%)	LOW (0-30%)	MEDIUM (31-60%)	HIGH (61-100%)
Chryanthellum americanum (L.) Vatke	Poaceae	Th	A	NN	0.00	0.00	2.30	1.84
Commelina benghalensis L.	Commelinaceae	H	P	N	0.00	0.00	1.56	0.58
Corchorus trilocularis L.	Tiliaceae	Th	A	N	4.71	10.15	14.60	15.96
Coronopus didymus (Linn.) Smith	Brassicaceae	Th	A	NN	0.00	0.00	0.00	0.00
Cyanotis axillaris Schult.	Poaceae	Th	A	N	5.87	0.00	0.00	0.00
Cynodon dactylon Pers.	Poaceae	H	P	N	1.68	2.83	0.00	2.38
Cyperus cyperoides Kuntze.	Cyperaceae	H	P	NN	2.77	1.90	6.02	0.00
Desmodium triflorum DC.	Fabaceae	H	A	NN	4.10	11.10	5.32	11.48
Dichanthium annulatum Stapf	Poaceae	H	P	NN	1.70	1.33	0.00	0.00
Digitaria ciliaris Koel.	Poaceae	Th	A	-	5.66	7.52	11.03	3.59
Echinochloa colona Link.	Poaceae	The	A	NN	0.00	0.00	0.00	0.72
Euphorbia hirta L.	Euphorbiaceae	Th	A	N	0.00	0.00	0.79	0.00
Evolvulus alsinoides L.	Convolvulaceae	H	P	NN	5.94	12.72	3.45	5.54
Evolvulus nummularius L.	Convolvulaceae	H	P	NN	3.14	8.63	6.13	8.32
Fimbristylis ferruginea Vahl	Cyperaceae	Th	A	NN	1.37	0.91	0.00	2.96
Hyptis suaveolens (L.) Poit.	Lamiaceae	Th	A	NN	2.02	0.67	2.62	0.00
Ichnocarpus frutescens (L.) R. Br.	Asclepediaceae	Ch	P	NN	0.00	0.00	0.00	1.70
Justicia simplex Don.	Acanthaceae	Th	A	N	3.17	0.00	0.00	0.00
Leucas aspera Spr	Lamiaceae	Th	A	N	1.67	0.61	0.00	0.00
Lindernia ciliata Pennell.	Scrophulariaceae	Th	A	N	6.59	0.00	0.00	0.00
Ludwigia perennis L.	Onagraceae	Th	A	NN	0.00	1.47	1.95	5.02
Malvastrum tricuspidatum Gray.	Malvaceae	Th	A	NN	2.27	0.76	2.32	0.92
Mukia maderaspatana Roem.	Cucurbitaceae	Th	A	N	0.00	1.77	0.00	2.27
Oplismenus compositus Beaub.	Poaceae	H	P	NN	2.80	7.04	20.82	6.84
Phyllanthus niruri L.	Euphorbiaceae	Th	A	NN	3.34	2.82	0.00	7.81
Phyllanthus urinaria L.	Euphorbiaceae	Th	A	NN	2.81	1.32	0.00	1.19
Physalis minima L.	Solanaceae	Th	A	NN	0.00	0.00	1.56	0.00
Rungia pectinata Nees.	Acanthaceae	Th	A	N	1.30	0.77	0.00	0.58
Setaria pumila R. & S.	Poaceae	Th	A	NN	0.00	0.00	1.37	0.00
Sida acuta Burm. F.	Malvaceae	Th	P	NN	4.20	10.01	6.82	4.88
Sida cordifolia L.	Malvaceae	H	P	NN	5.79	5.00	4.39	1.16
Sida rhombifolia L.	Malvaceae	H	P	NN	3.25	2.54	0.00	0.58
Sporobolus diander Beauv.	Poaceae	H	P	NN	0.00	0.00	1.56	0.00
Tephrosia purpurea Pers.	Fabaceae	Th	P	NN	0.00	1.03	0.00	0.00
Urena lobata L.	Malvaceae	Th	P	NN	0.00	5.58	0.76	9.18

A= Annual, P= Perennial; N= Native, NN= Non-native (Jackson, 1895) and personal communication with Dr. U Dhar.
Th = Therophyte, H = Hemicryptophyte, G = Geophytic, Ch = Chamaephytic

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Discussion

The presence of disturbance in the form of canopy openings increases resource availability and also modifies the microclimate, which is consistent with the disturbance patch invasion model (Gentle and Duggin, 1997). The model state that the removal of competitive biomass and disruption of inter specific competitive interactions creates patches of increased resources. In the present study area canopy openings, which resulted from local disturbance, create patches of greater light availability. Increase in light availability follows gradient of disturbance intensities. Light has long been recognized as an important plant resource (Maximov, 1929; Blankenship, 2002) that may interact with other plant resources to affect plant performance (Cole, 2003). The increase in light availability increases the overall performance of lantana particularly the growth rate (Duggin and Gentle, 1998). Moreover, Chandrashekar and Swamy (2002) also reported that light availability in relatively less canopy enhance the growth of individual lantana.

With increased growth rate, lantana proliferates luxuriantly, which, as demonstrated in this study results in changes in species composition and soil properties. The growth architecture of lantana is such that it prevents light infiltration to the ground. Resulting in marked heterogeneity in terms of irradiance beneath the lantana bush and affects species diversity beneath its canopy. Light availability on the forest floor has been recognized as a key factor that influences intrinsic traits of inhabiting species (Jones et al., 1994; Walters and Reich, 1996). The dense cover created by vertical stratification of lantana may reduce the intensity or duration of light under its canopy and thus decrease the herbaceous cover. This could be due to the creation of a photosynthetically inactive light regime at ground level (Fetcher et al., 1983; Turton and Duff, 1992). Below certain thresholds, however, light limitation alone can prevent herbaceous species survival regardless of other resource levels (Tilman, 1982). It is likely that herbs are influenced by the amount of light that reaches the forest floor, and this may be probably one of the mechanisms responsible for the decline of herbaceous vegetation. Sharma and Raghubanshi (2006, 2007) advocated that the growth architecture pattern of lantana is such that it prevents the light penetration to the forest floor, leading to the decline of tree seedlings and possibly the herb flora.

Species like *Anagallis arvensis* L, *Barleria cristata* L., *Dichanthium annulatum* Stapf, *Physalis minima* L., *Setaria pumila* R. & S., *Sporobolus diander* Beauv. with limited distribution as the lantana cover increases can be more susceptible to loss from physical damage or altered habitat conditions (Meier et al., 1995). Species like *Dichanthium annulatum* Stapf, *Evolvulus alsinoides* L., *Leucas aspera* Spr, *Malvastrum tricuspidatum* Gray., *Rungia pectinata* Nees., *Sida acuta* Burm. F., *Sida cordifolia* L., *Sida rhombifolia* L., *Tephrosia purpurea* Pers. which decrease and ultimately get locally extinct with increasing level of lantana cover may not recover quickly because of the altered physical environmental conditions (Roberts and Gilliam, 1995). Species which are unique (*Alysicarpus vaginalis* (L.) DC, *Andrographis echioides* Nees., *Begonia picta* Sm**.,** *Ceropegia bulbosa* L., *Cyanotis axillaris* Schult., *Justicia simplex* Don. and *Lindernia ciliata* Pennell.) to no lantana cover sites are native species and are highly sensitive to environmental perturbations, are of great concern.

Lantana also possesses the capability to trap wind blown litter. This trapping of litter is also dependent on lantana cover, as denser the lantana cover, greater the trapping potential. So, more organic matter accumulates/builds up with increasing lantana cover.

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Deposition of litter due to wind also affects the herbaceous vegetation (Everham and Brokaw, 1996).

Accumulation of litter beneath the lantana canopies builds up soil organic matter. Accumulation of soil N closely follows that of soil organic matter because, on average 99% of the N in terrestrial ecosystem is organically bound (Rosswall, 1976). Raghubanshi (1992) reported strong positive relation between total N content and organic C content of soil in the dry deciduous forest ecosystem. According to Rawat et al., (1994) superiority in N extraction from the soil along with an efficient retranslocation of N from the senescing leaves enables lantana to perform better as an invasive species. Several studies have shown that soil nutrient levels play an important role in determining community invasibility (Shea and Chesson, 2002; Reinhart and Callaway, 2006). This self perpetuating changed microhabitat could probably provide lantana with increased resource leading to its successful proliferation.

In conclusion the presence of *L. camara* in the dry deciduous forest of India alters the spatial pattern of herbaceous layer vegetation and also changes the microhabitat conditions which could probably help towards its successful proliferation.

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