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A Comparative Study of Lantana Camara infested and eradicated area in Nahan Forest Division, District Sirmour, Himachal Pradesh

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Abstract

Lantana camara, being a weed spreads rapidly in the surroundings and occupies the space of other vegetation thus affecting the natural vegetation of an area. It crowds out other native species and reduces biodiversity. It is important to study *Lantana camara* to find out how it affects the vegetation of an area and what type of problems the people are facing and to find a possible solution for its eradication with the help of local people. In this paper, an effort has been made to present the results of the Biodiversity Mapping in *Lantana camara* infested and eradicated area located in Nahan Forest Division, district Sirmour of Himachal Pradesh. The paper compares the *Lantana* infested and eradicated area and assesses the people's perceptions and regeneration status in the study area.

1. Introduction

Lantana camara regarded both as a notorious weed and a popular ornamental plant, has high degree of tolerance to different soil and different climatic conditions it can easily grow anywhere even in areas even with high disturbances. People face many problems because of *Lantana camara*, because it blocks the local path of rural people and cattle in the forests. It also affects the growth of green grass in the forest area. It is difficult to collect forest resources because of *Lantana camara.* It is believed to be harmful for the livestock because it decreases the milk yield in cattle. *Lantana camara* causes skin irritation and allergic reactions. *Lantana camara*, a species of flowering plant of Verbenaceae family, is a native of Central and South America and was introduced to the world as an ornamental plant. Its original distribution is unclear due to the introduction of number of ornamental varieties. Being the member of Verbenaceae family, the plant is characterized by square-shaped stem with short curved hooked spines. It is a perennial, evergreen shrub having coarse woody stem. It grows to a height of 2 to 5 meter with plentiful branched stem giving dense appearance. The leaves of *Lantana camara* are strongly aromatic and occur opposite in pairs. The length of leaves varies from 4 to 8 cm and the width from 2 to 5 cm with jagged rough margins and bright green upper surface. These are pale green below with petiole of about 2cm length. Flowers are small, multicolor, dense and flat topped with axillary or terminal clusters. Flowers are of small size andodorless. These are very attractive and may vary in color from generally yellow and pink on opening to orange and red or sometimes purple or blue. Fruit of *Lantana camara* is round, small, two seeded drupe or berry. Fruits areclustered into round heads. Firstly, the fruits are green in color then turns into dark purple then turn to black when ripe. Roots of *Lantana camara* are superficial and perennial. Roots goes 30 to 40cm deep in soil. Crown of the plant is about 70 to 100cm in diameter. *Lantana camara* is a drought resistant plant which grows well in high or low rainfall regions. *Lantana camara* grows on loamy soil, sandy soil as well as on stony hills. It has high degree of tolerance to different soil and climatic conditions. It grows naturally in open vegetation and it also grows well in areas having disturbances such as railways and roads etc. and areas recoveringfrom logging or fire. *Lantana camara* is called as a weed or a forest weed because it spreads very rapidly

in the surroundings and affects the vegetation in the area. Even after different eradication programs it is not easy to eradicate *Lantana camara* successfully. The stem of *Lantana camara* easily catches fire resulting in forest fire. Since it has high degree of tolerance, it can grow anywhere and it is very difficult to control it. Dhobhal *et al.* (2010) studied the impact of *Lantana camara* invasion on four major woody shrubs along Nayar river of Pauri Garhwal, in Uttarakhand Himalaya. They found that composition and structure of vegetation of Garhwal region was being modified due to the invasion of *Lantana camara*. Its rapid spreading, entangling nature of canopy of many individuals of a population and allelopathic nature pose serious threat to the native forest flora. Besides its natural tendency to invade, the area having sub-tropical climate integratessuitably to its luxurious growth. Z. *mauritiana Lam., M. koenigii (L.) Spreng, J. adhatoda L.* and *C. opaca* Stapf ex Haines were four native shrub species found abundantly along Nayar river of Garhwal Himalaya. Although, *L. camara* upsets the importance value indices (IVI) ofall four shrubs, its impact on *M. koenigii* and *J. adhatoda* was relatively more alarming, later as found to have morphologically weak structure and meager distribution in *L. camara* invaded localities of study area. The decrease in population of major shrub species can have crucial effect on associated species and consequently on the entire ecosystem. Prasad (2012) studied landscape–scale relationships between the exotic invasive shrub *Lantana camara* and native plants in a tropical deciduous forest in Southern India. In this study, the relationship between *Lantana camara* invasion and native forest understory vegetation was described after accounting for environmental influences. The data suggested that by association with grass decline and decreased recruitment of tree saplings, *L. camara* may be linked with the gradual transition of tropical deciduous forests into exotic-dominated shrub land, and overall native biodiversity loss. Negi *et al.* (2013) studied ecology and use of *Lantana camara* in India. Their study reviewed the current knowledge on *L. camara* with particular focus on its ecological attributes, such as, biomass productivity, reproductive biology, invasiveness, allelopathy, eradication measures and economic uses reported from India. Chatterjee (2015) studied the impact of *Lantana camara* and found it as a major threat to the ecosystem, including plants and animals. He concluded that a carefully knitted plan should be framed emphasizing on exploiting the species economically as well as on taming the threat so that the society can be benefitted by properly utilizing the plant and thus conserve the ecosystem with its bio-resources. Kumar *et al.* (2016) studied impact of *Lantana camara* on animal health and strategies to control. They found that *Lantana camara* is an invasive toxic weed which is dominating globally and is capable of over-run neighboring young plantations. The allelopathic effect is the major contributor for hampering the growth of surrounding vegetation and flare up wherever it finds place. The toxic components present in the plant cause toxicity in almost all the animals thus leading to economic loss among farmers. In this paper, an effort has been made to present the results of the biodiversity mapping in *Lantana camara* infested and eradicated area located in Nahan Forest Division, district Sirmour of Himachal Pradesh.

2. Material and Method

Nahan Block of district Sirmaur was selected for the present study. The study is based on primary and secondary data gathered from different sources.

2.1 Data Collection: Primary Data Collection was undertaken using different tools, viz. Biodiversity Mapping, Assessment of Biodiversity in *Lantana* infested and eradicated areas. Mapping and enlisting of the locally available plants was done with the help of local people using the specially designed format, which included the local name of the plant and its ethno-botanical use. Biodiversity Assessment in Lantana infested and eradicated area was done by using the quadrat method. Quadrat sampling is a classic tool for the study of ecology, especially, biodiversity assessment. This tool allows us to identify the relative abundance of plants andorganisms in an area. Quadrat sampling involves randomly placing of a quadrat on the ground in the area to be sampled. Then, the number of plants and types of plants for the entire habitat are estimated by counting them in the individual quadrats. Eight quadrates were placed in the area which is to be sampled. Out of these eight quadrates, four quadrates were placed in *Lantana* infested area and the other four quadrates were placed in the *Lantana* eradicated area for the assessment of biodiversity. Then, the number of plants present in each quadrate was counted and recorded on recording sheets. Assessment of regeneration

status was also done. Young plants of tree species up to 10 cm diameter are taken into consideration for the assessment of regeneration status of a particular species as suggested in national Forest inventory by FSI. Based on the phyto-sociological data from the plot level calculation, the regeneration status of the sampled species may be assessed in the following categories:

1. Good regeneration, if the seedlings are more in number than the saplings and likewisesaplings are more than the adults.
2. Fair regeneration, if the seedlings are more in numbers than the saplings but the saplings are equal or less than the adults.
3. Poor regeneration, if a species survives only in sapling stage, but not as seedlings(though sapling may be less, more or equal to adults).
4. No regeneration, if a species is absent both in seedling and sapling stage, but presentas adult.
5. New regeneration, if a species has no adults but only sapling and/or seedlings.

In order to gather people's perceptions on *Lantana camara*, focus group discussions were carried out in Kollar, Satiwala, Bankala, and Bikrambag panchayats of Nahan forest divisionof district Sirmaur. The primary data was collected from the local residents by using a semi-structured questionnaire. The questionnaire was based on *Lantana camara.* Information was gathered on profile of respondents; introduction of *Lantana camara* in the study area; useful and harmful aspects of *Lantana camara*; local methods of eradicating *Lantana camara* and awareness of people about *Lantana* eradication program of forest department.

2.2. Sampling: Sample size is a part of population chosen for a survey or experiment. In order to achieve the objectives of the present study, a sample of four groups of people having 35 to 40 people each were selected from different Panchayats of Nahan forest division.

3. Results and Discussion

The study was carried out in Nahan Forest Division of district Sirmour, Himachal Pradesh. Nahan is a tehsil of district Sirmour. District Sirmaur is located in outer Himalay which is commonly known as Shivalik range. The district is predominantly mountainous with deep valleys lying between ranges of varying elevations.

3.1 Biodiversity mapping of the Study Area: 106 species of plants belonging to 45 families were reported during the survey. This enumeration of the floristic diversity of the study area has been taken in context with trees, herbs, shrubs and climbers. The flora is diverse with 45 families and 106 species. The most species rich familyis Fabaceae (14 species) then Combretaceae and Moraceae (6 species) then Asteraceae and Poaceae (5 species) then Myrtaceae and Euphorbiceae (4 species) then Rutaceae, Malvaceae,Meliaceae, Solanaceae, and Anacardiaceae (3 species) and other families are represented by1 or 2 species each. Plant species present in the study are shown in Table 1.

Table 1: Enumeration of the plants species in the study area

Sr. No	Local Name	Botanical Name	Family	Growthhabit
1.	Puthkanda (Chaff flower)	*Achyranthes aspera*	Amaranthaceae	Herb
2.	Khair (Black cutch tree)	*Acacia catechu*	Fabaceae	Tree
3.	Kikar (Gum Arabic)	*Acacia nilotica*	Fabaceae	Tree
4.	Basuti (Malabar nut)	*Adhatoda vasica*	Acanthaceae	Shrub
5.	Bail patri (Stone apple)	*Aegle marmelos*	Rutaceae	Tree

6.	American aloe (Century plant)	*Agave americana*	Asparagaceae	Tree
7.	Neela phulnu (Goat weed)	*Ageratum conyzoides*	Asteraceae	Herb
8.	Siris (Bbeck tree)	*Albizia lebbeck*	Fabaceae	Tree
9.	Chaal (Axlewood)	*Anogeissus latifolia*	Combretaceae	Tree
10.	Neem (Indian lilac tree)	*Azadirachta indica*	Meliaceae	Tree
11.	Kachnar (Mountain ebony)	*Bauhinia variegata*	Fabaceae	Tree
12.	Maljhan, Tor (Malu creeper)	*Bauhinia vahlii*	Fabaceae	Climber
13.	Kumber (Black-jack)	*Bidens pilosa*	Asteraceae	Herb
14.	Simbal (Red cotton tree)	*Bombax ceiba*	Malvaceae	Tree
15.	Sala (Indian frankincense)	*Boswellia serrata*	Burseraceae	Tree
16.	Dhak (Bastard teak)	*Butea monosperma*	Fabaceae	Tree
17.	Bottlebrush	*Callistemon viminalis*	Myrtaceae	Tree
18.	Ak(Giant milkweed)	*Calotropis procera*	Apocynaceae	Shrub
19.	Bhang(Marijuana)	*Cannabis sativa*	Cannabaceae	Herb
20.	Kumbi (Wild guava)	*Careya arborea*	Lecythidaceae	Tree
21.	Karonda (Bengal currant)	*Carissa carandas*	Apocynaceae	Shrub
22.	Kandai (Wild karanda)	*Carissa opaca*	Apocynaceae	Shrub
23.	Chilla (Toothed leaf chilla)	*Casearia tomentosa*	Salicaceae	Tree
24.	Amaltas (Golden shower)	*Cassia fistula*	Fabaceae	Herb
25.	Peeta amaltas (Smwth senna)	*Cassia glauca*	Fabaceae	Tree
26.	Sicklepod (American sicklepod)	*Cassia obtusifolia*	Fabaceae	Shrub
27.	Panwad (Senna tora)	*Cassia tora*	Fabaceae	Herb
28.	Toon (Indian mahogany)	*Cedrela toona*	Meliaceae	Tree
29.	Raat ki rani (Night-blooming jasmine)	*Cestrum nocturnum*	Solanaceae	Shrub
30.	Dhalu ghas (Guria grass)	*Chrysopogon montanus*	Poaceae	Herb
31.	Ban haldi (Wild turmeric)	*Curcuma aromatica*	Zingiberaceae	Herb
32.	Doob (Bermuda grass)	*Cynodon dactylon*	Poaceae	Herb
33.	Sheesam (North Indian rosewood)	*Dalbergia sissoo*	Fabaceae	Tree
34.	Bans (Bamboo)	*Dendrocalamus strictus*	Poaceae	Tree
35.	Air potato (Air yam)	*Dioscorea bulbifera*	Dioscoreaceae	Climber
36.	Bis tendu (Bombay ebony)	*Diospyros montana*	Ebenaceae	Tree
37.	Tendu (East Indian ebony)	*Diospyros tomentosa*	Ebenaceae	Tree
38.	Mehandu (Hopbush)	*Dodonaea viscosa*	Sapindaceae	Largehrub
39.	Chamror	*Ehretia laevis*	Boraginaceae	Tree
40.	Amla(Indian gooseberry)	*Emblica officianalis*	Phyllanthaceae	Tree
41.	Bhaber (Sabai grass)	*Eulaliopsis binata*	Poaceae	Herb

42.	Dhudhla (Fire plant)	*Euphorbia heterophylla*	Euphorbiceae	Herb
43.	Chati dudhi (Asthma plant)	*Euphorbia hirta*	Euphorbiceae	Herb
44.	Safeda (Blue gum tree)	*Eucalyptus*	Myrtaceae	Tree
45.	Trimal/Chimbal (Roxburgh fig)	*Ficus auriculata*	Moraceae	Tree
46.	Bargad (Indian banyian)	*Ficus benghalensis*	Moraceae	Tree
47.	Gular (Cluster fig)	*Ficus glomerata*	Moraceae	Tree
48.	Peepal (Sacred fig)	*Ficus religiosa*	Moraceae	Tree
49.	Kambri (Wild fig)	*Ficus palmata*	Moraceae	Tree
50.	Kharpal (Grey downy blsam)	*Garuga pinnata*	Burseraceae	Tree
51.	Silver oak (Southren silky oak)	*Grevillea robusta*	Proteceae	Tree
52.	Dhaman (Phalsa)	*Grewia elastica*	Malveceae	Tree
53.	Behul (Bhimal)	*Grewia optiva*	Malvaceae	Tree
54.	Gumar (Australian cowplant)	*Gymnema sylvestre*	Apocynaceae	Shrub
55.	Papdi (Indian elm tree)	*Holoptelea integrifolia*	Ulmaceae	Tree
56.	Jacaranda (Blue jacaranda)	*Jacaranda mimosifolia*	Bignoniaceae	Tree
57.	Arandi (Physic nut)	*Jatropha curcas*	Euphorbiaceae	Shrub
58.	Jhingan (Indian ash tree)	*Lannea coromandelica*	Anacardiaceae	Tree
59.	Toothed-leaf limonia	*Limonia crenulata*	Rutaceae	Tree
60.	Mahua (Madhuka tree)	*Madhuca longifolia*	Sapotaceae	Tree
61.	Aam (Mango)	*Mangifera indica*	Anarcadiaceae	Tree
62.	Kamala(Red kamala)	*Mallotus philippines*	Euphorbiaceae	Tree
63.	Darek (Chinaberry)	*Melia azedarach*	Meliaceae	Tree
64.	Dambal (Dunal hook)	*Miliusa velutina*	Annonaceae	Tree
65.	Kaem (True kadamb)	*Mitragyna parvifolia*	Rubiaceae	Tree
66.	Tut (White mulberry)	*Morus alba*	Moraceae	Tree
67.	Kari patta (Curry tree)	*Murraya koenigi*	Rutaceae	Tree
68.	Tulsi (Holy basil)	*Ocimum sanctum*	Labiateae	Herb
69.	Nagfani (Prickly pear)	*Opuntia elatior*	Cactaceae	Herb
70.	Tat-balanga (Indian trumpet flower)	*Oroxylum indicum*	Bignoniaceae	Tree
71.	Khatti ambi (Creeping woodsorrel)	*Oxalis corniculata*	Oxalidaceae	Herb
72.	Sandan (Sandan tree)	*Ougeinia oojeinensis*	Fabaceae	Tree
73.	Congress grass (	*Parthenium hysterophorus*	Asteraceae	Herb
74.	Khajur (Dwarf date palm)	*Phoenix humulis*	Arecaceae	Tree
75.	Rusberry (Balloon cherry)	*Physalis angulata*	Solanaceae	Herb

76.	Chir (chir pine)	*Pinus roxburghii*	Pinaceae	Tree
77.	Poplar (Himalayan poplar)	*Populas*	Salicaceae	Tree
78.	Vilayati kikar (Mesquite)	*Prosopis juliflora*	Fabaceae	Tree
79.	Amrood (Guava)	*Psidium guajava*	Myrtaceae	Shrub
80.	Daru (Popmegranate)	*Punica granatum*	Lythraceae	Shrub
81.	Jungli gulab (Musk rose)	*Rosa moschata*	Rosaceae	Shrub
82.	Kadh (Pin red grass)	*Saccharum munja*	Poaceae	Herb
83.	Jungle aam (Indian soapberry)	*Sapindus mukorossi*	Sapindaceae	Tree
84.	Ashok (Ashoka tree)	*Saraca asoca*	Fabaceae	Tree
85.	Bhilwa (Marking nut tree)	*Semecarpus anacardium*	Anacardiaceae	Tree
86.	Sal (Sal tree)	*Shorea robusta*	Diptocarpaceae	Tree
87.	Kantakari (Yellow-fruit nightshade)	*Solanum xanthocarpum*	Solanaceae	Herb
88.	Tamoa (Java plum)	*Syzygium cumini*	Myrtaceae	Tree
89.	Teak	*Tectona grandis*	Lamiaceae	Tree
90.	Sain (Black murdah)	*Terminalia alata*	Combretaceae	Tree
91.	Arjun (Arjun tree)	*Terminalia arjuna*	Combretaceae	Tree
92.	Bahera (Bibhitaki)	*Terminalia bellirica*	Combretaceae	Tree
93.	Harad (Myrobalan fruit)	*Terminalia chebula*	Combretaceae	Tree
94.	Sain (Indian Laurel)	*Terminalia elliptica*	Combretaceae	Tree
95.	Peeli kaner (Yellow oleander)	*Thevetia peruviana*	Apocynaceae	Shrub
96.	Gudbelli(Giloy)	*Tinospora cordifolia*	Menispermaceae	Climber
97.	Gulbel (Heart-leaved moonseed)	*Tinospora sinensis*	Menispermaceae	Climber
98.	Naag chhatri (Himalayan trillium)	*Trillium govanianum*	Melanthiaceae	Herb
99.	Kalijiri (Purple fleabane)	*Vernonia anthelmintica*	Asteraceae	Herb
100.	Bahna (Chinese chaste tree)	*Vitex negundo*	Lamiaceae	Shrub
101.	Wild grapes (Riverbank grape)	*Vitis reparia*	Vitaceae	Climber
102.	Chili	*Wendlandia heynei*	Rubiaceae	Tree
103.	Dhai/Dhatki (Fire-flame bush)	*Woodfordia fruticosa*	Lythraceae	Shrub
104.	Kumbar (Common cocklevur)	*Xanthium strumarium*	Asteraceae	Herb
105.	Ber (Indian Jujube)	*Ziziphus mauritiana*	Rhamnaceae	Tree
106.	Jungli ber (Wild jujube)	*Ziziphus rugosa*	Rhamnaceae	Tree

Source: Primary Data

Growth habit of species: Total 106 species were reported in the survey havingdifferent life forms or growth habit. The different life form or growth habits are trees, herbs, shrubs and climbers. Most of the species are trees and the least number are climbers. There are 64 tree species, 22 herb species, 15 shrub species and 5 species of climbers. List of life forms are presented in Table 2.

Table 2: Growth habit of species reported from study area

Sr. No.	Growth Habit	No of Species	Percentage
1.	Trees	64	60.37 %
2.	Herbs	22	20.75 %
3.	Shrubs	15	14.15 %
4.	Climbers	5	4.71 %

Source: Primary Data

3.2 Biodiversity Assessment in *Lantana* infested and eradicated area: In the present study total eight quadrats were placed in the area which was to be sampled, out of which four were placed in *Lantana* infested area and four were placed in *Lantana* eradicated area. The size of each quadrat was 10×10 mts. Then the total numbers of plants present in these quadrats were counted. Total twenty-seven species of plants were recorded. Fifteen species of plants were reported in *Lantana* infested area and twenty species of plants were reported in *Lantana* eradicated area. The number of plants present in the quadrates of sampled area is presented in Table 3.

Classes of Trees: Trees found in these quadrates are classified into different classes on the base of their Girth. In the present study different species of trees were reported having different girth. So the trees were of different classes. In the present study there were trees of class 1, class 2, class 3 and class 4. Different classes of trees based on their girth as reported form the field are shown in Table 4.

Distribution of species in *Lantana* infested and eradicated area: Total 27 species of plant were recorded in all the eight quadrates. Out of these 27 species, 5 species were infinitely distributed and remaining 22 species were represented by 1161 plants in all eight quadrates. Excluding the species which were infinitely distributed in the quadrates, 13 species were present in Lantana infested area and 16 species were present in Lantana eradicated area. Out of 1161 plants, 401 plants were reported in Lantana infested area and remaining 760 plants were reported in Lantana eradicated area. The distribution of species and their as reported in the quadrates are presented in Table 5.

Phyto-sociological Analysis: The vegetation data were analyzed for % Frequency (F), Density (D) and Abundance (A).

Frequency (F): It is an important parameter of vegetation analysis, which shows the distribution of a species in the study area. For example if a species occurs in all quadrats, it means it is widely or uniformly distributed in entire study area and if a species occurs in few quadrats, it means that it is present in a part of the study area. The species which occurs in all the quadrats have the maximum frequency and the species that occurs in lesser quadrats have the minimum frequency. The % Frequency is calculated by using the following formula:

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

If the species occurs in all the quadrats studied, its frequency would be 100% and if a species occur in 10 quadrats out of 20 quadrats, its frequency will be 50%. It is a very important quantitative parameter. Raunkiaer (1934) made an elaborated study on the frequency of species and divided species in to 5 classes, based on his data which are class A,class B, class C, class D and class E. The distribution of frequency is shown in Table 6. Each species was classified in above mentioned class. A histogram was drawn with percentage of the total number of species on y axis and frequency classes A to E on X axis. The percentage of number of species falling in class A, B, C, D and E were calculated and compared with the standard values (Class A-53%, Class B-14%, Class C-9%, Class D-8%, Class E-16%) given by Raunkiaer and with the law of frequency as: $A > B > C \geq$ or $\leq D < E$. If the value of the ratio E+D/B+C is less than one, the vegetation stand/community is homogeneous. Greater the value than one greater would be the homogeneity of the stand.

Density (D): No of individuals of a particular species per unit area is known as density. Plant density gives an idea of how closely trees are growing in a given area. This value is expressed as plants per hectare. The density of plants is not an exact number of plants in the region.

$$\text{Density} = \frac{\text{Total no of individuals of the species}}{\text{Total no of quadrats used in sampling}}$$

Abundance (A): Abundance is also calculated like density but in abundance, only those quadrats are considered for calculation in which the species occurs. For example, if a species has occurred in only 2 quadrats out of 4 quadrates studied, then the total numbers of individuals are divided by 2 not by 4. The formula for calculation of species abundance is:

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

Table 3: Species present in *Lantana* infested and eradicated area

	Infested Area				**Eradicated Area**			
Species	**Presence of Species**				**Presence of Species**			
Name of species	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Kari patta (*Murraya koenigii*)	102	30	38	14	40	55	20	60
Sal * (*Shorea robusta)*	54	42	11	-	4	40	24	64
Sain ** (*Terminalia elliptica*)	18	12	12	-	11	12	14	11
Pink flower	8	-	-	-	45	22	10	-
Camela *** (*Callistememon viminalis*)	8	10	5	-	9	19	50	25
Papdi**** (*Holoptelea integrifolia*)	1	-	-	-	-	-	-	-
Puthkanda (*Achyramthesthes aspera*)	18	-	-	-	-	-	-	-
Harad***** (*Terminalia chebula*)	-	3	-	-	-	-	-	-
Jungli gulab(*Rosa moschata)*	-	5	-	-	-	-	1	-
Dhalu ghaas(*Chrysopogon montanus)*	∞	∞	∞	∞	∞	∞	∞	∞
Jungli berry (*Ziziphus mauritiana*)	-	3	-	-	-	-	-	-
Karonda (*Carissa carandas*)	-	4	-	-	-	-	-	-
Kandai******(*Carissa opaca)*	-	-	2	-	-	-	-	5

Khajur******* (*Phoenix humulis*)	-	-	-	1	-	-	-	-
Khatti ambi *(Oxalis corniculata)*	-	-	-	-	∞	∞	∞	∞
Congress grass (*Partheniumhysterophorus*)	-	-	-	-	120	-	12	45
Doob grass (*Cynodon dactylon*)	-	-	-	-	∞	∞	∞	∞
Gumar ******** (*Gymnema sylvestre*)	-	-	-	-	-	-	-	1
Panwad (*Cassia tora*)	-	-	-	-	∞	∞	∞	∞
Gud belli (*Tinospora cordifolia*)	-	-	-	-	20	5	7	9
Sheesam ********** (*Dalbergia sissoo*)	-	-	-	-	-	-	-	1
Dhak ********** (*Butea monosperma*)	-	-	-	-	-	-	-	1
Kungi	-	-	-	-	-	50	42	-
Simbal ********** (*Bombax ceiba*)	-	-	-	-	1	2	-	-
Kadh(*Saccharum munja)*	-	-	-	-	3	6	3	1
Guava********** (*Psidium guajava*)	-	-	-	-	2	-	-	-
Neela phulunu *(Ageratum conyzoides)*	∞	∞	∞	∞	-	-	-	-

Note **Infested Area:** **Quadrat 1:** *4 Pole stage and 50 Saplings. Poles having girth of 15cm,17cm, 18cm and 20cm respectively. **18 Saplings **1 Pole stage and 7 Saplings ****1 Sapling **Quadrat 2:** *2 Trees and 40 Saplings **2 Trees and 10 Saplings ***10 Saplings *****3 Sapling **Quadrat 3:** *1 Tree and 10 Saplings. Girth of tree is 90cm. **12 Saplings ***5 Saplings	**Eradicated area:** **Quadrat 1:** *4 Pole stage having girth of 10cm, 8cm, 10cm, 11cm respectively **11 Saplings ***9 Saplings **********1 Sapling **********2 Pole stage having girth of 10cm and 8cm. **Quadrat 2:** *18 Pole stage and 22 saplings. Poles having girth between 9 to 18cm. **12 Saplings ***1 Tree, 6 pole stage and 12 saplings. The girth of the tree is 92cm and thegirth of poles lies between 8 to 16cm. **********1 Tree and 1 sapling. The girth of the tree is 165cm. **Quadrat 3:** *9 Trees and 15 pole stage. Three trees have girth between 90-120cm, three trees have girth between 60-90cm, two trees have girth between 120-150cm,and one tree have girth between 150-180cm. the girth of poles lies between 12-20cm.
******2 Pole stage having girth of 25cm and 28cm. **Quadrat 4:** ********1 sapling	**3 Trees and 11 saplings. Trees have girth of 100cm, 108cm and 170cmrespectively. ***50 Saplings **Quadrat 4:** *4 Trees, 10 poles and 50 saplings. Trees have girth of 230cm, 125cm, 128cm,and 97cm respectively. **1 Tree and 10 saplings. The girth of tree is 122cm ***5 Trees and 20 saplings. Trees have girth of 86cm, 64cm, 72cm, 66cm and78cm respectively. ******5 Poles having girth of 15cm, 30cm, 32cm, 28cm and 18cm *********1 Tree having girth of 84cm **********1 Tree having girth of 132cm **********1 Tree having girth of 114cm

Table 4: Classes of Trees

Class of tree	**Girth (in cm)**
Class 1	180-280 cm
Class 2	120-180 cm
Class 3	90-120 cm
Class 4	60-90 cm

Table 5: Showing distribution of species in Lantana infested area and eradicated area

Sr. No.	**Name of species**	**Total no. of species presents inall quadrates of**	
		Infested area	**Eradicated area**
1.	Kari patta (*Murraya koenigii*)	184	175
2.	Sal (*Shorea robusta)*	107	132
3.	Sain (*Terminalia elliptica*)	42	48
4.	Pink flower	8	77
5.	Camela (*Callistememon viminalis*)	23	103
6.	Papdi (*Holoptelea integrifolia*)	1	-
7.	Puthkanda (*Achyramthesthes aspera*)	18	-
8.	Harad (*Terminalia chebula*)	3	-
9.	Jungli gulab(*Rosa moschata)*	5	1
10.	Dhalu ghaas(*Chrysopogonmontanus)*	Infinity	Infinity
11.	Jungli berry (*Ziziphus mauritiana*)	3	-
12.	Karonda (*Carissa carandas*)	4	-
13.	Kandai(*Carissa opaca)*	2	5
14.	Khajur (*Phoenix humulis*)	1	-
15.	Khatti ambi *(Oxalis corniculata)*	-	Infinity
16.	Congress grass (*Partheniumhysterophorus*)	-	177
17.	Doob grass (*Cynodon dactylon*)	-	Infinity
18.	Gumar (*Gymnema sylvestre*)	-	1
19.	Panwad (*Cassia tora*)	-	Infinity
20.	Gud belli (*Tinospora cordifolia*)	-	41
21.	Sheesam (*Dalbergia sissoo*)	-	1
22.	Dhak (*Butea monosperma*)	-	1
23.	Kungi	-	92
24.	Simbal (*Bombax ceiba*)	-	3
25.	Kadh(*Saccharum munja)*	-	13
26.	Guava (*Psidium guajava*)	-	2
27.	Neela phulunu *(Ageratumconyzoides)*	Infinity	-

Source: Primary Data

Table 6: Distribution of frequency

Raunkiaer's Frequency Class	Frequency Range
A	1-20%
B	21-40%
C	41-60%
D	61-80%
E	81-100%

Table 7: Result of Phyto-sociological analysis in *Lantana* infested area

Name ofspecies	Infested Area				A	B	C	D	E	F
	No of species in									
	Q 1	Q 2	Q 3	Q 4						
Kari patta(*Murraya koenigii*)	102	30	38	14	4	4	184	100%	4	76
Sal (*Shorearobusta)*	54	42	11	-	3	4	107	75%	3	26.75
Sain (*Terminaliaelliptica*)	18	12	12	-	3	4	42	75%	3	14
Pink flower	8	-	-	-	1	4	8	25%	1	8
Camela (*Callistememon viminalis*)	8	10	5	-	3	4	23	75%	3	7.66
Papdi (*Holopteleaintegrifolia*)	1	-	-	-	1	4	1	25%	1	1
Puthkanda (*Achyramthesthes aspera*)	18	-	-	-	1	4	18	25%	1	18
Harad (*Terminaliachebula*)	-	3	-	-	1	4	3	25%	1	3
Jungli gulab(*Rosamoschata)*	-	5	-	-	1	4	5	25%	1	5
Jungli berry(*Ziziphus mauritiana*)	-	3	-	-	1	4	3	25%	1	3
Karonda (*Carissa carandas*)	-	4	-	-	1	4	4	25%	1	4
Kandai (*Carissaopaca)*	-	-	2	-	1	4	2	25%	2	2
Khajur (*Phoenixhumulis*)	-	-	-	1	1	4	1	25%	1	1

Source: Primary Data

A. Total no of quadrates of occurrence;

B. Total no of quadrates study

C. Total no of individuals

D. Frequency (F) (in %)

E. Density (D)

F. Abundance (A)

Phyto-sociological analysis in Lantana infested area: The species having maximum frequency or 100 percent frequency in *Lantana* infested area is Kari patta (*Murraya koenigii*). Kari patta (*Murraya koenigii)* has highest density and abundance. The least abundant species are Papdi (*Holoptelea integrifolia*) and Khajur (*Phoenix humulis*).

Table 8: Result of Phyto-sociological analysis in *Lantana* eradicated area

Name ofspecies	Eradicated Area				A	B	C	D	E	F
	Eradicated Area									
	Q 1	Q 2	Q 3	Q 4						
Kari patta(*Murraya koenigii*)	40	55	20	60	4	4	175	100%	43.75	43.5
Sal (*Shorearobusta)*	4	40	24	64	4	4	132	100%	33	33
Sain (*Terminalia elliptica*)	-	12	14	11	3	4	37	100%	12	12
Pink flower	45	22	10	-	3	4	77	75%	19.25	25.66
Camela (*Callistememon viminalis*)	9	19	50	25	4	4	103	100%	25.75	25.75
Jungli gulab(*Rosa moschata)*	-	-	1	-	1	4	1	25%	0.25	1
Kandai (*Carissaopaca)*	-	-	-	5	1	4	5	25%	1.25	5
Congress grass (*Parthenium hysterophorus*)	120	-	12	45	3	4	177	75%	35.4	59
Gumar (*Gymnema sylvestre*)	-	-	-	1	1	4	1	25%	1.25	1
Gud belli (*Tinospora cordifolia*)	20	5	7	9	4	4	41	100%	10.25	10.25
Sheesam (*Dalbergia sissoo*)	-	-	-	1	1	4	1	25%	0.25	1
Dhak (*Buteamonos perma*)	-	-	-	1	1	4	1	25%	0.25	1
Kungi	-	50	42	-	2	4	92	50%	23	46
Simbal (*Bombaxceiba*)	1	2	-	-	2	4	3	50%	0.75	1.5
Kadh(*Saccharum munja)*	3	6	3	1	4	4	13	100%	3.25	3.25
Guava (*Psidiumguajava*)	2	-	-	-	1	4	2	25%	0.5	2

Source: Primary Data

A. Total no of quadrates of occurrence
B. Total no of quadrates study
C. Total no of individuals
D. Frequency (F) (in %)
E. Density (D)
F. Abundance (A)

Phyto-sociological analysis in *Lantana* eradicated area: The species having maximum frequency or 100 percent frequency in *Lantana* eradicated area are Kari patta (*Murraya koenigii*), Sal (*Shorea robusta),* Sain (*Terminalia elliptica*), Camela (*Callistememon viminalis*), Gud belli (*Tinospora cordifolia*) and Kadh (*Saccharum munja).* The species having highest density is Kari patta (*Murraya koenigii).* The species having highest abundance is *Kungi*.

Table 9: Differences in *Lantana* infested and Eradicated Area

***Lantana* infested area**	***Lantana* eradicated area**
13 species of plants werepresent	16 species of plants were present
Numbers of individuals in aspecies are less in number	Numbers of individuals in aspecies are more in number

The study thus reveals that the number of species in the infested and eradicated area were different. There was different species present infested and eradicated area. The numbers of individuals which represent a species were also different.

Regeneration Status: In the study area the regeneration status was poor because the surviving species were only in the sapling stage, not as seedling (though sapling may be less, more or equal to adults).

People's Perceptions on *Lantana camara*: The information was collected from the local people of study area and the same is presented in table 10.

Table 10: People's perception on *Lantana camara*

Parameter	**Reply**
Local name of *Lantana camara*	Barjita
Lantana camara introduced inthe area	8-9 years
Time it takes to grow fully	2 years
Height of plant	8-10 feet
Time taken to spread itself in surroundings	1 year
Which season it affects more	Rainy and winters, because it grows fully inrainy season and spines grows in winters.
Which season it grows rapidly	Rainy
Flowering season	Rainy and winters
Season of ripening of fruits	Winters
Season it which fruit is mostpoisonous	Rainy, when it is green in color
Depth of roots	1.5 feet approx.
Effects on surroundings	Slows or stops the growth of new plants, blocksthe path of local people and cattle, it becomes tough to walk in the forest and collect forest resources, it spreads rapidly in the nearby areas
Effects on vegetation	No vegetation survives under or near *Lantana* It slowdowns the growth of plants
Effect on richness of	It kills most of the plants and only a few species
biodiversity	of plants survive in the nearby area
Impact on regeneration	Slow regeneration or no regeneration.
Effect on livestock	Cattles fall sick if they consume *Lantana.* It is tough for the cattle to enter and graze in forestwith *Lantana camara*. It reduces blood in cattle, causes skin problemsand affects the quantity of dung in the cattle and leads to death. Twenty cattle died in the area after consuming

	Lantana camara
Impact on Humans	Handling of *Lantana camara* cause skin allergyor reaction; it causes itching, inflammation or burning sensation.
Effects on soil	Decreases soil fertility It holds the soil and prevents the soil erosion.
Growth parameters	It grows more in dry areas It grows rapidly in shady areas Frost just weaken the growth of *Lantana*
Useful Aspect	The bright color of flower attracts bees andbutterflies. Dry leaves are used as a fuel for cooking and heating purpose. Stem of *Lantana* burns easily, hence, stem of *Lantana* are used as a householdfuel for cooking and heating. It burns very easily and it produces less smoke.
Local methods of eradication	Root eradication or cutting is done with thehelp of *Drati* and *Drat*.
Local tools for eradication	*Drati, drat , kudali and fawda/ramba*
People had awareness of *Lantana* eradication program of forest department	

Source: Primary Data

In the Indian sub-continent *Lantana* has entered vast areas of dry-moist jungles and other culturable deserts, and has possibly affected the biodiversity, ecology and ecosystem services. It has occupied most Indian pasture lands (13.2 million ha) besides forest and fallow areas, and the cost of its control is estimated at US$ 70per ha. This intrusive weed stands out because of its quick spread, intensity of invasion, allelopathy, adaptable growth behaviour, reproductive biology traits and persistent resistance to cutting and burning. This paper reviews the current knowledge on *L. camara* with specific emphasis on its ecological attributes such as biomass productivity, reproductive biology, invasiveness, allelopathy, eradication measures and economic uses. Based on the literature review it can be pointed out that the positive impacts and economic uses of *Lantana* overshadow its negative impacts and need additional studies on cost-benefit concerns for decision making for its extermination and management. 106 plant species belonging to 45 families have been reported in the present study. Out of total 106 plants species, 64 were trees, 22 were herbs, 15 were shrubs and 5 were climber. Maximum number of species (14) belongs to family fabaceae. Pal *et al* (2014) carried out a study in Theog Forest Division on floristic diversity and found a total number of 442 species of plants belong to 97 different families. Subramani *et al* (2014) carried out a study in Churdhar wildlife sanctuary on addition to the Floral wealth of Sirmour districtand found a total number of 352 species belongs to 85 families were recorded. This includes 13 threatened Red listed species. Verma *et al* (2012) carried out a study in Phulang valley of Lippa-Asrang Wildlife Sanctuary of District Kinnaur, Himachal Pradesh. Intheir study they recorded 127 species belonging to 35 different families and the dominant families were Asteraceae followed by Fabaceae and Lamiaceae. Kumar (2014) studied Floral Diversity of Joginder Nagar and adjoining areas in District Mandi, H.P. In his study he found 100 different species of plants which belongs to 53 families. The family with maximum number of species was Asteraceae with 8 species, followed by Fabaceae with 7 species. Verma and Kapoor (2010) carried out a study of Assessment of Floristic Diversityin Pooh Valley of cold deserts of District Kinnaur, Himachal Pradesh. In their study, they recorded 192 species of plants which belonged to 45 different families. The dominant families were Asteraceae, Rosaceae, Lamiaceae and Polygonaceae. In the present study of *Lantana* infested and eradicated area, the more species of plants were found in *Lantana* eradicated area as compared to *Lantana* infested area and the number of individuals which represented a species were more in *Lantana* eradicated area and less in the infested area. The local people use root eradication or cut the plant with the help of *Drati* and *Drat*. The people of the study area revealed that it affects the health of livestock. Love *et al* (2009) studied management of *Lantana*, an invasive alien weed, in forest ecosystems of India. Theyconcluded that no effective management strategy was available for the

containment of this obnoxious alien weed. On the basis of critical assessment of the biological and ecological attributes of *Lantana* that enabled it to overcome the existing management practices, they have developed a management strategy. The strategy involved (i) its removal by cut rootstock method; (ii) weeding of saplings from beneath the trees used for perching by generalist birds that disperse the seeds throughout their home range and from surface drainage channels originating from the area covered by such trees. Kumar *et al* (2016) studied *Lantana camara*, an alien weed, its effect on animal health and approaches tocontrol. They resolved that only the utilization of the plant can be an effectual method for handling this weed. This can help in getting rid of the negative impact of this weed on environment and help in economic upliftment of rural economy. Nawab and Yogamoorthi (2016) studied Allelopathic effects of aqueous extract of *Lantana camara* L. on seed germination of Black gram *Vigna mungo* L. Their study envisaged that aqueous extracts of *Lantana camara* exhibit strong inhibitory allelopathic effect on the germination process of *Vigna mungo* L. Girish (2017) studied Antimicrobial activities of *Lantana camara* Linn. He concluded that traditionally, it has been used in treating various ailments and they are supported by scientific data. However, most of the pharmacological studies were preliminary and requires intensive preclinical and clinical studies to evaluate the efficacy and toxicity of these plant products. Thus, an efficient way of monitoring the species lies in the organized way of creating income generation openings of the rural people through proper use of the species. Stem of *Lantana* can be used for making furniture which is inexpensive than cane. Artisans of South India are skillfully using *Lantana camara*, for the making furniture, toys and articles of household utility (Kannan *et al*., 2008 and Perrings *et al*., 2010). This weed is mixed with mud to erect house walls in rural areas of Uttarakhand. *Lantana* leaves have admirable antimicrobial, fungicidal, insecticidal,nematicidal, biocidal activity, thus it is very useful in various folklore and ethno-medicine (Sharma *et al*. 1988; Sharma *et al*. 1999; Begum *et al*. 2000 and Saxena 2000 ;). Twigs and stems are used as fuel for cooking and heating and in production of valuable ethanol (Varshney *et al*., 2006). Aravind*et al* (2010) studied the impact of invasive plant, *Lantana camara* on bird groupings at Male Mahadeshwara Reserve Forestin South India and found an increase in *Lantana* density, which was interrelated with a drop in canopy birds (of the canopy microhabitat guilds) and insectivores (of the insectivore foraging guilds). They concluded that *Lantana* affects the structure of the bird community by decreasing diversity, and *Lantana* affects certain guilds more than others. Singh *et al.* 2014 studied the negative effect of litter of invasive weed *Lantana camara* on structure and composition of vegetation in the lower Shiwalik Hills, northern India. In their study, they concluded that *Lantana* invasion greatly reduces the density and diversity of the vegetation in the invaded area, and chemical interference of its litter plays an important role in invasion.

4. Conclusion

The comparative study of *Lantana* infested and eradicated area showed that the area in which *Lantana* is present has lesser number of species as compared to the *Lantana* eradicated area. Numbers of individuals which represent a species were more in *Lantana* eradicated area ascompared to *Lantana* infested area. The present study concluded that the *Lantana* eradicated area has richer diversity as compared to *Lantana* infested area; hence, the Lantana must be eradicated to preserve the biodiversity. The study recommends:

- Prevention of the disappearance of the plants due to massive deforestation;
- Create awareness among local people about *Lantana camara* and different methods oferadication of *Lantana*;
- Create awareness among local people about *Lantana* eradication program of Forestdepartment; and
- Strengthen the existing floral diversity by bringing awareness in surrounding people.

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Conflict of Interest: The authors declare that there is no conflict of interest.

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