OPEN ACCESS JOURNALS
Indiana Journal of Agriculture and Life Sciences
Abbreviate Tittle- Ind J Agri Life Sci
ISSN *(Online)*- 2583-1623
Journal Homepage Link- https://indianapublications.com/journal/IJALS
DOI- https://doi.org/10.5281/zenodo.21848973

INDIANA PUBLICATIONS
PRODUCTIVE AND QUALITY RESEARCH

Review Article

Volume-02|Issue-01|2022

Impact of Lantana camara L. on the Vegetation of the Uttarakhand Himalaya

Naina Srivastava

Botany Department, DAV PG College, Dehradun

Article History
Received: 30.01.2022
Accepted: 25.02.2022
Published:28.02.2022

Citation
Srivastava, N. (2022). Impact of Lantana camara L. on the Vegetation of the Uttarakhand Himalaya. *Indiana Journal of Agriculture and Life Sciences, 2*(1), 37-42.

Abstract: One of the more conspicuous aspects of ecological changes in the forest areas in the Uttarakhand Himalaya in the last 40 years has been the spread of *Lantana camara* L., a neotropical shrub. The species was introduced as an ornamental in the colonial era and has spread along river courses, as well as degraded forest margins and disturbed slopes in Garhwal as well as Kumaun in dense, near-impenetrable thickets, which exclude native shrub and herb cover. The review thereby brings together field based studies conducted in the Uttarakhand Himalayans and similar Himalayan and peninsular Indian montane ecosystems, to explore the effects of this plant on vegetation structure, species composition, soil processes, and regeneration of forest species like Chir Pine, Sal and mixed broadleaf forests. Allelopathic suppression of native seedlings, altered nutrient cycling and the combined effects of *Lantana camara* L., grazing and forest fire are measured and the socio-economic impact on communities who rely on forest resources is examined. The mixed success of mechanical, chemical and biological control measures are also discussed along with an evaluation of restoration strategies and research priorities required to address this invasion in a landscape already under stress from land-use change and climate change.

Keywords: *Lantana camara* L., Uttarakhand, Himalaya, Forest, alien species, invasive species.

INTRODUCTION

Walkers in the lower hills of Kumaun or Garhwal of the last few years will have noticed the same shrub by the roadside, by the edge of the forest and creeping into old abandoned terrace fields: a dense shrub, with small clustered flowers changing colour with age. This is *Lantana camara* L. and its presence is not incidental in the Uttarakhand Himalaya. The ornamental introduction has turned into one of the most intractable ecological issues in the sub-Himalayan and mid-elevation forests in the state.

Invasive alien plants are one of the world's main causes of bio-diversity loss and the forests of South Asia have been particularly welcoming to a few highly successful invasive species. Of these, *Lantana camara* L. is in an interesting situation; it was not a stowaway nor an accident of trade but a horticulturally intended introduction, whose descendants have since transacted to change the understorey of forests of the tropics and subtropics of the subcontinent (Kannan *et al*., 2013a). Across the Indian Himalayan Region, nearly 300 alien plant species have naturalised of which Uttarakhand has a considerable portion (Pathak *et al*., 2019).

The environmental consequences of such an invasion are already high. Chir Pine forests are found on drier south facing aspects and Sal forests are found along the Bhabar and lower Siwalik tracts, while at mid levels forests are found in a mosaic pattern of Banj oak and mixed broadleaves providing a resource base for timber, fodder, fuelwood and NTFP on which rural livelihoods are dependent. In pine forests around Nainital and in the Nayar catchment of Pauri Garhwal, a measurable decrease in tree regeneration, a decrease in the density of native shrub and alteration in herb layer have been reported (Dobhal *et al*., 2010; Kumar *et al*., 2020) where *Lantana camara* L. is established in dense cover.

This review synthesizes current field data– much of which is emerging within Uttarakhand itself to address three questions: what is the process of *Lantana camara* L. establishment and spread in Himalayan forest types; what is the effect of the presence of *Lantana camara* L. on structure, diversity, and regeneration of the native vegetation; and what has been learned, sometimes by trial and error, about ways to prevent and control the establishment and spread of *Lantana camara* L.. The published quadrat-based vegetation surveys, soil studies and management case studies are discussed and awareness is expressed of locations where evidence is sparse, inconsistent or limited to sites which may not be representative of the state's diverse landscape.

Biology and Invasive Nature of *Lantana camara* L.

Lantana camara L. is a member of the Verbenace family, and is native to the tropical areas of Central and South America (Ghisalberti, 2000). A scrambling, semi-woody shrub which may become an erect bush in open, sunny conditions or a sprawling shrubbier climber when it has other vegetation to cling to, to which it may climb up to 2 to 4 metres, but much more laterally. Recurved prickles are borne on its stems which render dense stands difficult to penetrate, having some practical implications for grazing animals and for herders who search for fodder and fuelwood.

***Corresponding Author:** Naina Srivastava

Plant life history largely accounts for its invader success. In warmer regions flowering is almost continual, and the flower clusters shift in colour through yellow to orange to pink or red which was once considered desirable in gardens. Individual flowers can yield fruit and a mature bush can yield thousands of small drupes in a season. These fruits are enjoyed by a variety of birds and some mammals that scatter the seed far from the parent plant and over long distances, establishing new plants along river banks, forest edges and disturbed areas (Ghisalberti, 2000). Germination can take place over a large range of time and seed banks in infested soils may persist for several years and if a site is treated and adult plants are removed, the plant may reinfest repeatedly since the seed bank is not affected.

In addition to its prolific production, *Lantana camara* L. grows in a variety of soil types and lighting conditions; it can thrive on shaded soils where many native species cannot. Its leaves have been found to possess a series of secondary metabolites such as triterpenoids and phenolic compounds, some of which have been suggested to be responsible for its toxicity to livestock and for its allelopathic activity on other plants (Ghisalberti, 2000). The prolific production of seeds, effective dispersal, physiological tolerance, and chemical defence, give this species a competitive advantage that is hard for native shrubs and seedlings of trees to compete with once established.

Distribution of *Lantana camara* L. in India and the Uttarakhand Himalaya

The first introductory report of *Lantana camara* L. in India dates back to the early 19th century as an ornamental curiosity in botanical gardens, but it became widely established throughout subsequent decades in cantonments and along roads and railways constructed during this time (Kannan *et al*., 2013a). To the time that independent India took the mantle of its forest estate, the grain of the plant was already set in many areas of the country from the dry deciduous forests of central India to the moist forests of the Western Ghats.

The story of settlement is slightly later and no less significant in the foothills of the Himalayas. *Lantana camara* L. is said to be introduced around Kathgodam in early 20th century in the central Himalaya around Nainital and spread to the neighboring Chir Pine and Sal forests over the last few decades (Kumar *et al*., 2020). Field surveys carried out through the Nayar river system in Pauri Garhwal report vast patches of the shrub growing in riparian corridors that may be due to soil moisture and disturbance available to the shrub for luxuriant growth (Dobhal *et al*., 2010, 2011).

On a wider scale of Indian Himalayan Region, an assessment for naturalised alien flora (NAF) listed 297 species belonging to 65 families with 181 species in Uttarakhand making it one of the more invaded states in the Himalayan region (Pathak *et al*., 2019), though some other states have experienced a little more invasions (Himachal Pradesh and Jammu and Kashmir). This area has been overrun by the few species, and *Lantana camara* L. is one of them. Occurrence in the field is so far limited to the Siwalik and Bhabar tracts stretching up to the mid-elevation Chir Pine belt, with a general upper limit of about 1,800 metres, although modelling indicated that the climatic range might be higher with future warming (Mungi *et al*., 2018). It is now regularly reported in protected lands neighbouring Uttarakhand's forest, such as tiger reserve habitats that are directly linked to the invasion of areas that are important for wildlife and forest resource use by humans.

Factors Responsible for Its Spread

No single factor is responsible for the dissemination of *Lantana camara* L. in the forests of Uttarakhand but rather the disturbance, climatic suitability and land management practices have created an environment suitable for *Lantana camara* L. to establish itself. Lopping for fodder, unregulated grazing and fuelwood extraction results in forest degradation and produces just the kind of environment *Lantana camara* L. seedlings need to become established (Dogra *et al*., 2009). When a few of these individuals establish themselves at a disturbed location they can spread outwards into neighbouring, less disturbed forest through fruit production and bird dispersal.

This process is modified by grazing pressure which often works to the invader's advantage at the expense of native browse species. The toxic effect of *Lantana camara* L. to livestock when it grows in large numbers, combined with its nonpalatable foliage, means that grazing animals are not selective about it and tend to continue browsing native shrubs and grass giving *Lantana camara* L. a selective release from herbivores that native plants do not have. This can cause a progressive imbalance in the competitive situation of a grazed forest compartment to the advantage of the shrub over time.

The climatic conditions in the sub-Himalayan and mid elevation belt of Uttarakhand are warm and humid with strong monsoon which closely parallels the environmental tolerance of the species, and modelling of its potential climate change distribution indicates that the region could expand instead of contracting in the future, both as a result of climate warming and continued anthropogenic disturbance (Mungi *et al*., 2018). These effects are exacerbated by land-use change: well-documented outmigration of rural labour in Uttarakhand has led to a loss of agricultural terraces in many areas of the middle hills, leaving exposed and disturbed bare ground that is quickly colonised by *Lantana camara* L. before natural forest succession can take hold. Corridors for the plant to pass into forest areas where it has not been as accessible previously are created with the construction of roads and with the development of other tourism-related infrastructure.

***Corresponding Author:** Naina Srivastava

Impact on Native Vegetation and Plant Diversity

Lantana camara L. invasion in forests in Uttarakhand clearly has an ecological footprint evident in the quantifiable reduction in the richness and abundance of native shrubs and herbs. Comparisons made between invaded and uninvaded areas of riparian forest at the Nayar river in Pauri Garhwal evinced considerable changes in the richness and index of species in the invaded stretches, in the basal area, density and frequency of resident tree and shrub species (Dobhal *et al*., 2011). A similar research in the same catchment which examined four popular native woody shrubs discovered that all four of them favored sites with high disturbance and moderate disturbance level, the same type of environment preferred by the invader, and that the four shrubs were put in direct competition where the *Lantana camara* L. thrives best, which was the gradient between high disturbance and low disturbance (Dobhal *et al*., 2010).

Native understorey species were determined to have decreased by about 29 to 40 percent in habitats dominated by *Lantana camara* L. and the co-dominant invasive *Ageratina adenophora* in a quadrat-based sampling of the Chir Pine forests near Nainital revealed that native understorey species had been replaced by both alien species as the most common shrubs in invaded plots (Kumar *et al*., 2020). This is not a homogenous and unconditional pattern, however. The identical literature noted that the two species had modified, and in some aspects enriched, local soil physico-chemical properties, a rebuttal that impact in invasion ecology is rarely a unidirectional and one-dimensional process and that various elements of an ecosystem may react to a common invader antagonistically.

Similar dynamics have been reported beyond the Himalaya proper, thus providing greater support to the Himalaya-specific results. The same study on the Vindhyan dry deciduous forests in central India discovered that the growth of *Lantana camara* L. cover was linked to local disappearance of tree population, which was partly related to the period of suppression of regeneration by the shrubs and partly by the alteration of the understorey light and nutrient environment beneath dense thickets (Sharma and Raghubanshi, 2006). Similar landscape-scale work in peninsular India has also associated the spatial distributional changes of the shrub with quantifiable changes in the original vegetation composition over time (Sundaram and Hiremath, 2012), implying that the trend that is observed in Garhwal and Kumaun forests can be attributed to a broader trend, and not a local exception.

Ecological Consequences of *Lantana camara* L. Invasion

Other than the immediate impacts on the plant community, *Lantana camara* L. invasion triggers a series of subsequent ecological shifts that impact soil chemistry, fire behaviour and wildlife utilisation of the forest. The litter of the shrub decomposes at a varying rate and with a varying set of nutrients than most native Himalayan understorey species, and in areas where it is abundant the soil nitrogen pooling and cycling processes have been observed to change significantly in dry deciduous forest systems (Sharma and Raghubanshi, 2009). In a more general sense, invasive vegetation has been known to be able to modify the nutrient cycling regime of an ecosystem in a manner that, in its turn, will cause further advantage to the invader as compared to slower-growing native species, creating a self-reinforcing loop which will get increasingly difficult to break at the same time it continues (Ehrenfeld, 2003).

Another field of ecological implication is that of fire dynamics, and such is the evidence at Himalayan and peninsular Indian sites, which is indeed not a closed issue. Under some circumstances *Lantana camara* L. may serve as fine fuel enhancing the frequency or intensity of ground fires whereas in other landscapes its thickets are dense, moisture-retaining, and may seem to slow fire propagation at some densities, a fact that complicates any simple story that relates the presence of the invader to increased fire risk uniformly (Day *et al*., 2003). This vagueness is important to Uttarakhand where Chir Pine forests already have a high natural fire load of resin-rich litter of needles, and where the overlay of a dense shrub layer has the potential to change fire behaviour in one way or other in response to local moisture, slope, and management history.

When it comes to wildlife, the image is also twofold. Thickets of *Lantana camara* L. have the potential to damage grazing lawns and open forest utilized by ungulates, diminishing forage, and in certain sheltered landscapes, modify the patterns of human-wildlife conflict with animals changing their ranging behaviour hence the changed habitat (Kannan *et al*., 2013b). Meanwhile, the thickets offer cover which some smaller mammals and birds seem to opportunistically exploit, demonstrating that the ecological impacts of invading species are not experienced equally by all of the species within a community.

Effects on Forest Regeneration and Ecosystem Functioning

The most significant long-term effect of *Lantana camara* L. invasion perhaps relates to the regeneration of the tree species characterising the types of forests of Uttarakhand. The initial experiments carried out in the Kumaun Himalaya comparing forest stands with sites that had been successfully colonized by Lantana shrubland revealed significant alterations in ecosystem functioning, such as productivity and nutrient standing stocks relative to the forests that were supplanted by Lantana shrubland (Bhatt *et al*., 1994). The paper continues to be used as a point of reference regarding what occurs when an invader does not merely coexist with a forest canopy but gradually occupies the locations where the layer of trees either has been cleared

***Corresponding Author:** Naina Srivastava

or worn in place either through logging, fire or perpetual grazing pressure.

The regeneration niche of tree seedlings is squeezed in many directions where there remains forest canopy. Thick *Lantana camara* L. shrubs decrease the penetration of light to the forest floor, compete with the soil moisture and nutrients, and, via allelopathic compounds that are released into the soil, are capable of directly inhibiting the germination and early development of native seedlings (Ghisalberti, 2000). Comparative analysis of growth characteristics of *Lantana camara* L. and native Himalayan shrubs like Berberis asiatica and *Pyracantha crenulata* in Chir Pine forest have indicated that the invasive species distributes biomass and litter turnover differently than its native competitors, differences that probably make it more likely to persist and spread once established in the understorey (Kumar *et al*., 2021).

The impact on Sal and mixed broadleaf forest regeneration, although not, in the Chir Pine example, quite comprehensively documented in Uttarakhand in particular as in the Chir Pine example, follow a similar logic: fewer seedlings grow, the cohort developing into larger size classes are thinner, and the resultant risk is that, without intercession, the existing overstorey will be replaced by nothing similar as the existing trees grow older and senesce or are harvested. It does not mean that the relationship between *Lantana camara* L. cover and regeneration is always negative in all conditions; studies conducted in the broader Himalayan foothills have also established that regeneration results may be strongly linked to the severity of other disturbances like fire and lopping and that moderate cover of shrubs may be consistently accompanied by suitable seedling recruitment where other disturbances are less intense. Despite this, the preponderance of the Uttarakhand-oriented evidence is towards a net suppressive influence on regeneration in the presence of a dense and long-established invasion.

Management, Control, and Restoration Strategies

The attempt to manage *Lantana camara* L. in Indian forests has been based on mechanical clearing, use of chemical herbicides, and other efforts to carry out biological control and their history is best characterized as ambivalent. Mechanical elimination, as either cutting, uprooting or a more targeted cut-root-stock technique that removes the plant below the site of resprouting, may be efficient in the short-term, but is labour-intensive, and unless the underlying seed bank, along with the root fragments, are also dealt with, risks reinvasion within a few growing seasons. The use of herbicides to control regrowth could be more effective, but has been associated with non-target damage to native vegetation, soil and water quality, especially in catchments that drain to drinking water sources, and so is less acceptable as a standard management tool on large forest areas.

Biological control using introduction of host-specific insects that feed *Lantana camara* L. has been tried in several countries with mixed results and results under Indian conditions have not been able to sustain population level population suppression alone (Day *et al*., 2003). Researchers who have been working on the species have reached the consensus that there is no single method that provides a lasting solution and that combined measures, involving mechanical or chemical initial clearance and active revegetation with native species are likely to be more effective than any single action used alone.

The experience of the Indians during the later years has most centred in restoration after removal. Case histories of tiger reserve landscapes report how dense stands of *Lantana camara* L. have been cleared and then replanting the cleared areas with native grass and trees to reestablish productive grassland habitat and woodland habitat, which relies heavily on follow-up monitoring to prevent reinvasion by surrounding, still-infested forest (Kannan *et al*., 2013b). Even deciding which locations are worth the investment needed to be completely restored is a management problem in itself as not all levels of invasion will have the same impact on native vegetation, so any work that defines threshold densities at which *Lantana camara* L. can start to significantly suppress native plant communities provides one method of priority of intervention to the sites where the ecological payback of restoration activity is likely to be most significant (Gooden *et al*., 2009).

In the case of Uttarakhand, the extent of the problem, distributed among Chir Pine, Sal and mixed broadleaf forest cover on much and terrain challenged terrain, suggests that management will be a case of selective, site based action, as opposed to an exercise of extermination on a statewide basis, in the foreseeable future at least.

Future Research Priorities

There are a few gaps in the existing evidence base that can be addressed to help management in Uttarakhand to cease become highly reactive, site-by-site based responses. There are few long-term series of monitoring plots to measure the same invaded and uninvaded stands across several decades, and it is challenging to separate the short-term changes in *Lantana camara* L. cover and long-term directional shift in forest composition. Comparative analyses between the various types of forests in the state as opposed to the dominant Chir Pine-centric nature of most research in Uttarakhand would shed light on whether or not the regeneration and diversity effects observed in Nainital and in the Nayar catchment can be generalised to Sal forest on the Bhabar tract or to higher-elevation broadleaf forests.

It is also necessary to conduct research that does more directly couple invasion status to the climate

***Corresponding Author:** Naina Srivastava

projections now accessible to the region as the interaction between regional warming, changing monsoon patterns and the climatic tolerance of *Lantana camara* L. is likely to dictate to which areas the invasion front should advance (Mungi *et al*., 2018). Systematic comparison of the outcomes of different combinations of interventions, as opposed to individual case studies, on the management side would fortify the evidence available to forest managers in decision making regarding how to use limited resources. Lastly, more ecological studies combined with the socio-economic aspects of the issue, such as the perceptions and reactions of local populations to the invasion, would be instrumental in guaranteeing that management priorities set by the researchers can also be practiced by the people, who need these forests in their daily lives (Pathak *et al*., 2019).

CONCLUSION

There is limited doubt in that the evidence collected in Garhwal and Kumaun over the last 30 years demonstrates that *Lantana camara* L. is now a permanent element of the Uttarakhand forest cover as opposed to a temporary nuisance. The ability to colonize disturbed soil, withstand grazing stress, change nutrient cycling in the soil and in most, but not all environments, inhibit the regeneration of native trees and shrubs mean that its further expansion has real implications on the structure of forests, animal populations and forest resources over which rural populations rely. Meanwhile, the image that comes out of the literature is not of a homogenized disaster: results differ by type of forest, disturbance history and density of invasion, and some of the more captivating results, among others, that the presence of Lantana cover can have on soil fertility, do not lend themselves to simple stories. The evidence that the cumulative literature supports is the argument in favor of long-term, adequately-resourced management, which integrates both targeted removal and active restoration of native species, informed by a better idea of where in the forest mosaic of Uttarakhand intervention will have the biggest ecological payoff. It will take such an undertaking as that long-term and comparative research that, in much of the diversified landscape of the state, is to this day, but half-immature.

REFERENCES

1. Bhatt, Y. D., Rawat, Y. S., & Singh, S. P. (1994). Changes in ecosystem functioning after replacement of forest by *Lantana* shrubland in Kumaun Himalaya. *Journal of Vegetation Science, 5*(1), 67–70.
2. Day, M. D., Wiley, C. J., Playford, J., & Zalucki, M. P. (2003). *Lantana: Current management status and future prospects* (ACIAR Monograph No. 102). Australian Centre for International Agricultural Research.
3. Dobhal, P. K., Kohli, R. K., & Batish, D. R. (2010). Evaluation of the impact of *Lantana camara* L. invasion on four major woody shrubs, along Nayar river of Pauri Garhwal, in Uttarakhand Himalaya. *International Journal of Biodiversity and Conservation, 2*(7), 155–161.
4. Dobhal, P. K., Kohli, R. K., & Batish, D. R. (2011). Impact of *Lantana camara* L. invasion on riparian vegetation of Nayar region in Garhwal Himalayas (Uttarakhand, India). *Journal of Ecology and the Natural Environment, 3*(1), 11–22.
5. Dogra, K. S., Kohli, R. K., & Sood, S. K. (2009). An assessment and impact of three invasive species in the Shivalik hills of Himachal Pradesh, India. *International Journal of Biodiversity and Conservation, 1*(1), 4–10.
6. Ehrenfeld, J. G. (2003). Effects of exotic plant invasions on soil nutrient cycling processes. *Ecosystems, 6*(6), 503–523.
7. Ghisalberti, E. L. (2000). *Lantana camara* L. (Verbenaceae). *Fitoterapia, 71*(5), 467–486.
8. Gooden, B., French, K., Turner, P. J., & Downey, P. O. (2009). Impact threshold for an alien plant invader, *Lantana camara* L., on native plant communities. *Biological Conservation, 142*(11), 2631–2641.
9. Kannan, R., Shackleton, C. M., & Uma Shaanker, R. (2013a). Reconstructing the history of introduction and spread of the invasive species, *Lantana*, at three spatial scales in India. *Biological Invasions, 15*(6), 1287–1302.
10. Kannan, R., Shackleton, C. M., & Uma Shaanker, R. (2013b). Playing with the forest: Invasive alien plants, policy and protected areas in India. *Current Science, 104*(9), 1159–1165.
11. Kumar, M., Verma, A. K., & Garkoti, S. C. (2020). *Lantana camara L.* and *Ageratina adenophora* invasion alter the understory species composition and diversity of chir pine forest in central Himalaya, India. *Acta Oecologica, 109*, Article 103642.
12. Kumar, M., Verma, A. K., & Garkoti, S. C. (2021). Functional traits, growth patterns, and litter dynamics of invasive alien and co-occurring native shrub species of chir pine forest in the central Himalaya, India. *Plant Ecology, 222*(6), 723–738.
13. Mungi, N. A., Coops, N. C., Ramesh, K., & Rawat, G. S. (2018). How global climate change and regional disturbance can expand the invasion risk? Case study of *Lantana camara L.* invasion in the Himalaya. *Biological Invasions, 20*(7), 1849–1863.
14. Pathak, R., Negi, V. S., Rawal, R. S., & Bhatt, I. D. (2019). Alien plant invasion in the Indian Himalayan Region: State of knowledge and research priorities. *Biodiversity and Conservation, 28*(12), 3073–3102.
15. Sharma, G. P., & Raghubanshi, A. S. (2006). Effect of *Lantana camara* L. cover on local depletion of tree population in the Vindhyan tropical dry deciduous forest of India. *Applied Ecology and Environmental Research, 5*(1), 109–121.
16. Sharma, G. P., & Raghubanshi, A. S. (2009). *Lantana* invasion alters soil nitrogen pools and

***Corresponding Author:** Naina Srivastava

processes in the tropical dry deciduous forest of India. *Applied Soil Ecology, 42*(2), 134–140.
17. Sundaram, B., & Hiremath, A. J. (2012). *Lantana camara L.* invasion in a heterogeneous landscape: Patterns of spread and correlation with changes in native vegetation. *Biological Invasions, 14*(6), 1127–1141.

***Corresponding Author:** Naina Srivastava