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Research article

Exotic species invasion threats to forests: A case study from the Betla national park, Palamu, Jharkhand, India

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Abstract: Exotic Species Invasion (ESI) cause a little recognized, but very substantial impact to forest ecosystems worldwide. Climatic variability, physiographic range, increasing trade, travel and tourism have accelerated the spread of unwanted non-native species to conservation areas, making vulnerable to the establishment of ESI. Exotic Invasive Plants (EIPs) are known to displace native plants, alter ecosystems processes, hydrology, primary productivity, nutrient cycling and soil structure and most importantly reduce native biodiversity. There is evidence to suggest that the threats due to ESI may increase with climate change and associated changes in habitats. In this paper, we assess the threat of EIPs to natural forests in Betla National Park (BNP), Palamu in Jharkhand State, India. Based on intensive field surveys and using quadret method we identified 142 EIPs in the BNP forest. 21 plots of 20 × 20 m for trees, 5 × 5 m for shrubs and 1 × 1 m for herbs were laid randomly adjoining the forest at 10 to 100 m distance from the road and settlement area. Total 14 EIPs were recorded among which *Lantana camara* and *Parthenium hysterophorus* were found to be the most dominant species. . The survey revealed that apart from the ecological harm, invasive plants adversely affect the livelihood of all those who are dependent on forests. The paper identifies impact, early detection and rapid control, prevention of spread and habitat restoration as urgent measures for combating the threats.

Keywords: Exotic invasive plants - Risk assessment - BNP forest - Climatic change impact.

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INTRODUCTION

Exotic Species that become invasive are considered to be main direct drivers of biodiversity loss across the globe. Management of Exotic Species Invasion (ESI) is seen as major challenge in the field of biodiversity conservation. ESI, the non-native species threaten ecosystems, destroy habitats and create problems to other native species through invasion. It is considered as the second greatest agent of species endangerment and extinction. The ecological cost is often the irretrievable loss of native species and ecosystems. It also causes heavy economic loss, in terms of reduced crop and livestock production, reduced native biodiversity, increased production costs and so forth. Biodiversity has become one of the most popular topics for discussion at local, national and global level. Biodiversity entails all forms of biological entities inhabiting the earth including prokaryotes–wild plants and animals, microorganisms, domesticated animals and cultivated plants and even genetic material like seeds and germ-plasma (Kothari 1993). Exotic Invasive Species (EIS) are species, native to one area or region, that have been introduced into an area outside their normal distribution, either by accident or on purpose and which have colonized or invaded their new home, threatening biological diversity, ecosystems and habitats, and human wellbeing (CBD 2000). Biological invasion worldwide threatens biodiversity, ecosystem dynamics, resource availability, national economy and human health studied by (Ricciardi *et al.* 2000). The spread of EIS is now recognized as one of the greatest threat to the ecosystem. Exotic invasive species (animal pests, viruses, pathogens and plants) have become one of the most serious threats to the ecological and economic well-being of every habitat and region on the Earth (Boy *et al.* 2013). The introduction of alien species to a new location can either be accidental or intentional studied by (Enserink 1999). Accidental

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introductions are helped by travel across countries and continents and import of various items such as timber, food grains, fodder etc. (Shimono *et al.* 2008). Intentional introductions are for a variety of purposes such as agriculture, horticulture, forestry and ornamental (Cremer 2003). All invasive species possess certain biological attributes which contribute to their success as invaders in a new habitat. For invasive alien plants (IAPs), these attributes include production of a large number of easily dispersible, light weight seeds, fast growth rate and better competitive resource capture and utilization abilities compared to native plants (Burns 2006). The economic damage due to ESI is estimated to be to the tune of 1.4 trillion dollars globally. In many countries, the overall loss due to invasions is over 1% of the GDP. In the United States alone, for example, the annual costs of containing the spread of IAS are reported to be more than US$ 135 billion (Boy *et al.* 2013). The impacts of IAPs include displacement of native plant species, change of soil chemical profile, rewarding pollinators better than the native species thereby reducing the reproductive success of local species, changing hydrological regimes, making the new habitat fire prone and limiting the photosynthetic efficiency of the local species by reducing light availability (Nilsson & Grelsson1995). Subsequent impacts would happen by reduced availability of forest resources like medicinal plants from natural forests and timber from forest plantations. As in the classical case of Kaziranga National Park (Assam, India) where in the movement of the endangered one horned rhinoceros was limited by thickets of *Mimosa diploticha* var. *diplotricha*, the impact on fauna would also be critical studied by (Vattakkavan *et al.* 2002). Indirect impacts occur by way of complete elimination of food plants of the fauna and by making the habitat fire prone. It was believed that the threat of IES would be much low in natural habitats as compared to disturbed habitats. Forests were considered to be immune to large scale plant invasions. Climate change and the emergence of invasive alien plant species (IAPS), which are commonly referred as weeds, are two of the greatest threats to biodiversity and ecosystem services (Burgiel & Muir 2010, IUCN 2000) defines IAPS as plants that have become established in natural or semi-natural ecosystems or habitats, an agent of change, and threatens native biological diversity. A study of (IPCC 2007) identified that climate change is one of the factors for emergence of invasive species. Increase in atmospheric temperatures and CO_2 concentrations are likely to increase opportunities for the introduction of invasive species because of their adaptability and ability to disturb a broader range of bio geographic conditions and environments (Mooney 2000). A study by (Lodge *et al.* 2006) showed that IAPS endanger the environment, the economy and human welfare. It also reduces biodiversity, replaces important native species and increases investment in agriculture and silviculture operations (Ricciardi *et al.* 2000) and disrupts prevailing vegetation dynamics and nutrient cycling (Richardson & Higgins 1998). The estimated damage from IAPS worldwide totals more than US $1.4 trillionna year (5 percent of the global economy). Impacts affect a wide range of sectors including agriculture, forestry, aquaculture, transportation, trade, energy and recreation (Stern 2006).

The prime objective of the present paper is to report the Exotic Species Invasion (ESI) Threats to Forests in Betla National Park (BNP) Palamu, Jharkhand, India. We have also reported effect of ESI on different plant species, environment and different ecosystem etc. In addition to the above the preventive measures of ESI of National Park have been also studied**.**

MATERIALS AND METHODOLOGY

Study Area

Betla National Park (BNP) situated between latitude 23°25' N to 23°55' N and longitude 83°50' to 84°36' E, was notified in 1973 as one of India's first nine tiger reserves established under Project Tiger . It is located in the western part of the Chhotanagpur Plateau and spans an area of 1129.93 km^2 comprising the Palamau Wildlife Sanctuary and Betla National Park is spread over Latehar, Palamau and Garhwa District in Jharkhand (Fig. 1). It is also part of the Central India Landscape and extends into the Sanjay-Dubri Tiger reserve and Achanakmar-Kanha tiger landscape through the Jashpur and Mahan forest of Chhattisgarh. The vegetation types mainly categorized as dry moist forest, dry Sal forest, moist Sal forest, high level plateau Sal forest and moist forest. BNP is also becoming home to many unwanted non-native plants. Very limited research has been carried out about ESI in BNP.

Data collection

Questionnaire survey was carried out from October 2015 to June 2016. Total 140 individuals who have long been inhabited in the study area and utilizing the local resources for their livelihood were interviewed to explore their perception regarding ESI. Total 21 sampling plots of various sized quadrates 20 × 20 m for trees, 5 × 5 m

for shrubs and 1 × 1 m for herbs were laid at 10 to 100 m distance in adjoining forest from road and human settlement area. Nested plots 5 × 5 m and 1 × 1 m quadrates were allocated randomly in two corners of 20 × 20 m plot (Tiwari *et al.* 2005, Bajpai *et al.* 2015). Community consultations, individual interviews, field observations, literature review, group discussions were conducted to collect data.

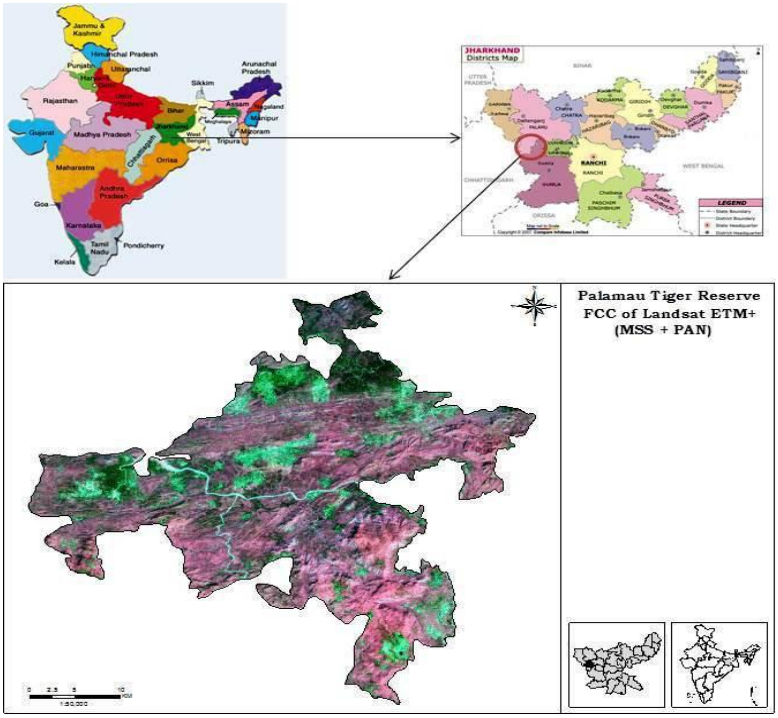

Figure 1. Study Area of Betla National Park, Palamu, Jharkhand, India.

Data analysis

Both quantitative and qualitative techniques were used for data analysis. By using following method density and frequency were calculated. The analysis was interpreted in a simple and understandable chart form. Density is an expression of numerical strength of a species in a community studied by using formula (Mishra 1968).

$$\text{Density (D)} = \frac{\text{Total No. of individuals of a species in all the quadrates}}{\text{total number of quadrates studied}}$$

Frequency denotes the number of sampling unite in which, a particular species occurs and so it expresses the distribution of dispersion of various species in community.

$$\text{Frequency (F)} = \frac{\text{Total No. of quadrates in which the species occurred}}{\text{Total number of quadrates studied}} \times 100$$

RESULTS AND DISCUSSION

ESI in study area

All together 14 EIPs were encountered in the sampled areas (Table 1). Among the ESI observed, *Lantana camara & Parthenium hysterophorus* was most common in the study area. It has the highest cover in the adjoining forest, near settlement where human disturbances were high. Based on household survey *Lantana camara* & *Parthenium hysterophorus* was found to be the most problematic ESI. An area where tree canopy is dense and the undergrowth do not find sufficient sunlight, invasion of species is low compared to open and degraded land. Therefore, with increasing tree canopy there is decreasing invasion of unwanted species. After *Lantana camara* & *Parthenium hysterophorus*, *Agertum houstonianum* and *Ipomoea purpurea, Ipomoea hederfolia* were other to ESI found with high density in the study area. The spread of EIPs especially *Perthanium h*ysterophorus complex and is threatening both the natural biological richness and livelihood of inhabitants. Many locals have stopped grazing their livestocks in forest as the palatable grasses in the forest like *Imperata cylindrical*, *Cynodon dactylon* are rapidly being replaced by the ESI especially by Perthanium hysterophorus.

Table 1. Exotic Species Invasion (ESI) Observed in Betla National Park, Palamu, Jharkhand, India.

S.N.	Specie	Introduction	Purpose	Habitat	Origin
1	*Alternanthera brasiliana* (L.) Kuntze	Intentional	Ornamental	Subshrub	Central & South America
2	*Alternanthera philoxeroides* (Mart.) Griseb.	Unknown	Unknown	Herb	South America
3	*Amaranthus spinosus* L.	Accidental	NA	Herb	South & Central America
4	*Ipomoea purpurea* (L.) Roth	Intentiona	Ornamental	Climber	Central America
5	*Ipomoea hederifolia* L.	International	Ornamental	Climber	Cenral America
6	*Jatropha gossypifolia* L.	Intentional	Hedge plant	Shrub	Tropical America
7	*Lantana camara* L.	Intentional	Ornamental	Shrub	Central & South America
8	*Leucaena leucocephala* (Lam.) de Wit	Intentional	Social forestry	Tree	Mexico & Central America
9	*Merremia vitifolia* (Burm.f.) Hallier f.	Accidental	NA	Climber	South Asia
10	*Mimosa pudica* L.	Intentional	Ornamental	Herb	Tropical America
11	*Parthenium hysterophorus* L.	Accidental	NA	Herb	North & South America
12	*Prosopis juliflora* (Sw.) DC.	Intentional	Fire wood	Tree	Central & South America
13	*Sphagneticola trilobata* (L.) Pruski	Intentional	Ornamental	Herb	South America & West Indies
14	*Synedrella nodiflora* (L.) Gaertn.	Accidental	NA	Herb	Tropical America

Effect of Exotic Species Invasion

Effects on ecosystem

After studies we found that invasive exotic plant species (IEPS) threaten the environment, reduce biodiversity, replace economically important plant species and increase the investment in agriculture and silviculture practices, prevail vegetation dynamics and alter nutrient cycling (Richardson & Higgins 1998). They can promote hazards like forest fire. Plant invasions dramatically affect the distribution, abundance and reproduction of many native species (Sala *et al.* 1999). In the study area too, impacts of Invasive Exotic Plant species especially *Parthenium hysterophorus* was well observed and none of the ecosystems were free from their impact. Edges of forests, agricultural lands and wetlands have been severe IEPS intrusion. Although all ecosystems are susceptible to invasion, ecosystems entwined with higher level of human interventions (*e.g.* forestry, agriculture, wetland and rangelands) are likely to pose greater susceptibility (Yelenik *et al.* 2007). In the study site, rangeland, agriculture land as well as fallow lands and roadsides were highly susceptible to invasion of *Ipomoea purpurea* (L.) & *Ipomoea hederifolia* L. IEPS (Fig. 2).

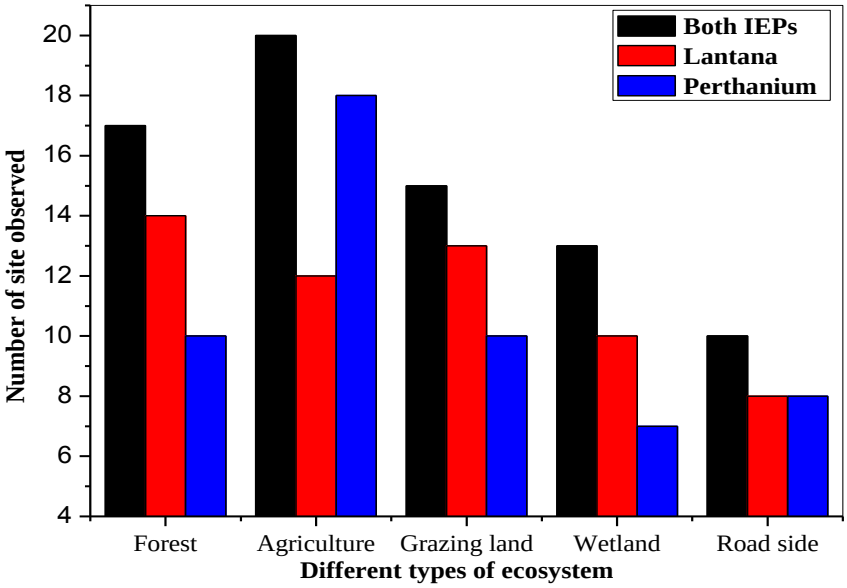

Figure 2. showing impact of invasive exotic plant species on important ecosystem.

Effects on Forest

As per surveys revealed that the forest, roadsides and fall low lands previously dominated by *Alternanthera, Ipomoea, Jatropha, Lantana* etc. were invaded by IEPS. Some plants failed to maintain their biomass in the changing climate and their dominance was fairly slacked off by IEPS. As a result, dense and diverse forests are

more resistant to ecological invasion (Pimm 1984). However, forests in studied area has invaded about 20% area particularly forest edges and plantation forests of the studied ecosystem. These species suppress the growth of native trees, shrubs and grasses growing beneath or close to them. Subsequently foliage for wildlife animals is reduced leading to starvation and death of the animals.

Effects on human ecosystem

The full costs of invasions also include the social and health impacts of exotic invasive species on humans, in particular to the rural communities depending on forests. As a result of the impacts of exotic invasive species on native forest biodiversity, a loss of food sources and traditional medicines may be experienced thereby compromising not only the health of local people but also the livelihoods of those dependent on the collection and sale of such items for income. For small-scale landowners, exotic invasive species can also decrease the value of their land. Forest workers, as part of their jobs, and people living in and around forests are more exposed to exotic invasive species such as the reservoirs and hosts of many emerging infectious diseases. Examples of such diseases include Lyme disease, hay fever also known rhinitis, some immune disorders, eczema, Ebola and Marburg hemorrhagic fevers, malaria, yellow fever, leishmaniasis, trypanosomiasis and Kyasanur forest disease. People living in and around invaded forest areas may also suffer allergic or other negative reactions to the exotic invasive species themselves or to the measures used to control them such as chemical and biological pesticides. A commonly planted tree for land restoration and as a source of forest products, mesquite (*Prosopis juliflora*) is a major cause of allergies in India. Sensitivity to mesquite pollen has been shown to result in asthma, rhinitis and conjunctivitis. In some places, children living close to areas infested with Dendrolimus sibiricus have experienced significant allergic reactions to the hairy caterpillars that have entered their homes. The hairs on larvae and egg masses of gypsy moth (*Lymantria dispar*) also cause allergies in some people. All these invasive plants and trees have had serious socio-economic impacts and ultimately increased poverty in the local communities. Some area of the study site is densely populated by subsistence farmers and livestock rearing is an integral part of their livelihood.

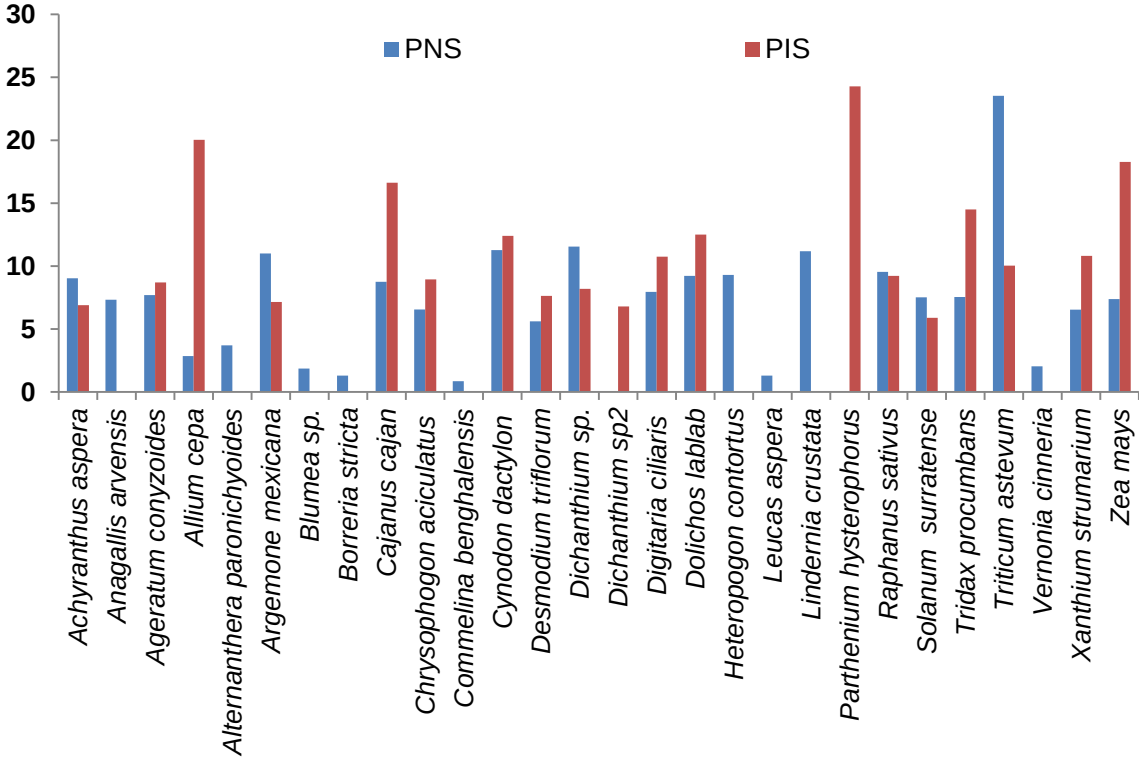

Figure 3. Reperesenting the comparative account of parthenium (exotic species invasion) non invaded and invaded study sites.

Impacts on Wetland and Rangeland Ecosystems

P. hysterophorus and *I. purpurea* is distributed throughout the study site; it can be just in any type of soil and environment. Nearby wetlands and throughout the rangeland is the most favourable environment for the

invasion of invasive species. Apart from those species, water bodies of the study area were invaded by Jalkumbhi (*Pistia stratiotes* L.) and unwanted water favoring plants. *I. purpurea* mostly prefer damps areas such as wetland margins, drainage lines and gullies.

Impact on Agricultural Ecosystem

IEPS are also considered biological polluters and are capable of hybridizing with native plant relatives that result in genetically modified to a plant's genetic make-up results into great peril of biodiversity, which has also same impact in the study site. *Parthenium hysterophorus has* adverse impacts on most of the agricultural crops as nutrients and fertilizers supplied to the main crop are being exploited by this species (Fig. 3).

Agricultural crops, particularly ginger, millet, rice and grasses, were outcompeted by others and their productivity declined. Reduction in production of cereals and grasses in studied area as a result of invasion by Lantana, Perthanium. According to (Oerke *et al*. 1995) there was a loss of 13 percent of agricultural outputs due to weeds. Many grasses species, such as *Artemisia* spp, *Solanum xanthocarpum* and *Urtica* sp. of fallow lands and *Scrophularia* species, *Hypoxis aurea* etc. of agricultural lands were threatened by invasion of *Perthaniums, Mimosa, and Sphagneticola* invasive exotic plant species in the study site. Impact of *P. hysterophorus* on livestock is more severe in the study site. There are a number of livestock mortalities, particularly of buffaloes. The cases generally happened in the spring when the plant flowers are in full bloom. Similarly, IEPS affect the dynamics and composition of soil and have impacts on ecosystem functions, such as soil nutrient cycling and soil chemistry. In the study site, IEPS were growing in a wide range of soils but not flourishing in shade. Soil texture in agriculture land of the study area is silt clay.

Methods to control of Exotic Species Invasion

The following steps are proposed to manage existing EIPs and prevent any new incursions.

Preventive measures

This study revealed the presence of invasion exotic plants in all the forest areas surveyed. It also showed direct and indirect impacts due to these invasions. It is recommended that a more comprehensive forest surveillance covering all the forest divisions in the State needs to be carried out before evolving proper control strategies. To prevent new incursions of ESI into forests, the following steps are to be adopted:

i. All plants, plant prop gules and soil intended for transportation into forest areas (soil for civil works, seedlings of forest tree species) should be thoroughly monitored for the presence of seeds and other prop gules of ESI**.**

ii. Import of seeds, seedlings and other prop gules of all plant species should be done only after risk assessment and observing proper quarantine procedures.

iii. Forest areas, especially those which are tourist destinations, need to have water filled dips at the entry point so as to wash agricultural implements and tires of vehicles free of ESI propagules before entering into forest areas.

Early detection and rapid control

The most economical way to contain ESI is to establish an efficient surveillance system so as to detect ESI soon after their arrival and eradicate them when their population is small and the spread is limited. To achieve this, sea ports, airports and tourist and pilgrimage routes into forest areas are to be monitored regularly for new invasive species using proper tools and methods. The staff of quarantine/customs and forest department need be trained to identify ESI which are potential threats so as to adopt measures to stop incursions and contain the population.

Prevention of spread

For ESI which have already established in some areas and immediate eradication is difficult, efforts should be focused on preventing their spread by:

1) Restricting the movement of soil and plant parts from infested areas to un-infested areas and

2) Removing the weeds manually or mechanically (cutting or pulling) before flowering and fruiting and burning them at the site.

Habitat restoration

Manual/mechanical control may be difficult, costly and unsustainable for exotic weeds which have established in large areas. In such cases, systematic restoration strategies should be taken up. To achieve this,

remove the weeds manually or mechanically (pulling along with roots/tubers) in small areas at a time and subsequently plant the area with fast growing native species. Assisted regeneration may also be attempted in such areas.

CONCLUSION

Exotic Species Invasion (ESI) is a serious threat to forests of Jharkhand since they impact heavily on native biodiversity, productivity and result in landscape level changes. In this observation we have found that total 14 IEPs in covered area and some species like *Lantana*, *Perthanium* and *Ipomoea purpurea* are highly dominated over native resources. The invasion is more serious in agriculture land followed by disturbed sites, such as newly constructed earthen roads. The invasion is seriously affecting agriculture productivity. A few households are using these species for making compost manure and producing bio-briquettes for energy. Promoting bio-briquette production and market linkage would help to improve the health condition of different ecosystems and provide additional income to local community. Furthermore, it supports controlling forest degradation and loss of biodiversity. The problem demands urgent attention. Prevention of new incursions can be achieved by adopting risk assessments before import of plants and planting material. Forest surveillance, early detection and rapid control, manual/mechanical removal of weeds followed by planting of native species and assisted regeneration are suggested as immediate steps to control invasion and reduce impacts. Herbicidal application in forest areas need to be avoided as far as possible.

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