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Spatial modelling of congruence of native biodiversity and potential hotspots of forest invasive species (FIS) in central Indian landscape

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ABSTRACT

The tropical forest ecosystems across the globe are under major threats from spread of exotic invasive plant species. Identification of biodiversity rich areas prone to large-scale plant invasion and their prioritisation is vital for targeting prevention and control programmes. Recent availability of field inventoried forest native and forest invasive species (FIS) data from a nation-wide biodiversity project in India, has served as a valuable source of information for conservation prioritization. Our approach considers prioritisation of phytogeographic areas based on congruence of spatial pattern of phytorichness distribution and spatial pattern of potential spread of hotspots of multiple FIS. We modelled native phytorichness at landscape scale following a three-tier methodology of mapping of habitat types, field sampling of vascular plants and spatial modelling with landscape matrices for central Indian landscape in India. The hotspots of multiple FIS were modelled with occurrences of 98 species, and optimally chosen environmental covariates using MaxEnt. We then integrated phytorichness and FIS invasion hotspots information to identify priority zones (high, medium and low) for informed policy decisions for conservation actions. Study emphasises that potential hotspots of invasive species should be considered for conservation priority setting.

1. Introduction

Spatial conservation prioritisation is indispensable to reverse the impending loss of biodiversity. Conservation priority setting approaches (e.g. Conservation International's Global Biodiversity Hotspots (Myers, 2003), WWF Global 200 (Olson and Dinerstein, 2002)) have advocated biodiversity richness, uniqueness, endemism and habitat loss as criteria to rank biogeographic regions to guide conservation efforts. Invasive species has emerged as the second greatest threat to biodiversity worldwide after habitat loss (IUCN, 1998). Global Strategic Plan for Biodiversity (2011–2020) Aichi Biodiversity Targets put special focus on invasive plants. National Biodiversity Targets, 2015 call for identification of priority invasive alien species, their pathways and development of strategies by 2020 to manage them (National Biodiversity Targets, 2015). Because invasive species are a potentially serious threat they should also be considered in the development of conservation priorities (Stohlgren et al., 2006; Rouget, Richardson, Cowling, Lloyd, & Lombard, 2003).

Field studies show that invasive plants can significantly decrease native plant species richness or diversity (Aguilera, Alpert, Dukes, & Harrington, 2010; Levine et al., 2003; Vivrette and Muller, 1977). Meta-analyses also suggest that invasive plants are harmful to native plant species (Gaertner, Breeyen, Hui, & Richardson, 2009; Pyšek et al. 2012; Vilà et al., 2011). A positive relationship has been observed between invasive plant dominance and native plant decline (Didham, Tylianakis, Hutchison, Ewers, & Gemmell, 2005; Hulme, 2008). The relationship between native and non-native species richness can be an important component in determining conservation priorities (Jarnevich, Stohlgren, Barnett, & Kartesz, 2006). A hotspot of biodiversity with higher probability of invasion by multiple invasive species has higher value for conservation. A hotspot of biodiversity that has not yet been invaded may be a better choice, with steps taken to try and prevent large-scale invasion (Jarnevich et al., 2006). The prioritisation of biodiversity rich habitats at regional scale is thus important for early detection of new invasions and aid control effort prioritization.

Good baseline information on both native and non-native species distribution patterns is important. Macro-ecological and species distribution models have been used for estimating species richness over broad spatial scales. The patterns of richness of native biodiversity have been modelled using grid and landscape matrices (Nagendra and Gadgil, 1998; Roy et al., 2012; Roy et al., 2005).

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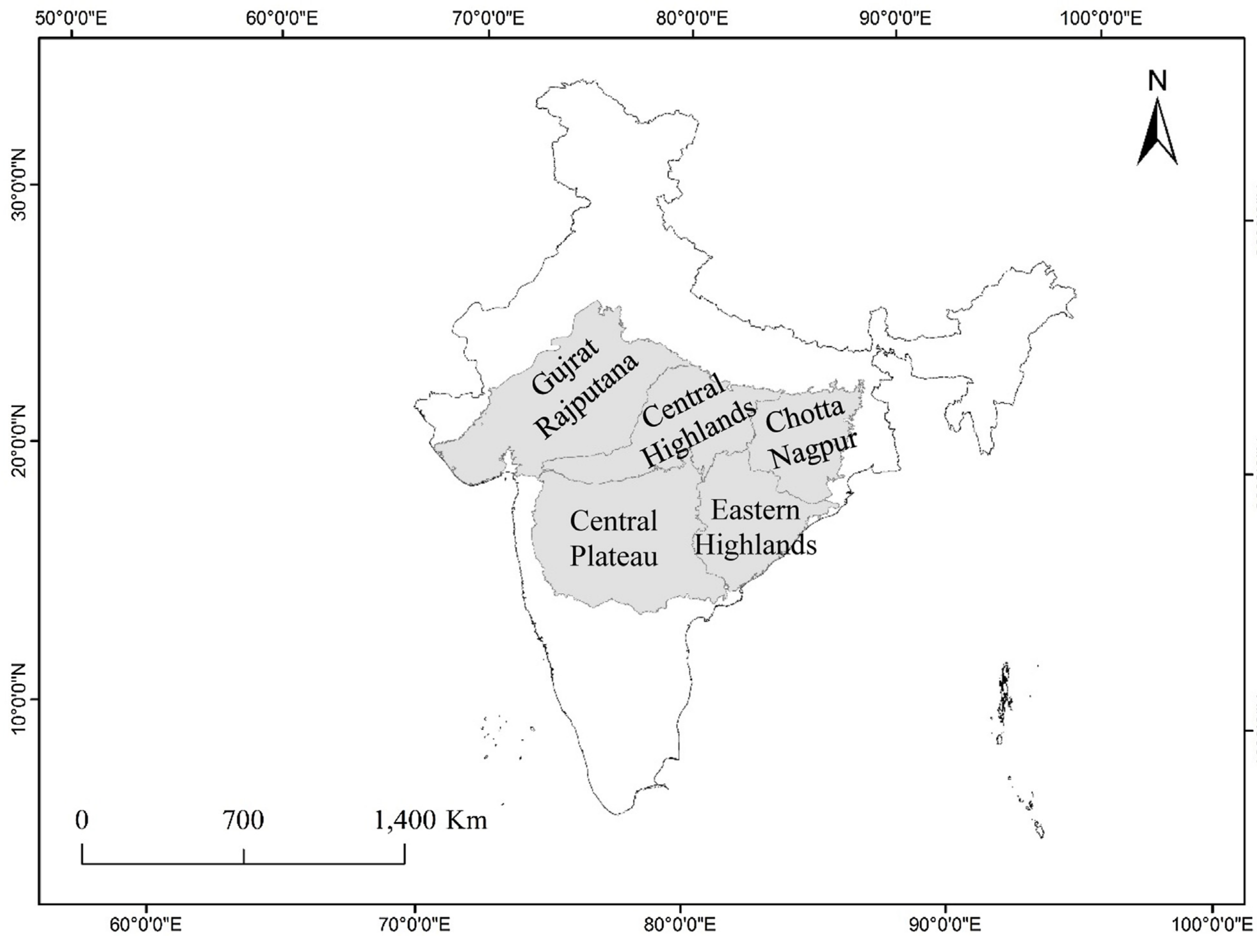

Fig. 1. Location map of the study area (shaded area).

Species distribution models have been used to identify hotspots of invasion to guide surveillance, pre-emptive response, control and management of invasive (Adhikari, Tiwary, & Barik, 2015; Catford, Vesk, White, & Wintle, 2011; Duursma et al., 2013; Li, Liu, Kraus, Tingley, & Li, 2016; Liang, Clark, Kong, Rieske, & Fei, 2014). But none of these risk assessment frameworks consider native biodiversity distribution and hotspots of large-scale invasion to describe and demonstrate a spatially explicit risk prioritisation.

In this study, we propose priority sites for control effort prioritization for most noxious forest invasive species (FIS) plants in the central Indian landscape (India). The priority sites were spatially ranked by phytorichness levels and hotspots of invasion of multiple FIS. The study objectives include (i) generation of phytorichness at landscape scale (hereafter phytorichness) map by multi-criterion landscape modelling, (ii) generation of hotspots of invasion map by stacking of potential distribution maps of most noxious FIS, (iii) prioritise zones for conservation actions.

2. Study area

The study area i.e. central Indian landscape is located between 8°4′ and 37°6′ north latitude and 68°7′ and 97°25′ east longitude (Fig. 1). The study area is spread over 1,404,605 km^2 and comprises part of the Deccan Peninsula (include biotic provinces viz., central highlands, Chotta-Nagpur, eastern highlands, central plateau) and Semi-arid (including Rajputana biotic province) biogeographic zones in India. The climate varies from eastern tropical to sub-tropical and semi-arid. Champion and Seth (1968) recognised three major forest type groups in the study area namely tropical moist deciduous (rainfall between 100 and 200 cm), dry deciduous (rainfall between 70 and 100 cm) and thorn forests (rainfall between 20 to 70 cm). The major grassland types in the study area are namely *Dicanthium*/*Cenchrus*, *Schima*/*Dichanthium*, *Cymbopogon* and *Phragmetes*/*Saccharum* types. The total area under forest, scrubland and grassland is 360,247 km^2.The study area has key wildlife habitats and corridors such as Kanha-Navegaon-Tadoba, Pench-Kanha-Nagzira and Navegaon-Tadoba-Andhari complexes for a large population of tigers and elephants and associated species.

3. Methodology

The methodology for spatial prioritisation of phytorichness from exotic plant invasion risk includes (i) systematic field inventory for forest native and FIS; (ii) generation of phytorichness map by multi-criterion landscape modelling; (iii) generation of hotspots invasion map by stacking of potential distribution maps of FIS; and, (iv) prioritisation of risk zones. The flowchart of methodology is shown in Fig. 2.

3.1. Native plants and invasive (FIS) sampling

The inventory of vascular plants in the study area was carried out between 2004 and 2008 under the biodiversity project (http://bis.iirs.gov.in). Sample plots of 20 m × 20 m for trees, 5 m × 5 m for shrubs and 1 m × 1 m for herbs were laid out following stratified