Research Article

Invasive Alien Species of Terrestrial Vegetation of North-Eastern Uttar Pradesh

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The vegetational landscape of north-eastern *Terai* region at the foot hills of Central Himalayas is a mosaic of grassland, old-field, wasteland, and forest ecosystems. Like many other parts of the country, this region is also infested with alien intruders which not only interfere with the growth and production of food crops but also exercise adverse effects on the biodiversity of native species. The present study attempts to catalogue the invasive alien species of the terrestrial vegetation of north-eastern Uttar Pradesh especially with reference to their habit, taxonomic position, and nativity. A total of 1135 plant species within 580 genera under 119 families are so far known to occur in the region. Of these, only 149 species within 100 genera under 41 families have been found to be invasive aliens as evident from their center of origin, past history, nature of aggregation, and invasion observed under field conditions. About 80% of these invaders have been introduced from neotropics. Out of 173 invasive plants across India, this region shares 149 species, out of which 66% of species have come from Tropical America, 14% from African continent, and the rest from other countries. A better planning in the form of early identification and reporting of infestation and spread of noxious weeds is needed for their control.

1. Introduction

Invasion of alien plant species in recent times has been recognized as the second worst threat after habitat destruction [1]. The International Union for Conservation of Nature and Natural Resources (IUCN) defines “alien invasive species” as an alien species which becomes established in natural or seminatural ecosystems or habitat as agent of change and threatens native biological diversity. Identifying the processes that determine the distribution and diversity of exotic species is a major area of research in ecology because exotics impose significant economic, social, and environmental costs, including human health [2]. Biological invasion may be considered as a form of biological pollution and the significant component of anthropogenic changes leading to extinction of native species. The ecological approach to plant invasion has been mostly based on (a) biological and ecological features promoting the invasion success of particular species [3, 4] and (b) the character and invasibility of invaded communities [5]. Recently, both approaches are

treated as complementary [6, 7]. The phytogeographical and floristic approaches are important for research on alien plants [8]. A number of workers have studied and provided catalogues of the invasive alien plant species in different parts of the world [9–12]. Establishment of a database of naturalized species is the first step in the development of invasion biology. A naturalized species is an introduced species that can consistently reproduce and sustain population over many generations without direct intervention by humans [13, 14]. After successful establishment few naturalized species disperse and produce viable offsprings in areas far from the sites of their introduction. Such naturalized species are then called invasive. It is estimated that as many as 50% of invasive species, in general, can be classified as ecologically harmful [13].

Due to increasing trade and transcontinental transport, the floras of Indian subcontinent have a number of alien species from various parts of the world as evident from the studies made at different parts in India, namely, Upper Gangetic Plain [15, 16], Khandwa Plateau [17], Kodaikanal

and Palani Hills [18], Kashmir Himalaya [19, 20], Ranchi [21], Gangtok [22], Allahabad [23], Rajasthan [24], South Gujarat [25], and Doon Valley [26]. This paper presents observations on the habit and nativity of invaders of north-eastern Uttar Pradesh and their impact on the diversity of native plants.

2. The Site, Climate, and Vegetation

The study was conducted in the *Terai* landscape of north-eastern Uttar Pradesh. This area is characterized by even topography and fine alluvial deposits from Rapti and Gandak rivers. Mean altitude of the study area is 95 m amsl. The region slopes gently from north-west to south-east direction. Administratively the study area (~10,000 km²; 27°5' to 27°40'N latitude and 83°30' to 84°E longitude) falls in Gorakhpur district of Uttar Pradesh state. It is bounded by Nepal in the north and Bihar state of India in the east. The landscape comprises a mosaic of human habitations, agricultural fields, grasslands, commercial plantations, and forests. The climate is typically monsoonic with three distinct seasons, namely, summer (March to mid-June), rainy (mid-June to mid-October), and winter (mid-October to February). The total average annual rainfall is about 1814 mm; about 87% of annual rainfall is received during warm rainy season and the rest 13% is distributed in the form of occasional showers from November to May. Relative humidity ranges between 74 and 87%. The mean maximum temperatures during wet summer, winter, and dry summer season are 35.2°, 27°, and 24–39°C and mean minimum temperatures are 26.2°, 12.1°, and 24.2°C, respectively (based on climatic data for 2000–2005). The soil of the region is classified as Gangetic alluvium, ranging from clayey to sandy loam in texture with pH ranging from 6.5 to 7.5. In the northern area there are a few elevated mounds, locally called *dhus*, which range in size from a few hundred meters to 4–5 km and have brown sandy soil.

3. Data Sources and Methods

Over the period between 1960 and 2013, a comprehensive list of invasive alien plant species of north-eastern Uttar Pradesh was made. The truly aquatic plants were avoided but marshy plants were considered as component of terrestrial vegetation. Several extensive reviews on invasive plant species are available [12, 27–33]. The website <http://www.isws.in/invasive-plants-of-india.php> [34] was also searched for information on the origin and nativity of these invaders. Some information pertaining to the nativity of the species in India has been extracted from 18, 21–24, and 36–40.

Invasive alien species occurring in this region were compiled based on the literature survey, field observation, and discussion with local people. They were divided into three categories: naturalized, interfering, and noxious. Self-replacing plant populations by recruitment through seeds/ramets and capable of independent growth were categorized as *naturalized*. Alien and native plants which impacted agriculture adversely especially on the disturbed sites were taken as

noxious. The adverse impact of noxious species was in the form of competition for space with tillage or forage crops and harbouring of pests or disease vectors, harmful to crops/native species. In addition to efficient vegetative mode of propagation the seeds of these species are mostly wind-distributed and may remain viable for several years. The species which were neither injurious nor noxious but caused profuse interference and hindrance to the growth of crop/native species over a large area by virtue of their vast numbers were taken as *interfering*.

4. Results

A total of 149 species of invasive aliens of the terrestrial vegetation of north-eastern Uttar Pradesh have been documented. These 149 alien species belonged to 100 genera under 41 families. The alien species amounted to 13.1% of 1135 wild terrestrial plant species of the region. The habit, nativity, and the impact of invasive species on forest, grassland, and agricultural communities were noticed to prepare a catalogue of invasive alien/exotic plant species (Table 1). 100 aliens have their origin in Tropical America compared to 21 species in African continent. About 28 species of alien plants reached the study area from such far off places as Afghanistan, Australia, Brazil, East Indies, Europe, Madagascar, Mascarene Islands, Mediterranean, Mexico, Peru, Temperate South America, Tropical West Asia, West Indies, and Western Europe.

The herbaceous elements predominated the regional alien flora. The number of dicot alien species was 136, under 93 genera and 32 families. On the other hand, there were only 13 species of monocot aliens distributed among 9 genera under 5 families (Amaryllidaceae, Arecaceae, Cyperaceae, Liliaceae, and Poaceae). Of 41 families having alien species, Asteraceae was the most dominant (29 species) followed by Convolvulaceae (11), Amaranthaceae and Solanaceae (9 species each), Euphorbiaceae (8), Caesalpiniaceae and Papilionaceae (7 each), Poaceae (6), Capripadaceae, Cyperaceae, Tiliaceae, and Verbenaceae (4 each), Asclepiadaceae, Chenopodiaceae, Lamiaceae, Malvaceae, Mimosaceae, and Onagraceae (3 each), Acanthaceae, Oxalidaceae, Papaveraceae, Pedaliaceae, Portulacaceae, and Scrophulariaceae (2 each), and Amaryllidaceae, Apocynaceae, Arecaceae, Brassicaceae, Cannabaceae, Cuscutaceae, Cactaceae, Liliaceae, Polygonaceae, Primulaceae, Passifloraceae, Piperaceae, Rosaceae, Sterculiaceae, Ulmaceae, Urticaceae, and Zygophyllaceae (1 species each). Of these aliens, 15 species were judged as noxious, 43 species as interfering, and 91 as naturalized species (Figure 1). Habit wise analysis shows that 80% of species are herbs, 12% are shrubs, 6% are herbaceous climbers, and 2% are trees (Figure 2). The eight dominant families contributed 47% of the invasive alien flora of wild terrestrial vegetation of north-eastern Uttar Pradesh (Figure 3).

5. Discussion

Alien species are nonnative or exotic organisms that occur outside their natural adapted ranges and dispersal potential

TABLE 1: Wild invasive plant species in terrestrial vegetation of north-eastern Uttar Pradesh.

S. No.	Name of the Species	Family	Habit	Nativity	Categories
1	<i>Acacia farnesiana</i> (L.) Willd	Mimosaceae	Tree	Tropical South America	Naturalized
2	<i>Acanthospermum hispidum</i> DC.	Asteraceae	Herb	Brazil	Naturalized
3	<i>Aerva tomentosa</i>	Amaranthaceae	Herb	Tropical America	Naturalized
4	<i>Ageratum conyzoides</i> L.	Asteraceae	Herb	Tropical America	Noxious
5	<i>Ageratum houstonianum</i> Mill.	Asteraceae	Herb	Tropical America	Interfering
6	<i>Alternanthera paronychioides</i> A. St. Hill	Amaranthaceae	Herb	Tropical America	Naturalized
7	<i>Alternanthera pungens</i> Kunth	Amaranthaceae	Herb	Tropical America	Naturalized
8	<i>Alternanthera sessilis</i> (L.) R. Br. ex DC.	Amaranthaceae	Herb	Tropical America	Naturalized
9	<i>Amaranthus spinosus</i> L.	Amaranthaceae	Herb	Tropical America	Naturalized
10	<i>Anagallis arvensis</i> L.	Primulaceae	Herb	Europe	Naturalized
11	<i>Antigonon leptopus</i> Hook and Arn.	Polygonaceae	climber	Tropical America	Noxious
12	<i>Argemone mexicana</i> L.	Papaveraceae	Herb	Tropical South America	Noxious
13	<i>Argemone ochroleuca</i> Sweet.	Papaveraceae	Herb	Mexico	Interfering
14	<i>Asphodelus tenuifolius</i> Cav.	Liliaceae	Herb	Tropical America	Naturalized
15	<i>Blainvillea acmella</i> (L.) Philipson	Asteraceae	Herb	Tropical America	Interfering
16	<i>Blumea eriantha</i> DC.	Asteraceae	Herb	Tropical America	Interfering
17	<i>Blumea lacera</i> (Burm f.) DC.	Asteraceae	Herb	Tropical America	Interfering
18	<i>Blumea obliqua</i> (L.) Druce	Asteraceae	Herb	Tropical America	Interfering
19	<i>Borassus flabellifer</i> L.	Arecaceae	Tree	Tropical Africa	Naturalized
20	<i>Calotropis gigantea</i> (L.) R. Br.	Asclepiadaceae	Shrub	Tropical Africa	Interfering
21	<i>Calotropis procera</i> (Ait) R. Br.	Asclepiadaceae	Shrub	Tropical Africa	Interfering
22	<i>Cannabis sativa</i> L.	Cannabaceae	Herb	Central Asia	Interfering
23	<i>Cassia absus</i> L.	Caesalpinaceae	Herb	Tropical America	Naturalized
24	<i>Cassia alata</i> L.	Caesalpinaceae	Shrub	West Indies	Naturalized
25	<i>Cassia hirsute</i> L.	Caesalpinaceae	Herb	Tropical America	Naturalized
26	<i>Cassia obtusifolia</i> L.	Caesalpinaceae	Herb	Tropical America	Naturalized
27	<i>Cassia occidentalis</i> L.	Caesalpinaceae	Herb	Tropical South America	Naturalized
28	<i>Cassia pumila</i> Lam.	Caesalpinaceae	Herb	Tropical America	Naturalized
29	<i>Cassia tora</i> L.	Caesalpinaceae	Herb	Tropical South America	Noxious
30	<i>Celosia argentea</i> L.	Amaranthaceae	Herb	Tropical Africa	Naturalized
31	<i>Chenopodium album</i> L.	Chenopodiaceae	Herb	Europe	Interfering
32	<i>Chenopodium ambrosioides</i> L.	Chenopodiaceae	Herb	Tropical America	Interfering
33	<i>Chenopodium murale</i> L.	Chenopodiaceae	Herb	Tropical America	Naturalized
34	<i>Chloris barbata</i> Sw.	Poaceae	Herb	Tropical America	Naturalized
35	<i>Chrozophora rottleri</i> (Geis) Spring	Euphorbiaceae	Herb	Tropical Africa	Naturalized
36	<i>Cleome burmanni</i>	Capparidaceae	Herb	West Africa	Naturalized
37	<i>Cleome gynandra</i> L.	Capparidaceae	Herb	Tropical America	Naturalized
38	<i>Cleome ruidosperma</i> DC.	Capparidaceae	Herb	Tropical America	Naturalized
39	<i>Cleome viscosa</i> L.	Capparidaceae	Herb	Tropical America	Naturalized
40	<i>Clerodendrum splendens</i> G. Don	Verbenaceae	Climber	Africa	Interfering
41	<i>Convolvulus arvensis</i> L.	Convolvulaceae	Herb	Europe	Naturalized
42	<i>Corchorus aestuans</i> L.	Tiliaceae	Herb	Tropical America	Naturalized
43	<i>Corchorus fascicularis</i> Lam.	Tiliaceae	Herb	Tropical America	Naturalized
44	<i>Corchorus olitorius</i> L.	Tiliaceae	Herb	Tropical Africa	Naturalized
45	<i>Coronopus didymus</i> (L.) Smith	Brassicaceae	Herb	Tropical America	Interfering
46	<i>Crotalaria mucronata</i> Ait	Papilionaceae	Herb	Tropical America	Interfering
47	<i>Croton bonplandianum</i> Boil.	Euphorbiaceae	Herb	Temperate South America	Naturalized
48	<i>Cryptostegia grandiflora</i> R. Br.	Asclepiadaceae	Herb	Madagascar	Interfering

TABLE 1: Continued.

S. No.	Name of the Species	Family	Habit	Nativity	Categories
49	<i>Cuscuta reflexa</i> Roxb.	Cuscutaceae	Herb	Mediterranean	Interfering
50	<i>Cynodon dactylon</i> (Linn.) Pers	Poaceae	Herb	Africa	Naturalized
51	<i>Cyperus difformis</i> L.	Cyperaceae	Herb	Tropical America	Naturalized
52	<i>Cyperus flabelliformis</i> Rottb.	Cyperaceae	Herb	Africa	Interfering
53	<i>Cyperus iria</i> L.	Cyperaceae	Herb	Tropical America	Naturalized
54	<i>Cyperus cyperoides</i> L.	Cyperaceae	Herb	Tropical America	Naturalized
55	<i>Datura innoxia</i> Mill.	Solanaceae	Shrub	Tropical America	Noxious
56	<i>Datura metel</i> L.	Solanaceae	Shrub	Tropical America	Interfering
57	<i>Datura stramonium</i> L.	Solanaceae	Shrub	Tropical America	Noxious
58	<i>Digera muricata</i> (L.) Mart	Amaranthaceae	Herb	South-West Asia	Interfering
59	<i>Duranta repens</i> Linn.	Verbenaceae	Shrub	America	Naturalized
60	<i>Echinochloa colonum</i> (L.) Link	Poaceae	Herb	Tropical South America	Naturalized
61	<i>Echinochloa crus-galli</i> (L.) Beauv.	Poaceae	Herb	Tropical South America	Noxious
62	<i>Echinops echinatus</i> Roxb.	Asteraceae	Herb	Afghanistan	Naturalized
63	<i>Eclipta prostrata</i> (L.) Mart.	Asteraceae	Herb	Tropical America	Naturalized
64	<i>Emilia sonchifolia</i> (L.) DC.	Asteraceae	Herb	Tropical America	Naturalized
65	<i>Erigeron bonariensis</i> L.	Asteraceae	Herb	South America	Interfering
66	<i>Eupatorium adenophorum</i> Sprengel	Asteraceae	Shrub	Mexico	Noxious
67	<i>Eupatorium odoratum</i> L.	Asteraceae	Shrub	Tropical America	Interfering
68	<i>Euphorbia chamaesyce</i> L.	Euphorbiaceae	Herb	West Africa & Mauritius	Naturalized
69	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Herb	Tropical America	Naturalized
70	<i>Euphorbia heterophylla</i> L.	Euphorbiaceae	Herb	Tropical America	Naturalized
71	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae	Herb	Tropical America	Naturalized
72	<i>Flaveria trinervia</i> (Spreng.) C. Mohar	Asteraceae	Herb	Tropical Cent. America	Naturalized
73	<i>Galinsoga parviflora</i> Cav.	Asteraceae	Herb	Tropical America	Naturalized
74	<i>Glossocardia bosvallia</i> (L. f.) DC.	Asteraceae	Herb	West Indies	Naturalized
75	<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	Herb	Tropical America	Interfering
76	<i>Gomphrena celosioides</i> Mart.	Amaranthaceae	Herb	Tropical America	Naturalized
77	<i>Gomphrena globosa</i> Linn.	Amaranthaceae	Herb	America	Naturalized
78	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	Herb	Tropical South America	Naturalized
79	<i>Hyptis suaveolens</i> (L.) Poit	Lamiaceae	Herb	Tropical America	Interfering
80	<i>Imperata cylindrica</i> (L.) Raensch.	Poaceae	Herb	Tropical America	Naturalized
81	<i>Indigofera glandulosa</i> Roxb. Ex Willd	Papilionaceae	Herb	Tropical America	Naturalized
82	<i>Indigofera hirsuta</i> Hook.	Papilionaceae	Herb	Tropical Africa	Naturalized
83	<i>Indigofera linearis</i> Ali	Papilionaceae	Herb	Tropical Africa	Naturalized
84	<i>Indigofera linifolia</i> (L. f.) Retz.	Papilionaceae	Herb	Tropical South America	Naturalized
85	<i>Ipomoea eriocarpa</i> R. Br.	Convolvulaceae	Climber	Tropical Africa	Interfering
86	<i>Ipomoea fistulosa</i> Mart DC.	Convolvulaceae	Shrub	Tropical America	Interfering
87	<i>Ipomoea muricata</i> L.	Convolvulaceae	Climber	Tropical America	Naturalized
88	<i>Ipomoea nil</i> (L.) Roth.	Convolvulaceae	Climber	North America	Naturalized
89	<i>Ipomoea obscura</i> (L.) Ker. Gawl.	Convolvulaceae	Climber	Tropical Africa	Interfering
90	<i>Ipomoea pes-tigridis</i> L.	Convolvulaceae	Climber	Tropical East Africa	Interfering
91	<i>Ipomoea purpurea</i> (Linn.) Roth	Convolvulaceae	Herb	America	Interfering
92	<i>Ipomoea quamoclit</i> L.	Convolvulaceae	Climber	Tropical America	Interfering
93	<i>Jatropha curcas</i>	Euphorbiaceae	Herb	Tropical America	Naturalized
94	<i>Jatropha gossypifolia</i> L.	Euphorbiaceae	Shrub	Brazil	Naturalized
95	<i>Lagascea mollis</i> Cav	Asteraceae	Herb	Tropical Cent. America	Noxious
96	<i>Lantana camara</i> L.	Verbenaceae	Shrub	Tropical America	Noxious
97	<i>Leonotis nepetifolia</i> (L.) R. Br.	Lamiaceae	Herb	Tropical Africa	Interfering

TABLE 1: Continued.

S. No.	Name of the Species	Family	Habit	Nativity	Categories
98	<i>Leucaena leucocephala</i> (Lam.) de. Wit	Mimosaceae	Herb	Tropical America	Noxious
99	<i>Lippia alba</i>	Verbenaceae	Herb	Trop. America & West Indies	Interfering
100	<i>Ludwigia adscendens</i> (L.) Hara	Onagraceae	Herb	Tropical America	Naturalized
101	<i>Ludwigia octovalvis</i> (Jacq.) Raven	Onagraceae	Herb	Tropical America	Naturalized
102	<i>Ludwigia parviflora</i> Roxb.	Onagraceae	Herb	Tropical Africa	Naturalized
103	<i>Malvastrum coromandelianum</i> (L.) Gar.	Malvaceae	Herb	Tropical America	Naturalized
104	<i>Martynia annua</i> L.	Pedaliaceae	Herb	Tropical America	Interfering
105	<i>Mecardonia procumbens</i> (Mill.) Small	Scrophulariaceae	Herb	Tropical North America	Naturalized
106	<i>Melilotus alba</i> Desv.	Papilionaceae	Herb	Europe	Naturalized
107	<i>Melochia corchorifolia</i> L.	Sterculiaceae	Herb	Tropical America	Naturalized
108	<i>Merremia dissecta</i> (Jacq.) Hallier f.	Convolvulaceae	Herb	Tropical America	Naturalized
109	<i>Mikania micrantha</i> Kunth.	Asteraceae	Climber	Tropical America	Noxious
110	<i>Mimosa pudica</i> L.	Mimosaceae	Herb	Brazil	Naturalized
111	<i>Nicotiana plumbaginifolia</i> Viv.	Solanaceae	Herb	Tropical America	Naturalized
112	<i>Ocimum americanum</i> L.	Lamiaceae	Herb	Tropical America	Naturalized
113	<i>Opuntia elatior</i> Mill.	Cactaceae	Herb	Tropical America	Noxious
114	<i>Oxalis corniculata</i> L.	Oxalidaceae	Herb	Europe	Naturalized
115	<i>Oxalis corymbosa</i> DC.	Oxalidaceae	Herb	South America	Naturalized
116	<i>Parthenium hysterophorus</i> L.	Asteraceae	Herb	Tropical North America	Noxious
117	<i>Passiflora foetida</i> L.	Passifloraceae	Herb	Tropical South America	Interfering
118	<i>Pedaliium murex</i> L.	Pedaliaceae	Herb	Tropical America	Naturalized
119	<i>Peperomia pellucida</i> (L.) Kunth.	Piperaceae	Herb	Tropical South America	Naturalized
120	<i>Peristrophe paniculata</i> (Forsk.) Brummitt	Acanthaceae	Herb	Tropical America	Interfering
121	<i>Physalis minima</i> L.	Solanaceae	Herb	Tropical America	Naturalized
122	<i>Physalis peruviana</i> L.	Solanaceae	Herb	Tropical America	Interfering
123	<i>Pilea microphylla</i>	Urticaceae	Herb	Tropical South America	Naturalized
124	<i>Portulaca oleracea</i> L.	Portulacaceae	Herb	Tropical S. America	Naturalized
125	<i>Portulaca quadrifida</i> L.	Portulacaceae	Herb	Tropical America	Naturalized
126	<i>Rauvolfia tetraphylla</i>	Apocynaceae	Herb	West Indies	Naturalized
127	<i>Ricinus communis</i> Linn.	Euphorbiaceae	Shrub	Africa	Interfering
128	<i>Rubus ellipticus</i> Smith	Rosaceae	Shrub	Tropical America	Naturalized
129	<i>Ruellia tuberosa</i> L.	Acanthaceae	Herb	Tropical America	Naturalized
130	<i>Saccharum spontaneum</i> L.	Poaceae	Herb	Tropical West Asia	Interfering
131	<i>Scoparia dulcis</i> L.	Scrophulariaceae	Herb	Tropical America	Naturalized
132	<i>Sesbania bispinosa</i> (Jacq.) W. F. Wight	Papilionaceae	Shrub	Tropical America	Naturalized
133	<i>Sida acuta</i> Burm f.	Malvaceae	Herb	Tropical America	Naturalized
134	<i>Solanum khasianum</i>	Solanaceae	Herb	Tropical America	Interfering
135	<i>Solanum nigrum</i> L.	Solanaceae	Herb	Tropical America	Naturalized
136	<i>Solanum torvum</i> Sw.	Solanaceae	Shrub	West Indies	Interfering
137	<i>Solvia anthemifolia</i> (Juss) R.	Asteraceae	Herb	America	Interfering
138	<i>Sonchus asper</i> Hill.	Asteraceae	Herb	Mediterranean	Interfering
139	<i>Sonchus oleraceus</i> L.	Asteraceae	Herb	Mediterranean	Interfering
140	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	Herb	West Indies	Naturalized
141	<i>Tithonia diversifolia</i> (Hense) A. Gray	Asteraceae	Shrub	Mexico	Naturalized
142	<i>Trema orientalis</i> L.	Ulmaceae	Tree	Africa	Naturalized
143	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Herb	Tropical America	Naturalized
144	<i>Tridax procumbens</i> L.	Asteraceae	Herb	Tropical Cent. America	Naturalized

TABLE 1: Continued.

S. No.	Name of the Species	Family	Habit	Nativity	Categories
145	<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	Herb	Tropical America	Naturalized
146	<i>Urena lobata</i> L.	Malvaceae	Shrub	Tropical Africa	Interfering
147	<i>Xanthium strumarium</i> L.	Asteraceae	Herb	Tropical America	Noxious
148	<i>Youngia japonica</i> (L.) DC.	Asteraceae	Herb	Tropical South America	Naturalized
149	<i>Zephyranthes candida</i> Lindl.	Amaryllidaceae	Herb	America	Naturalized

FIGURE 1: Families accounting for >5 species invasive in the terrestrial vegetation of north-eastern Uttar Pradesh.

FIGURE 2: Number (%) of plant invasive species under different habit categories within terrestrial vegetation of north-eastern Uttar Pradesh.

[35]. These invasive species are widely distributed in all kinds of ecosystems throughout the world and include all categories of living organisms. Nevertheless, plants, mammals, and insects comprise the most common types of invasive alien species in terrestrial environments [36]. Many alien plant species support our farming and forestry systems in a big

FIGURE 3: Species number under three different categories of invasive plants.

way. However, some of these aliens become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade, and outcompete native species [37]. An important requirement for successful colonization of invaders is open habitat with reduced competition. Generally, the microsites created by grazing may be occupied by invader species [38–40]. The invaders usually dominate the highly disturbed and man-made landscapes. So far, no ready hand catalogue of invasive species is available for this region. The present catalogue of invasive exotic species is likely to serve as basic information for future research towards conservation of native plant species of the region.

As evident from the data, the vegetation of north-eastern Uttar Pradesh shows greater incidence of invaders as compared to the whole of Uttar Pradesh [41] and India [42]. Reddy documented all invasive plant species irrespective of their habitat and use. In the present case, however, only the wild invasive plant species of terrestrial vegetation were considered and truly aquatic and ornamental invasive species were excluded. Many species, recorded as invader of north-eastern Uttar Pradesh, are common to Indian Himalayan region and the whole of Uttar Pradesh. For example, 103 invaders are common to the whole of the state of Uttar

Pradesh [41] and 95 species to the whole of India [42]. Among the invasive species of north-eastern Uttar Pradesh, 70.5% are native to American continent. Other such studies vary slightly in percent share of tropical American nativity. While Singh et al. [41] reported 73% of invasive plant species of Uttar Pradesh, for Indian Himalayan region, however, Sekar [43] also noticed 73% invaders of American nativity. Reddy [42] noticed 58% of the invasive flora of India to be natives of American continent.

Alien species have been classified into naturalized and noxious species by various workers [13, 44, 45]. Our field observation and discussion with local people indicate that there are 15 most noxious invasive plant species in this region, namely, *Ageratum conyzoides*, *Antigonon leptopus*, *Argemone mexicana*, *Cassia tora*, *Datura stramonium*, *Datura innoxia*, *Echinochloa crus-galli*, *Eupatorium adenophorum*, *Lantana camara*, *Lagascea mollis*, *Leucaena leucocephala*, *Mikania micrantha*, *Parthenium hysterophorus*, *Opuntia elatior*, and *Xanthium strumarium*. Some species such as *Ageratum conyzoides*, *Eupatorium adenophorum*, *Lantana camara*, and *Parthenium hysterophorus* are harmful to native species [41, 46, 47]. Further, some of these species are known to be highly allergic, causing diseases in human beings [48, 49]. Since they are rarely palatable, their dominance drastically reduces the number of grazers by way of reducing the carrying capacity of the pasture and wasteland [40]. *Datura innoxia* and *Datura stramonium* are serious threat to the native species of the region and are known to cause delay in seedling growth of neighbouring plants [50]. *Leucaena leucocephala* alters the natural growth of native plants because not only it obstructs plenty of sunlight to reach surface layer but also its allelopathic exudates cause retardation in seedling growth of neighbouring plants [51]. *Mikania micrantha* could climb trees and cover the whole habitats through fast vegetative propagation and could also suppress the growth of crops and natural vegetation through competition and allelopathic effects [45]. These species occur as invasive species under shifting agriculture in north-eastern Uttar Pradesh and combine an effective seed based reproduction with clonal propagation [52]. Many invasive species such as species of *Eupatorium* tend to respond to temporarily nutrient-enriched soil substrata and grow and quickly cover the gaps in disturbed forests. They can destroy arable soil, negatively affect the growth of orchard, and could also supplant grasses in pasture, excreting a toxic volatile that prevents grazing [48].

The herbaceous invasive plant species were recorded as the dominant invasive flora (80%) of north-east Uttar Pradesh, in the form of 119 invasive species. The greater viability and tolerance to harsh conditions could result in the preponderance of herbs across the region. Invasive species of Asteraceae exhibited a much higher reproductive capacity than those of other families. This high reproductive potential is achieved by partitioning of reproductive capital into a large number of propagules that are minute, light, and wind dispersed [53]. Various other workers have also reported the dominance of Asteraceae among invasive alien species in Uttar Pradesh [41] and in Indian Himalayan region [43].

The invasive species cause loss of biodiversity through species extinction and their impact on ecosystem function. Differences between native and invasive plant species in their resource acquisition and consumption may cause a change in soil structure, decomposition, and nutrient content of the soil. Thus, invasive species are a serious hindrance to conservation with significant undesirable impacts on the goods and services provided by ecosystems. Biological invasions now operate on a global scale and are likely to undergo rapid increase in this century due to interaction with other changes such as increasing travel and tourism. A quick monitoring of invasion can, therefore, be done through qualitative approach like species inventory method.

6. Conclusion

Plant invasions in the new areas alter indigenous community composition, deplete species diversity, affect ecosystem process, and thus cause huge economic and ecological imbalance. A quick inventory and plant identification network are, therefore, needed for early detection and reporting of noxious and naturalized weeds in order to control the spread of invasive plant species.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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