

INVASIVE ALIEN FLORA OF INDIA

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FOREWORD

Biodiversity loss caused by invasive species may soon surpass the damage done by habitat destruction and fragmentation. Biological invasions are an important component of human-caused global environmental change. Invasive alien species are now a major focus of global conservation concern. The decisions need to be made on whether benefits derived from the invasive spread of an alien species outweigh the reduced value of ecosystem services, e.g. the loss of grazing land in areas invaded with *Prosopis*. It is necessary to consider actions to deal with the current problems caused by invasive species and to reduce the magnitude of the problem in the future.

The present book on invasive alien flora of India is therefore timely one. It focuses on 173 species of invasive alien plants in India. These include the most serious invasives, such as *Alternanthera philoxeroides*, *Cassia uniflora*, *Chromolaena odorata*, *Eichhornia crassipes*, *Lantana camara*, *Parthenium hysterophorus*, *Prosopis juliflora* and others. I am confident that this publication is will be immense value to foresters, environmentalists, field researchers and conservation managers to pay attention on the ecological impact of invasive aliens both at the species and at the ecosystem levels..

PREFACE

The invasion of alien species is recognized as a primary cause of global biodiversity loss. The problem of invasive species is great and probably become more severe since the growing human population will result in more disruption of ecosystems and hence systems that are more invasion prone. The opportunity of accidental introductions will may become more with rapidly increasing global commerce. In view of this, the present study attempted to document the invasive alien plant species in the flora of India.

This book provides identification of 173 alien plant species invading the different landscapes of India. In the background chapter, the relevant data based on literature survey is provided for better understanding of the nature of invasive alien species. The text and photographs were developed to assist in the State-wise or region-wise survey and monitoring of these invading species.

A better planning is needed for early detection and reporting of infestations of spread of new and naturalized weeds by creation of *Plant Detection Network* in each State by establishing communication links between taxonomists, ecologists and land managers to monitor and control.

We hope this book would be of use to foresters, environmentalists, ecologists, taxonomists and the general public who are interested in the conservation of plant wealth of India. When a book of this kind is brought out there is a scope for improvement in the future. Yours suggestions are most welcome in this regard.

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1. Background

“Loss of habitat constitutes the greatest threat to the existence of biodiversity

The second worst threat is the biological invasion of alien species (Convention for Biological diversity, 1992)”

An alien plant, also referred to as exotic, introduced, foreign, non-indigenous or non-native, is one that has been introduced by humans intentionally or otherwise through human agency or accidentally from one region to another. An alien plant that has escaped from its original ecosystem and is reproducing on its own in the regional flora is considered a naturalized species. Those naturalized aliens that become so successful as to spread in the flora and displace native biota or threatens valued environmental, agricultural or personal resources by the damage it causes are considered invasive.

Humans have been transporting animals and plants from one part of the world to another for thousands of years, sometimes deliberately for social or personal gain and sometimes accidentally. In most cases, such introductions are unsuccessful, but when they do become established as an invasive alien species (defined by IUCN (2000) as “an alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity”), the consequences can be catastrophic. According to the Convention for Biological Diversity, invasive alien species are the second largest cause of biodiversity loss in the world and impose high costs to agriculture, forestry, and aquatic ecosystems. In fact, introduced species are a greater threat to native biodiversity than pollution, harvest, and disease combined.

The global extent and rapid increase in invasive species is homogenising the world’s flora and fauna (Mooney & Hobbs, 2000) and is recognized as a primary cause of global biodiversity loss. Bio-invasion may be considered as a form of biological pollution and significant component on global change and one of the major causes of species extinction (Mooney and Drake, 1987; Drake et al., 1989).

Foresters, taxonomists and ecologists are now well aware of the problems caused by the invasion of alien species into natural areas and the associated negative effects on global patterns of native biodiversity. Once established, some alien species have the ability to displace or replace native plant and animal species, disrupt nutrient and fire cycles, and cause changes in the pattern of plant succession. Studies are underway to better understand the impacts of these species on native ecosystems.

Many invasive plants continue to be admired by people who may not be aware of their weedy nature. Others are recognized as weeds but property owners fail to do their part in preventing their spread. Some species do not even become invasive until they are neglected for a long time. Invasive plants are not all equally invasive. Some only colonize small areas and do not do so aggressively. Others may spread and come to dominate large areas in just a few years. The loss due to invasive species in United States estimated to be ~\$125-150 billion each year and 25% of US agriculture gross national product lost due to foreign pests and weeds (McNeely et al. 2001). Alien plants can spread rapidly because of our mobile society and the intentional transportation of ornamental and forage plants (Randall and Marinelli, 1997).

1.1 Characteristic features of Invasive species:

Invasive species possess characteristic features like “pioneer species” in varied landscapes, tolerant of a wide range of soil and weather conditions, generalist in distribution, produces copious amounts of seed that disperse easily, grows aggressive root systems, short generation time, high dispersal rates, long flowering and fruiting periods, broad native range, abundant in native range. Preliminary data from one interesting study shows that invasive species are likely to have relatively small amounts of DNA in their cell nuclei. Apparently, the cells in these plants are able to divide and multiply more quickly and consequently the entire plant can grow more rapidly than species with higher cellular DNA content. This gives them a leg up in disturbed sites.

1.2 Global trade and Species introductions: intentions and accidents

The trade-based global economy stimulates the cultivation of economically important species. But it also stimulates the accidental spread of some species or others. International law regulating the unintentional introduction of harmful alien species through trade is weak. There are two major conventions with provisions on aliens. One is the International Plant Protection Convention (IPPC), which presently addresses crop pests only. The IPPC could be expanded in scope to explicitly protect native (non-agricultural) plant life from introduced pests. The other major international agreement addressing alien species, the Convention on Biological Diversity, lacks teeth (Jenkins, 1999). Article 8(h) addresses alien species by calling for the parties to: “as far as possible and as appropriate: ... Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species”.

1.3 Monitoring:

Monitoring is required in the invasive species management to *determine*: location/early detection of problematic species, whether a species is likely to become a problem in an area, whether a species is responding to management efforts (if taken?), the impact of alien plant control methods on native species. Monitoring of Invasion can be done through *qualitative approach* like species inventory (seasonally) and *quantitative approach* using phytosociological methods and *mapping* using ground-based methods (via map overlays or GPS), remotely-sensed images (aerial photos, high resolution multi-spectral digital data).

1.4 Control:

Current control methods for invasive aliens are expensive, lengthy, and risky because total eradication is required to prevent reestablishment. Effective site-eradication procedures require multi-year treatments, continued monitoring, and follow-up treatments. All infestations on adjacent lands must be treated to prevent reinvasion.

Unfortunately, infestations common along railway tracks, roads, and utility right-of-ways are rarely treated for eradication, fostering widespread immigration to adjacent lands.

Common methods for control of invasive weed species are: Mechanical, Chemical and Biological control.

Mechanical Control: It is one of the common method employed for control of invasive species. Mechanical control involves ploughs, scythes, mowers, hoes, cultivators, rotary weeders etc. Using these tools, the weeds are physically lifted from the soil, cut off or buried. But it is laborious and needs lot of man power.

Chemical Control: This method has proved costly and partly successful in several cases. Using of chemicals is not desirable due to pollution that they cause.

Biological Control: In most cases of alien pest invasions, biological control has proven the most effective and environmentally sound approach to their management. Introducing a natural enemy (e.g. water hyacinth weevil *Neochetina spp.* for *Eicchornia*; *Lantanophaga pussilidactyla* insect for *Lantana camara*, *Zygogramma bicolorata* insect and *Cassia uniflora* plant species for *Parthenium hysterophorus*) for eradication of invasive species is a current focus of interest for biological conservationists. But biological control may not be evenly effective over all areas infested by the invasive species.

Past research studies for developing eradication methods were often limited in duration (only one or two years) and habitats (one site). Appropriate long-term support and funding has been lacking. Control projects for invasive species, offer a logical, long-term solution but none have been seriously attempted in India. The high investments and long-term research required for control programs have been made only for western rangeland alien plant species, and more recently for tropical aliens in Florida.

Crucial aspects of alien plant ecology that influence control strategies are as follows:

1. Invasive aliens continue to spread because natural predators were not imported from the plant's home range and native predators are too weak;
2. After an alien plant is introduced there is a "lag phase" of decades to centuries before an exponential spread phase (Baskin 2002). Thus, some species that currently appear non-invasive may eventually begin to spread rapidly.
3. Invasive alien plants can prevent or retard natural succession and reforestation by forming dense infestations.
4. Invasion by aliens continues to decrease biological diversity and detract from their primary mission;
5. The partial shade tolerance of some alien species (*Cassia pumila*) allows them to become established under developed forest canopies;
6. *Alternanthera philoxeroides*, *Eichhornia crassipes* and *Pistia stratiotes* are invading riparian/aquatic habitats to the exclusion of native species and regeneration;
7. The initial spread of aliens were observed along highway and utility right-of-ways, "disturbed habitats," and riparian systems, greatly facilitates migration into extensive forest areas; and
8. Because many "disturbed habitats" occur in cities, alien plants can present severe problems for urban forestry programs, which is made more difficult by alien species mixtures.
9. Allelopathic effect by species like *Prosopis juliflora*, *Hyptis suaveolens*, *Lantana camara* retard the growth of other species.
10. The invasions potentially lead to an increase in species richness, as invasive species are added to the existing species pool. But also leads to extinction of native species, resulting in decrease of species richness. The negative interactions is primarily the competition with natives for food and sustenance, which may not allow coexistence.

1.6 Research Issues, Legal and Institutional Needs:

There is no question that understanding and dealing with the invasive problem is an enormous challenge. To meet this need SCOPE (Scientific Committee on Problems of Environment) is calling for a focused, coordinated, and broadly based approach to the invasive species problem that would engage the large, and global concerned with these issues. It is recognized that research initiatives in India are now needed to improve the understanding of the ecology of the invasive process, the knowledge on predictive powers on which species are likely to become invasive and under what conditions, characteristics of invasive species, impacts of global climate change on invasive species.

It is realized that a legal and institutional approach to the country's biosecurity threat is a prerequisite to long-term success against introduction of invasive species. The government should strengthen its quarantine authority through new legislations which prohibits the introduction of alien species without an approved consent or permit. Also unauthorized introduction of wild and domesticated animals and plants into new areas, between states and within the country should be reviewed and monitored by several government departments, *viz.* Forest, Agriculture, Environment, Veterinary and Public Health.

We need to develop techniques to make rapid assessment of the status and movement of invaders and of their potential ecosystem impacts. At present our knowledge about the status of invaders is generally of two states only – it is present (which is derived from flora lists) or it is firmly established and doing devastating damage (often learned from the popular newspapers). Information is needed between these two extremes. In order to acquire this information a rapid sapling approach is needed that would produce a quantitative assessment of the status of invading species, that could be repeated at intervals, to provide a clear focus on emerging problems, helping to alleviate the crisis management approach to invaders. Efforts are needed to utilize developing technologies for tracking invasives including remote sensing and GIS. Further, we need to develop

global maps of the distributions of the most abundant and most devastating invasive species, as well as the most sensitive ecosystem types (Mooney, 1999).

2. India (study area)

India has a characteristic geographic location at the junction of the three major biogeographic realms, namely, the Indo-Malayan, the Eurasian and the Afro-tropical ($6^{\circ} 45'$ to $37^{\circ} 6'N$ latitude and $68^{\circ} 7'$ to $97^{\circ} 25'$ E longitude) with a land frontier of about 15,200 km and a coastline of 7,516 km. Its geographical area is 3287.263 sq. km (3, 287 million Ha.). It is the seventh largest country in the world and the second largest in Asia. It is considered to be one of the twelve centres of origin and diversity of several plant species in the world.

Physiographically, the Indian mainland may be divided into three distinct regions: the Himalaya, the Indo-Gangetic Plain, and the Peninsular India. The Himalaya form a mountain chain along the extreme northern margins of India, extending east-west about 2,500 km in length, varying in width between 240 to 340 km, occupying an area about 500,000 sq.km in India, and rising from the low lying Indian plains to the highest peaks at Kanchenjunga (8,586 m) in Sikkim. The Indo-Gangetic plain comprises alluvial low lands lying parallel to the south of the Himalaya (ca. 2,400 km). This region is agriculturally more productive. The Peninsular India (Deccan, Eastern Ghats, Western Ghats) lies south to the Indo-Gangetic plain, the two being separated roughly by the boundary of Tropic of Cancer.

Climate: India is mainly a tropical country but due to great altitudinal variations, almost all climatic conditions from hot deserts to cold deserts exist. There are four seasons in the year: (1) Spring (January-March), (2) Summer (April-June), (3) South-West monsoon (July-September), and (4) Winter season (October-December). The south-west or the summer monsoon is the main source of rainfall in the country providing 80% of the precipitation, though some precipitation is received in winter months too.

Flora:

According to World Conservation Monitoring Centre (WCMC), 1,604,000 species have been described at the global level. Thus India accounts for 8 % of the global biodiversity existing in only 2.4% land area of the world. According to Nayar (1989) the number of flowering plant species endemic to the present political boundaries of this country is 4900 out of a total of 15000, i.e. 33 %. Hajra & Mudgal (1997) report 5400 endemics in 17000 angiospermous species of India, which comes to 31.76 %. India is an important center of agri-biodiversity having contributed 167 species to the world agriculture and homeland for 320 species of wild relatives of crops.

India's rich vegetation wealth and diversity is undoubtedly due to the immense variety of the climatic and altitudinal variations coupled with varied ecological habitats. There are almost rainless areas to the highest rainfall area in the world. The altitude varies from the sea level to the highest mountain ranges of the world. The habitat types vary from the humid tropical Western Ghats to the hot desert of Rajasthan; from cold desert of Ladakh and icy mountains of the Himalayas to the long, warm coast line stretches of Peninsular India. The extreme diversity of the habitats has resulted in such luxuriance and variety of flora and fauna that almost all types of forests, ranging from scrub forest to the tropical evergreen rain forest, coastal mangrove to the temperate and alpine flora occur in this region. Champion and Seth (1968) have recognized 16 major forest types comprising 221 minor types in India. Of these, the Tropical moist deciduous forest forms the major percentage (37%) of forest cover in India. Tropical dry deciduous forest forms 28.6% and the remaining ones are scattered in minor percentage. Presently, India has 678,333 sq.kms (20.64 %) of forest cover (FSI, 2003).

The flora of India shows close affinity with the flora of Indo-Malayan and Indo-Chinese region. This fact prompted Hooker (1904) to the erroneous conclusion that India has no flora as a separate entity but is an admixture of the floras from adjacent countries. According to Nayar (1977) 35% of Indian flora has south-east Asian and Malayan, 8%

temperate, 1% steppe, 2% African, and 5% Mediterranean- Iranian elements. The cultivated and naturalized aliens constitute only 18%. Chatterjee (1939) reported 6,850 species as endemic to India for the first time. The subsequent phytogeographers after critical analysis of flora have convincingly concluded that India has a flora of its own and as many as 5400 (33%) taxa of Indian flora are endemic to present Indian boundaries.

The following alien species are commonly cultivated for food / forage / timber / ornamental / other economic purposes in our country.

a. Introduced plants from Australia:

Acacia dealbata, *Acacia decurrens*, *Acacia holosericea*, *Acacia longifolia*, *Acacia mangium*, *Acacia melanoxylon*, *Araucaria bidwilli*, *Araucaria columnaris*, *Araucaria cunninghamii*, *Araucaria excelsa*, *Brassia actinophylla*, *Callistemon lanceolatus*, *Callitris cupressiformis*, *Callitris glauca*, *Castenospermum australe*, *Casuarina equisetifolia*, *Eucalyptus alba*, *Eucalyptus camaldulensis*, *Eucalyptus citriodora*, *Eucalyptus globulus*, *Eucalyptus grandis*, *Eucalyptus paniculata*, *Eucalyptus punctata*, *Eucalyptus saligna*, *Eucalyptus tereticornis*, *Eucalyptus torelliana*, *Eucalyptus viminalis*, *Grevillea banksii*, *Grevillea robusta*, *Melaleuca leucodendron*, *Stenocarpus sinuatus*, *Thuja occidentalis*, *Thuja orientalis*.

b. Introduced species from Western Asia and Europe:

Allium cepa, *Allium sativum*, *Althaea rosea*, *Asparagus officinalis*, *Avena sativa*, *Brassica oleracea*, *Cicer arietinum*, *Coriandrum sativum*, *Ficus carica*, *Lactuca sativa*, *Lens culinaris*, *Medicago sativa*, *Morus nigra*, *Nerium oleander*, *Papaver somniferum*, *Pisum sativum*, *Spinacea oleracea*.

c. Introduced species from the Mediterranean Area and Africa:

Aloe variegata, *Antirrhinum majus*, *Asparagus plumosus*, *Avena fatua*, *Briza maxima*, *Calendula bicolor*, *Capsella bursa-pastoris*, *Carthamus tinctorius*, *Cassia didymobotrya*, *Catharanthus roseus*, *Chenopodium album*, *Chenopodium murale*, *Chrysanthemum coronarium*, *Cichorium endivia ssp. divaricatum*, *Convolvulus arvensis*, *Cyperus flabelliformis*, *Foeniculum vulgare*, *Haworthia coarctata*, *Hordeum vulgare*, *Ipomoea*

batatas, Ipomoea cairica, Lathyrus sativus, Nasturtium officinale, Nerium indicum, Nigella damascena, Oxalis purpurea, Pelargonium inquinans x zonale, Pelargonium x hybridum, Pennisetum typhoides, Plantago major, Poa annua, Raphanus sativus, Ricinus communis, Salvia officinalis, Sansevieria trifasciata, Senecio vulgaris, Sisymbrium officinale, Spargula arvensis, Stellaria media, Taraxacum officinale, Verbena officinalis, Verbena supina, Veronica arvensis, Vicia benghalensis.

d. Introduced species from Europe/ America/Mexico/West Indies/Brazil

Agave americana, Agave sisalana, Allamanda cathartica, Allamanda violacea, Anacardium occidentale, Arundo donax, Angelonia biflora, Annona muricata, Annona reticulata, Annona squamosa, Arachis hypogaea, Asclepias physocarpa, Averrhoa bilimbi, Averrhoa carambola, Bauhinia blakeana, Begonia manicata, Beta vulgaris, Bignonia alliacea, Bignonia megapotamica, Bixa orellana, Bixa orellana, Bougainvillea glabra, Bougainvillea spectabilis, Brassica rapa, Browallia viscosa, Brunfelsia americana, Caesalpinia coriaria, Caesalpinia pulcherrima, Caladium bicolor, Capsicum annuum, Capsicum frutescens, Carica papaya, Cassia grandis, Catesbaea spinosa, Ceiba pentandra, Centaurea cyanus, Cereus caesius, Cestrum diurnum, Cestrum nocturnum, Chenopodium ambrosioides, Chorisia speciosa, Citharexylum subserratum, Cleome spinosa, Clitoria ternatea, Cocos nucifera, Colvillea racemosa, Conyza bonariensis, Coreopsis lanceolata, Coreopsis stillmanii, Coriandrum sativum, Cosmos bipinnatus, Couroupita guianensis, Crescentia cujete, Cuphea lanceolata, Dahlia variabilis, Datura stramonium, Daucus carota, Delonix regia, Delphinium ajacis, Dianthera secunda, Dianthus barbatus, Dieffenbachia seguine, Duranta repens, Eruca sativa, Eschscholtzia californica, Euphorbia pulcherrima, Fragaria vesca, Furcraea foetida, Gaillardia pulchella, Godetia amoena, Gossypium herbaceum, Gossypium hirsutum, Graptophyllum pictum, Guazuma tomentosa, Gustavia augusta, Hamelia patens, Helianthus annuus, Hibiscus elatus, Hibiscus liliiflorus, Hibiscus sabdariffa, Iberis amara, Ipomoea indica, Iresine herbstii, Jacaranda mimosaeifolia, Jacquemontia pentantha, Jacquinia ruscifolia, Jatropha panduraefolia, Jatropha multifida, Kigelia pinnata, Lathyrus aphaca, Lychnis coeli-rosa, Lycopersicon esculentum, Magnolia grandiflora, Malpighia coccigera, Malpighia glabra, Malva parviflora, Malvaviscus arboreus, Manihot esculenta, Manilkara achras, Medicago lupulina, Medicago polymorpha, Mentha piperita, Millettia peguensis, Monstera deliciosa, Morus nigra, Musa acuminata, Nicotiana alata, Nicotiana tabacum, Ochroma pyramidale, Oenothera rosea, Opuntia elatior, Opuntia imbricata, Opuntia microdasys, Opuntia vulgaris, Oxalis latifolia, Papaver rhoeas, Parkinsonia aculeata, Passiflora edulis, Passiflora suberosa, Pavonia hastata, Persea americana, Petrea volubilis, Petunia axillaris, Phoenix dactylifera, Physalis peruviana, Pinus caribaea, Pinus gregii, Pinus merkusii, Pinus michoacana, Pinus occidentalis, Pinus oocarpa, Pinus patula, Pinus pringlei, Pinus pseudostrobus, Pinus rudis, Pinus taiwanensis, Pisonia grandis, Pithecellobium dulce, Plumeria alba, Plumeria rubra, Portlandia grandiflora, Portulaca grandiflora, Portulacaria afra, Prunus domestica, Psidium guajava, Punica granatum, Pyrostegia venusta, Rauwolfia tetraphylla, Ravenia spectabilis, Reseda odorata, Rhoeco discolor, Rivina humilis, Russelia equisetiformis, Salvia splendens, Solanum grandiflorum, Solanum tuberosum, Solidago canadensis,

Spergula arvensis, *Stellaria media*, *Stigmaphyllon ciliatum*, *Tabebuia chrysantha*, *Tabebuia pentaphylla*, *Tabebuia rosea*, *Tagetes erecta*, *Talinum calycinum*, *Tamarindus indica*, *Tecoma gaudichaudii*, *Tecoma stans*, *Tecomaria capensis*, *Tecomella undulata*, *Theobroma cacao*, *Thevetia peruviana*, *Thunbergia alata*, *Thunbergia erecta*, *Thyrallis glauca*, *Tithonia rotundifolia*, *Tropaeolum majus*, *Vaccaria pyramidata*, *Verbena peruviana*, *Vernonia elaeagnifolia*, *Vicia hirsuta*, *Viola odorata*, *Viola tricolor*, *Yucca gloriosa*, *Zebrina pendula*, *Zea mays*, *Zephyranthes grandiflora*, *Zinnia elegans*.

In India, comprehensive studies on invasive species and plant invasions are still missing.

In view of this, the present study attempted to focus on the invasive alien species in the flora of India.

3. Methodology

The present study was conducted during 2003 - 2007, to compile a comprehensive list of invasive alien plant species. The challenge is recognizing which introduced species incur ecological and economic costs and which simply becomes part of India's tropical/subtropical/temperate landscape and cause no real harm. It is very difficult to choose alien species, from all over the country, that really are "invasive" or "worse" than any others.

After an extensive review of literature on global invasive species (Mooney and Drake, 1987; Heywood, 1989; Cox, 1999; Cox, 2004; Cracraft and Grifo 1999; D'Antonio and Vitousek, 1992; Drake *et al.* 1989; Randall *et al.* 1997; Huxel, 1999; Jenkins, 1999; Lonsdale, 1999; Mooney, 1999; Elton, 2000; Mooney and Hobbs, 2000; Almeilla and Freitas, 2001; Cowie, 2001; McNeely *et al.* 2001) and of India and their spread based on history, species origin, species behavior and field observations, a list of 173 species of invasive aliens was prepared. The websites were also examined extensively for background information. Of these, some species may have invaded only a restricted region, but have a huge probability of expanding and causing great damage. Some species are ready colonizers in disturbed areas and may have less impact on natural

populations. Other species may already be globally widespread and causing cumulative but less visible damage.

The nativity of the species is provided based on Matthew, 1969; Maheswari and Paul, 1975; Nayar, 1977; Sharma, 1984; Hajra and Das, 1982; Saxena, 1991; Pandey and Parmar, 1994; Reddy *et al.* 2000; Reddy & Raju, 2002; Reddy & Reddy, 2004; Murthy *et al.* 2007; Negi and Hajra, 2007.

4. Results and Discussion

Total 173 species in 117 genera and under 44 families were documented as Invasive alien plant species, representing 1% of the Indian flora. The 173 invasive alien species were shown along with family name, habit and nativity in table 1.

Tropical America (with 128 species) region contribute the greatest to the number (74%) followed by tropical Africa (11%). The other regions, which contribute minority, are Afghanistan, Australia, Brazil, East Indies, Europe, Madagascar, Mascarene Islands, Mediterranean, Mexico, Peru, Temperate South America, Trop. West Asia, West Indies and Western Europe.

Habit wise analysis shows that herbs with 151 species (87.3%) predominate followed by shrubs (14), climbers (5) and trees (3). Of the 44 families, Asteraceae is the most dominant family with 33 species followed by Papilionaceae (15), Convolvulaceae (10), Caesalpiniaceae (9), Solanaceae (9), Amaranthaceae (8), Poaceae (8), Euphorbiaceae (7), Mimosaceae (6) and Tiliaceae (5). The top ten families contribute 110 species with proportion of 63.6%. The 17 families represent one species each, i.e. Apocynaceae, Araceae, Arecaceae, Balsaminaceae, Cactaceae, Liliaceae, Melastomataceae, Nyctaginaceae, Oxalidaceae, Papaveraceae, Passifloraceae, Piperaceae, Polygonaceae, Rubiaceae, Salviniaceae, Typhaceae and Urticaceae.

While a number of lists of invasive plant species are in worldwide circulation, criteria used in these listings often are not documented clearly. Surveys have shown that more than half of alien plant species currently spreading naturally were intentionally introduced, and that most of the alien species that endanger India's native ecosystems were first introduced for horticultural purposes. Thus reducing the intentional use of high-risk alien plants could reduce the spread and impact of invasive plants in the country.

All these species reported here, were reported as "weeds" in other countries or invasive alien plants in most of the regions. Almost 80% of the Invasive alien plant species were introduced from Neotropics.

The invasive alien species are ready colonizers in disturbed areas and cause considerable ecological damage to India's natural areas, speed the disappearance of threatened and endemic species, reduce the carrying capacity of pastures, increase the maintenance costs of croplands, and interfere with our enjoyment of the outdoors. Of these, some species may have invaded only a restricted region, but have a huge probability of expanding, and causing great damage. Other species may already be globally widespread and causing cumulative but less visible damage.

Among the 173 species, majority are *generalists* found in all kinds of systems like forests, crop lands, waste lands, plantations, gardens and road sides. The 33 species are invaders of wetlands, i.e. *Aerva javanica*, *Aeschynomene americana*, *Alternanthera paronychioides*, *Alternanthera philoxeroides*, *Asclepias curassavica*, *Cassia alata*, *Corchorus trilocularis*, *Cyperus difformis*, *Cyperus iria*, *Echinochloa colona*, *Echinochloa crusgalli*, *Eclipta prostrata*, *Eichhornia crassipes*, *Fuirena ciliaris*, *Gnaphalium coarctatum*, *Gnaphalium pensylvanicum*, *Gnaphalium polycaulon*, *Grangea maderaspatana*, *Ipomoea carnea*, *Ludwigia adscendens*, *Ludwigia octovalvis*, *Ludwigia perennis*, *Mecardonia procumbens*, *Monochoria vaginalis*, *Pistia stratiotes*, *Portulaca*

quadrifida, *Rorippa dubia*, *Saccharum spontaneum*, *Salvinia molesta*, *Sesbania bispinosa*, *Sonchus asper*, *Sonchus oleraceus* and *Typha angustata*.

The predominance of Asteraceae species in invasive category shows the high impact of neotropical flora on Indian region.

In addition to negative impact on indigenous flora and economy, some alien plants were very much useful to local people. A prominent examples are *Prosopis juliflora*, *Borassus flabellifer* and *Leucaena leucocephala*. Among the reasons for the admiration expressed for these plants are: adaptability, rapid growth and multiple uses. *Prosopis juliflora* used for coal extraction, firewood, erosion control, fencing. *Borassus flabellifer* is an economically important species, introduced to India in ancient times. The cut flower stalks yield sugar and toddy, the fruits are roasted and eaten, leaves are used for thatching. *Leucaena leucocephala* used for firewood, erosion control, fodder, green manures, providing shade and shelter for other crops. Several alien weedy plants like *Argemone mexicana*, *Cassia tora*, *Cleome viscosa*, *Chamaesyce hirta*, *Croton bonplandianum*, *Eclipta prostrata*, *Ipomoea carnea*, *Malachra capitata*, *Mimosa pudica*, *Physalis angulata*, *Tridax procumbens* were used in native medicine. *Alternanthera philoxeroides* and *Portulaca oleracea* were used as leafy vegetables.

Table 1. List of Invasive Alien plant species in India.

Sl.no.	Species	Family	Habit	Nativity
1	<i>Acacia farnesiana</i> (L.) Willd.	Mimosaceae	Tree	Trop. South America
2	<i>Acacia mearnsii</i> De Wild.	Mimosaceae	Tree	South east Australia
3	<i>Acanthospermum hispidum</i> DC.	Asteraceae	Herb	Brazil
4	<i>Aerva javanica</i> (Burm.f.) Juss.ex Schult.	Amaranthaceae	Herb	Trop. America
5	<i>Aeschynomene americana</i> L.	Papilionaceae	Herb	Trop. America
6	<i>Ageratina adenophora</i> (Spreng.) King & Robinson	Asteraceae	Herb	Trop. America
7	<i>Ageratum conyzoides</i> L.	Asteraceae	Herb	Trop. America
8	<i>Ageratum houstonianum</i> Mill.	Asteraceae	Herb	Trop. America
9	<i>Alternanthera paronychioides</i> A. St. Hil	Amaranthaceae	Herb	Trop. America

10	<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	Amaranthaceae	Herb	Trop. America
11	<i>Alternanthera pungens</i> Kunth	Amaranthaceae	Herb	Trop. America
12	<i>Alternanthera tenella</i> Colla	Amaranthaceae	Herb	Trop. America
13	<i>Antigonon leptopus</i> Hook. & Arn.	Polygonaceae	Climber	Trop. America
14	<i>Argemone mexicana</i> L.	Papaveraceae	Herb	Trop. Central & South America
15	<i>Asclepias curassavica</i> L.	Asclepiadaceae	Herb	Trop. America
16	<i>Asphodelus tenuifolius</i> Cav.	Liliaceae	Herb	Trop. America
17	<i>Bidens pilosa</i> L.	Asteraceae	Herb	Trop. America
18	<i>Blainvillea acmella</i> (L.) Philipson	Asteraceae	Herb	Trop. America
19	<i>Blumea eriantha</i> DC.	Asteraceae	Herb	Trop. America
20	<i>Blumea lacera</i> (Burm.f.) DC.	Asteraceae	Herb	Trop. America
21	<i>Blumea obliqua</i> (L.) Druce	Asteraceae	Herb	Trop. America
22	<i>Borassus flabellifer</i> L.	Arecaceae	Tree	Trop. Africa
23	<i>Calotropis gigantea</i> (L.) R.Br.	Asclepiadaceae	Shrub	Trop. Africa
24	<i>Calotropis procera</i> (Ait.) R.Br.	Asclepiadaceae	Shrub	Trop. Africa
25	<i>Cardamine hirsuta</i> L.	Brassicaceae	Herb	Trop. America
26	<i>Cardamine trichocarpa</i> Hochst. ex A.Rich.	Brassicaceae	Herb	Trop. America
27	<i>Cassia absus</i> L.	Caesalpiniaceae	Herb	Trop. America
28	<i>Cassia alata</i> L.	Caesalpiniaceae	Shrub	West Indies
29	<i>Cassia hirsuta</i> L.	Caesalpiniaceae	Herb	Trop. America
30	<i>Cassia obtusifolia</i> L.	Caesalpiniaceae	Herb	Trop. America
31	<i>Cassia occidentalis</i> L.	Caesalpiniaceae	Herb	Trop. South America
32	<i>Cassia pumila</i> Lam.	Caesalpiniaceae	Herb	Trop. America
33	<i>Cassia rotundifolia</i> Pers.	Caesalpiniaceae	Herb	Trop. South America
34	<i>Cassia tora</i> L.	Caesalpiniaceae	Herb	Trop. South America
35	<i>Cassia uniflora</i> Mill.	Caesalpiniaceae	Herb	Trop. South America
36	<i>Catharanthus pusillus</i> (Murray) Don	Apocynaceae	Herb	Trop. America
37	<i>Celosia argentea</i> L.	Amaranthaceae	Herb	Trop. Africa
38	<i>Chamaesyce hirta</i> (L.) Millsp.	Euphorbiaceae	Herb	Trop. America
39	<i>Chamaesyce indica</i> (Lam.) Croizat	Euphorbiaceae	Herb	Trop. South America
40	<i>Chloris barbata</i> Sw.	Poaceae	Herb	Trop. America
41	<i>Chromolaena odorata</i> (L.) King & Robinson	Asteraceae	Herb	Trop. America
42	<i>Chrozophora rotleri</i> (Geis.) Spreng.	Euphorbiaceae	Herb	Trop. Africa
43	<i>Cleome gynandra</i> L.	Cleomaceae	Herb	Trop. America
44	<i>Cleome monophylla</i> L.	Cleomaceae	Herb	Trop. Africa
45	<i>Cleome ruidosperma</i> DC.	Cleomaceae	Herb	Trop. America
46	<i>Cleome viscosa</i> L.	Cleomaceae	Herb	Trop. America
47	<i>Clidemia hirta</i> (L.) D. Don	Melastomataceae	Herb	Trop. America

48	<i>Conyza bipinnatifida</i> Wall.	Asteraceae	Herb	Trop. America
49	<i>Corchorus aestuans</i> L.	Tiliaceae	Herb	Trop. America
50	<i>Corchorus fascicularis</i> Lam.	Tiliaceae	Herb	Trop. America
51	<i>Corchorus tridens</i> L.	Tiliaceae	Herb	Trop. Africa
52	<i>Corchorus trilocularis</i> L.	Tiliaceae	Herb	Trop. Africa
53	<i>Crassocephalum crepidioides</i> (Benth.) Moore	Asteraceae	Herb	Trop. America
54	<i>Crotalaria pallida</i> Dryand	Papilionaceae	Herb	Trop. America
55	<i>Crotalaria retusa</i> L.	Papilionaceae	Herb	Trop. America
56	<i>Croton bonplandianum</i> Boil.	Euphorbiaceae	Herb	Temperate South America
57	<i>Cryptostegia grandiflora</i> R.Br.	Asclepiadaceae	Herb	Madagascar
58	<i>Cuscuta chinensis</i> Lam.	Cuscutaceae	Herb	Mediterranean
59	<i>Cuscuta reflexa</i> Roxb.	Cuscutaceae	Herb	Mediterranean
60	<i>Cyperus difformis</i> L.	Cyperaceae	Herb	Trop. America
61	<i>Cyperus iria</i> L.	Cyperaceae	Herb	Trop. America
62	<i>Cytisus scoparius</i> (L.) Link	Papilionaceae	Herb	Europe
63	<i>Datura innoxia</i> Mill.	Solanaceae	Shrub	Trop. America
64	<i>Datura metel</i> L.	Solanaceae	Shrub	Trop. America
65	<i>Dicoma tomentosa</i> Cass.	Asteraceae	Herb	Trop. Africa
66	<i>Digera muricata</i> (L.) Mart.	Amaranthaceae	Herb	SW Asia
67	<i>Dinebra retroflexa</i> (Vahl) Panz.	Poaceae	Herb	Trop. America
68	<i>Echinochloa colona</i> (L.) Link	Poaceae	Herb	Trop. South America
69	<i>Echinochloa crusgalli</i> (L.) Beauv.	Poaceae	Herb	Trop. South America
70	<i>Echinops echinatus</i> Roxb.	Asteraceae	Herb	Afghanistan
71	<i>Eclipta prostrata</i> (L.) Mant.	Asteraceae	Herb	Trop. America
72	<i>Eichhornia crassipes</i> (C. Martius) Solms-Loub.	Pontederiaceae	Herb	Trop. America
73	<i>Emilia sonchifolia</i> (L.) DC.	Asteraceae	Herb	Trop. America
74	<i>Euphorbia cyathophora</i> Murray	Euphorbiaceae	Herb	Trop. America
75	<i>Euphorbia heterophylla</i> L.	Convolvulaceae	Herb	Trop. America
76	<i>Evolvulus nummularius</i> (L.) L.	Convolvulaceae	Herb	Trop. America
77	<i>Flaveria trinervia</i> (Spreng.) C. Mohr.	Asteraceae	Herb	Trop. Central America
78	<i>Fuirena ciliaris</i> (L.) Roxb.	Cyperaceae	Herb	Trop. America
79	<i>Galinosoga parviflora</i> Cav.	Asteraceae	Herb	Trop. America
80	<i>Glossocardia bosvallea</i> (L.f.) DC.	Asteraceae	Herb	East Indies
81	<i>Gnaphalium coarctatum</i> Willd.	Asteraceae	Herb	Trop. America
82	<i>Gnaphalium pensylvanicum</i> Willd.	Asteraceae	Herb	Trop. America
83	<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	Herb	Trop. America
84	<i>Gomphrena serrata</i> L.	Amaranthaceae	Herb	Trop. America
85	<i>Grangea maderaspatana</i> (L.) Poir.	Asteraceae	Herb	Trop. South America
86	<i>Hyptis suaveolens</i> (L.) Poit.	Lamiaceae	Herb	Trop. America
87	<i>Impatiens balsamina</i> L.	Balsaminaceae	Herb	Trop. America
88	<i>Imperata cylindrica</i> (L.) Raensch.	Poaceae	Herb	Trop. America

89	<i>Indigofera astragalina</i> DC.	Papilionaceae	Herb	Trop. America
90	<i>Indigofera glandulosa</i> Roxb. ex Willd.	Papilionaceae	Herb	Trop. America
91	<i>Indigofera linifolia</i> (L.f.) Retz.	Papilionaceae	Herb	Trop. South America
92	<i>Indigofera linnaei</i> Ali	Papilionaceae	Herb	Trop. Africa
93	<i>Indigofera trita</i> L.f.	Papilionaceae	Shrub	Trop. Africa
94	<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	Shrub	Trop. America
95	<i>Ipomoea eriocarpa</i> R.Br.	Convolvulaceae	Herb	Trop. Africa
96	<i>Ipomoea hederifolia</i> L.	Convolvulaceae	Herb	Trop. America
97	<i>Ipomoea obscura</i> (L.) Ker.-Gawl.	Convolvulaceae	Herb	Trop. Africa
98	<i>Ipomoea pes-tigridis</i> L.	Convolvulaceae	Herb	Trop. East Africa
99	<i>Ipomoea quamoclit</i> L.	Convolvulaceae	Herb	Trop. America
100	<i>Ipomoea staphylina</i> Roem. & Schult.	Convolvulaceae	Herb	Trop. Africa
101	<i>Lagascea mollis</i> Cav.	Asteraceae	Herb	Trop. Central America
102	<i>Lantana camara</i> L.	Verbenaceae	Herb	Trop. America
103	<i>Leonotis nepetifolia</i> (L.) R.Br.	Lamiaceae	Herb	Trop. Africa
104	<i>Leucaena leucocephala</i> (Lam.) de Wit	Mimosaceae	Herb	Trop. America
105	<i>Ludwigia adscendens</i> (L.) Hara	Onagraceae	Herb	Trop. America
106	<i>Ludwigia octovalvis</i> (Jacq.) Raven	Onagraceae	Herb	Trop. Africa
107	<i>Ludwigia perennis</i> L.	Onagraceae	Herb	Trop. Africa
108	<i>Macroptilium atropupureum</i> (DC.) Urban	Papilionaceae	Climber	Trop. America
109	<i>Macroptilium lathyroides</i> (L.) Urban	Papilionaceae	Climber	Trop. Central America
110	<i>Malachra capitata</i> (L.) L.	Malvaceae	Herb	Trop. America
111	<i>Malvastrum coromandelianum</i> (L.) Garcke	Malvaceae	Herb	Trop. America
112	<i>Martynia annua</i> (Houstoun in Martyn) L.	Pedaliaceae	Herb	Trop. America
113	<i>Mecardonia procumbens</i> (Mill.) Small	Scrophulariaceae	Herb	Trop. North America
114	<i>Melilotus alba</i> Desv.	Papilionaceae	Herb	Europe
115	<i>Melochia corchorifolia</i> L.	Sterculiaceae	Herb	Trop. America
116	<i>Merremia aegyptia</i> (L.) Urban.	Convolvulaceae	Herb	Trop. America
117	<i>Mikania micrantha</i> Kunth	Asteraceae	Climber	Trop. America
118	<i>Mimosa pigra</i> L.	Mimosaceae	Shrub	Trop. North America
119	<i>Mimosa pudica</i> L.	Mimosaceae	Herb	Brazil
120	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Herb	Peru
121	<i>Monochoria vaginalis</i> (Burm.f.) C. Presl.	Pontederiaceae	Herb	Trop. America
122	<i>Nicotiana plumbaginifolia</i> Viv.	Solanaceae	Herb	Trop. America
123	<i>Ocimum americanum</i> L.	Lamiaceae	Herb	Trop. America
124	<i>Opuntia stricta</i> (Haw.) Haw.	Cactaceae	Herb	Trop. America
125	<i>Oxalis corniculata</i> L.	Oxalidaceae	Herb	Europe

126	<i>Parthenium hysterophorus</i> L.	Asteraceae	Herb	Trop. North America
127	<i>Passiflora foetida</i> L.	Passifloraceae	Herb	Trop. South America
128	<i>Pedaliium murex</i> L.	Pedaliaceae	Herb	Trop. America
129	<i>Pennisetum purpureum</i> Schum.	Poaceae	Herb	Trop. America
130	<i>Peperomia pellucida</i> (L.) Kunth	Piperaceae	Herb	Trop. South America
131	<i>Peristrophe paniculata</i> (Forssk.) Brummitt	Acanthaceae	Herb	Trop. America
132	<i>Phyllanthus tenellus</i> Roxb.	Euphorbiaceae	Herb	Mascarene Islands
133	<i>Physalis angulata</i> L.	Solanaceae	Herb	Trop. America
134	<i>Physalis pruinosa</i> L.	Solanaceae	Herb	Trop. America
135	<i>Pilea microphylla</i> (L.) Liebm.	Urticaceae	Herb	Trop. South America
136	<i>Pistia stratiotes</i> L.	Araceae	Herb	Trop. America
137	<i>Portulaca oleracea</i> L.	Portulacaceae	Herb	Trop. South America
138	<i>Portulaca quadrifida</i> L.	Portulacaceae	Herb	Trop. America
139	<i>Prosopis juliflora</i> (Sw.) DC.	Mimosaceae	Shrub	Mexico
140	<i>Rhynchelytrum repens</i> (Willd.) C.E. Hubb.	Poaceae	Herb	Trop. America
141	<i>Rorippa dubia</i> (Pers.) Hara	Brassicaceae	Herb	Trop. America
142	<i>Ruellia tuberosa</i> L.	Acanthaceae	Herb	Trop. America
143	<i>Saccharum spontaneum</i> L.	Poaceae	Herb	Trop. West Asia
144	<i>Salvinia molesta</i> D. S. Mitch.	Salviniaceae	Herb	Brazil
145	<i>Scoparia dulcis</i> L.	Scrophulariaceae	Herb	Trop. America
146	<i>Sesbania bispinosa</i> (Jacq.) Wight	Papilionaceae	Shrub	Trop. America
147	<i>Sida acuta</i> Burm.f.	Malvaceae	Herb	Trop. America
148	<i>Solanum americanum</i> Mill.	Solanaceae	Herb	Trop. America
149	<i>Solanum seaforthianum</i> Andrews	Solanaceae	Climber	Brazil
150	<i>Solanum torvum</i> Sw.	Solanaceae	Shrub	West Indies
151	<i>Solanum viarum</i> Dunal	Solanaceae	Herb	Trop. America
152	<i>Sonchus asper</i> Hill	Asteraceae	Herb	Mediterranean
153	<i>Sonchus oleraceus</i> L.	Asteraceae	Herb	Mediterranean
154	<i>Spermacoce hispida</i> L.	Rubiaceae	Herb	Trop. America
155	<i>Spilanthes radicans</i> Jacq.	Asteraceae	Herb	Trop. South America
156	<i>Stachytarpheta jamaicensis</i> (L.) Vahl	Verbenaceae	Herb	Trop. America
157	<i>Stachytarpheta urticaefolia</i> (Salisb.) Sims	Verbenaceae	Herb	Trop. America
158	<i>Stylosanthes hamata</i> (L.) Taub.	Papilionaceae	Herb	Trop. America
159	<i>Synadenium grantii</i> Hook. f.	Euphorbiaceae	Shrub	Trop. America
160	<i>Synedrella nodiflora</i> (L.) Gaertn.	Asteraceae	Herb	West Indies
161	<i>Torenia fournieri</i> Linden ex E. Fournier	Scrophulariaceae	Herb	Australia
162	<i>Tribulus lanuginosus</i> L.	Zygophyllaceae	Herb	Trop. America

163	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Herb	Trop. America
164	<i>Tridax procumbens</i> L.	Asteraceae	Herb	Trop. Central America
165	<i>Triumfetta rhomboidea</i> Jacq.	Tiliaceae	Herb	Trop. America
166	<i>Turnera subulata</i> J.E. Smith	Turneraceae	Herb	Trop. America
167	<i>Turnera ulmifolia</i> L.	Turneraceae	Herb	Trop. America
168	<i>Typha angustata</i> Bory. & Choub.	Typhaceae	Herb	Trop. America
169	<i>Ulex europaeus</i> L.	Papilionaceae	Shrub	Western Europe
170	<i>Urena lobata</i> L.	Malvaceae	Shrub	Trop. Africa
171	<i>Waltheria indica</i> L.	Sterculiaceae	Herb	Trop. America
172	<i>Xanthium strumarium</i> L.	Asteraceae	Herb	Trop. America
173	<i>Youngia japonica</i> (L.) DC.	Asteraceae	Herb	Trop. South America

5. Information of Plants

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7. Index to Species

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Waltheria indica

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