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RESEARCH ARTICLE

INVASIVE ALIEN SPECIES IN THE FLORA OF JAMMU AND KASHMIR, INDIA

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ABSTRACT

The integrity of natural ecosystems is increasingly being jeopardized due to the large scale introduction of invasive alien species. Such species are introduced either intentionally or unintentionally and they tend to spread outside of their natural range into the new areas where they grow, survive, reproduce and produce self sustaining populations which out-compete the native species and sometimes become aggressive colonizers. Once unappreciated as sleeper environmental issue, invasions are now considered as one of the serious environmental issues over the world. All the invasive alien species reported in the area have adverse consequences on the biodiversity of the region particularly plant diversity. They are found to intrude into, marginalize and out-compete the native species in their natural habitat and rendering them rare, vulnerable and extinct. There are also threats to the food security and human health besides huge loss to state economy. The control and eradication of invasive alien species will definitely result in the conservation of precarious biological diversity of the state.

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INTRODUCTION

The Himalayas is an enchantment serene territory of nature where the magnificence of the world's highest mountains is mirrored in the rugged beauty and unique culture of the people who live in their shadows. The whole Himalayan belt abounds in a rich floral diversity which has been facing a number of threats since globalization. The second major threat to the native plant species in the world is the invasion caused by the invasive alien species. Those alien species which become established in a new environment, survive and proliferate exponentially are considered invasive alien species (IAS). These species are introduced either intentionally or unintentionally and spread outside of their natural range into the new areas where they grow, survive, reproduce and produce self sustaining populations which out-compete the native species and sometimes become aggressive colonizers. International Union for Conservation of Nature and Natural Resources (IUCN) defines invasive alien species as "an alien species which becomes established in natural or semi-natural ecosystems or habitat, an agent of change, and threatens to the native biological diversity". The integrity of natural ecosystems worldwide is increasingly being jeopardized due to the large scale introduction of invasive alien plant species. This process is rapidly breaching biogeographical barriers which are responsible for global biodiversity maintenance and leading to increasing homogenization (Lodge, 1993, Werren *et al.*, 2002).

Globalization of earth's biota due to breaching of biogeographical barriers that isolated continental biotas for millions of years is transforming local and regional floras. Such biotic homogenization is the result of increasing global trade and transport. Once unappreciated as sleeper environmental issue, invasions are now considered as one of the serious environmental issue over the world. Such species are causing huge damage to the biodiversity. The nations have agreed to halting and eventually reversing the loss to biodiversity of the world. To build support and momentum for this urgent task, the United Nations General Assembly at its 65th session declared 2011-2020 to be the "United Nations Decade on Biodiversity", with a view to contribute to the implementation of the Strategic Plan for Biodiversity. Throughout the United Nations Decade on Biodiversity, governments are encouraged to document status survey of biodiversity for its overall conservation at regional, national and international level. Taking note to the importance of the studies on the invasive alien species, present study was aimed at compiling the first ever inventorisation of the invasive alien species of the state of Jammu and Kashmir. The present study in part will support the implementation of the Strategic Plan for Conservation of Biodiversity. The main objectives of the present study are:

- Documentation of the invasive alien species in the flora of Jammu and Kashmir.
- Record the origin, spread, introduction pathways and invasion status.
- Toxicity levels and impact on the environment.
- To spread public awareness on the impact of invasive alien species on people and economy.

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Fig. 1. The geographical map of the state of Jammu and Kashmir

Table.1 Invasive Alien Species in Jammu and Kashmir

S.No	Name of the Species	Common Name	Family	Nativity
1.	<i>Ageratum conyzoides</i> Linn.	Billy goat weed	Asteraceae	South & Central America
2.	<i>Ageratum houstonianum</i> Mill.	Blue Weed	Asteraceae	Central America
3.	<i>Alternanthera philoxeroides</i> (Mart.) Griseb	Alligator Weed	Amaranthaceae	Tropical America
4.	<i>Argemone ochroleuca</i> Sweet.	Pale Mexican Pricklypoppy	Papaveraceae	Central America
5.	<i>Calotropis procera</i> (Willd)R.Br.	Apple of Sodom	Apocynaceae	Tropical Africa
6.	<i>Ceratophyllum demersum</i> L.	Soft Hornwort	Ceratophyllaceae	Europe
7.	<i>Conyza canadensis</i> (L.) Cronq.	Canadian Flebane	Asteraceae	North America
8.	<i>Datura stramonium</i> L.	Jimsonweed	Solanaceae	Tropical America
9.	<i>Echinochloa colona</i> (L.) Link.	Junglerice	Poaceae	Trop. South America
10.	<i>Eichhornia crassipes</i> (Mart)Solms	Water Hyacinth	Pontederiaceae	South America
11.	<i>Heracleum lanatum</i> Michx.	Cow Parsnip	Apiaceae	North America
12.	<i>Hyptis suaveolens</i> (L.) Poit.	Bush Mint	Lamiaceae	Tropical America
13.	<i>Ipomoea carnea</i> (Mart. Ex Choisy) Austin.	Morning Glory	Convolvulaceae	Tropical America
14.	<i>Lantana camara</i> L.	Tick Berry	Verbenaceae	Central & South America
15.	<i>Lemna minor</i> L.	Duck Weed	Araceae	North America
16.	<i>Opuntia Stricta</i> (Haw.) Haw.	Common Prickly Pear	Cactaceae	Caribbean
17.	<i>Parthenium hysterophorus</i> Linn.	Congress Grass	Asteraceae	North America
18.	<i>Potamogeton natans</i> L.	Broad leaved Pondweed	Potamogetonaceae	North America
19.	<i>Prosopis juliflora</i> (Sw.) DC.	Mesquite	Fabaceae	South America & Mexico
20.	<i>Ricinus communis</i> Linn.	Castor Bean	Euphorbiaceae	North-East Africa
21.	<i>Senna tora</i> (L.) Roxb.	Sickle Senna	Fabaceae	Tropical America
22.	<i>Solanum viarum</i> Dunal	Sodom Apple	Solanaceae	Tropical America
23.	<i>Typha angustata</i> Bor. & Chaub.	Small Bullrush	Typhaceae	Europe
24.	<i>Urtica dioica</i> L.	Stinging Nettle	Urticaceae	Europe
25.	<i>Xanthium spinosum</i> L.	Spiny Cocklebur	Asteraceae	South America
26.	<i>Xanthium strumarium</i> L.	Cocklebur	Asteraceae	South & Central America

Such baseline information will act as a foundation stone for further advanced studies on the various aspects of the invasive alien species and would serve as a benchmark for future investigation.

Study area: The state of Jammu and Kashmir is referred as the "Paradise on Earth". It is famous for its tall and towering mountains with snow capped peaks, lush green meadows, lakes and picturesque topography.

It is situated between 32° 17' to 37° 06' north longitude and 73° 26' to 80° 30' east latitude occupying a central position in the Asian continent. The state lies in the extreme north of the Indian Republic sharing boundaries with Tibet in the east, China and Afghanistan in the north, Pakistan in the west and Indian states of Punjab and Himachal Pradesh in the south. The state is located along the mountainous arc of mighty Himalayas.

The three regions of the state are referred as Sub- Himalayan Jammu, Himalayan Kashmir and Trans-Himalayan Ladakh. The geographical area of the state is 222,236 Sq. Kms which is 6.74 percent of the total area of the country.

Sub-Himalayan Jammu: The Himalayan foothills-Shiwaliks are situated to the north of the plains of Jammu with an altitude of 600-1220 m above sea level. The outer plains are towards the southern part of Jammu where they merge with Punjab Plains. The narrow strip of plains is an extension of Great Indian Plain which is alluvial in nature. It stretches from river Ravi to Chenab with an elevation of 330-360 m. The Shiwaliks almost run parallel to the outer plain region which is traversed by the streams, ravines and gullies flowing from the foothills. At higher elevations the topography changes and hill slopes appear wooded. In the Shiwaliks lie the famous lakes of Mansar and Surinsar to the east of Jammu city. The Jammu city is also the winter capital of the state situated at an altitude of 366 m on the southern slopes of the Shiwaliks between 32° 44' north latitude to 74° 55' longitude on the bank of river Tawi. The climate of the region is sub-tropical except highland areas. The climate is influenced by the advent of south-west monsoon between July to mid September causing plenty of rainfall in the sub-continent. Jammu region experiences a monsoon type of climate. July and August are the rainiest months recording about 67 percent of the total rainfall. The mean annual rainfall recorded at Jammu in 2016 is 1009.95 mm. The winter in the region is comparatively warm. The mean daily temperature remains below 20° C. January is the coldest month with mean monthly temperature of 13.5° C. Western-Disturbance from the Mediterranean Sea brings moderate to heavy rainfall and snowfall in some highlands during winter. There is a marked increase in temperature from mid March. The mean monthly temperature in March has been recorded as 21° C. The month of June experiences the highest temperature of the year.

The weather is mostly dry and hot as little rainfall is received during this season. To the north of Shiwaliks are situated Middle Himalayas which sprawl between Ravi in the east to Poonch in the west though they continue towards north-west beyond Muzzafrabad in Azad Kashmir. Middle Himalayas vary in their elevation between 1820 to 2240 m with a width of 60 Kms in the eastern part of Jammu division and 10 Kms near Rajouri. Chenab is the typical river of the Middle Himalayas and it is formed of two main streams- Chandra and Bhaga, both of which arise from Lahool in Himachal Pradesh, and after merging together enter Tandi near Kishtwar as Chenab. It drains parts of southern slopes of Pir Panjal, Jammu hills and foothill plains. The Jammu region is dotted by many valleys like Padder, Kishtwar, Bhaderwah, Kud, Batote, Ramnagar, Rajouri and Poonch. The south-west monsoon also influences the climate of Middle Himalayan region which is largely warm and temperate. Mean maximum and minimum temperatures recorded at Jammu in 2016 are 17.79°C and 6.94°C respectively in January and 38.20°C and 26.29°C in June. Whereas, mean maximum and minimum temperatures recorded at Bhaderwah in 2016 are 13.10°C and 0.63°C in January and 31.05°C and 15.86°C in June. The Middle Himalayan forests in the Chenab valley are predominantly coniferous with intermittent speckles of broad leaved species. The region is famous for its scenic beauty and forest resources including a number of medicinal plants. The beautiful flowering herbs and shrubs together with the forest tree species

represent a rich floral diversity. The Jammu-Srinagar National Highway which is about 260 Kms has been carved out through Middle Himalayas via Chenani-Nashri tunnel, Batote, Ramban, Ramsoo and Banihal pass.

Himalayan Kashmir: The Himalayan Kashmir is enclosed between Greater Himalayas in the north and Lesser Himalayas- the Pir Panjal in the south. The convex bulge of Pir Panjal and concave surface of the Greater Himalayas have given rise to an oval basin of Kashmir. The valley is nestled in the north-west folds of the Himalayas. It is encompassed by tall and towering mountain chains on all sides except for certain passes and a narrow gorge at Baramulla formed by river Jehlum between two parallel mountains- Pir Panjal and Kazi Nag. The various mountains girdling the valley on all sides are Nanga Parbhat and Tosh Maidan in the north, Mahadev, Gwash Brari and Amarnath in the south, Pir Panjal in the south-west and Kazi Nag in the north-west. The Harmukh guards valley on the eastern side. The valley is a structural basin representing an old lacustrine bed. It is 135 Kms in length and 40 Kms wide at an altitude of 1600 m above sea level in the Jehlum flood plain and with an area of 4865 Sq. Km. The summer capital of Jammu and Kashmir is Srinagar which is the nucleus of Kashmir valley. It is located between 34° 05' latitude and 74° 50' longitude on the bank of Jehlum from south-east to north-west. Srinagar city is often called as the "Venice of the East". A number of transverse valleys open into the main longitudinal valley of Kashmir like Sindh and Lidder valleys in the east, Kahmil and Lolab in the north-west.

The famous meadows of Khilanmarg, Gulmarg, Kongawattan, Yusmarg and Pahalgam are part of the valley region. The famous Dal lake is situated in the heart of the Srinagar city, Wular lake which is the deepest lake in Asia is present in the Baramulla district and Mansbal lake near Ganderbal is famous for its scenic beauty. The Lolab valley which lies in Kupwara district across Pir Panjal is also oval in shape. Another valley- the Kishenganga valley is formed by river Kishenganga which is a tributary of Jehlum. The road from Kashmir valley to Skardu lies along the upper portion of Kishenganga valley from Kanzalwan. The two important passes – Razdiangin and Nestchun which lead to Gurez and Karnah respectively also exist there. Gurez is a large valley lying to the north of Kashmir, 'W' in shape and traversed by Kishenganga and Burzil streams. Karnah lies to the north-west of Kashmir on the southern of Kishenganga comprises of the valleys of Kazinag and Shamshbari streams. The famous Amarnath cave which is the abode of Lord Shiva in Kashmir Himalayas is situated in the Lidder valley at an altitude of 3888 m, as also the base camp of Pahalgam. Sind valley which is carved by river Sind and owes its name to the river Sind arises in the mountains at the eastern extremity of Sarbal near Baltal. Sind valley is guarded by the mountains- The Harmukh beyond Zozila pass which lends its way to Ladakh from Srinagar across Greater Himalayas, the only road link from state. Sonamarg which is also known as the meadow of gold lies in the Sind valley. Sonamarg offers a base for treks to the famous high altitude lakes – Vishansar (4084 m), Kishansar (3810 m), Gadsar (3800 m) and Gangbal (3658 m). The route that connects the Kashmir valley with Central Asia leads through the valley of Sind. The climate of the Kashmir valley is temperate while it is rigorous in the surrounding mountains.

The salubrious and invigorating climate of the valley of Kashmir is much similar to that of Switzerland and that is why Kashmir is also referred as "Switzerland of Asia". Due to encompassing mountain ranges its seasons are marked by sudden changes. The spring season follows winter and brings an altogether change in weather conditions all over the valley. The vegetation begins to grow in this flower blossoming season. However, rains are common in the months of March and April due to the Western Disturbance from Mediterranean Sea. The rains in spring melt snow at high elevations causing floods which sometime create havoc in the vicinal areas of Jehlum- the main drainage artery of Kashmir. The summer in Kashmir lasts for four month. The temperature increases up and July remains the hottest month when the mercury may go up to 37°C. The mean monthly temperature during summer remains above 20°C and tourists are seen visiting the side valleys like Pahalgam, Gulmarg, Sonamarg and Yusmarg. The thick cover of vegetation includes narrow leaved and broad leaved trees, wild and beautiful mesmerizing flowering herbs and shrubs in the lush green meadows together with the medicinal flora form a rich floral diversity in the Kashmir Himalayas. The winter in Kashmir also lasts for four months from mid November to mid March. The snowfall in winter is the gift of the Western Disturbance also known as temperate cyclones which originate from the Mediterranean Sea and after crossing Iran and Afghanistan strikes the valley of Kashmir and surrounding hills causing snowfall. The water of the lakes and rivers gets frozen and temperature falls to freezing point. The January is the coldest month. On an average 120 cm of snow is received in the three months December to February. Kashmir is also famous for winter sports like Snow-skiing at Gulmarg.

MATERIALS AND METHODS

The study followed a random sampling method so that no bias is introduced at any level. The survey areas were selected in all the districts of the state. The survey and data collection on the invasive alien species of Jammu and Kashmir was carried out from 2014 to 2017. The various localities visited for the sampling and study include Kathua, Samba, Akhnoor, Rajouri, Poonch, Udampur, Doda, Bhaderwah, Kishatwar, Ramban, Anantnag, Pulwama, Srinagar, Rainawari, Sopore, Bandipora, Kulgam, Baramulla, Gulmarg, Pahalgam and Sonamarg. The author has conducted many random field trips in different urban, sub-urban and rural localities of the research area. Each study site was further identified into different land use types such as riparian land, forest land, orchards, grasslands, waste lands, disturbed land, roadsides, marsh land and wet lands. The study areas were visited different times of the year to record phenology of the species concerned like flowering, fruiting, seed dispersal and seedling stage. The samples were collected, systematically pressed, dried and preserved for identification. The plant specimens were also photographed in their wild state in the ecosystems of their occurrence as well as in the laboratory. The equipments, tools and other related material employed in the study include microscope, dissection microscope, camera lucida, magnifying lens, plant press, cutters, photographic camera, field note-book and polythene bags. The plant specimens were identified by applying taxonomic keys and reference to the local floras. The identification was also facilitated by way of consultations with experts in the field of taxonomy and final confirmation was

done by visiting to the local herbaria. Online identification system and ISSG database were also used to identify and determine the alien origin of species. The common names of the plants were ascertained by way of investigations from the elderly men in the vicinity. The information gathered by way of questioning to the farmers and native men was cross verified. The plant specimens and photographs of species explored during the course of study were handed over and kept for record in nearest concerned institution. The studies on various aspects of the problem like origin, impacts, toxicity levels and invasiveness were done and have been discussed.

RESULTS AND DISCUSSION

The study revealed the dominant presence of 26 invasive alien species (IAS) in the area. All the 26 species belonging to 19 families of angiosperms present in Jammu and Kashmir have been documented. They were found growing in diverse habitat such as grass land, forest land, agricultural land, fallow land, waste land, marsh land and wet land. The habit, morphology, dispersal mechanisms and phenology of invasive alien species were observed and recorded. Similarly, the impact of such species on the native plant species as also the agriculture and the people were observed, analyzed and recorded. Sixteen out of 26 invasive alien species recorded in the study area have their native range in South or Central America, five in North America, three in Europe, two in Africa. All the 26 invasive alien species are discussed as under:

Ageratum conyzoides Linn.

Common Name: Billy goat weed, white weed

Family: Asteraceae

Native Range: South and Central America

Description: Erect, 10-50 cm tall, softly hairy, annual herb with rank smell. Leaves simple, ovate, cordate or cuneate, lamina 4-5 cm by 2-3 cm, crenate or serrate. Heads pale-blue or pinkish purple or white, 6-10 mm across, in dense terminal corymbs, several disc florets only, ray florets absent, corolla 5, tubular. Involucral bracts narrowly linear, ribbed, scarious margined, glabrous. Achenes black, hairy along the angles, pappus hairs concave below.

Dispersal: Propagation takes place through seeds which are easily blown by wind to long distances.

Impact: An aggressive colonizer of agricultural land, grassland, forestland, forest edges, fallow land and orchards, and by virtue of competition, allelopathy and habitat destruction it reduces and seriously threatens the native species diversity. It is also toxic in nature causing liver lesions and tumors.

Prevention and Control: (i) It is relatively easy to uproot by mechanical means rather than hand-picking due to its shallow rooted habit. (ii) It is susceptible to the selective application of standard herbicides like butachlor, 2, 4-D, bentazone, oxidiazon, ametryne, terbutryne and acetochlor.

Ageratum houstonianum Mill.

Common Name: Blue Weed, Mexican Paint Brush

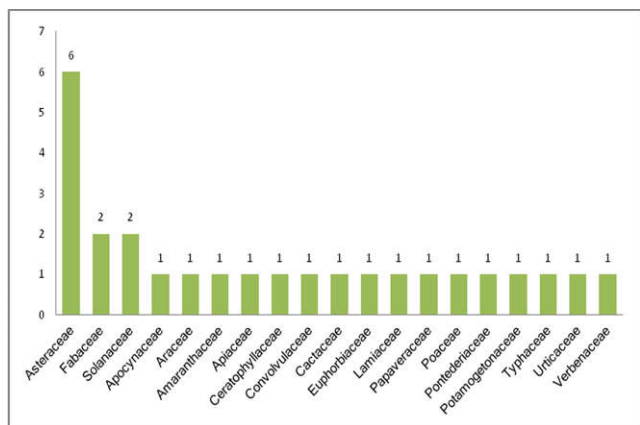


Fig. 2. Dominant families of Invasive Alien Species (IAS) present in Jammu and Kashmir

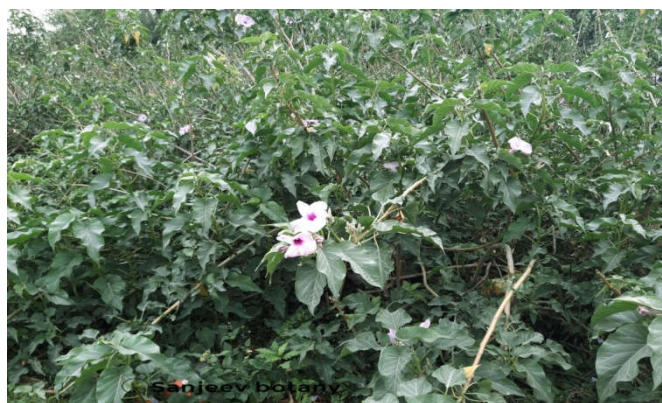


Fig.6 A dense stand of *Ipomoea carnea* (Mart. Ex Choisy) Austin. in a fallow land

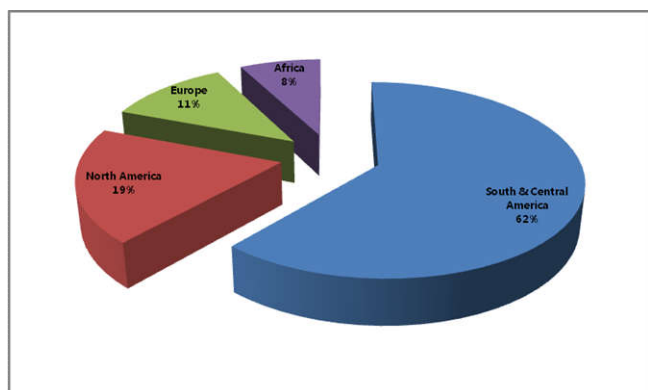


Fig. 3. Native Range of Invasive Alien Species (IAS) in the flora of Jammu and Kashmir



Fig.7 Impenetrable thickets of *Lantana camara* L. in a large tract of forest land

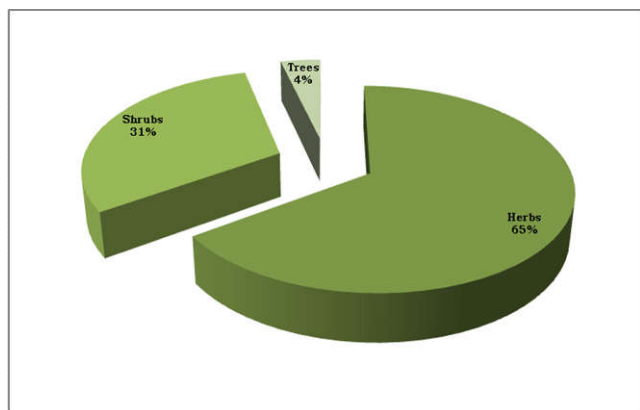


Fig. 4. Dominant life-forms of Invasive Alien Species (IAS) in Jammu and Kashmir



Fig. 8 A dense stand of *Parthenium hysterophorus* L. in a grassland



Fig.5 A dense stand of *Ageratum houstonianum* Mill. in an orchard of the study area

Family: Asteraceae

Native Range: Central America

Description: Erect or decumbent, annual hairy herb, 15-60 cm tall, stem reddish to green, hairy. Leaves simple, ovate to deltoid, lower opposite, upper alternate, hairy, lamina 3-6 cm by 2-4 cm, crenate-serrate. Heads homogametic, in terminal corymbs, 5-8 mm across, several disc florets only, ray florets absent, corolla 5, tubular, lavender blue, pink, lilac or white. Involucral bracts stipitate glandular on outer surface. Achenes hairy, pappus scales 5, white.

Dispersal: Propagation occurs through seeds dispersed by wind to long distances.

Impact: An allelopathic weed usually seen in dense populations in grasslands, agricultural land, forestland, forest edges and fallow land causing displacement of native plant species besides reducing crop yields.

Prevention and Control: (i) The hand picking of weed is not advisable due to its allergic nature. (ii) A 20% solution of common salt is safely used in non-cropping areas. (iii) It is susceptible to the standard broad leaved herbicides like 2, 4-D, dicamba and metsulfuron-methyl.

Alternanthera philoxeroides (Mart.) Griseb.

Common Name: Alligator weed

Family: Amaranthaceae

Native Range: Tropical America

Description: Erect or decumbent perennial herb, aquatic or terrestrial, stem cylindrical, branched, hollow, rooting from the nodes or floating in water. Leaves simple, opposite, sessile, elliptical, 2-7 cm by 1-2 cm, glabrous, entire, acute or mucronate, base cuneate. Inflorescence terminal and axillary, almost round clusters, flowers imperfect, bracts and bracteoles subequal, sepals 5, subequal, oblong, white, petals lacking, stamens infertile. Fruit if present, an indehiscent utricle.

Dispersal: Propagation occurs asexually through stem fragments in the absence of seed formation due to infertile stamens.

Impact: Often forming dense mat in moist agricultural fields, rice fields, marshes, irrigation channels, ditches, ponds and shallow slow flowing water bodies, and causing habitat loss, interspecific competition and reduction in native species diversity. It is also known to clog water channels.

Prevention and Control: It is difficult to control from land due to extensive underground biomass. (i) Physical removal is both time consuming and expensive. An integrated management of the alligator weed involves both the physical and chemical control. (ii) It is susceptible to the standard broad leaved herbicides like 2, 4-D and picloram sprayed to control the terrestrial infestation.

Argemone ochroleuca Sweet.

Common Name: Pale Mexican Pricklypoppy

Family: Papaveraceae

Native Range: Central America

Description: Erect, prickly, glaucous, annual herb, 60-80 cm tall. Leaves simple, sessile, amplexical, lobed, sinuate-pinnatifid, basal in rosette, upper alternate, variegated with white, lamina 10-20 cm by 5-7 cm, segments incised dentate, sharp yellowish spines on the margin, midrib and veins, veins on lower side purplish-blue. Flowers solitary axillary and terminal, 2.5-3 cm across, calyx 3, prickly, petals 6, free, creamish-white, becoming yellowish on fading, stamens 13 or

more, free. Ovary unilocular, stigma sessile. Capsule ellipsoid, 2-4 cm long, prickly, 4-6 valves. Seeds many, globose, brownish-black.

Dispersal: Propagation occurs through seeds which are dispersed by water, animals and humans.

Impact: An aggressive colonizer of sandy streambeds, river flats, arable land, grassland, wasteland and fallow land. It is highly toxic to livestock. The allelopathic effects and dense crowding edges out native species.

Prevention and Control: (i) The uprooting of seedlings reduces infestation. A light tillage of affected land at the seedling stage controls the aggressive colonization of weed. (ii) It is susceptible to a wide range of standard herbicides like picloram, butachlor, 2, 4-D, dicamba, diuron and terbutryne.

Calotropis procera (Willd.) R.Br.

Common Name: Apple of Sodom

Family: Apocynaceae

Native Range: Tropical Africa and Arabian Peninsula

Description: Erect or decumbent, perennial, hoary shrub containing milky latex, 1-1.5 m in height with cylindrical branches, densely white tomentose, often woody near the ground. Leaves opposite-decussate, thick, ovate, ovate-oblong to elliptic, 6-17 by 4-12 cm, cordate or amplexicaul, shortly acuminate, entire, white tomentose when young, later glabrescent, glaucous. Inflorescence a dense, multiflowered, axillary and terminal, umbellate cymes, flowers white, blotched with purple or purplish-pink, 2-2.5 cm across, corolla 5, fused, twisted, corona staminal, stamens 5, fused with stigma forming gynostegium, bicarpellary, syncarpous, ovary superior, enclosed in staminal tube. Follicles turgid, 8-10 by 4-6 cm, sub-globose to obliquely ovoid, recurved. Seeds many, obovate, flat, topped with white silky pappus.

Dispersal: Propagation occurs through seeds which are formed in large number and dispersed chiefly by wind.

Impact: Generally seen in dense thickets in poor and over-grazed areas like grasslands, fallow lands, open lands, waste lands and roadsides causing reduction in native species diversity through competition and habitat loss, besides being toxic to humans and animals.

Prevention and Control: It is difficult to control due to deep feeder root system and succulent habit. The weed control involves (i) Uprooting through mechanical methods, and (ii) Use of herbicide foliar spray to the seedlings. Chemical control is only successful if the top of the root is also removed.

Ceratophyllum demersum L.

Common Name: Soft Hornwort, Foxtail

Family: Ceratophyllaceae

Native Range: Europe

Description: A robust, submerged, rootless, much branched, perennial hydrophyte. Leaves dark green, sessile, rigid, in whorls of 6-8, finely segmented into linear segments, 1-2.5 cm long, distantly toothed, capillaceous leaves aggregated towards the summit and collapsing when withdrawn from water. Flowers minute, unisexual, solitary axillary, male and female in separate axils, involucre 8-12 partite, perianth absent, stamens 4-10, carpel one, ovary superior. Fruit an achene, style persistent.

Dispersal: Propagation occurs through seeds, stem fragments and hibernacula (winter buds). Birds, water and human mobility are the main dispersal agencies of seeds and propagules.

Impact: It often forms large masses in quite or slow flowing streams, canals, ditches, ponds and lakes, and becomes threat to the human use of water body. Rapid growth and allelopathic nature of weed have negative impact on native species in the aquatic ecosystems.

Prevention and Control: (i) Mechanical harvesting is useful to contain the infestation. (ii) Environment friendly alternatives like manipulation of water flow and re-shaping water channels seem beneficial.

***Conyza canadensis* (L.) Cronq.**

Common Name: Canadian fleabane

Family: Asteraceae

Native Range: North America

Description: A coarse, hairy, erect herbaceous annual, about 1.5 m tall with rigid and sparsely branched stem. Leaves simple, sessile, narrowly lanceolate or oblanceolate, elliptic, alternate, lamina up to 10 cm by 1 cm, with some shallow teeth or ciliate margin, acute, sparsely hairy. Heads arranged in terminal and axillary panicles, 2-3 mm across, bracts leafy, ray florets 25-45, pistillate, corolla white, linear, disc florets 12-25, perfect, corolla tubular, pale-yellow. Achenes 1-1.5 mm long, light yellowish-grey, narrowly cylindrical-ellipsoid, pappus hairs white.

Dispersal: Propagation occurs through seeds dispersed by wind, water and animals.

Impact: It is an aggressive colonizer of grassland, riparian land, fallow land and road sides causing disruption of habitat due to overcrowding and hence displaces and reduces native species.

Prevention and Control: (i) The infestation is controlled by tillage in the initial phase. The hand de-weeding and crop rotation are also useful practices. (ii) It is susceptible to broad-leaved herbicides like glyphosate, 2, 4-D, dicamba, paraquat and triazines.

***Datura stramonium* L.**

Common Name: Indian Apple, Downy Thorn Apple

Family: Solanaceae

Native Range: Tropical and Sub-tropical America

Description: Erect, strongly foetid, softly tomentose, shrubby annual, up to 1 m tall. Leaves simple, deep-bluish green, broad ovate to ovate-lanceolate 8- 10 cm by 7-12 cm, entire or repand-toothed. Flowers solitary, white, 11-14 by 5-8 cm, lobes 10, spreading. Capsule globose, 3-5 cm across, nodding, covered with long spines.

Dispersal: Propagation occurs through seeds formed in large number and dispersed through water, humans and animals.

Impact: Generally colonizes in overgrazed grasslands, disturbed land, forest lands, fallow lands and road sides causing disruption of habitat with negative impact on native species diversity besides being highly toxic to humans and animals causing hallucination.

Prevention and Control: (i) Hand pulling of the isolated plants before seed set is useful. (ii) It is susceptible to broad-leaved systemic herbicides like 2, 4-D, glyphosate, dicamba and atrazine.

***Echinochloa colona* (L.) Link.**

Common Name: Junglerice

Family: Poaceae

Native Range: Tropical South America

Description: Annual, tufted grass, erect or geniculately ascending culms, reddish-purple, up to 60 cm tall, often branching from base, with no ligules on stem. Leaves flaccid, linear or lanceolate, 10-20 by 0.5-0.8 cm, marked with purple bars, glabrous, base cordate, acuminate. Panicle erect or nodding, linear, 5-10 cm, green or purple tinged. Spikelets ovoid-ellipsoid, hermaphrodite, crowded in 4 rows, 3 mm long. Caryopsis broadly ellipsoid, whitish.

Dispersal: Propagation occurs through seeds dispersed by wind, water, cattle and humans.

Impact: A common weed of riparian land, grassland, moist land, swamps, margins of water bodies and waste land with negative impact on native species diversity and crop yields.

Prevention and Control: (i) It is easy to uproot and destroy in younger stages. Hand weeding from agricultural crops like rice is often a common practice of control. (ii) The selective application of herbicides like oxyfluorfen, paraquat and butachlor is a useful control.

***Eichhornia crassipes* (Mart.) Solms.**

Common Name: Water hyacinth

Family: Pontederiaceae

Native Range: South America

Description: A free-floating, perennial herb, up to 1 m tall with submerged rhizome and roots. Leaves 6-10, arranged in basal rosettes on rhizome, separated by short internodes,

petiole often swollen, lamina up to 15 cm across, roughly circular or reniform, glabrous. In dense stands, petioles are elongated up to 1 m in length with circular leaves, about 30 cm long and bulbous with kidney shaped leaves where the plants are not in dense mats. Roots arise from the base of each leaf in dense mass. Inflorescence a spike, flowers 8-15, sessile, perianth tube with 6 mauve or purple lobes, 4 cm long, standard perianth lobe with yellow diamond patch surrounded by deep purple, carpels 5, stamens 6. Fruit a capsule.

Dispersal: Propagation occurs through seeds and stolons. Seeds are dispersed by birds, water and mammals.

Impact: The weed forms thick stands over shallow streams, ponds, pools and ditches which dramatically alter the ecosystem ecology and results in elimination of native species through competition and disruption of habitat.

Prevention and Control: It is generally subjected to physical removal and fed to the cattle to bring down the infestation.

Heracleum lanatum Michx.

Common Name: Cow parsnip, white leaf hogweed

Family: Apiaceae

Native Range: North America

Description: Erect, pubescent, perennial shrub, up to 2m tall with perennial and odorous rootstock. Stem robust, branched, grooved, hollow. Leaves pinnately lobed, 20-50 cm long, pinnae 2-3 pairs, elliptic to ovate, 7-10 cm by 3-5 cm, densely white tomentose, serrate, mucronate or obtuse, upper leaves sheathed, sheath large and boat shaped. Inflorescence in compound umbels, 10-20 cm across, peduncles 15-28 cm long, pubescent, umbellules 20-25-flowered, flowers small, white, bracts usually absent, bracteoles 5-8, linear to lanceolate, calyx teeth minute, petals 5, free, notched at tip, outer petals large, bi-lobed. Fruit flattened, obconic, 7-12 mm by 4-6 mm, broad lateral wings, minutely hairy, glabrous when mature, primary rays many, hairy.

Dispersal: Propagation occurs mainly through seeds dispersed by wind, water, animals and humans.

Impact: Generally seen in thickets in woodlands, open slopes, meadows, fence lines and riparian land at high altitude. The invasive growth in thick stands destroys the habitat and a significant reduction in the native species diversity. Due to the presence of furano-coumarins in its sap it causes skin rashes and dermatitis to humans.

Prevention and Control: The management of the infestation of cow parsnip is difficult due to the presence of underground rhizomes and seeds formed in large quantities. The severity of infestation around the fields can be contained by repeated cultivation and cutting of weed over the years.

Hyptis suaveolens (L.) Poit.

Common Name: Bush Mint

Family: Lamiaceae

Native Range: Tropical America

Description: A strongly aromatic, annual hairy herb, about 1 m tall with furrowed, quadrangular stem. Leaves opposite, ovate, 2-8 cm by 1.5-5 cm, pubescent, serrate. Flowers 2-5, in axillary racemes, corolla bilipped, middle lobe of lower lip tripartite, purplish-blue.

Dispersal: Propagation takes place through seeds dispersed by water, wind and human activities.

Impact: An aggressive colonizer of open land, riparian land, grass land, fallow land, forest land and roadsides where its dense populations displace and reduce the native species.

Prevention and Control: (i) The uprooting of seedlings reduces infestation. A light tillage of affected land at the seedling stage controls the aggressive colonization of weed. (ii) It is susceptible to the standard herbicides like picloram, butachlor, 2, 4-D, dicamba, diuron and terbutryne.

Ipomoea carnea (Mart. Ex Choisy) Austin.

Common Name: Morning glory

Family: Convolvulaceae

Native Range: Tropical America

Description: Erect or sub-erect, robust, gregarious, diffuse, perennial shrub, 2-3 m tall with milky latex in all parts. Stem slender, woody, hollow, glabrous, light-brown in older parts. Leaves simple, alternate, petiolate, ovate, cordate, entire, acute, pubescent, 12-26 cm by 5-15 cm. Flowers purplish-pink, terminal cymes, trumpet like, 7-8 by 6-7 cm., petals 5, gamopetalous, funnel-shaped. Capsule ovoid, 1.5 by 1.2 cm, seeds black, densely silky with long and brownish hairs.

Dispersal: Propagation occurs through stem fragments and seeds dispersed by wind, water and human activities.

Impact: A gregarious aggressive shrub seen in swamps, pools, ponds, ditches as well as on land where its dense growth coupled with allelopathic effects results in reduced species diversity through loss of aquatic habitat and disruption of ecosystem due to its major role in hydrosere.

Prevention and Control: (i) Manual and mechanical removal is not effective in the aquatic environment. (ii) Although the weed is susceptible to the commonly used herbicides but their use is restricted in aquatic habitat due to the harmful effects on other organisms.

Lantana camara L.

Common Name: Lantana, Tick berry

Family: Verbenaceae

Native Range: Central and South America

Description: An aromatic straggling, gregarious shrub with quadrangular prickly branches, densely interlaced into large impenetrable thickets.

Leaves simple, rugose, scabrid with rough hairs, ovate, 3-10 cm by 3-6 cm, base usually cordate. Flowers variable, yellow, red or orange-red, in dense terminal and axillary flat-topped inflorescences, 4 cm across. Fruit a spherical drupe, 5 mm across, fleshy, turning black and shining on maturity.

Dispersal: Propagation occurs both vegetatively through adventitious shoots and by seeds which are dispersed by birds to long distances.

Impact: It is extensively seen on a wide range of soils including grasslands, field margins, forest lands, forest edges, disturbed land, fallow land and roadsides forming permanent impenetrable thickets resulting in loss of habitat and seriously threatening native plant biodiversity.

Prevention and Control: Though it is susceptible to broad-leaved standard herbicides the cleared areas are rapidly colonized through root sprouting or seed. As such it has become difficult to control. A combination of mechanical and chemical treatment besides biological control by using natural pests and pathogens need to be introduced on war-footing to contain the infestation.

Lemna minor L.

Common Name: Common Duckweed

Family: Araceae

Native Range: North America

Description: A small, free floating hydrophyte. Fronds oval, oval-obovate, 2-5 mm long, 1.5-3.5 mm across, upper surface slightly convex along a faint longitudinal ridge, green or occasionally diffusely reddish, lower flat, light green, seldom slightly reddish, veins 3. Rootlet solitary, upto 2 cm long, white with obtuse tip. Flower arises singly from the thallus, 1 mm across, membranous cuplike scale, carpel 1, stamen 2. Fruit 1 mm long, seed 1, ribbed.

Dispersal: Propagation occurs extensively by vegetative means in summer. It also propagates and over-winters by the formation of small starchy buds 'turions', which sink to the bottom of water body.

Impact: It is often seen forming thick green carpet over the surface of ponds, ditches, lakes, slow streams and marsh lands causing elimination of native species in such ecosystems.

Prevention and Control: (i) Introduction of natural predatory birds like fishes, domesticated water fowls is a useful control.

Opuntia Stricta (Haw.) Haw. var. stricta

Common Name: Common prickly pear

Family: Cactaceae

Native Range: Caribbean

Description: Erect or sprawling, succulent, branched, perennial shrub, 2-3 m tall. Cladodes green to bluish-green, flattened, obovate, 10-25 cm by 7-10 cm, glabrous, areoles

scattered, bearing tiny glochids and spines. Spines yellowish, stout, curved, 2-4 cm long, arise from areoles. Leaves dark brown, 5 mm long, slightly recurved, caducous. Flowers yellow, arise from the margins of cladodes, 5-6 cm across, epigynous, perianth 12, free, outside reddish, many free stamens. Fruit a berry, obovoid, succulent, 4-8 cm long, covered with glochids, deeply depressed at apex, reddish when ripe, pulp reddish containing many seeds.

Dispersal: The pulpy fruits are eaten and dispersed by birds and mammals. Clonal propagation also occurs through dislodged cladodes.

Impact: It usually grows in dense stands in open lands, grasslands, fallow land and wasteland in arid and semi-arid areas. Infestation increases pressure on pastures and grasslands besides exerting negative impacts on native species, agriculture, forestry, animal husbandry, humans, aesthetics and recreation.

Prevention and Control: (i) It is difficult to control through physical and even mechanical methods. Isolated plants are cleared physically. (ii) Many herbicides are effective against this cactus but the treatment proves very costly.

Parthenium hysterophorus Linn.

Common Name: Congress grass

Family: Asteraceae

Native Range: North America

Description: A whitish hairy, rigid, erect, branched, annual herb, 50-150 cm tall with longitudinally grooved stem and branches. Leaves simple, pinnately and irregularly much dissected, alternate, forming rosette in younger plants, dissected tips acute, entire. Heads heterogametic, axillary and terminal, whitish with minute or hairy involucre bracts, 4-5 mm across, ray florets 5, fertile, disc florets 50 or more. Achenes ellipsoid-obovate and brittle.

Dispersal: Propagation occurs through seeds formed in large number and dispersed by wind, water, birds, animals and vehicles.

Impact: An aggressive weed usually seen in dense populations across grasslands, forest land, agricultural land, fallow land, disturbed land, wasteland and even roadsides disrupting natural ecosystems, replaces native species and also reduces crop yields besides exerting toxic effects in cattle and humans causing dermatitis, respiratory disorders and occasional deaths.

Prevention and Control: The hand picking of weed is not advisable due to allergic effects. (i) Eucalyptus oil is used as a natural herbicide. (ii) It is susceptible to the standard herbicides like 2, 4-D, dicamba, glyphosate, atrazine and S-metolachlor. (iii) Biological control through leaf feeding beetle *Zygogramma bicolorata* remained partially successful.

Potamogeton natans L.

Common Name: Broad leaved Pondweed

Family: Potamogetonaceae

Native Range: North America

Description: A perennial, rhizomatous aquatic macrophyte, with trailing stems ascending through water. Leaves dimorphic, submerged narrowly linear, opaque phyllodes, up to 2 mm broad, floating leaves leathery, long-petioled, ovate to lanceolate, 5-9 cm by 3.5-4.7 cm, petiole up to 6 cm long. Stipules free, 5-9 cm, persistent, linear-lanceolate. Spikes 4.5 cm long, female flowers pink, 4 mm across, perianth segments 2. Fruitlets obovoid, 3.5-4 mm long, 2.5-3 mm broad.

Dispersal: Propagation occurs through seeds and stolons dispersed through water, birds and animals.

Impact: An aquatic weed of lakes, ponds, ditches, slow streams and marshland with larger effects to marginalize and reduce native species as also the death of water bodies.

Prevention and Control: (i) Manual and mechanical clearance is useful to contain the infestation.

Prosopis juliflora (Sw.) DC.

Common Name: Southwest thorn, Mesquite

Family: Fabaceae

Native Range: South America and Mexico

Description: A deciduous tree or shrub, 3-12 m tall, bark brownish, fissured in long vertical stripes, main branches crooked, young zigzag, canopy flat topped, spines in axillary pairs, straight, divergent, 1-4 cm. Leaves bipinnate, pinnae 1-3 pairs, 4-18 cm long, leaflets elliptic-oblong, emarginate or obtuse, up to 29 pairs. Inflorescence axillary racemes, cylindrical, 7-15 cm long, solitary or more, florets pale to greenish yellow, sessile, densely clustered, mildly fragrant. Legume, compressed, curved, straw yellow, endocarp segments up to 25 with oval seeds.

Dispersal: Propagation occurs through seeds dispersed by animals, water and humans.

Impact: An aggressive colonizer adapted to a wide range of soils and seen in grasslands, fallow land, forest lands, disturbed land where it often forms dense thorny thickets and edges out native tree species.

Prevention and Control: It is difficult to control through mechanical and chemical methods due to reintroduction and re-establishment of seeds. The widespread use of herbicides may have adverse effects on environment. Cultural control by hand clearance and burning of young seedlings prevents dense growth.

Ricinus communis Linn.

Common Name: Castor bean

Family: Euphorbiaceae

Native Range: North-eastern Africa

Description: Evergreen, glaucous shrub, 3-5 m tall, stem hollow, branched, non woody. Leaves simple, 15-50 cm long,

alternate, long petiolate, stipulate, stipules 1-3 cm long, fused into a sheathing bud, caducous, lamina orbicular, membranous, palmately lobed, lobes 5-12, coarsely toothed, reddish-purple to bronze when young, with a reddish tinge when mature. Inflorescence a terminal panicle, cyathia unisexual, in lateral cymes, calyx 3-5 partite, corolla absent, male cyathia towards base with many branched stamens, female cyathia distal, gynoecium tricarpellary syncarpous, styles 3, reddish, ovary superior, softly spiny. Fruit ellipsoid to sub-globose, dehiscent, brown, spiny, 1.5-2 cm long, seeds compressed, mottled, shining with caruncle at the base.

Dispersal: Propagation takes place through seeds dispersed by birds, rats, water and human activities.

Impact: Often seen in thick stands occupying grasslands, riparian areas, disturbed areas, field margins, fallow lands and waste lands exerting negative impact on native species. Highly toxic seeds cause vomiting and even death if ingested accidentally.

Prevention and Control: (i) Physical removal of seedlings and young plants bring down the infestation. (ii) Large plants require stump-treatment with herbicides such as glyphosate, picloram and 2, 4-D.

Senna tora (L.) Roxb.

Common Name: Sickle Senna

Family: Fabaceae

Native Range: Tropical America

Description: Erect, gregarious, 30-75 cm tall, annual with strong unpleasant odour. Stem cylindrical, branched, glabrous. Leaves pinnately compound, alternate, leaflets usually in 3 pairs, obovate-oblong, 2-6 by 1-3.5 cm, obtuse, ciliate. A rod like gland is situated between each of the lowest two pairs of leaflets. Flowers 1 cm long, axillary, solitary or pairs, sepals 5, petals 5, free, unequal, yellow, fertile stamens 7, ovary superior. Legume 12-20 cm long, slender, falcate, brown, imperfectly septate between the seeds. Seeds many, cylindrical, obliquely truncate, brownish, shining.

Dispersal: Propagation occurs through seeds dispersed by water, animals, contaminant of agricultural produce and human activities.

Impact: An aggressive gregarious colonizer of grasslands, fallow lands, waste lands, forest lands and agricultural crops, and seen to out-compete, marginalize and reduce native species diversity.

Prevention and Control: (i) The uprooting of seedlings reduces infestation. A light tillage of the affected land at the seedling stage controls the aggressive colonization of weed. (ii) It is susceptible to the selective application of herbicides like picloram, butachlor, 2, 4-D, dicamba, diuron and terbutryne.

Solanum viarum Dunal

Common Name: Sodom apple

Family: Solanaceae

Native Range: Tropical America

Description: Erect, perennial herb, up to 1.5 m high. Stem and branches terete, pubescent, armed with recurved prickles 2-5 by 1-5 mm. Leaves simple, unequal paired, petiole stout, armed with flat straight prickles, 0.5 to 1.8 cm long, leaf blade broadly ovate, 6-13 by 5-11 cm, prickles and coarse glandular hairs on both surfaces. Raceme 1-5 flowered, flowers 1.5 cm across, sepals 5, petals 5, lanceolate, white, stamens 5, epipetalous, anthers yellow. Fruit a globose berry, mottled green when young, yellow on maturity, 2-3 cm across. Seeds discoid, brown.

Dispersal: Propagation occurs through seeds dispersed by rats, animals and human activities.

Impact: It is an invasive weed of grasslands, forest land, riparian land and fallow land where it often grows in patches with negative impacts on native species.

Prevention and Control: (i) It can be controlled by physical clearing of shoots and roots followed by burning. (ii) It is susceptible to the selective application of herbicides like picloram, glyphosate and dicamba.

Typha angustata Bor. and Chaub.

Common Name: Small Bullrush

Family: Typhaceae

Native Range: Europe

Description: Erect, gregarious, robust herb of marshes, swamps, still waters, usually 1-2.5 m tall. Leaves linear, about 7 ft. long, 1cm wide, glabrous, erect to slightly spreading. Flowers small, crowded in 2-3 trete, terminal cylindrical spike, spikes unisexual 12-20 by 1-2.4 cm and separated by intervals, upper spikes male, slender and paler, lower ones female and pale-brown. Fruit an achene.

Dispersal: Propagation occurs through seeds and rhizomes. Seeds are dispersed by wind to long distances. Hydrochory is also successful.

Impact: It is an aggressive colonizer of disturbed wetlands including ponds, ditches, lakes and slow streams where its strong competitiveness, very high adaptability and monospecific thick stand formation ability often excludes native species from such habitats.

Prevention and Control: (i) It is subjected to cutting and dredging which are the common approaches to control. (ii) Though it is susceptible to narrow-leaved herbicides but their use in aquatic environment has harmful effects on other flora and fauna.

Urtica dioica L.

Common Name: Stinging Nettle, European Nettle

Family: Urticaceae

Native Range: Europe

Description: A stinging herbaceous perennial, 80-175 cm tall with robust, grooved, pubescent and fibrous stem, arising from basal rhizomes. Leaves simple, opposite, 5-10 cm by 2-3 cm, lower ovate, upper lanceolate, base cordate, acuminate, coarsely serrate, stipules four per node, 1-2 mm wide, lanceolate, lamina with conspicuous stinging hairs at least on the upper surface, non-stinging hairs relatively coarse and sparse. Inflorescences axillary, spike-like, four per node, many-flowered, flowers small, greenish and unisexual, flowers tiny, greenish, males more upright or patent and the females tending to be pendent, the male with four perianth segments and four stamens, the female with two smaller and two larger perianth segments and ovary unilocular with a sessile tufted stigma, dioecious. Fruit an achene, encircled by persistent perianth.

Dispersal: Propagation takes place through underground rhizomes and seeds formed in large numbers. Seeds are dispersed by wind, water and animals.

Impact: Dense populations are generally seen in places like wastelands, fallow lands, grasslands, orchards, roadsides and often forming monospecific stands which besides its horizontal spread through rhizomes disrupts habitat and restricts or prevents the growth of native species.

The stinging trichomes cause irritation, pain and burning sensation related health problems in humans and animals.

Prevention and Control: The control and eradication of stinging nettle is difficult due to stinging leaves and a large root mass. (i) It can be controlled to some extent by repeated tillage and cultivation of the infested area. Repeated cutting also prevents monospecific stand formation. (ii) Repeated herbicide treatment by using picloram, 2, 4-D, clopyralid, triclopyr and dicamba.

Xanthium spinosum L.

Common Name: Spiny cocklebur

Family: Asteraceae

Native Range: South America

Description: Erect, annual herb, up to 1 m tall. Stem branched, striate, yellowish or brownish grey, pubescent. Leaves lanceolate, irregularly toothed or lobed, 3-8 cm by 1-2 cm, strigose, silvery tomentose beneath, armed with axillary 3-pronged spines 2-4 cm long. Heads in axillary clusters, monoecious, inconspicuous, greenish. Burs pale-yellowish, oblong, 1-1.5 cm, 2-celled, covered with hooked spines.

Dispersal: Propagation occurs through seeds dispersed by water, animals and humans.

Impact: An aggressive weed of disturbed land, fallow land, grassland, moist soils and roadsides with negative impacts on native species.

Prevention and Control: (i) Uprooting of isolated young plants. (ii) Selective application of herbicides like 2,4-D and Imazaquin.

Xanthium strumarium Linn.**Common Name:** Common cocklebur**Family:** Asteraceae**Native Range:** South and Central America

Description: A stout, unpleasant smelling, coarse shrubby annual, up to 1.3 m tall with purple spotted stem. Leaves simple, undulate, scabrid, 5-13 cm by 5-10 cm, obscurely lobed, toothed. Heads green, males 6 mm across, distal, female involucre with 2 enclosed apetalous flowers. Fruiting involucre ovoid, hard, 1.5-2 cm long, clothed with hooked prickles. Achenes black, 1.5 mm long, ribbed on the faces, topped with remains of styles.

Dispersal: The spiny burs get attached to the fur of animals, human clothing and also dispersed by water.

Impact: An aggressive weed of agricultural land, grass land, fallow land, disturbed land and open land forming thick stands and besides eliminating native species drastically reducing soil fertility and crop yield.

Prevention and Control: (i) The adoption of zero tillage can reduce population because burs seldom germinate on the soil surface. Physical removal in the seedling stage reduces infestation. (ii) It is susceptible to broad-leaved herbicides like glyphosate, 2, 4-D, dicamba, paraquate and triazines.

Conclusion

Biological invasions are the consequences of human caused global environmental change. The trade based global economy promotes the cultivation of economically important plant species which may lead to the accidental spread of same species or others. The international regulation controlling the unintentional introduction of undesirable alien species through trade is weak. Similar to deforestation invasive alien species are playing a significant role in the disruption of ecological ecosystems. The severity of the invasion problem has grown tremendously in the present global economic setup where the global economy has reached into virtually every corner of the planet. All the invasive alien species reported in the study have serious consequences on the biodiversity of the region. They are found to intrude into, marginalize and out-compete the native species in their natural habitat and rendering them rare, vulnerable and extinct. Majority of the species reported in the study were also reported as invasive alien plants in many other parts of the world. Most of them have their origin in the countries of Tropical America besides Europe, Africa and Mediterranean. The invasion of alien species is a primary cause of biodiversity loss in the region. Other than biodiversity, there are many other negative impacts of invasive alien weeds in the sectors of growth and development like agriculture, forestry, horticulture and even fisheries. There are also threats to the food security and human health besides huge loss to state economy. A better planning is required for early detection and reporting of the infestation of new and naturalized weeds by creation of Plant Detection Network in each district of the state by establishing communication links between taxonomists, ecologists and land managers to monitor and control such invasive species.

Current control methods of invasive alien weeds are expensive, lengthy, and risky because total eradication is required to prevent re-establishment. Effective site-eradication procedures require multi-year treatments, continued monitoring, and follow-up treatments. All infestations on adjacent lands must be treated to prevent re-invasion. Unfortunately, infestations common along railway tracks, roads, and utility right-of-ways are rarely treated for eradication, fostering widespread immigration to adjacent lands. Mechanical control is one of the common methods employed for control of invasive species in the region. Mechanical control involves ploughs, scythes, mowers, hoes and rotary weeders.

By using these tools, the weeds are physically lifted from the soil, cut off or buried. Though this method is laborious and needs lot of manpower yet it seems to be one of the best approaches to the management of invasive alien species. Chemical control methods have proved costly and partly successful in several cases. Use of chemicals is not desirable due to pollution that they might cause. Biological control of alien weed invasions can also be an effective and environmentally better approach to their management. But biological control is not evenly effective over all areas infested by the invasive species. Control and eradication of invasive alien species is not a management goal in itself but only one means to achieve higher goals such as conservation of biological diversity besides the protection of human health and prevention of economic loss.

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