Eco. Env. & Cons. 29 (3) : 2023; pp. (1390-1399)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i03.059

Invasive plant species, a burning problem of the present-day World, their threats and mitigation measures

Haleema Bano*[1], Umar Ashraf Mir[1] and R.A. Rather[1]

[1]***Division of Environmental Sciences, Faculty of Horticulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar 190 025, Srinagar, Jammu and Kashmir, India.***

(Received 10 May, 2023; Accepted 5 July, 2023)

ABSTRACT

Global ecological integrity has been jeopardised by invasive alien plant species. They not only have an impact on the variety of species in native ecosystems, but also pose a biological integrity danger. A number of invasive alien plant species have been found in India, including some tropical American species that are said to be very troublesome and have had negative ecological, economic, and social effects. These species include *Parthenium hysterophorus L., Lantana camara L., Eupatorium odoratum L., Hyptis suaveolens (L) Poit.*, and *Ageratum conyzoides L.* Although these weeds can be seen growing in a variety of environments, they are most luxuriant in untended forests and cultivated areas. Records from the state of Jharkhand also support this. Along from quickly colonising land and displacing native plants, it is also known to cause havoc on the environment, endanger tourism-related activities, and pose a range of health risks to people. Similar to how it makes feed scarce while also being poisonous and unpleasant for livestock. Large swaths of land are being invaded by these species, particularly forests where they have almost completely replaced the forest floor vegetation and slowed the growth of native trees. Additionally, they hamper forest operations because of their spreading and bushy development patterns. These plants share comparable growth tactics that enable them to successfully invade natural ecosystems, including quick growth rates, brief life cycles, higher reproductive capacity, high levels of competition, and allelopathy. This review study discusses a number of biological, ecological, and plant invasiveness risks.

Key words: *Allelopathy, Global ecology, Native ecosystem, Luxuriant, Forest operations, Colonizing*

Introduction

Due to their destructive effects on biodiversity and ecosystem function, invasive alien plant species have drawn the attention of ecologists, biological conservationists, forestry planners, natural resource managers, and social development planners on a global scale. The ensuing effects can be described as "catastrophic," as they ultimately pose a threat to the integrity of the environment and, more significantly, to humankind's ability to feed itself. Exotic or non-native species that have evolved elsewhere and have been purposefully or accidently introduced outside of their natural adaptation ranges and dispersal potential are considered "Alien" species. Not all plants brought in from other ecosystems are dangerous, but only a tiny proportion of those with a strong capacity for reproduction and proliferation

([1]*Prof. Associate Prof.)

turn out to be invasive. Because of their rapid growth, they outpace the local biota in terms of habitat exploitation and nutrient and water resource exploitation. One of the most important global processes affecting the structure, composition, and function of natural and semi-natural ecosystems has been identified as plant invasions (Mooney and Hobbs, 2000). Around the world, the issue keeps getting worse at significant socioeconomic, health, and ecological cost. Through their effects on agriculture, forestry, fisheries, and natural systems, which are a significant foundation of peoples' lives in poor nations, invasive alien plant species worsen poverty and pose a threat to development. Climate change, pollution, habitat loss, and disturbance brought on by humans all exacerbate this damage. Native and indigenous plant communities around the world are threatened by invasive alien plant species, particularly where these communities are disrupted (D. Antonio *et al*., 2001). However, relatively few alien plant species seem to have the capacity to invade undisturbed native plant communities (Rejmanek *et al*., 1989). Studies of earlier imports demonstrate that invasive plant species' effects are complex and have the power to significantly alter the make-up of communities (Holway *et al*., 2002; Carlton *et al*., 2003). The ultimate effects of invasion, however, are significant, subtle, and frequently irreversible.

Mechanism of invasion

Four phases make up the invasive process: introduction, establishment, lag time, and expansion phase. While species can spread naturally by way of birds, animals, water, and wind migration (Herbold and Moyle, 1986), today's increased human mobility and the expansion of the global population have caused alien species to migrate in new ecosystems at a large scale (Moore *et al*., 2004). In addition to other factors, an introduced species' capacity to thrive depends on its ability to adapt to its surroundings (Holzmuellller and Jose, 2009). A lag period with little to no rise in species spread follows it. The lag period could last a short while or years. The majority of weed species in New Zealand have lag phases that last, on average, 20 to 30 years, with 4% of species having lag phases longer than 40 years (Aikio *et al*., 2010). The expansion phase, which comes after the lag period and is when most control attempts are performed, sees a sharp increase in the occurrence of the species (Holzmuellller and Jose, 2009).

Why the invasive species get advantage over native biota?

The properties of alien plants that spread quickly into new areas give them an advantage over the local biota. They may persist, for instance, in a variety of ecological conditions that frequently span a considerable geographic range (Sax and Brown, 2000; Rejmanek *et al*., 1996). They originated on vast continents with a diversified biota, and they already have links with damaged or anthropogenic habitats (Elton *et al*., 1958). The following characteristics of invasive species that seem to make them more likely to become invaders are generally shared by them. However, it is very difficult to determine the most advantageous biological character promoting invasiveness.

- Accelerated development and brief life cycles
- Efficiency of resource usage and consumption
- A lot of flowers and a lot of seeds
- Able to flourish in a variety of environments
- The genetics of evolution and high genetic variability
- Delayed germination and protracted seed dormancy
- Effective seed dispersal technique
- Ability to alter an intruded environment Capability of sexual or asexual reproduction
- Utilization of nearby pollinators
- They can out compete native species because of their different phenology.
- Provide shade, as this can seriously harm native plants.
- Grazing, pest, and disease resistant

The support of the ecosystem for biological invasion

Invasiveness of alien plants is also influenced by the ecosystems conditions, such circumstances include the following:

- Environments damaged by man-made activities such as overgrazing and removing land for habitation, as well as by natural disasters like fire and flood.
- Moderately moist environments appear to be more open to invasion than extremely dry or extremely wet ones.
- Lack of competition, predatory animals, herbivorous organism bugs, and diseases, among other natural rivals.
- An environment with recently developed vegetation.

- Habitats with low native species diversity and physical or temporal exclusion
- Ecosystems are slowly recovering from a prior perturbation.
- More herbicides and fertilizers are used, which results in less native plant competition and suitable development circumstances for alien species.
- An environment with relatively rich soils that are high in nutrients (such as riparian areas);

Biological invasion: An emerging global threat

The impact of invasion is severe and lowers the ecosystem's carrying capacity (Banerji *et al*., 1958). Native societies' sustainability is inevitably impacted by invasion since it changes their structure, makeup, and functions (Webster *et al*., 2006). The second-most significant hazard to the continued existence of native species has been determined to be the invasion of alien species, after habitat degradation (Jenkins *et al*., 1999). By outcompeting native species' seeds for germination and stifling the growth of native seedlings, invasive plant species in a forest landscape replace native species. The ability of invading plant seedlings to absorb more resources and their thick growth, which shades saplings of native species, are two techniques for doing this. Invasive plant species compete with crops for soil and water resources in agricultural environments, lowering crop output and feed quality. Water body clogging by aquatic invasive plant species threatens the survival of native aquatic flora and fauna and has a negative impact on the public water supply and irrigation system. The dynamics and composition of soil are impacted by the invasion of foreign plant species. In fact, pollution, harvesting, and disease all these when taken together pose a bigger danger to native biodiversity than alien invasive species (Drake *et al*., 1989).

Threat to biodiversity

Invasive alien plants pose a serious threat to biodiversity that is on par with habitat degradation. They contribute to the extinction of species and the loss of biodiversity. They also played a role in the 42% decline of endangered and threatened species in the United States (Wilcove *et al*., 1998). Over the past few years, there have been varying effects of invasive alien species on biodiversity in different environments. In certain areas, the impact is low and has little effect on biodiversity, while in others, the impact is large and has a big impact on the local biodiversity. The Millennium Assessment identified invasive alien species as one of the primary causes of biodiversity loss over the previous 50 to 100 years, according to UNEP (2005). The research also predicts that the tendency will persist across all biomes on a global scale. Invasive species like *Ageratum conyzoides* L. (Goat weed), *Parthenium hysterophorus* L. (White top), *Lantana camara* L. (Lantana), and *Eupatorium adenophorum Spreng* (Crofton weed) are major invaders in the North Western part of India, greatly reducing the diversity of native species, according to a study by Dogra *et al*., (2009). *Mikaniamic ranthakunth* (Mikania) and *P. hysterophorus* are two other very invasive Neotropical plants that have established themselves in India. The Western Ghats are home to the Giant Sensitive Plant, *Mimosa diplotricha* C. Wright, which has rapidly increased its range (Ramkrishnan *et al*., 1996). Direct competition with the native flora can result in monocultures of an alien species, such as by *Psidiumcattleianum Sabine* (strawberry guajava) in Mauritius and *P. hysterophorus* (White top) in Australia and India (Evans, 1997). Raghubanshi and Tripathi (2009) found that in Vindhyan dry deciduous forests, areas with high *Lantana camara* cover have little to no understorey vegetation, but areas with low *Lantana* cover do have some understorey species. The establishment of tree species seedlings is hindered by dense cover produced by the horizontal stratification of lantanas, which lowers the intensity and duration of light (Sharma and Raghubanshi, 2006).

Genetic pollution, a process of unchecked hybridization and introgression that results in homogeneity or replacement of local genotypes, can put native species in danger of extinction. Native species have decreased and even gone extinct as a result of hybridization's negative impacts. Due to hybridization with foreign species, 3 of the 24 species in the United States that were categorised as endangered have now become extinct (Mc Milan and Wilcove, 1994). The bulk of the time, invasive species outnumber native species in terms of numbers. Additionally, hybridization frequently results in a decrease of fitness for the native species (Rhymer and Simberloff, 1996). Through habitat alteration, genetic pollution can potentially lead to extinction by bringing previously separate species together. These events can be especially harmful when rare species come into contact with more abundant ones since the abundant ones may interbreed with them, forming hybrids and suffocating the entire gene pool of the rarer species, ultimately causing the extinction of the native species (Kumar *et al*., 2009).

Threat to food security, agriculture and livestock production

In the distant past, the introduction of economically advantageous plants and animals outside of their original range helped the human society to gain from such crops and cattle. In terms of agricultural yield, it was discovered that the introduced crop held more promise in the new habitat than in their native one. The simultaneous introduction of invasive species and their takeover of grazing and agricultural lands was the introduction's unfavourable feature. A severe challenge to the production of food and fibre for people is posed by alien invasive plants in agricultural landscapes that compete with crop plants for water and nutrients. A number of alien plants viz. *Ageratum conyzoides* L., (Goat weed), *Argemonemexicana* L., (Mexican poppy), *Alternantherasessilis* (L.) DC., (Sessile Joyweed), *Bidenspilosa* L., (Spanish tassle), *Celosia argentea* L., (Silver cocks comb), *Emilia sonchifolia* (L.) DC., (Tassel flower), *Oxalis corniculata* L., (Yellow wood sorrel), *Parthenium hysterophorus L*., (White top weed), *Portulacaoleracea* L., (Purslane), *Scopariadulcis* L., (Sweet broom), *Sidaacuta Burm*. (Common wireweed), *Sonchusasper* L., (Sow thistle) are common weeds of agricultural landscapes (Divakara *et al*., 2013). Their weeding requires both labour and financial resources. Crop weeding by hand is the most common job performed by people worldwide. In Southeast Asia, weeds typically diminish rice yield by 30–35%, which accounts for 30% of all the food energy consumed by humans (Holm *et al*., 1977). Additionally, they alter the nitrogen cycle of the soil and have allelopathic effects, which reduce crop output. The Food and Agriculture Organisation of the United Nations estimates that over 33% of the potential yearly world food harvest was destroyed in the 1970s by insects, illnesses, and weed infestations, resulting in a loss of $75 billion. In 1975, weeds reduced global crop production by an estimated 11.5% (Parker and Fryer, 1975). Weeds decrease potential crop yields by 12% in US agriculture. According to the USBC (1998), this decrease in crop yield amounts to an annual loss of crop production of around US$33 billion. According to estimates, 73% of weeds are non-native (Pimentel, 1993). It is expected that imported weeds are to blame for around $27.9 billion in crop losses.

On grasslands, invasive species may change the hydrology, nutrient cycling and accumulation, and carbon sequestration (Polley *et al*., 1997). The production of forage for livestock is decreased as a result of species like *Lantana camara, Parthenium hysterophorus, Argemonemexicana,* and *Eupatorium odoratum* that alter grassland and impede the growth of grasses and other native fodder species present in their understorey. Cattle are poisoned by *Lanatanacamara's* seed and leaves. In open pastureland and close to agricultural landscapes, *Eupatorium odoratum* grows as dense thickets. It prevents native organisms from sprouting and expanding. When dried, it becomes extremely flammable and encourages forest fires. Food security is eventually threatened by the total effects of invasive alien species on land resources, agriculture, and livestock. Invasive alien species, which thrive in new habitats when their hosts are plentiful and their natural adversaries are missing, have caused significant economic damage, particularly the introduction of agricultural pests and diseases as contaminants in crops and animals. There is a serious incidence of triffid weed reported from Ghana, where it has taken over 59% of all arable areas in Ubombo, South Africa, reducing the recommended number of animals that graze by 150%. In addition, the triffid weed in western and central Africa acts as a different host for a pest grasshopper. Triffid weed eradication in natural settings is projected to cost between US $ 151 and $ 164 per ha. Invasive plant species can quickly colonise pasture and agricultural lands due to their rapid growth. *Parthenium hysterophorus*, often known as the "white top weed," grows quickly in disturbed areas, such as newly cleared or ploughed soil, areas that have been overgrazed, and it spreads quickly by seed dispersal. The highest likelihood of survival of seeds is their capacity for longest viability, they can remain alive until a maximum of two years, and buried seeds may stay dormant for up to 20 years—is what makes it most conducive to invasion. When the unappealing White top weed takes over the grazing meadows, there is a shortage of feed, which has a detrimental impact on the productivity of the cattle. In Ethiopia, the White top weed invaded agricultural areas after being introduced with tainted food imports. The result was an unexpected drop in crop production (GISP, 2004).

Threat to forest ecosystem

Invasion is very difficult to succeed in unaltered tropical forests (Cronk and Fuller, 1995). But a phenomenon that is less well understood and requires immediate action is plant invasion of the forest ecosystem, which has been made easier by the recent global trend in declining forest cover. Plant invasion in tropical forests is more severe than it is in temperate forests, according to Cronk and Fuller (1995). Species like *Lantana camara, Sennaspectabilis* (DC.) *Irwin and Barneby* (Spectacular cassia), *Psidium cattleianum Sabine* (Cattley guava), *Chrysobalanusicaco* L. (Coco plum), *Clidemiahirta* (L.*), D Don.* (Soap bush) exerts great competitive pressure with the forest flora thus influencing their regeneration. For their (alien spp.) use in agroforestry, commercial forestry, and erosion control, alien trees have long been planted. It is becoming more and more clear that woody tree species have the potential to become invasive. A well-illustrated example of a tree invasion is the *Tamarix* spp. instance in western North America (Shaforth *et al*., 2005). The salt cedar, also known as *Tamarix ramosissima*, *T. chinensis* (Lour.), and their hybrids, which are all native to Eurasia and were introduced to Western North America in the middle of the 19th century, now cover between 40,000 and 60,000 ha. of land (Robinson 1965; Zavaleta, 2000; Gaskin and Schaal, 2002). Detrimental effects of the *Tamarix* invasion include displacement of native riparian vegetation, increase in fire risk, and loss in water table due to high evapotranspiration rates. The federal, state, and local governments have made significant investments to stop the *Tamarix* invasion in the western United States (Shafroth and Briggs, 2008). Argentina and Australia have both reported *Tamarix* invasions (Shafroth and Briggs, 2008; Gryphon *et al*., 1989). According to studies conducted in South Africa on the effects of invasive foreign tree species, stream flows have decreased by 4.7 to 13.0 percent (Dye, 1996; Le Maitre *et al*., 1996; Prinsloo and Scott, 1999; Le Maitre *et al*., 2000).

Threat to ecosystem functioning

Invading biological species have a variety of effects on ecosystems. Ecosystems' functioning can change as a result of invasive species. For instance, invasive plants can change native ecosystems' hydrology, nitrogen cycle, and fire patterns. The invasion process more frequently has an impact on the fragile and isolated ecosystems (SCBD 2001). Diverse invasive species have different effects on ecosystem services. They have an impact on the delivery of food, the purification of freshwater, pollination, natural pest management, disease regulation, soil fertility, and the cycling of nutrients and water (Eiswerth *et al*., 2005). It has been discovered that watershed areas with dense stands of invasive species have a significant impact on catchment hydrology, which is another effect of invasive plants. From watershed regions where there are several invasion patches, there is a reported 30–70% decrease in water discharge (Goldenhuys, 1986). Le Maitre *et al*., (2000), have categorised the invasive alien plant species according to how much water they use. They include *Acacia mearnsii*, *Acacia cyclops*, *Acacia dealbata*, *Pinus* spp., *Eucalyptus* spp., *Prosopis* spp., *Acacia saligna*, *H. Wendel*, *Meliaaze Populus* species, Hakea species, and Jacaranda mimosifolia Jacaranda D. Don, *Sesbaniapunicea*, *Rubus* spp., *A. longifolia*, *Psidiumguajava*, *Caesalpineadecapetala*, Black Wattle, Green Wattle, and English Oak Quercusrobur L. It is concerning to note that, regardless of the species, they are of little use to the bulk of the local biota and have detrimental consequences on the hydrologic ecosystems. The Salt Cedar (*Tamarix* spp.) of the southwestern United States, where this species has invaded significant areas along riparian corridors, results in silt capture and channel narrowing, is an example of how invasive species negatively affect water control. The end result is a reduction in the water holding capacity of streams, which results in more frequent and severe flooding and the related expenditures of flood control (Zavaleta, 2000). Due to changes in host-pathogen relationships and species competition, invasive species have a direct impact on the distribution, composition, and availability of biodiversity and local forest resources. The interaction between native species and how they affect ecological processes like the pollination process seed distribution, and hydrological cycles—which are gravely upset by the invasion of alien species-determines to a large extent the ecological impact of the loss of biodiversity caused by invasive exotic species. Alien plant invasions have an impact on local biodiversity and community organisation through interference competition and exploitation competition (direct interactions like allelopathy and resource utilisation). According to Chapin *et al.* (2000), the effects of incursion on relationships among species such grazing, exploitation, and Cooperation can alter the diversity of species. Attack ofexotic plants effects native biodiversity and community structure by exploitation, competition and direct interactions such as allelopathy (Callaway and Ridenour, 2004). The impacts of invasion on species interactions such as predation, herbivory, parasitism, and mutualisms, can change the abundance of species (Chapin *et al*., 2000).

Risk to the soil structure

It has been discovered that plant invasions alter soil microbial communities and biogeochemical cycles in ways that can feed back to their own advantage. According to Dukes and Mooney (2004), invasive plants that fix nitrogen, leach chemicals that prevent other species from fixing nitrogen, release substances that change the availability of nutrients like nitrogen and phosphorus, and affect topsoil erosion can all affect nutrient cycle. By altering the soil nutrient pools, some invasive plants can change the native soil ecosystem. For instance, they can increase the soil nitrogen (N) availability to plants by N fixation (Levine *et al*., 2003; Vitousek *et al*., 1987). Through the quick consumption of soil N, other invasive plants may decrease nitrogen pool (Asner *et al*., 2005), by releasing salts like Tamarix (Zavaleta, 2000), *Mesembryanthemum crystallinum* L. (the iceplant) (Vivrette and Muller 1977), decreasing the pH soil, or secreting specific chemical substances, invasive plants can make soil least feasible for other species (Callaway and Ridenour, 2004). In comparison to the soil under the native shrub species *Vaccinium*, *Berberisthunbergii* DC, and *Microstegium vimineum*, *A. Camus* have invaded hardwood forests in New Jersey, Europe, and have caused alkalinity in soil, according to Kourtev *et al.* (1999). Additionally, these two species helped increase nitrate accessibility and net capacity nitrogen fixation in the soils they attacked. Invasion is frequently associated with higher soil phosphorus levels. Herr *et al.* (2007) found that an invasive to Europe, *Solidagogigantea* had lower soil pH and higher labile phosphorus fractions in invaded areas than in non-invaded areas. Invasive alien plants have also been reported contributing to soil degradation.

Socio-economic threat

According to Li and Xie (2002) and Wan *et al*. (2002), invasive alien species speed up the extinction of species and genetic diversity while destroying ecosystem structure and function. The overall result is significant economic loss. According to Pimentel *et al*. (2000), invasive alien species have cost the United States 138 billion dollars in losses. The cost of foreign invasive species in terms of the economy, environment, and society is very significant. They have such a large impact on ecosystem functioning that they sometimes force a country's long-term development planning to change course. According to IUCN estimates, the environment costs the world economy $400 billion a year (UNEP, 2003). The loss caused by invasive alien species on World Bank projects was estimated by the IUCN to be US$13,000,000,000 (UNEP 2004). The production of cattle and agriculture both suffered significant effects. In addition to providing food and water, freshwater ecosystems also provide water for agriculture, tourism, recreation, and hydroelectric projects, all of which are important to local livelihoods. These opportunities are now seriously threatened by the arrival of aquatic invasive alien plant species like *Eichornia cressipes* (Water hyacinth), *Alternanthera philoxeroides* (Alligator weed), and *Pistiastratiotes* L. (Water lettuce). Annual investments in the US for the management of foreign aquatic weed species total $100 million (OTA, 1993). More than US$ 25 million is spent year on water hyacinth eradication, and another US$ 15 million is paid annually to repair water lettuce damage (Huntley, 1996). The primary effect of alien species invasion is followed by a decrease in the supply of forest products, which has a direct impact on rural livelihood because these goods are the only source of subsistence for rural livelihood.

Threat to human health

When humans and animals come into touch with or ingest invasive plants, they can suffer catastrophic consequences. The pyrolizidine alkaloids found in *Echiumplantagineum* L. (Paterson's curse) are toxic to grazing animals. Humans are also irritated by the plant and suffer from hay fever. *Heracleummantegazzianum* (Giant hogweed) sap sensitises the skin to UV radiation, causing blisters and scarring.Inhaling the smoke of giant hogweed produces respiratory tract burns (Portland Plant List, 2010). Mosquito habitat is provided by species such as *Lanatana camara* and *Eichornia cressipes*. Mosquito-borne infections are becoming more common in areas where these species have spread. Eichorniacressipes' decomposition and death damage water sources and raise the risk of bacterial infection.Eichorniacressipes' decomposition and death damage water sources and raise the risk of microbial infection which leads to the development of water-borne infectious diseases. *Parthenium hysterophorus* pollen grains are allergenic to the skin and respiratory system. Humans and livestock are allergic to *Ageratum conyzoides* and *Calotropisprocera* (Apple of Sodom). Moreover, invading exortic plant species can serve as host shelters for pathogens that can infect humans, animals, and plants, as well as other creatures.

Threat to tourism

Invasive plant species wreak havoc on recreation and tourism, especially ecotourism and educational tourism. In protected tourist wildlife sanctuaries, species such as *Lantana camara* cause annoyance to visitors. The route to the woodland is blocked by their spiky character and dense growing habit. They conceal the natural beauty of a forest setting. Because of the relevance of evolutionary studies, the Galapagos Islands are well-known as educational tourism destinations. Mauchamp *et al*. (1998) reported the extinction of numerous indigenous plants in the Galapagos Islands as a result of *Lantana camara* invasion. Freshwater aquatic organisms such as *Eichornia cressipes* and *Alternanthera philoxeroides* obstruct tourist boating, water skiing, and swimming activities. *Melaleuca quinquenervia* (Cav.) S.F. Blaka (Broad leaf paper bark), Mimosa pigra L. (Giant sensitive weed), Fallopia japonica (Japanese knotweed), and *Opuntiastricta* (cactus) (cf. Global Invasive Species Database) reduce access to natural tourist spots.

Control measures

The most economical and safest way to manage invasive species is by prevention. Early detection and rapid response of invasive species is much more effective than trying to control a widespread infestation. If eradication is not possible, the invasive species may be subject to control and management efforts.

There are various methods used for the control and management of invasive species:

Biological control:- It is the intentional manipulation of natural enemies by humans for the purpose of controlling pests reducing the population using prey targeting the invasive species. Natural enemies used in classical biological control of weeds include different organisms, such as insects, mites, nematodes, and pathogens. In North America, most weed biological control agents are plant-feeding insects, of which beetles, flies, and moths are among the most commonly used. This option involves much research and testing to make sure the prey targets only the invasive species intended.

Chemical control: - It includes the use of pesticides, herbicides, fungicides, and insecticides. Although chemical use can be very effective, they can be dangerous to other species or to the ecosystem in general.

Cultural control: It includes manipulation of habits to increase mortality of invasives or reduce it's its rate of damage (selection of pest-resistant crops, winter cover crops, changing planting dates). Cultural measures are aimed at changing human behavior to address the issue of spreading invasives — using opportunities to educate people about practices to increase awareness to prevent the spread of invasives (signage, public awareness campaigns). Cultural practices include mulching, soil solarization with plastic film, thermal weed control (e.g., flaming, hot water, and steam), prescribed burning, water manipulation, and prescribed grazing with domesticated herbivores (e.g., cattle, sheep, goats, and horses).

Mechanical control: This techniques include mowing, hoeing, tilling, girdling, chopping, and constructing barriers using tools or machines. Mechanical treatments complement herbicide (chemical) control and sometimes increase efficiency.

Physical or manual control: It involves physical activities (i.e. harvesting) such as hand-pulling, digging, flooding, mulching, manual destruction or removal of nests, egg masses, or other life stages; generally includes the destruction of invasive species by hand.

Conclusion

The threat posed by invasive alien plant species has grown in tandem with the fast expansion of globalization. By modifying species composition, fire regimes, food webs, nutrient cycling, and hydrology, these species contribute to lower agricultural, livestock, and forest productivity, alter soil quality, and promote land degradation, as well as influencing important ecosystem services. They pose a significant threat to native species diversity, perhaps contributing to the extinction of rare and endangered species. The ultimate impact is massive economic and environmental devastation. Plant species invasion has compelled natural resource managers all over the world to pay massive sums of money in order to manage them. For a secure future that ensures enough food production and ecological harmony for subsequent generations, more comprehensive education campaigns, approaches to management, concerted enforcement efforts, and effective legislation are needed. (Miller and Schellas, 2008). Despite alarming reports from around the world on many aspects of biological invasion and their negative consequences, there is still a gap between awareness and decision-making programmes. In the next years, such updated data will be required, as will the formation of a multidisciplinary strategy at the administrative and scientific levels for the control and eradication of invasive species.

References

Aikio, S., Duncan, R.P. and Hulme. P.E. 2010. Lag phases in alien plant invasion: separating the facts from the artefacts. *Oikos.* 119: 370-378.

Asner, G.P. and Vitousek, P.M. 2005. Remote analysis of biological invasion and biogeochemical change. *Proc Natl Acad Sci USA.* 102: 4383–4386.

Banerji, N.L. 1958. Invasion of Eupatorium glandulosum in east Nepal. *Bulletin of Botanical Society.* 10 (1/2): 14-8.

Callaway, R.M. and Ridenour, W.M. 2004. Novel weapons: invasive success and the evolution of increased competitive ability. *Frontiers Ecol Environ.* **2**: 436–443.

Carlton, J.T. 2003. Community assemblage and historical biogeography in the North Atlantic Ocean: The potential role of human-mediated dispersal vectors. *Hydrobiology*. 503: 1-8.

Chapin, F.S., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L., Hooper, D.U., Lavorel, S., Sala, O.E., Hobbie, S.E., Mack, M.C. and Diaz, S. 2000. Consequences of changing biodiversity. *Nature.* 405: 234–242.

Cronk, Q.C.B. and Fuller, J.L. 1995. Plant invaders: the threat to natural ecosystems worldwide, Chapman and Hall, London.

D'Antonio, C.M., Levine, J.M. and Thomson, M. 2001. Ecosystem resistance to invasion and the role of propagule supply: A California perspective. J. Mediterr. *Ecol.* 27: 233-245.

Das, R., Divakara, B.N. and Prasad, S. 2013. Invasive alien plant of Jharkhand- A guide to common man, Institute of forest productivity, Ranchi.

Divakara, B.N., Prasad, S. and Das, R. 2013. Documentation of invasive plant species in Latehar and Hazaribagh District: Jharkhand, India. *Indian Forester.* 139 (2): 113-117.

Dogra, K.S., Kohli, R.K. and Sood, S.K. 2009. An assessment and impact of three invasive species in the Shivalik hills of Himachal Pradesh, India. *Inter. J. Biodiversity Conservation.* **1** (1): 004-010.

Drake, J.A., Mooney, H.A., Dicastri, F., Grooves, R., Kruger, F., Rejmanek, M. and Williamson, M. 1989. Biological Invasions: A Global Perspective, John Willey, Chichester, UK.

Dukes, J.S. and Mooney, H.A. 2004. Disruption of ecosystem processes in western North America by invasive species. *Rev ChilHist Nat.* 77: 411–437.

Dye, P.J. 1996. Climate, forest and stream flow relationships in South African afforested catchments. *Commonwealth Forestry Review*. 75: 31-38.

Eiswerth, M.E., Darden, T.D., Johnson, W.S., Agapoff, J. and Harris, T.R. 2005. Input-output modelling, outdoor recreation, and the economic impacts of weeds. *Weed Sci.* 53: 130–137.

Elton, C.S. 1958. The ecology of invasion by animals and plants. TMetheun and Co., London.

Evans, H.C. 1997. Partheniumhysterophorus: A review of its weed status and the possibilities for biological control. *Biocon News Infor.* 18: 89-98.

Gaskin, J.F. and Schaal, B.A. 2002. Hybrid *Tamarix* widespread in U.S. invasion and undetected in native Asian range. *Proceeding of the National Academy of Science, of the United States of America.* 99: 11256-11259.

Geldenhuys, C.J. 1986. Costs and benefits of the Australian Blackwood Acacia melanoxylon in South African forestry In: Macdonald IAW. FJ Kruger and AA Ferrar (eds.) the ecology and management of biological invasions in southern Africa. Cape Town: *Oxford University Press*. 275-84.

GISP, 2004. Africa invaded: The growing danger of invasive alien species: Global Invasive Species Programme. Cape Town. http://www.gisp.org/downloadpubs/gisp%20afric a%202.pdf

GISP, 2007. The economic impact and appropriate management of selected invasive alien species on the African continent. Report prepared by CSIR. South Africa.

Griffin, G. F., Stafford Smith, D. M., Morton, S. R., Allen., G. E. and Masters, K. A. 1989. Status and implications of the invasion of Tamarisk (*Tamarixaphylla*) on the Finke River, northern territory, Australia. *Journal of Environmental Management.* 29 : 297-315.

Herbold, B. and Moyle, P.B. 1986. Introduced species and vacant niches. *Amer. Natur.* 128: 751-760.

Herr, C., Chapuis-Lardy, L., Dassonville, N., Vanderhoeven, S. and Meerts, P. 2007. Seasonal effect of the exotic invasive plant Solidagogigantea on soil pH and P fractions. *J. Plant Nutr. Soil Sci.* 170: 729–738

Holway, D.A, Lach, L., Tsutsui, N.D. and Case, T.J. 2002. The causes and consequences of Ant invasions. *Ann.*

Rev. Ecol. Syst. 33: 181-233.

Holzmueller, E.J. and Jose, S. 2009. Invasive plant conundrum: What makes the aliens so successful? *Journal of Tropical Agriculture.* 47 (1-2): 18-29.

Huntley, B.J. 1996. South African experience regarding alien species: impacts and controls. In: Sandlund, O.T., Schei, P.J., Viken, A. (Eds.), Proceedings of Norway/UN Conference on Alien Species. *The Norwegian Ministry of Environment, Trandheim,* pp. 182–188.

Jenkins, P.T. 1999. Invasive species and biodiversity management (Eds Sandlund OT, Schei PJ, Viken A), Kluwer, London, 24: 229-235.

Kourtev, P.S., Huang, W.Z. and Ehrenfeld, J.G. 1999. Differences in earthworm densities and nitrogen dynamics in soils under exotic and native plant species. *Biol. Invasions*. 1: 237-245.

Kumar, P., Singh, P.K. and Dubey, R.K. 2009. Invasive alien species: In – National conference on Invasive Alien Species – *A Threat to Native Biodiversity*, 22nd May 2009. pp 18.

Le Maitre, D.C., Van Wilgen, C. Chapman, R.A. and McKelly, D.H. 1996. Invasive plants and water resources in the Western Cape Province, South Africa: modeling the consequences of a lack of management. *Journal of Applied Ecology*. 33 : 161-172

Le Maitre, D.C., Versfeld, D.B. and Chapman, R.A.2000. The impact of invading alien plants on surface water resources in South Africa. A preliminary assessment. Water SA, 26: 397-407

Levin, D.A., Fransicso-Ortega, J. and Jansen, R.K. 1996. Hybridization and the extinction of rare plant species. *Conserv. Biol*. 10: 10-16.

Levine, J.M., Montserrat, V., D'Antonio, C.M., Dukes, J.S., Grigulis, K., Lavorel, 2003. Mechanisms underlying the impacts of exotic plant invasions. Proc R SocLond B 270: 775–781

Li, Z.Y. and Xie, Y. 2002. Invasive Alien Species in China (in Chinese). Forestry Publishing Company of China, Beijing.

Mauchamp, A., Aldaz, I., Ortiz, E. and Valdebenito, H. 1998. Threatened species, a reevaluation of the status of eight endemic plants of the Galapagos. *Biodiversity Conserv.* 7 : 97–107.

McMillan, M. and Wilcov, D. 1994. Gone out but not forgotten: Why have species protected by the Endangered Species Act become extinct? *Endangered Species Update.* 11(11): 5-6.

Miller, J.H. and Schellas, J.W. 2008. Adaptive collaborative restoration: a key concept for invasive plant management. In: Kohli, R.K., Jose, S., Singh, H.P., and Batish, D.R. (eds). Invasive plants and Forest Ecosystems, CRC Press, Boca Raton, FL., USA, pp. 251-265.

Mooney, H.A. and Hobbs, R.J. (eds.)2000. Invasive Species in a Changing World. Island Press, Washington, D.C.

Moore, P.D. 2004. Favoured aliens for the future. Nature, pp. 427.

OTA, 1993. Harmful Non-Indigenous Species in the United States. Office of Technology Assessment, United States Congress, Washington, DC.

Parker, C. and Fryer, J. 1975. Weed control problems causing major reduction in world supplies. FAO *Plant Protection Bulletin.* 23: 83-95.

Pimentel, D. 1993. Habitat factors in new pest invasions. In: Kim, K.C., McPheron, B.A. (Eds.), Evolution of Insect Pests— Patterns of Variation. Wiley, New York, pp.165–181.

Pimentel, D., Lach, L., Zuniga, R. and Morrison, D. 2000. Environmental and economic costs of non indigenous species in the United States. *Biosciences.* 50: 53-65.

Polley, H.W., Johnson, H.B. and Mayeux, H.S. 1997. Leaf physiology, production, water use, and nitrogen dynamics of the grassland invader Acacia smallii at elevated CO2 concentrations. *Tree-physiology.* 17 (2): 89-96.

Prasad, S., Divakara, B.N., Kumar, P. Kumar, A. 2012. Medicinal attributes of invasive alien flora of Latehar, Jharkhand. In: Singh, S., Das, R. (Eds.). Non timber forest product and medicinal plant,IFP/2012/03, Ranchi, pp. 230-233.

Prinsloo, F.W. and Scott, D.F. 1999. Stream flow responses to clearing of alien invasive trees from zones at three sites in the Western Cape. *Southern African Forestry Journal*. 185: 1-7.

Raghubanshi, A.S. and Tripathy, A. 2009. Effect of disturbance, habitat fragmentation and alien invasive plants on floral diversity in dry tropical forests of Vindhyan highland: a review. *Tropical Ecology*. 50 (1): 57-69.

Ramakrishnan, P.S., Das, A.K. and Saxena, K.G. 1996. Conserving Biodiversity for Sustainable Development. Indian National Science Academy, New Delhi. pp 246.

Rejmanek, M. 1989. Invasibility of plant communities. Biological Invasions: A Global Perspective (Eds Drake JA, Mooney HA, di- Castri F, Groves RH, Kruger FJ, Rejmanek M, Williamson M). Wiley and Sons, Chichester, England, pp. 369-388.

Rejmanek, M. 1996. A theory of seed plant invasiveness: The first sketch. *Biol. Conserv.* 78: 171-181.

Robinson, T. W. 1965. Introduction, spread and areal extent of salt cedar (*Tamarix*) in the western states. U.S. Geological Survey Professional Paper 491-A. United States Government Printing Office, Washington, D.C.

Sax, D.F. and Brown, J.H. 2000. The paradox of invasion. *Global Ecol. Biogeogr*. 9: 363- 371.

SCBD. 2001. Review of the efficiency and efficacy of existing legal instruments applicable to invasive alien species (Technical series no. 2). Montreal: Secretariat

of the convention on biological diversity, CBD. 42 p.
Shafroth, P. B., Cleverly, J. R., Dudley, T. L., Taylor, J. P., C. van Riper lll, Weeks, E. P. and Stuan, N. 2005. Control of *Tamarix* in the Western United States: Implications for water salvage, wildlife use, and riparian restoration. *Environmental Management.* 35: 231-246.
Shafroth, P.B., Briggs, K.M.2008. Restoration ecology and invasive Riparian plants: An introduction to the special section on *Tamarix* spp. in Western North America. *Restoration Ecology*. 16 (1): 94-96.
Sharma, G.P. and Raghubanshi, A.S. 2006. Tree population structure, regeneration and expected future composition at different levels of Lanatanacamara L. invasion in the Vindhyan tropical dry deciduous forest of India. *Lyonia.* 11: 25-37.
Sharma, R. and Dakshini, K.M.M.1998. Integration of plant and soil characteristics and the ecological success of two Prosopis species. *Plant. Ecol*. 139: 63-69.
Silander, J.A.J. and Klepsis, D.M. 1999. The invasion ecology of Japness Barberry (Berberisthunbergia) in the New England landscape. *Biol. Invasions*. **1**: 189-201.
Thorpe, A.S., Archer, V. and Deluca, T.H. 2006. The invasive forb Centaureamaculosa increases phosphorus availability in Montana grasslands. *Appl. Soil Ecol.* 32: 118–122.
UNEP, 2003. Treaty on International Trade in GMOs to become Law. Press Release, 13 June. United Nations Environment Programme, Nairobi.http://www.unep.org/Documents. Multilingual/Default.asp
UNEP, 2004. GEO Yearbook 2003. United Nations Environment Programme, Nairobi http://www.unep.org/geo/yearbook/yb2003/ index.html.
UNEP, 2005. Implications of the findings of the Millenium Ecosystem Assessment for the future work of the convention-Addendum Summary for decision makers of the biodiversity synthesis report.UNEP/CBD/SBSTTA/11/7/Add 1. 31, August 2005.
USBC, 1998. Statistical Abstract of the United States. US Bureau of the Census, US Government Printing Office, Washington, DC.
Vitousek, P.M., Walker, L.R., Whiteaker, L.D., Mueller-Dombois, D. and Matson, P.A. 1987. Biological invasion by Myricafaya alters ecosystem development in Hawaii Science. 238: 802–804.
Vivrette, N.J. and Muller, C.H. 1977. Mechanism of invasion and dominance of coastal grassland by *Mesembryanthemum crystallinum*. *Ecol Monogr.* 47: 301–318.
Wan, F.H., Guo, J.Y. and Wang, D.H. 2002. Alien invasive species in China: Their damages and management strategies. *Biod. Sci*. 10(1): 119-125.
Webster, C.R., Jenkins, M.A. and Jose, S. 2006. Woody invaders and the challenges they pose to forest ecosystems in the eastern United States. *J. Forest.* 104: 366-374.
Wilcove, D.S., Rothstein, D., Dubow, J., Philips, A. and Losos, E. 1998. Quantifying threats to imperiled species in the United States. *Bioscience*. 48: 607-615.
www.portlandoregon.gov/bes/article/306412
Zavaleta, E.2000. The economic value of controlling an invasive shrub. *Ambio.* 29: 462-467.
Zhang, L.Y. and Ye, W.H. 2002 .Community invasibility and its influencing factors. *Acta Phytoecolgica Sinica.* 26(1): 109-114.