

## INVASIVE ALIEN TREE SPECIES – A THREAT TO BIODIVERSITY

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### Abstract

The spread of Invasive Alien Species (IAS) is now recognized as one of the greatest threats to the ecological and economic well being of the planet. These species are causing varying degree of damage to biodiversity and valuable natural and agricultural systems upon which human beings depend. Direct and indirect health effects are increasingly serious and the damage done is often irreversible. The effects are exacerbated by global changes and chemical and physical disturbances to species and ecosystem.

Alien tree species have long been introduced for commercial forestry, agroforestry, erosion control and landscaping. Pakistan has a long history of introduction of foreign plant and animal species. The main objective of introduction of exotic forest tree species was to fill the gap between supply and demand of timber, fuel-wood and fodder. Out of 700 alien species 2 forest tree species viz. *Broussonetia papyrifera*, and *Prosopis juliflora* were recognized as high impact invasive. *Eucalyptus camaldulensis* is another example highlighting the invasive behaviour. In addition, *Robinia pseudoacacia*, *Ailanthus altissima* and *Leucaena leucocephala* are also aggressive in nature and may pose threat to the local flora and fauna in the future. This paper presents the present status, impact and possible control measures of invasive alien forest tree species.

### Introduction

The spread of invasive alien species (IAS) is creating complexity and far reaching challenges to both natural biological wealth of the earth and well being of its citizens. While the problem is global, the nature and severity of the impacts on society, economic life, health and natural heritage are distributed uneven across nations and regions. Thus some aspects of the problem require solution tailored to the specific values, needs and priorities of nations while others call for consolidated action by the world community. Preventing the international movement of invasive alien species and coordinating a timely and effective response to invasion will require cooperation and collaboration among governments, economic sectors, non-government organizations and international treaty organizations. The problems and scale of solution may appear dauntingly complex, the issue presents an unparalleled opportunity to respond with action that link preservation and management of biodiversity with protection of health and livelihood of the world's human population.



## Impact of Invasive Alien species

### Impact at global level

Biological invasion by alien species is one of the major threats to the local biodiversity. The impact of invasive species on indigenous species is immense and irreversible on global level. Climate change, environmental pollution and habitat degradation are threats resulting from intentional and unintentional introduction of tree species to establish in modified habitat. As many as 10% of the world 300,000 vascular plants, have the potential to invade other ecosystem and affect native biota in a direct or indirect way (Rejmanek *et al.*, 2000)

Economic loss is always coupled with biodiversity loss. The invasive alien species may cause enormous economic losses to national economy. The data on economic losses due to invasive alien species in many countries are not available at present though sporadic information on biodiversity losses and environmental degradation have been published. However, it has been reported that just 79 invasive species in USA caused US\$ 97 billion losses from 1906-1991 and another 15 species may cause US\$ 134 billion losses in future (Randall & Marinelli, 1996).

Invasive alien species are causing billions of dollar worth of damage in Southeast Asia in addition to displacement and in some cases extinction of native species. Despite the scale of damage, the importance given to control IAS in the convention on Biological Diversity (CBD) and the many international protocols and initiatives to tackle this issue, almost no attention is paid to this threat in most of the developing countries including Pakistan.

In many cases, the introduction of invasive species resulted in some financial benefits, but the main question pertaining to significant losses in terms of biodiversity values and skills remain unattended. It is generally believed that the damage caused to biodiversity through species extinction and disruption of natural ecosystem is far greater than benefits of introduced invasive species.

The rate of introducing alien species is greatly increasing with the globalization of trade and more people traveling around the world. Moreover as natural areas are transformed by rapid development, the openings for invasion are more numerous.

There is often a short-term advantage of planting an exotic species in places where its natural pests and diseases are absent. In some cases these species spread out of control displacing natural vegetation and profoundly changing the natural ecology. The Chinese Super – tree *Paulownia tomentosa*, for example, is listed as invasive in many countries. Several introduced conifers have become established in the Southeast Asian region and the spread of



Australian Eucalyptus and Acacias has a profound effect. Both *Acacia auriculiformis* and *Acacia mangium* grow well in the region and spread naturally over cleared and burned areas. These species create conditions of great flammability and can thrive with regular fire episodes in lands where natural forest fires were almost unheard of. Such fires occur annually in Bornco and Sumatra, but these species are spreading at the expense of native species and transforming these islands into fire escape monsoon forests.

Similarly salt cedar (*Tamarix* spp.) was introduced from Central Asia to Southwest United State nearly 200 years ago to control erosion along riverbanks. The tree now form dense forest on more than 400,000 ha of riparian habitat. These forests have little value but having severe impacts on hydrological system. The economic impact of salt cedar is US\$ 7-16 billion over 55 years. Invasive alien pines and *Acacia* in South Africa threaten not only unique native flora but reduce water table. Cost to restore the impact of pine, Hakeas and *Acacia* is \$2 billion in South Africa. Similarly in Britain the economic impact of 12 most serious invasive alien plant species is estimated at US\$ 344 million/year. Many countries are experiencing great problems with alien eucalyptus from Australia. The species of Eucalyptus can be particularly harmful in environmental term because their leaf litter contains chemical compounds that prevent other species from growing.

Forest production can be seriously affected by pests and diseases. Alien diseases and pests have caused major changes in the composition of forests in many countries over the past century, including the decline of species like elm (*Ulmus amricana*), chestnut (*Castanea dentata*) and hemlock (*Tsuga heterophylla*).

The longhorn beetle (*Tetropium fuscum*) arrived from Europe in packing wood poses serious threat to North American forest. Red spruce (*Picea rubens*), the most economically important tree in Maritime Canada, is infested by this beetle and appears to attack white (*P. glauca*) and black (*P. mariana*) spruce (Whittenberg *et al.*, 2000). Annual cost of human, plant and animal health from the introduced disease organism is estimated about \$41 billion per year in USA.

The basic requirement for effective control or eradication of an invasive species is that the resultant benefits should outweigh the cost of such programme. It is estimated that the net benefit of controlling *Melaleuca* infestation in Florida, USA is to be of US\$ 168.6 million/year mainly from tourism, while the value in term of honey obtained from its plantations would be just US\$ 15 millions (Diamond *et al.*, 1991).



### **Impact of Invasive Alien Forest tree species in Pakistan**

The scale of threat from IAS has been consistently under appreciated in Pakistan but is clearly alarming. IAS is probably the second greatest threat to biodiversity after loss of habitat. The foresters consistently plant exotics without taking into consideration the future consequences. The exotics can replace local tree species, change watershed capacity, increase fire hazard, cause outbreaks of pest species, reduce water table, and deplete weak soil.

It has been observed that the *E. camaldulensis* planted on the Malakand Hills has badly effected the growth of shrubs, herbs and grasses. One of the associate species of scrub forest i.e. *Dodonaea viscosa* has been wiped out due to toxic effect of this exotic species.

The research on the listing, description, magnitude and impacts of invasive alien species in Pakistan has been done on very small scale. The meager studies undertaken list 700 alien species of vascular plants against 4500 indigenous species (Khatoun and Ali, The Herald January, 1999). Of these 700 alien species, 6 species such as *Broussonetia papyrifera*, *Prosopis juliflora*, *Eichhornia crassipes*, *Salvinia molesta*, *Parthenium hysterophorus*, and *Lantana camara* could be recognised as high impact invasive.

Biodiversity and economic impact of invasive alien tree species has not so far been carried out. Therefore it is difficult to estimate the actual loss due to these species. *Broussonetia papyrifera* became highly invasive species in the natural ecosystem of Himalayan foothills and is a growing threat to the natural vegetation of National Parks and other valleys in Islamabad upto South Azad Jamu and Kashmir. Moreover, it is also a human-health hazard and causing pollen allergy to about 45.5% inhabitant of Islamabad. It is also labelled as an allergen causing cold, sneezing and cough.

*Prosopis juliflora* invaded the riparian forest of *Acacia nilotica* in Sindh and excluded the native species due to its allelopathy. Similarly this species invaded a number of compartments in irrigated plantations of Chichawatni and Pirowal. Like many other invasives this plant contains toxic metabolites that keep local herbivores away and also prevent the growth of indigenous plant species in the vicinity.

*E. camaldulensis* is another example highlighting the invasive behaviour in farm forestry and mountainous areas of Malakand-Dir due to its aggressiveness and release of allelo-chemicals (phenolic terpenes) into the environment (Hussain *et al.*, 2000 and Saleh, 2002). In spite of fast producer of biomass merely because of large amount of water and nutrient intake, there is



very little return of humus to the soil because of slow decomposition of leaves. There is a rapid loss of nutrients due to short rotation. It has also allelopathic effects on crop and other plant species due to soil poisoning and toxicity. The tree exhibits a number of ecological and social hazards. It has been established as a big fire hazard due to its inflammable leaf litter. The root system has tempered with under ground utility services in many areas. It also poses a threat to road travelers and traffic being liable to breakage during strong winds. The tree does not support resting and association of most birds because of its oily smell. Above all, it does not have any fodder value.

*Robinia pseudoacacia*, *Ailanthus altissima* and *Leucaena leucocephala* have also been introduced in various parts of the country. These species are also aggressive in nature and spread both through seed and root suckers. Presently they do not pose any threat but may threaten the local flora and fauna in future.

Till date no comprehensive cataloguing (even of indigenous species) is not available; therefore nothing could be reported with certainty about the number of alien invasive tree species in Pakistan.

### Conclusion

- i. Fortunately, the magnitude of alien species in Pakistan is not as great as for some other countries, but unfortunately there is virtually no awareness about this important global issue among nursery growers, general public, policy makers and even among researchers and the Provincial Forest Departments.
- ii. New intentional introductions both authorized and unauthorized are going unabated.
- iii. The awareness campaigns on the importance of indigenous flora and the danger of alien species are needed more in Pakistan than anywhere else in the world.
- iv. As there is no legislation, the Biodiversity Action Plan (BAP) of Pakistan deals with this problem very superficially through Action 6.6 of BAP as reads: "Take measures to control invasive alien species of fauna and flora, and to prevent further introductions".
- v. The Quarantine Department checks only imported plants or animals species for any pests or pathogens accompanying these. There is no provision to check the possible ecological impact of the imported species per se.
- vi. Careful management can minimize the danger of alien trees to become invasive in natural ecosystems. Forest Departments, plant growers, NGOs etc., therefore need awareness about the



danger of unintentional entry of IAS "These organization must conduct detail risk assessment before intentional introduction of exotic trees, and ensure that such species may not become invasive in years to come.

- vii. Careful planning of forestry operations is greatly needed in using alien conifers, *Eucalyptus* or *Acacia*. This can reduce the probability of their escaping and becoming invasive.
- viii. The use of native species or sterile trees that can only be established through cuttings is the only sure way to prevent alien trees from becoming invasive.

### Recommendations

- An important first step in prevention of alien species invasion is to identify those which can become invasive. These may be put on a "black list" to prohibit entry under national legislation. Species cleared for introduction through passing a risk assessment analysis can reasonably be declared as safe (put on a "white list"), though monitoring is still required to ensure that the prediction remains accurate overtime. The potential invasiveness of the majority world's species is known and they should be placed on a "gray list".
- As a preventive measure, no alien species should be introduced without appropriate analysis and environmental impact assessment (EIA) procedures.
- Mitigation (eradication, containment, suppression) strategy be developed according to the objective of management of alien forest tree species.
- Control measures like mechanical, chemical, biological, habitat management or integrated pest management be cost effective and environmentally safe.
- Formulation of effective legislation, its enforcement and implementation.
- Promotion of awareness and education on IAS by arranging workshops, seminars, publicity and campaigns.
- Development of national strategy surveys and inventory.
- Development of cooperation between institution to mitigate the threat of alien species.
- Capacity building through education and training and further research on biology and control of IAS.
- Inclusion of prevention and management issues of IAS in Forest Policy.
- Development of database on IAS and information sharing at national



and international level.

- Establishment of coordination mechanism at national, regional and international level.
- Provision of adequate financial and technical support by relevant national, regional and international assistance agencies.

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APPENDIX-I

LIST AND BRIEF INFORMATION ABOUT INTRODUCED INVASIVE  
FOREST TREE SPECIES IN PAKISTAN

1. *Broussonetia papyrifera* (Family: Moraceae)

**English name:** Paper mulberry **Local name:** Gul toot

**Origin:** A native of Japan, South East Asia and China

**Description:** A medium sized dioecious tree, 3 to 12 m tall. Crown is spreading and rounded, trunk whitish-grey. Leaves 4-18 X 3-14 cm, broadly ovate to elliptic ovate, sometimes palmately lobed, subcordate, scabrid above, softly hairy on undersurface. Male catkins appearing before the leaves, 3-5 cm long and occur between March and August. Fruit is: a berry containing 5-15 small seed and ripen between May and September, Juicy, orange-red, in globose heads, 3 cm broad.

**History of introduction:** The introduction of this species in subcontinent is more than 100 years old. According to Parker (1924) it was first introduced in 1880 at Saharanpur and until 1924 it had spread up to Lahore along irrigation channels and into Shahdra plantation. Parker at that time predicted that this tree would become common in the sub Himalayan tract as well as in the more heavily irrigated portions of the plains especially the places where any prior vegetation was scant. (Surraya Khatoon, 1999).

**Affected areas and impacts:** Paper mulberry is the most problematic invasive in northern Pakistan. It is distributed from Lahore to Peshawar valley through Salt range, but worst affected are the federal capital Islamabad and Rawalpindi. It has the typical features of invasiveness by fast growth rate, seed dispersal through birds, and ability to vegetative propagation. Its fruits are relished by crows who thus acts as the vector for its seed dispersal; therefore both crows and Paper Mulberry are promoting each other. The increased population of crows has become a nuisance for the residents of affected areas. It was introduced in Islamabad to make the capital green. In less than thirty years period it became a highly invasive species in the natural ecosystem of Himalayan foothills. Around Rawal Lake it has replaced the entire natural vegetation. Margalla Hills is a National Park representing good examples of Himalayan foothill vegetation. This invasive species is a growing threat to the natural



vegetation of National Park and other valleys in the East of Islamabad and up to south of Azad Jammu and Kashmir.

Besides threatening the natural vegetation, it is also a human-health hazard. The specie is labelled as an allergen causing cold, sneezing and cough. In a report of Pakistan Medical Research Council (1995), about 45.5 % of allergic patients in Islamabad and Rawalpindi showed positive sensitivity to the pollen of *B.papyrifera*.

**Control measures:** The newly sprouting shoots from trees stumps and ground covers are being cut and burnt. First phase of this operation in Islamabad started from Faisal Avenue and the trees are being replaced with better timber trees. This operation started in 1992 but is not effective as it continues to comeback due to its invasive nature (Mazhar Hussain, Director Environment, CDA).

**Researchable aspects:** Survey is needed to identify natural enemies of *B.papyrifera* in its native area, and trying the host specific natural enemies for its control in Pakistan.

Possibilities may be explored for the end-use of its different parts before deciding for control e.g. bark of this plant is used in Japan for painting, fibre from its bark is used in making paper, rope etc in Thailand and Japan (Hussain *et al.*, 2000). It is also reported that the species can be used for manufacture of pulp and paper (Suleman and Nadeem, 1995). However, commercial use found may advocate to maintain large populations of this species, which would continue to be a threat for native biodiversity and human health.

## **2. *Prosopis juliflora* (Family: Leguminosae, sub-family Mimosaceae)**

**English name:** Mesquite. **Local name:** Kikari

**Origin:** A native of West Indies, Southwestern United States and Mexico.

**Description:** It is an almost evergreen large spiny shrub or small tree with pinnately compound leaves. Flowers minute, greenish yellow, arranged in dense, hanging spikes. Pod 14-20 X 1-1.5 cm, yellow, containing a sweet pulp eaten by birds.

**History of introduction:** It was introduced in 1878 by the British for afforesting deserts of Sindh and southern Punjab (Parker, 1924).



**Affected areas and impacts:** Mesquite is a highly invasive species established in Pakistan and can be seen everywhere from mountains to seacoast. It is also found in the Pabbi Hills, the Salt Range, the mining wastes, plains, riparian forests, waste lands, saline and waterlogged areas, desert Suleiman Range and anywhere one can visualize. It is common in almost all the linear land strips along highways, canals and railway tracks.

The worst hit by all accounts, is the riparian forest of *Acacia nilotica* in Sindh. *Prosopis juliflora* forms almost pure populations wherever it invades, excluding all native species due to its allelopathy. Therefore it is a great danger to native biodiversity. It provides only cheap fuel wood and nothing else, whereas indigenous *Acacia nilotica* is a multipurpose species, a source of timber, fuel wood, tannins fodder and enhancer of soil fertility by nitrogen fixation.

*P. juliflora* is right now invading the Indus delta mangrove forests which is a real reason of concern. Despite the known invasiveness of mesquite, it is presently being introduced along Makran coast for sand-dune stabilization by the Forest Department. Like many other invasives, the plant contains toxic metabolites, which keep local herbivores away and also prevent the growth of indigenous plant species in the vicinity (Khatoon and Ali, 1999). The species has grossly invaded a number of forest compartments in irrigated plantations of Chichawatni and Pirowal. Tens of thousands of rupees are spent every year to eradicate the species but the objective has not been so far achieved.

**Control measures:** Only mechanical removal of the plant by cutting the bushes and trees is practiced by the forest department. Sometimes local people are encouraged to take away the plant for meeting their fire wood needs.

**Researchable aspects:** Survey of natural enemies from its native area and try the host specific ones for its control. Controlled cutting of the plant to meet the fire wood demand along with replacement with more useful local plants like *Acacia nilotica* may be considered. Effect of complete and partial shade on this species may also be investigated.

### 3. *Robinia pseudoacacia* (Family: papilionaceae)

**English name:** Black locust, Robinia

**Origin:** A native of southeast and central United States.

**Description:** A medium sized to large, deciduous tree 30, m in height with open crown and a straight bole. Young branches glabrescent. Leaf 10–15 cm long,



compound, leaflets. 2.0–2.5 cm long, elliptic to oval, entire, inflorescence an axillary raceme, upto 20 cm long, pedicel upto 3–8 cm long. Bract and bracteoles small. The flowers are small, yellowish to white and fragrant, appearing between March and June. The pods are small 2.5–3 cm long and 1–5 cm wide. The pods mature between August and October. Reproduced both from seed and vegetative means.

**History of introduction:** Native to United States, because of its adaptability, the specie is grown throughout temperate zones of the world. In Pakistan, it has been successfully established in the plains and in the hills of Punjab and NWFP. Plantations are being raised in Malakand, Abbottabad, Gilgit and some other parts of Northern areas. Forest department planted the species as a source of fire wood, fodder and for the purpose of soil stabilization.

**Affected areas and impacts:** In Pakistan the specie has been successfully established in the plain and in the hills of Punjab and NWFP. Plantation are being raised in Abbottabad, Malakand, Gilgit and some other parts of Northern areas. Presently it does not pose a threat, as mostly planted along the roadsides. But the plantations recently raised in various localities of Malakand, Chitral and other parts of the country may threaten the local flora and fauna in the near future.

**Control measures:** The trees growing on road side can be controlled mechanically through selective cuttings and supplemented with chemical control. Simultaneously other local trees species should be planted to fill the micro-habitat after cutting these trees.

**Research aspects:** Affect of mechanical and biological control measures to be determined.

#### 4. *Ailanthus altissima* (Mill.) Single (Family: Simarubaceae)

**English name:** Tree of Heaven. **Local name:** Asmani

**Origin:** A native to China and Japan

**Description:** A deciduous tree, grows upto a height of 20 m but height of 6–10 m are more common. The crown is usually open. The leaves are pinnately compound and long approximately to 30–40 cm. The flowers are born in terminal panicle. The fruit is 3.5–5 cm in diameter. Flowers occurs in April while fruit matures between May and June. It is reproduced from seeds, cuttings and root suckers.



**History of introduction:** The tree is native to China and Japan. It has been successfully cultivated throughout the world. It has been naturalized in Pakistan and can be seen almost anywhere when one travels from 0 to 1700 m elevation. Extensive areas can be observed in Malakand, Hazara, Gilgit, Baluchistan and Azad Jammu and Kashmir.

**Effected areas and impact:** It is an extremely aggressive. The species grows well on all kinds of soil including porous dry, hard, wet, acidic, alkaline, rocky, swampy and marginal sites in general. The species spread aggressively through root suckers in Hazara especially in Abbottabad and Mansehra. It may pose threat to indigenous flora in the future.

**Control measures:** The tree best controlled through mechanical means. It can also be supplemented with chemical control. At the same time local tree species adapted to the locality be planted to fill the microhabitat after cutting of the species to avoid monoculture plantations.

**Research aspect:** Effective control measures to check the spread of the species particularly in the watershed areas.

5. *Eucalyptus camaldulensis* Dehn. (Family: Myrtaceae)

**English Name:** Red River Gum (Local Name) Sufeda, Lachi,

**Origin:** Native to Australia

**Description:** A large, evergreen tree upto 40 m tall, with a diameter of 1 to 2 m. The crown is spreading and irregular. The leaves are simple, narrow and lance shaped, 6-30 cm long and 0.8 to 2 cm wide smooth and stem may be crooked. The bark is whitish, pale gray with mottle reddish patches.

The flower occurs in groups of five and tens, bloom usually between May and June. The fruit is a capsule containing many small seeds, and is shaped like a half globe 0.7 cm in diameter. The capsule mature between September and October.

**History of introduction:** Introduced in undivided India in 1860. In 1911, again tried in Botanical Garden at Lahore. In May, 1913 several species of Eucalyptus were planted. Experiment has established that *E. rostrata* (Syn. *E. camaldulensis*) could grow any where in Pakistan. In 1962 seed of Eucalyptus including



*E. camaldulensis* was procured from Australia and planted to introduce *E. camaldulensis* for afforestation and reclaiming high sub-soil water table areas in Pakistan. A provenance study of *E. camaldulensis* was conducted at 4 various locations for the selection of best one. It is now widely grown on farmland and public forests.

**Affected areas and impact:** *Eucalyptus camaldulensis* has established itself in Pakistan and can be seen everywhere from the mountains to the seacoast. The species is also found in the linear land strips, village surroundings and grazing lands. Most of the man-made irrigated plantation has sizeable areas under *E. camaldulensis*. At least 7.7 million cft. of biomass was estimated in 1992 (FSMP, 1992). The Sindh province alone has 6,000 ha of land under this species.

It has been established that although *E. camaldulensis* has been the tree of choice in most of the social forestry projects in the Asia and Pacific Region due to its fast growth, high survival rate, short rotation and wide ecological range, yet in Malakand-Dir region of NWFP and other countries, it has registered pronounced deleterious effects on the environment. Water shortage has been felt in the project area and wells were found tube wells are running dry due to lowering of water table. This shortage is mainly attributed to the introduction of *E. camaldulensis* in the form of plantations that have been carried out over the past 13 years resulting in an approximately 14.723 million trees. In spite of fast producer of biomass merely because of large amount of water and nutrient intake, there is very little return of humus to the soil due to slow decomposition of leaves. There is also a rapid loss of nutrients on account of its fast growth and short rotation. The allelopathic effects on crop and other plant species due to soil poisoning and toxicity are growth pronounced. The tree exhibits a number of ecological and social hazards. It has been established as a big fire hazard due to its inflammable leaf litter. The root system has tempered with under ground utility services in many areas. It also poses a threat to road travelers and traffic as liable to breakage during strong winds. The tree does not support resting and association of most birds because of its oily smell and thin crown. It does not have any fodder value.

**Control measures:** The species should be planted in rain fed areas with > 700 mm of annual rainfall after proper planning and assessment. In the monoculture plantations adequate thinning should be done and indigenous species be planted in the gaps. It should be planted on saline and water logged and other problematic lands rendered toxic due to industrial and house hold influents. The overall impact on the environment at the national and international level need to



be critically examined and a policy be framed to regulate their number keeping in view the water nutrient budget and other problems associated with the species.

**Research aspects:** Scientific studies should be initiated to determine its detrimental effects under different climatic and soil conditions. Trials on root behaviour on water and nutrient uptake, effect on soil, native flora and fauna, climate and environment under local ecological condition be conducted.