Stocktaking
of

National Forest Invasive Species Activities

INDIA

Country Report

to

ASIA PACIFIC FOREST INVASIVE SPECIES NETWORK,

Asia Pacific Forestry Commission

FAO Regional Office, Bangkok

October 10, 2005

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Abbreviations

APFC	Asia Pacific Forestry Commission
APFISN	Asia Pacific Forest Invasive Species Network
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Cum	Cubic metres
DST	Department of Science and Technology
FAO	Food and Agriculture Organisation
FIS	Forest Invasive Species
FRI	Forest Research Institute
GDP	Gross Domestic Product
GMOs	Genetically Modified Organisms
GOI	Government of India
HFRI	Himalayan Forest Research Institute
IAS	Invasive Alien Species
ICAR	Indian Council of Agricultural Research
ICFRE	Indian Council of Forestry Research & Education
IFGTB	Institute of Forest Genetics and Tree Breeding
IPPC	International Plant Protection Convention
IWST	Institute of Wood Science and Technology
KFRI	Kerala Forest Research Institute
LMOs	Living Modified Organisms
mha	Million hectares
MoEF	Ministry of Environment & Forests
NP	National Park
NTFP	Non Timber Forest Produce
PA	Protected Area
PQ	Plant Quarantine
R&D	Research and Development
SFDs	State Forest Departments
TIFAC	Technology Information Forecast and Assessment Council
UTs	Union Territories

Political Map of India

1 Country background

1.1 Geographical location

India occupies a strategic position in Asia, looking across the seas to Arabia and Africa on the west and to Myanmar, Malaysia and the Indonesian Archipelago on the east. Geographically, the Himalayan ranges keep India apart from the rest of Asia. India is located to the north of the equator between 8° 4′ and 37° 6′ north latitude and 68° 7′ and 97° 25′ east longitude. It is bounded on the south east by the Bay of Bengal. On the north, north east and north west lies the Himalayan ranges. Kanyakumari constitutes the southern tip of the Indian Peninsula and Indira Point in the Andamans and Nicobar Islands as the southern most tip of India. India measures 3214 km from north to south and 2933 km from east to west. It has a land frontier of 15,200 km and coastline of 7516.5 km. India shares its political borders with Pakistan and Afghanistan on the west and Bangladesh and Myanmar on the east. On the northern boundary are situated China, Tibet, Nepal and Bhutan. In the South, it is separated by Sri Lanka by a narrow channel of sea called Palk Strait and the Gulf of Mannar.

1.2 Area

2 The total land area of the country is 328.7 million hectares (mha) which forms 2.4% of the world's total area. There are 28 states and seven union territories administered through 593 districts. There are 384 Urban Agglomerations (UAs), 5161 towns, 35 million plus UAs and 27 million plus cities. Of the total area of 328.7 mha land use statistics are available for roughly 3.05 m ha accounting for 93% of the total land area. Of this, roughly 264 mha of land is available for agriculture, forestry and related purposes.

1.3 Population

3 As per the census, total population of India as on March 01, 2001 stood at 1027 million which rose by 21.34% during the period from 1991 to 2001. This constitutes 16.7% of world's population. India became only the second country in the world after China to cross the one billion mark. The population density of India is 324 persons per

square kilometre. The sex ratio (females per 1000 males) is 933 which rose from 927 as at the 1991 census (Census of India, 2001).

1.4 Economy

4 India is the world's fourth largest economy on purchasing power parity basis with an estimated GDP of US$ 2.2 trillion (2000). The annual growth rate of real GDP during the years 1997-2002 was estimated at 5.4 %, which was one of the highest among major economies of the world in recent years. However, in per capita terms, Indian economy ranks a low 145th in the world. Agriculture and allied sectors play a key role in the economy contributing upto around 20 % of the GDP (GOI, 2002) and accounting for 64 % of the employment (GOI, 1999). Another important feature of the economy is that the organised sector accounts for only 27.96 million jobs (19.314 million in the public sector and 8.646 million in the private sector) (GOI, 2002). It means that most of the people work in the unorganised sectors. Despite this growth rate, about 25% of population still lives below poverty line. There is large variability in the poverty across different states of the country.

1.5 Climate

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

1.6 Topography

6 India's mainland comprises of the following four broad geographical areas:

(a) the Northern Mountains which has the great Himalayas

(b) the vast Indo-Gangetic Plains

(c) the Southern (Deccan) Penninsula bounded by the Western and Eastern Ghats and, lastly

(d) The Coastal Plains and Islands Northern Mountains: The northern mountains correspond to the Himalayan Zone, alongside country's northern boundaries including the Jammu and Kashmir (J&K), Himachal Pradesh (HP), north-west Uttar Pradesh (UP), Sikkim, part of Assam, and the North-Eastern States of Arunanchal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya. The Himalayas comprise of mountain ranges, which form an indomitable physical barrier, as the world's biggest and largest mountain ranges. The Himalayas also contain the cold deserts and fertile valleys.

Great Plains: Also known as the Indo-Gangetic plains, the Great Plains are formed by the basin of three distinct river systems - the Indus, the Ganges and the Brahmaputra. The plains extend from Rajasthan in the west to the Brahmaputra valley in the east. This region covers the States of Punjab, Haryana, and the Union Territories of Chandigarh and Delhi and major parts of U., Bihar, West Bengal, and parts of Assam. These plains comprise one of the world's greatest stretches of flat and deep alluvium soils and are among the most densely populated areas of the world (456 persons per sq.km). The desert region, with the Great Thar desert, extends from the edge of Rann of Kutch to larger parts of Rajasthan (western) and lower regions of Punjab and Haryana.

Deccan Penninsula: This zone covers the whole of south India which includes the States of Tamilnadu, Karnataka, Andhra Pradesh and Kerala. The region also covers the States of Madhya Pradesh, parts of Bihar, Orissa and Purulia district of West Bengal. Density of population is 202 persons per sq. km. The Indo-Gangetic plains and the peninsular plateau are separated by mountains and hill ranges known as the Aravalli, Vindhya, Satpura, Ajanta and Maikala ranges.

Coastal Plains and Islands: The peninsula is flanked on the two sides by the Eastern and the Western Ghats, respectively. On either side of the ghats outward to the sea, lies a coastal strip. The western coastal plains lie between the Western Ghats and the Arabian sea in the west, whereas the eastern coastal plains face the Bay of Bengal in the east. This is also a region with very high-density of population (349 persons per sq. km).

The country is further divided into ten bio-geographical zones which are Trans-Himalayan, Indian Desert, Semi-arid, Himalayan, Deccan Peninsula, Gangetic Plains, Northeastern, Coastal regions, Western Ghats and Indian Islands.

1.7 Watersheds

7 There are mainly three watersheds in the country

(1) The Himalayan range with its Karakoram branch in the north

(2) The Vindhyan and Satpura ranges in Central India, and

(3) The Sahyadari or Western Ghats on the west coast

All the major rivers originate in one or the other of these watersheds.

Rivers

12 rivers are classified as major rivers whose total catchment area is 252.8 mha. The Ganga-Brahamputra-Meghna system is the biggest with a catchment area of about 110 mha.

1.8 Soils

8 India has a wide range of soils, each type being specific to a locality. Alluvial and black cotton soils are the two most important soil groups for agricultural production. Alluvial soils cover about 78 mha (about 24%) of the total land and occur in the great Indo-Gangetic Plains, in the valleys of Narmada and Tapti in Madhya Pradesh and the Cauvery in Tamilnadu. These soils are considered very well for the production of wheat, rice, other cereals, pulses, oil seeds, potato, sugarcane, etc. The black cotton soils cover about 51.8 mha and are found in the states of Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Tamilnadu, Uttar Pradesh and Rajasthan. These are also considered good for cultivation of cotton, cereals, pulses, oil seeds, citrus fruits, vegetables, etc. In addition, red soils have been estimated to occur in 51.8 mha and are primarily found in Tamilnadu, Karnataka, Kerala, Maharashtra, Andhra Pradesh, Madhya Pradesh, Bihar and West Bengal. These are most suited for rice, ragi (millet), tobacco and vegetable cultivation. Laterite and lateritic soils occur in 12.6 mha. These are not considered good for agriculture. The area of desert soils is about 37 mha. These are also not found suitable for agriculture.

1.9 Forests

1.9.1 National Forest Policy

9 The role of India's forests in the national economy and ecology was emphasized in the National Forest Policy, 1988, which focused on ensuring environmental stability, restoring the ecological balance, and preserving the remaining forests. Other objectives of the policy include meeting the needs of fuel wood, fodder, and small timber of rural and tribal people while recognizing the need to actively involve local people in the management of forest resources. Also during 1988, the Forest (Conservation) Act, 1980, was amended to facilitate stricter conservation measures. The goal is to increase the forest cover to 33 percent of geographical area by 2012 from the then official estimate of 23 percent. In June 1990, the GOI adopted a resolution that envisaged involvement of local communities in management of forests as well as sharing of usufructs with them. The joint forest management has now become central theme of most of the afforestation programmes in all the states.

10 The forests of India are endowed with rich flora and fauna. There are about 45,000 plant species in India which is 12% of the global plant wealth. The animal species are approximately 81, 250. There are 92 National Parks and 500 Wildlife Sanctuaries in India. The total extent of protected areas include five designated World Heritage Sites, fourteen Biosphere Reserves, six Ramsar Sites, twenty eight (37761 square km) Project Tiger Reserves and nine Elephant Reserves (Forests and Wildlife Statistics, MoEF, 2004). As such, country has to meet the needs of 16% of the world's population from 1% of the world forest resources. The same forests have also to cater for the 19% of the world's cattle population.

1.9.2 Forest laws

11 The legal framework is provided by four main national laws viz. Indian Forest Act, 1927; Wildlife (Protection) Act, 1972; and Forest (Conservation) Act, 1980 and Biological Diversity Act, 2002. The Indian Forest Act provides the basis for forest administration in the country. The states can also enact their own laws; rules and regulations for administration and management of forests within the overall legal provisions of the central enactments. Most of the states have enacted their own legislations for management of forests as well as regulations of felling of trees, transportation and trade

within the country. The Wildlife (Protection) Act governs the conservation of wildlife and related matters within the Protected Area (PA) network (national parks and sanctuaries, which covers a total area of 15.6 mha) and outside the PA network. The Forest (Conservation) Act, 1980 regulates the diversion of forest land for non-forestry purposes. The Biological Diversity Act, 2002 governs the protection and control of theft of biodiversity and biodiversity related traditional knowledge. Two other major central laws affecting forest administration are the Mines Act, 1952 and the Environment (Protection) Act, 1986. The provisions of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) are implemented through The Foreign Trade (Development and Regulation) Act, 1992.

1.9.2 Extent of forest area

12 As per the State of Forest Report 2003, the total forest cover in the country is 67.83 mha, which constitutes 20.64% of its geographical area. Of this, very dense forests (canopy density above 70%) constitute 5.128 mha (1.56% of geographical area), moderate dense forests (canopy cover between 40-70%) 33.93 mha (10.32%) and open forests constitute 28.77 mha (8.76%). The State of Madhya Pradesh with 7.64 mha of forests has the maximum forest cover among all states/UTs followed by Arunachal Pradesh (6.802 mha) and Chattisgarh (5.59 mha). The total tree cover of the country has been estimated as 9.99 mha (about 3.04%). There has been an increase in forest and tree cover (over the last assessment carried out during 2001) by 2.122 mha which is 0.65 of geographical area. The total growing stock of wood in the country is estimated to be 6,414 million cubic metres (cum) that includes 4,782 million cum inside the forests and 1,632 million cum of trees outside forests.

1.9.3 Forest Types

13 India's forests show greatest variation and range depending upon rainfall, soil, topography and climatic factors. The forests range from tropical rainforests to dry thorn forests and mountain-temperate forests. There are four major forest types (tropical, sub-tropical, temperate, and alpine) and 16 detailed forest types in the country. The detailed forest types are:

1. Tropical Wet Evergreen Forest (Two subgroups)
2. Semi-Evergreen Forest (Two subgroups)
3. Most Deciduous Forest (Three subgroups)
4. Littoral and Swamp Forest (Five subgroups)
5. Dry deciduous Forest (Two subgroups)
6. Thorn Forest (Two subgroups)
7. Dry Evergreen Forest
8. Subtropical Broadleaved Hill Forest (Two subgroups)
9. Subtropical Pine Forest
10. Subtropical Dry Evergreen Forest
11. Montane Wet Temperate Forest (Two subgroups)
12. Himalayan Moist Temperate Forest
13. Himalayan Dry Temperate Forest (Two subgroups)
14. Sub Alpine Forest
15. Moist Alpine Scrub Forest
16. Dry Alpine Scrub Forest

14 More than half of the forest area in India is tropical-moist and dry-deciduous type. Of the 16 forest types in the country, the tropical deciduous forests form the major forest type of India with 38.2 % of the total forest area. Other predominant forest type is the moist deciduous forests which cover 30.3% of the forest area. The forests are both a resource and a habitat for the rich flora and fauna found in the country.

1.9.5 Classification of forests, forestland ownership and management authority

15 The forests are classified as 'Reserved', 'Protected' and unclassified forests which are notified by the state/UT governments concerned. Forests are largely under public ownership. In some of the states, mainly the north-eastern states, the local communities also own major chunk of forests. The subject of 'forests and wildlife' is included under

the 'Concurrent List' of the Constitution of India and both central and state governments can legislate on forestry related matters though the administrative and technical control on forests remains with the states/ UTs. Each state has a State Forest Department (SFD) that functions independently of SFDs in other states. The broad policy framework, laws and management guidelines for all states are framed by the Ministry of Environment and Forests (MoEF), Government of India (GOI) in consultation with the states/UTs.

1.10 Contribution of forests to national and community economies

16 Forests play a vital role in nation's economy. They provide tangible as well as intangible benefits. The tangible benefits include providing fuel wood, timber, non-timber forest products like bamboos, lac, gum, resin, katha, medicinal plants and raw materials for wood based industries like paper, pulp, plywood etc. They also provide materials for defence and communications as well as grazing for cattle. The intangible benefits include conservation of soil fertility and play an important role in the maintenance of the water regime of the land. The forests provide water, perhaps the most important forest product. The organic matter which they yield improves the fertility and increases the water holding capacity of the soil thereby reducing the run-off. The presence of vegetation acts as a physical check to the velocity of the run-off and reduces its soil carrying capacity. Thus forests protect the hilly areas against excessive soil erosion. Similarly, they protect flat lands against desiccation and erosion caused by winds. They exert a beneficial influence on the growth of agricultural crops and on the climate of the region in which they exist.

17 Tribal population and forest fringe dwellers are highly dependent on forests for their livelihood. The forests provide them employment and also NTFPs, fuelwood and fodder. Gross estimates are available for collection of fuelwood & fodder. Sustainable yield of timber from India's forests is estimated at 12 million cum as against the recorded and unrecorded withdrawals of 48.98 million cum at present. Analysis of FSI data reveals that roughly 103 million tonnes of fuel wood is removed annually from forests as against 17 million tonnes available on a sustained basis. Similarly sustainable harvest of fodder from forests is estimated at 65 million tonnes as against the present level of removal of 350 million tonnes annually. Alternative arrangement for procuring 285 million tonnes of fodder would cost USD 4640 millions with an average price of USD 16.3/MT of fodder. Analysis of sustained yield vis-à-vis actual yield of only three forest produce puts the cost

of sustainability at USD 9940 million. However, no systematic studies have been conducted to assess the exact value of the services provided by the forests in the country. (Kishwan & Ratho, 2005).

1.11 Eco-tourism & environmental services

18 Tourism sector in India provides employment to over 8.5 million people. In 1997-1998, it generated foreign exchange of US$ 2530 million. Eco-tourism is being encouraged by the central and the state governments and there is a substantial increase in the number of visitors to national parks and sanctuaries. Eco-tourism forms about 2-4% of the entire tourism industry. The MoEF, GOI is in the process of finalizing the eco-tourism policy for the country. The environmental services include providing water, clean air, carbon sequestration, mitigation of noise pollution and amelioration of climate etc.

2. Forest invasive species background

19 Over the last many decades, a number of Forest Invasive Species (FIS), without realizing the consequences, have been introduced in India knowingly or unknowingly. Checklist of known FIS is appended at **Annexure – I** in the prescribed format. The FIS are further categorized as floral (weeds and plants having national and regional distribution), entomological (insects) and pathogenic (fungi). Approximately, 111 FIS have been identified under the above mentioned categories. No systematic studies have been carried out so far to inventorize the FIS available in its various biogeographial regions. However, India being a vast country, it would be possible to have a detailed inventory through some project support. Many of the invasive species have naturalized in India and are being used for various purposes ranging from medicinal uses, attachments to religious sentiments to uses in furniture, compositing etc. Appropriate strategies will have to be devised for their control, eradication and management in connection with various stakeholders.

2.1 General background on weeds

20 Weeds of invasive nature growing in the forest vegetation form a category of FIS; they include both indigenous as well as exotic taxa. Weed flora of India is very rich. These plants pose a lot of management problem and adversely affect the productivity besides incurring heavy costs in preventive and damage control measures. It is generally very difficult to distinguish between native and exotic species, as they grow intermixed. Exotic invasive species, however, are usually confined to the areas managed or otherwise influenced by man and his dispersing agencies.

21 Weeds have been classified weeds into the following three categories. (Babu, 1977)

i) Category I: - This group comprises of the species, which are thoroughly naturalized and appear to behave as wild plants. These plants are of tropical American origin and are usually obnoxious. They have Napoleonic ambitions to colonize new areas. Members of *Asteraceae, Amaranthaceae, Solanaceae, Malvaceae, Brassicaceae*, etc. belong to this category.

ii) Category II: - This group includes the plants of cultivated origin that have become naturalized or run wild. These weeds represent the members of the families such as *Solanaceae, Cucurbitaceae, Asteraceae, Apiaceae, Brassicaceae, Fabaceae, Lamiaceae, Convolvulaceae,* etc.

iii) Category III: - Species falling under this category are exclusively cultivated, and also met with as escapes which include members of *Acanthaceae, Caryophyllaceae, Malvaceae, Asteraceae, Poaceae, Amaryllidaceae*, etc.

Similarly based on his studies of the flora of the Garhwal Himalayas, Gaur (*Flora of the District Garhwal, Northwest Himalaya*1: 1999) has categorized weeds of the northwest Himalayas according to their seasonal appearance e.g.

(i) Weeds appearing in the rainy season, and

(ii) Weeds appearing in the winter and spring season.

22 The weed flora of North-eastern India is very diverse. Weeds of north-east are required to be taxonomically evaluated in terms of their rich genetic and species diversity. Exotic weeds, owing to their aggressive nature can expand their zone of occupancy in quick succession, spread over large tracts, and endanger the natural

elements of flora and bring about abrupt changes in floristic composition. With seasonal variations invasive species pass through vigorous reproductive phases without any obstruction and hinder the efforts to eradicate them. Invasive plants have appeared at different times and have always sustained and multiplied at the cost of indigenous species. They have occupied vast areas and have even driven many indigenous species into red data categories. In North-eastern India, there are some recent districts, regional and state level floras in addition to Kanjilal's classic work: *Flora of Assam* but for an accurate and up to date inventorization and taxonomic characterization of weeds, a detailed floristic study is the most desirable proposition. Dutta (*Some Common Weeds of the Tea Estates in North-East India,* 1982) worked on the weed flora of the region but confined himself to the tea estates.

2.2 Impacts of existing FIS:

23 Impact of a few major FIS is explained below

Lantana camara is one of the most obnoxious weeds that has encroached most of the areas under community and reserve forestlands. The outer fragile Himalayas are almost completely encaptured by this rapidly spreading weed. This weed, not only ruins common agricultural and forestlands but also makes shade as well as allopathy impacts on the regeneration of important forestry species. Due to spread of *Lantana,* the yields of crops and pastures get reduced. The harvesting costs have increased manifolds. Heavy expenditure is incurred for afforestation of lands infested with this weed which requires frequent weedings so as to avoid suppression of young seedlings of planted species. Afforestation cost is also increased due to loss of stand and slower growth rate due to weed competition.

Parthenium weed is difficult to control as it seeds prolifically. Seed germinates readily and the plant tolerates a wide variety of conditions. The weed is a menace to agriculture because it has allopathic effect and competes with pastures and reduces their carrying capacity. The weed affects human and animal health by causing respiratory problems, severe dermatitis and tainted milk.

Eupatorium glandulosum is found in the temperate region of the south and the north; ecological disruptions have given way to this weed. This weed spreads fast and checks the regeneration of other species particularly in Western Ghats and has replaced the valued flora at places. It comes in disturbed soils. In most of the goat-travelled paths, it

comes up well; that is why it is locally known as *'goat weed'*. Since the plant has no local or commercial use, it has widely spread in denuded and forestlands.

Ulex europaeus represents a fire hazard to private property in the Western Ghats. It invades watersheds, which supply a substantial amount of drinking water. It is threatening agricultural and grazing lands. Thickets of this weed are impenetrable to humans and have persistent spiny litter.

Acacia mearnsii was introduced in Western Ghats particularly in the Nilgiris to provide fuelwood to the rural people to save the shola forests, which were degraded in the past by human activities. It was also planted in the tea gardens to provide shade to the tea plants but now it has covered most of the shola forests and become menace in the Nilgiri Hills. Regeneration of shola forests is effected due to profuse regeneration and invasive nature of this species.

Mikania micrantha is a perennial fast growing weed of Neotropical origin and has become a major menace to the natural forests, plantations and agricultural systems in North-east and South-west India. This weed spreads very fast in areas where canopy is open.

Cytisus scoparius was introduced from European countries in the Western Ghats for ornamental purposes but now it has become menace in the Nilgiri Hills particularly in the shola forests and grazing lands. It reduces the regeneration of shoal species and invades on the grasslands, thus decreases the production of grass for the cattle of Nilgiris. This species spreads fast in the areas disturbed by forest fires or other biotic interferences.

Euphorbia royleana in the Himalayan zones comes up profusely and has covered thousands of hectares of land. This plant represents a desert environment. Being cactus in habit, it has no use in conserving or making of soil. Similarly, in this zone there are a few other plants viz. *Artemisia vulgaris, Carrisa carander* and *Dodonea viscosa*, which have spread like weeds and have large areas under their control. *Cannabis sativa* weed has canvassed most of the deforested and community lands, complicating land management.

24 Beside the above, unabated free grazing and intense human activities have led the way to many other plant species having no use in supporting ecology and economy of

the region. These are *Agave catula, Ageratum conizoides, Cassia tora, Clerodendron viscosum* etc.

2.3 Cross-sectoral threats

25 The FIS not only affects the productivity of forests but also cause heavy losses to agricultural production, blocking of water bodies, water transport ways, affecting wildlife habitat in the forests and wetlands and commercial activities such as cultivation of medicinal plants etc.

2.4 Current methods /techniques for prevention of monitoring control of weeds

26 Presently the following species specific methods are being employed for prevention and control of weeds:

Mechanical: Mechanical control involves hoes, cultivators, harrows, rotary weeders, discs, ploughs, scythes, mowers and manual uprooting. The weeds are physically lifted from the soil, cut off or buried. In most of the forestry operations the FIS such as lantana, eupatorium, mikania, mimosa, etc. are uprooted manually and either burnt or buried. In some places, those are being used for making compost.

Chemical: This is one of the most common methods employed for control of FIS. Most chemicals are species specific though their use is not always desirable due to environmental degradation and pollution that they often cause and their effects on other useful species.

Tillage: Tillage helps in the burial of most small annual weeds. If all growing points are buried, most annual weeds will be killed. Tillage also disturbs the rooting system of most of the perennial weeds. The root system is cut to enough depth so that the plant dies from desiccation before it can re-establish its roots. In moist soils or if it rains soon after tillage, the roots may quickly re-establish themselves. In effect one may transplant the weed with little or no injury. Mowing is effective on tall growing plants. Tall annual weeds are mowed or scythed to reduce competition with crop plants and to prevent seed production.

Crop competition: Crop competition is one of the cheapest and most useful methods farmers can use. Often it means using the best crop production methods so favorable to

the crop that weeds are crowded out. Actually competition makes full use of one of the oldest laws of nature-"Survival of the fittest". Weeds compete with crop plants for light, soil moisture, nutrients and carbon dioxide. One mustard plant (weed) requires twice as much nitrogen and phosphorus, four times as much potassium, and four times as much water as a well developed oat plant. Early weed competition usually reduces crop yields far more than late season weedy growth. Therefore, early weed control is extremely important. Late weed growth may not seriously reduce yields, but it makes harvesting difficult, reduces crop quality, and reinfests the land with seeds and harbors insects and diseases. In planning a control programme, it is important to know the weed's life cycle. If it is possible to interrupt the cycle it becomes very effective control. In crop production, this may be a shift in planting date or a well-timed chemical spray; thus the crop gets the upper hand or competitive advantage. Smothering with plastics, tar, paper, straw, saw dust or any other similar material is largely a matter of competition for light. Most weed seedlings cannot penetrate the thick coverings and die because of lack of light.

Crop rotation: Certain weeds are more common in some crops than in others. Besides the annual weeds, for the parasitic weeds, such as striga in sorghum and orabanche in tobacco, the hosts are the crop species grown. Rotation of crops is an efficient way to reduce weed growth. A good rotation for weed control usually includes strong competitive crops grown in each part of the rotation. In growing mixed crops as in the tropics, the weed problem is eliminated to a greater extent in most of the irrigated crops.

Biological control: In biological weed control, a 'natural enemy' of the plant is used which is harmless to desired plants. Insects or disease organisms are the usual natural enemies. Also parasitic plants, selective grazing by livestock, and highly competitive replacement plants are other forms of biological control. The outstanding example of biological weed control is the one on Cactus (*Opuntia spp.*) with a moth borer *Cactoblastic cactorum* and or *Lantana camara* with several kinds of caterpillars and a fly, which damages the berries. Researchers have located and tested numerous biological agents against Parthenium weed. These include a gall forming moth, leaf minor, weevil, beetles and a rust fungus.

2.5 Actions being considered to prevent introduction of FIS

27

i) **Limit soil disturbances**: To limit the establishment of invasive plant infestations, prevent unnecessary soil disturbances, wherever possible.

ii) **Immediate re-vegetation of disturbed sites**: To limit the potential establishment of invasive plants on disturbed ground, re-vegetate the area with approved species through a time bound plan. If the area has a known invasive plant population, it may be better to control the plants prior to re-vegetation.

iii) **Use certified "Weed Free" Seeds for re-vegetation of disturbed sites**: To ensure virtually invasive plant free seed mix, a purchaser should request a "**Certificate of Seed Analysis**". To get a more detailed "Certificate of Seed Analysis" the purchaser can request a larger seed sample analyzed, rather than the typical 25 gm sample to improve the confidence of the analysis. Alternatively, one can start with pure seeds and then prepare the seed mix manually.

iv) **Clean equipment and materials**: Practice due diligence by ensuring that all equipment, materials and vehicles are free of invasive plant seeds and plant parts before arriving on site. All agricultural implements or any equipment potentially exposed to invasive plants must be cleaned prior to use. Also equipment, materials and vehicles exposed to weeds are to be cleaned prior to leaving the infested site.

v) **Use of "Weed free" hay bales for erosion control and feed**: The use of straw bales for erosion control is discouraged. Unlike hay, it is very difficult to determine if the straw bales are free of invasive plant seeds. Therefore, certified "weed free" hay bales acquired from producers with a "Certificate of Inspection" should be used for erosion control. Hay imported for feed should as well be certified as "weed free."

vi) **Early detection and eradication**: Because a single plant and small infestations are much easier to control than large infestations, it is important to manage invasive plants proactively through continuous monitoring. To do this effectively, field staff should be trained in the identification of restricted and noxious invasive plants, collection of survey information, and the importance of destroying individual invasive plants and reporting new infestations in a timely manner.

vii) **Pre-activity invasive plant survey**: An invasive plant survey should be completed prior to the commencement of any land disturbing activity to identify potential problem areas. Sites with invasive plants identified should be taken note

of in order to alter practices to limit their spread (e.g. control prior to land disturbance, cleaning of equipment and materials before leaving the site). As the pre- activity invasive plant survey acts as a heads up for potential infestations, a follow-up survey should be completed to assess the invasive plant conditions as a result of the activities.

viii) **Limit seed introductions in Fill**: Inspect gravel pits, soil stockpiles or other fill sources for invasive plants prior to movement of the material to ensure the product has a low risk of introducing invasive plants.

ix) **Communication**: Communication between various stakeholders and provincial and municipal government agencies is beneficial to transfer information for promoting regional awareness. Information such as the invasive plant history of certain locations or invasive plant infestation locations may be beneficial to all parties.

x) **Incorporate invasive plant management in planning phase**: Inventory of invasive plants should be considered in all operational plans to ensure effective and efficient management. Effective invasive plant management plans should incorporate education, survey, control, and prevention measures.

xi) **Education and awareness**: Invasive plant education and awareness programmes developed co-operatively or individually by companies and agencies are essential in order to put the above prevention measures into practice. The people have to be made aware of the harmful effects of these weeds and how to utilise the eradicated raw materials for economic uses. The invasion of the weeds needs to be controlled and utilize their raw material for economic uses. For example, the Eichhornia weed is being utilised for electricity generation and eupatorium for preparation of compost. Forest Research Institute has made furniture and buckets from *Lantana camara* wood.

2.6 Technical and financial barriers

28 Some of the FIS have widely spread in almost all the biogeographical regions of the country; many intermingled with commercially valuable plant and animal species. Their biological control may be injurious to other species and the chemical control may result in chemical pollution of the soil and environment. The mechanical control

measures prove very time consuming and need a lot of finances. Adequate and thorough research is needed to find out the most cost effective ways to control the FIS.

2.7 Potential future FIS threats

29 Indian economy has major stakes in agriculture, horticulture and forestry activities and is actively engaged in import and export of planting materials and products. India has a well-established quarantine system, which regulates the import and export of these materials to check the entry or exit of the harmful pathogens. But still the possibility of various pathogens being introduced into the country or sent to other countries despite the quarantine regulations cannot be overruled. In the forestry sector, in the last few decades some new pathogens got into India along with some exotic tree species introduced in the plantation programmes.

30 To conserve the forest wealth by protecting trees and timber from bio-deterioration due to microbes, insect pests and marine borers, 'Wood Bio-degradation Division' of Institute of Wood Science and Technology, Bangalore under the Indian Council of Forestry Research and Education (ICFRE) has been engaged in studies on the diverse groups of microbes, insect-pests and marine organisms which cause bio-deterioration of trees and timber. In addition to this, the institute is also involved in studies of insect diversity in different forest ecosystems like mangroves in west and east coasts, forests in Western and Eastern Ghats and also in Western and Eastern Plains. Many species have been collected and documented which include both indigenous and bio-invasive species.

Bio-invasions associated with wood imports

31 Insects are major determinants of forests productivity. Periodic outbreaks of insects occur in the natural forests that causes heavy losses. In monocultures, the outbreaks of insect pests are frequent which reduces the productivity of the plantations besides causing mortality in extreme cases.

32 There is a huge gap between demand and supply of timber in the country. As against an annual requirement of 64 million cum (excluding fuel wood), the supply is of the order of 43 million cum from all sources. Imports of wood and wood products constitute one of the major sources of supply. The situation is likely to remain the same for some more years to come, as several sections of the society have clear economic

incentives to continue importing timber for a variety of uses. The volume of trade is increasing. As volume of trade in forest products increases so do the chances of invasion of alien species that can cause large-scale infestations and possible destruction of forest ecosystems, where natural immunity does not exist. Under the new regulations of World Trade Organisation wherein a lot of restrictions have been eased for facilitating free trade, the chances of introduction of FIS are even more.

2.8 National priorities in combating/controlling FIS

33 Through regulations and strict monitoring, the authorities have been laying emphasis on checking introduction of Invasive Alien Species (IAS) through trade and tourism. Strict checking of import of plant and animal species and products is being ensured at all the entry points. National priorities include considering common regulations for coordination by the various agencies in the country which control major pathways of IAS by one agency and strict checking at all the possible entry points, creating general awareness among the public, policy makers and other authorities, exchange of information among the neighbouring countries through the established international and regional networks, finding adequate financial resources and capacity building of research and development activities for identification, prevention, eradication, control and management of IAS. Details of a case study conducted for investigation of bio-invasion associated with wood are give at **Annexure -II**

2.9 Level of public awareness of existing and potential FIS

34 At present there is not much awareness among the public of the existing and potential threats of the IAS including FIS and also no systematic national level initiative has been made in this direction. However, awareness on the problem is increasing and a few scientific seminars/workshops on the subject have been organized at the national and states levels. But, much needs to be done in creating awareness among the public, policy makers and academicians about the socio-economic effects of FIS. India is party to a number of international and regional convention/institutions/instruments to address the problem of the IAS. Participation in the meetings of these institutions/instruments and their publicity in the media is also helping in creating awareness among the public.

3. Management and institutional framework

3.1 Policies, laws, regulations and national and local agencies having lead responsibility

35 India follows international quarantine regulations, which are amended from time to time. Directorate of Plant Protection, Quarantine and Storage, Faridabad under the Ministry of Agriculture, GOI with its network of stations particularly at port of entries, is the nodal agency to enforce the regulations. Two institutes i.e. FRI, Dehradun and Institute of Forest Genetics and Tree Breeding, Coimbatore under the ICFRE are authorized institutes to issue phytosanitary certificates for exporting any products or produce of forest origin.

36 The regional offices for wildlife preservation of the GOI under the Ministry of Environment and Forests (MoEF) established at New Delhi, Mumbai, Chennai and Kolkata with their sub-regional offices at Amritsar, Kochi and Guwahati check and regulate the import and export of wildlife species at airports and sea ports. But with the limited manpower and infrastructure, the measures need a lot of strengthening.

37 The State Forest Departments (SFDs) concerned are solely responsible for managing the forests in the country. The management of weeds in Indian forests encompasses a task of stupendous magnitude, which consumes major chunk of funds allocated to the forestry sector. Organisations like the ICFRE and its institutes, Botanical Survey of India, Botany Departments of the Universities, State agencies, Van Vigyan Kendras, NGOs, etc. work on different aspects of the forest vegetation but not much on weed control. Indian Council of Agricultural Research (ICAR) with its network of institutes, Agriculture Universities, Krishi Vigyan Kendras, etc. have, however, done a lot of work on the management of weeds in agriculture. Given the challenges that are arising in forest areas due to FIS, further re-orienting the research priorities and strengthening of ICFRE institutes and other similar organizations is required.

38 Nevertheless, in consonance with the provisions of the International Plant Protection Convention (IPPC), the GOI issued terms and conditions for inspection and fumigation, disinfection or disinfestations of exportable plants and plant products for issuance of phytosanitary certificates. Thereafter, the procedures in this regard have been outlined by the Directorate of Plant Protection, Quarantine & Storage in 1988. Subsequently, GOI issued the list of the officers in central/state governments authorized to inspect/treat and issue the phytosanitary certificates, during November, 1993, (Plant Quarantine Manual on Export Certification and Issuance of Phytosanitary Certificates, 1998).

39 India is well aware of the problems of bio-invasion and its obligations towards SPS Agreement and is gearing itself up to meet the challenges. Till recently, there were no separate rules for import of wood and wood products, these being treated as agricultural commodities. During the study period (November 2003), the GOI (Ministry of Agriculture, Department of Agriculture and Cooperation) notified the plant quarantine regulation (Regulation of Import to India Order) (referred to as PQ Order, 2003 in this report) that has generated a great deal of debate. Five amendments followed quickly (up to September 2005), reflecting the importance attached to the problem. The sixth amendment is under consideration.

40 Though India is moving closer to meeting the standards set by International Plant Protection Convention (IPPC), a standard setting organization acceptable to SPS, with a basic framework to meet its obligations, adequate technical manpower, infrastructural facilities and linkages between enforcement authorities, R & D institutes, industry and other groups are required for effective implementation.

3.2 Barriers for cooperation

41 No barriers exist for soliciting cooperation in the identification, monitoring or control of the FIS.

3.3 Situation of overlapping authority

42 There are no overlapping or conflicting responsibilities for managing the IAS. However, there is need for better coordination.

3.4 Institutions and organizations responsible for research

43 The ICFRE and its institutes, the state forest research institutes, the SFDs and agricultural universities are responsible for undertaking research on various aspects of FIS management.

4. Strategies, mechanisms and measures to control FIS

4.1 National, trans-boundary strategies & mechanisms and quarantine measures

44 The Directorate of Plant Protection, Quarantine & Storage, located at Faridabad, Haryana, under the Ministry of Agriculture (Department of Agriculture and Co-operation) is responsible for implementation of plant quarantine regulations in India and is headed by the Plant Protection Adviser (PPA) to the GOI. Presently, there are 25 plant quarantine stations functioning all over India. The plant quarantine stations at major/minor stations are headed by Plant Protection Officers and are assisted by Technical Officers of Grade-I, II & III. They are responsible for issuing the phytosanitary and quarantine certificates as per the regulations.

45 The plant quarantine regulations have been formulated by the Plant Quarantine Organization of India under the Ministry of Agriculture. A copy of the regulations, Plant Quarantine Order, 2003 (PQ Order 2003), is available at *www.plantquarantineindia.org*

46 The regulations specify general conditions of import of plants, plant products, soil, live insects, mites, nematodes and microbial cultures including algae / bio-control agents, timber etc (Chapter II of PQ Order 2003 and Chapter III special conditions for import of plant species of PQ Order 2003). Post entry quarantine measures have also been specified (Chapter III of PQ Order 2003). The order also specifies the formats to be used for various types of permits and contains details regarding import of plant material such as (a) points of entry into the country, (b) list of inland container depots and container freight stations, (c) list of foreign post offices, (d) list of plants/planting materials and countries from where import is prohibited along with justifications, (e) list of plants and plant materials for restricted import only by authorized institutions, (f) list of

plants/planting materials, where imports are permissible on the basis of phytosanitary certificate issued by the exporting country, (g) list of quarantine weed species (Schedule-VIII of PQ Order, 2003, appended as **Annexure – III**), (h) list of inspection authorities for certification of post-entry quarantine facilities and inspection of growing plants (Schedule-XI of PQ Order, 2003 appended as **Annexure –IV**).

47 With reference to Schedule-XI of the PQ Order 2003, the GOI is yet to officially designate the State Forest Departments and the ICFRE institutes as authorities for monitoring, control of FIS and implementation of import / export controls from forest, national parks and other protected areas.

48 **International quarantine regulations are very stringent**. The Cartegna Protocol on Bio-safety entered into force on 11 September, 2003 after it was ratified by 50 governments. Till date 100 governments have ratified the protocol (http://www.biodiv.org). Its aim is to ensure that recipient countries have both the opportunity and the capacity to assess risks involving the products of modern biotechnology. The Protocol established a harmonized set of international rules and procedures designed to ensure that countries are provided with the relevant information to enable them to make informed decisions before agreeing to the import of Living Modified Organisms (LMOs) via a Bio-safety Clearing House, a mechanism set up to facilitate the exchange of information on and experience with LMOs. In addition, commodities that may contain LMOs are to be clearly labeled as such when being exported. The treaty known as **Advance Informed Agreement** procedure requires countries exporting LMOs to gain consent from importing country, prior to export, and to ensure that exports are accompanied with appropriate documentation. The aim is to ensure that recipient countries have both the opportunity and the capacity to assess risks involving the products of modern biotechnology.

49 Utmost care has to be taken by the countries which export or import the planting material or wood so as to ensure that harmful organisms should not be exported along with the consignment. For this each consignment must be accompanied with a phytosanitary certificate indicating that the consignment is free from all injurious organisms. Even then some harmful organisms may be inadvertently introduced in many countries including India. When these organisms enter a new environment free from competitors and life threatening forms, their population increases with likelihood of the

organisms turning invasive in due course of time. These invasive organisms including insects cause heavy losses to the forest and forest products.

4.2 Mechanical, biological and chemical control measures

50 Adequate strategies, mechanisms and measures for the effective control of the weeds of agriculture, horticulture, and floriculture are adopted throughout the length and breadth of the country. These include prevention, control, suppression, eradication, etc. However, information available on management of FIS in forest areas is not adequate. Some of the control measures undertaken for major FIS in India are given at **Annexure V.**

4.3 Mechanisms/institutions for conveying information

51 Presently there is no fool proof system of reporting about the existence of IAS or FIS in India either to the government officials or the general public. Only when a species becomes invasive and starts affecting socio-economically, measures are taken for its eradication and control.

4.4 Mechanisms and partnerships

52 Many of the NGOs, universities and private institutions undertake research in collaboration with the government departments and cooperate in monitoring and control of the FIS

5 Facilities and services available for national or regional cooperation

5.1 Tools and information for sharing

53 The information available on various effective control methods FIS, the ongoing projects on management of the FIS and the FIS which got introduced accidentally in the recent past or likely to create problems can be shared with the members of the network.

5.2 List of experts/scientists in the field

54 Information on resource persons having expertise in dealing with the FIS is being obtained from various sources including universities which will be communicated in due course. However, information on a few scientists/experts is given at **Annexure VI.**

5.3 Research institutions for undertaking research

55 In India, a number of government institutions are available for undertaking research on FIS. The universities also have well equipped laboratories, training facilities and field sites for undertaking research. Details of some of the institutions are

1) Forest Research Institute (FRI)

56 One of the institutes of the ICFRE is one of the oldest forestry research organizations in South Asia and very well reputed for scientific research in forestry. Several collaborative projects with international organizations have been successfully completed in the past and several more are being implemented currently. With this experience and expertise the Council has immense potential and scope for national and regional co-operation in FIS. Some of the facilities available are highlighted below:

57 Infrastructural, scientific and technical facilities are available in ICFRE and its regional institutes. Besides, the regional institutes maintain herbaria of forest plant and insect species. The plant specimens have been authentically identified and can be utilized as important reference collections for taxonomical and other related studies of invasive species. ICFRE has experienced plant taxonomists, entomologists, and pathologists. The expertise is available on the fungi belonging to Ascomycotina, Deuteromycotina and Basidiomycotina, especially those infecting forest species.

58 The forest pathology division of FRI has all the necessary equipment and space for inoculation, incubation and growth studies, like incubators, autoclaves, growth chambers, laminar flows, ovens, electronic balances, research microscopes, microphotography, pH meter, growth chambers, seed germinators, etc. A glasshouse

essentially required for experiments on the invasive species in isolation is also available in the division. These facilities can be extended to the member countries for collaborative work**.**

59 The division of forest entomology in FRI maintains an authentic reference collection of insects with more than 22,000 species of insects out of which 1,700 are 'type' specimens. The division provides insect identification services for other organizations. The Institute is recognized by many International organizations such as FAO, IUFRO etc.

2) Himalayan Forest Research Institute, Shimla

60 It has a well equipped laboratory and field station at different altitudinal ranges for testing and control of incidences of pest infestations in forest areas.

61 These **i**nstitutes have **c**onference hall and multimedia facilities along with accommodation for participants for arranging workshops / seminars at both national and international levels

3) Kerala Forest Research Institute (KFRI), Peechi, Kerala

62 KFRI is one of the pioneer institutes which has done quite substantial work on the FIS and has got a number of excellent scientists and facilities for undertaking collaborative projects at international as well as regional levels. Results of some of the research projects undertaken by the KFRI on FIS are given at **Annexure VII.**

Facilities available with the institute which can be shared

Services of experts

63 Experts in the areas of weed ecology, bio-control, plant pathology, entomology, plant taxonomy, insect taxonomy, fungal taxonomy and biotechnology are working in the institute. Their services will be available for collaborative research.

Experimental sites

64 Experimental sites for conducting surveys and field trials will be available anywhere within the state with the help of the forest department. Moreover, the institute has its own field stations with extensive areas for conducting field testing.

Research infrastructure

65 Glass house, net house, inoculation rooms, cold rooms for culture storage, laboratory with excellent microscopes and most modern equipments like atomic absorption spectrophotometer, auto analyzer, and HPLC digestion system. a world class biotechnology laboratory is an added facility.

Conduct of workshops and seminars

66 The institute has been a venue of several national and international seminars and workshops. We have a world class fully air-conditioned auditorium with excellent audio and video facilities, three extra seminar rooms to run concurrent sessions (all air-conditioned), facility for power-point presentation, power backup and other connected facilities.

5.4 Venues for holding workshops/seminars

67 All the institutes mentioned above and a number of other well furnished and equipped venues with air connectivity are available for holding international workshops/seminars. The names of a few such institutions are as below

S.No	**Institutions**	**Nearest Airport**
1	FRI Dehradun	Delhi 270 Km/Jolly- Grant 25 Km.
2	IWST, Bangalore	Bangalore
3	KFRI, Peechi	Kochi 55 Km
4	IFGTB, Coimbatore	Coimbatore
5	HFRI, Shimla	Delhi/Shimla
6	TFRI, Jorhat	Guwahati/Jorhat
7	AFRI, Jodhpur	Jodhpur

68 Near to the venues for holding international workshops/seminars, field visits can be conducted for the participants to the sites where FIS control measures have been successfully undertaken.

5.5 International treaties, MOUs and other agreements

69 India is signatory to a number of international Conventions/Treaties and Agreements dealing with invasive species some of which are mentioned below:

1 Convention on Biological Diversity (Nairobi, 1992)

2 Cartegna Protocol on Biosafety to the Convention on Biological Diversity (Montreal, 2000)

3 United Nations Convention on the Law of the Sea (Montego Bay, 1982)

4 The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971)

5 Convention on Migratory Species of Wild Animals (Bonn, 1979)

6 IUCN-Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species (2000)

7 Agenda 21 – United Nations Conference on Environment and Development (Rio, 1992)

8 Asia Pacific Forest Invasive Species Network, FAO Regional office, Bangkok.

6 Related websites

70

S. No.	Institute/Organisation	Website
1	Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture, GOI	www.plantquarantineindia.org
2	Forest Survey of India, Dehradun	www.fsiorg.net
3	Indian Council of Forestry Research & Education, P O New Forest, Dehradun –248 006, Uttaranchal (INDIA)	www.icfre.org
4	Kerala Forest Research Institute Peechi - 680 653, Kerala, India.	www.kfri.org
5	MoEF, GOI	www.envfor.nic.in

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9) Forests and Wildlife Statistics, Ministry of Environment and Forests, 2004.

Annexure-I

Checklist of Forest Invasive Species having National Distribution

1. Floral FIS (Weeds and plants)

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
1.	*Acacia farnesiana*	Babool	Australia	-	-	Seeds	Wild animals	Grassland and open forest area creating dense thickets through which livestock cannot move	-	-	National
2.	*Acacia mearnsii*	Black Wattle	Australia	For tannin, fuel plantations on high altitudes in South India	Early 1800	Animals ,water, regenerates rapidly after fire, both by re-sprouting and by growing from a persistent soil seed-bank	Logging, wild animals, commercial nurseries	In Western Ghats, forests & grazing lands, degraded lands, forest areas of Nilgiri hills of South India.	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
3.	*Achyranthes aspera*	**Prickly chaff flower, utlihot, ublisoth, bonsodh, upomargo**	India	-	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations	Commonly available throughout the area.	-	-	National
4.	*Ageratina adenophora*	crofton weed	Mexico	-	-	Air, water	Animals, transport network, nurseries	The weed has occupied vacant places in teak, rubber and other forest plantations and causing serious threat to forests	In hilly areas of south and north India, it forms dense thickets on grazing lands	-	Foot hills of Himalayas, north-east and southwest India
5.	*Ageratum conyzoides*	Goat weed, gondhwabon, gandhali bon Gandhela, Podina ghas, Mamira ghas, mahkua	Tropical America, naturalized throughout India	Intentional, contaminated in crop seeds	1860	Air, water	Animals, graziers and fodder collectors	Wastelands, plantations, pastures and all forest types to 1500 m above sea level	Increasing per year	-	National
6.	*Ageratum. houstonianum*	Gandhela, Podina ghas, Mamira ghas	Tropical America	Intentional	C. 1900	Openings mixed with grasslands	Graziers and fodder collectors	Along the outskirts of forests, natural and plantations		-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
7.	*Alternanthera philoxeroides*	Alligator weed	Indonesia and Myanmar	-	-	Through water ways	Not found	Alligator weed causes major blockages of water flow in waterways such as irrigation canals and rivers	The weed has been reported to accumulate heavy metals causing water pollution.		National
8.	*Argemone mexicana*	**Prickly poppy, Mexican poppym kuhumkanto, shial katehi**	Central and Tropical America, West Indies, naturalized throughout India	Accidental	-	Fodder, forage, water run off, transportation of grains and vegetables, etc.	Animal and human agencies, causes a host of diseases in human beings, its seeds mixed with mustard seeds.	Forests, agricultural fields, orchards, throughout the area	-	-	National
9.	*Cassia occidentalis*	**Coffee senna, medelwa**	India	-	-	Fodder, forage, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations.	Not uncommon throughout the area	-	-	National
10.	*Cassia tora*	**Tavra, foetid cassia, bon medelwa, alokoni**	India	-	-	Fodder, forage, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations	Not uncommon, throughout the area	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
11.	*Chromolaena odorata L.*	Siam weed, devil weed	Tropical South and Central America	Via ballast in ships, as an ornamental plant	1840	By wind, spreads rapidly in lands used for forestry, pasture and plantation crops	Wild animals and dispersal of seeds by wind	Spreading in dry open areas of forests, plantations and scrubland. In forest areas of Western Ghats and Eastern Ghats, colonizes mostly in forest clearings and fringes of forests.	-	-	National
12.	*Cuscuta spp.*	Dodder	-	-	1965 in West Bengal	Transported through seeds	-	A single plant of cuscuta can produce as high as 50, 000 seeds and can grow to a length of 2 km. This weed attaches itself to stems and leaves of a wide variety of host plants and establishes a parasitic union.	It is causing severe damage to forest and agricultural crops in India.	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
13.	*Cyperus pilosus*	**Harkota bon**	India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Throughout the area	-	-	National
14.	*Cyperus rotundus*	**Mutha**	India.	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Throughout the area	-	-	National
15.	*Cytisus scoparius*	Yellow broom	Europe	Introduced intentionally as ornamental plants	-	Regenerates rapidly after fire, both by resprouting and by growing from a persistent soil seed-bank	Wild animals	Covers open areas and forms dense mono-specific thickets.	-	-	National
16.	*Desmodium laxiflorum*	**Bionic sopota**	India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Throughout the area	-	-	National
17.	*Dioscorea deltoidea*	**Bonoria kath alu**	India	-	-	Through man, animals, cattle and water.	Through man, animals, cattle and water	Throughout the area	-	-	National
18.	*Dioscorea pentaphylla*	**Paspotia alu**	India	-	-	Through man, animals, cattle and water.	Through man, animals, cattle and water	Throughout the area	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
19.	*Eclipta prostrata*	**Kehraj**	Cosmopolitan in warm countries, India	-	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals, man and nursery operations.	Common throughout the area	-	-	National
20.	*Eichornia crassipes*	Water hyacinth, bih meteka	South America (Brazil), naturalized in India	Intentionally introduced by transport through ships	c. 1914-1916	Through man, cattle, other animals, water transport, spread through stolons	Through man, animals, cattle and water	Nuisance for aquatic ecosystems as it causes hindrance in navigation, chokes irrigation systems and reduces value of water bodies	Almost all the ecosystems	-	National
21.	*Eupatorium glandulosum*	Kala bansa	-	-	1950	From South America	-	Forest areas, plantations, cultivated fields etc.	-	-	National
22.	*Euphorbia hirta L*	Garden spunge, Asthma plant	Tropical America	-	-	Air, water	Animals, nurseries	Cultivated lands, gardens, lawns, wastelands	-	-	National
23.	*Eupatorium odoratum*	**Siam weed, sam holok, bagh dhoka, pohu odal, german habi**	Central and South America. Naturalized in India	Accidental	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals, birds, man and nursery operations.	Common throughout the area.	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
24.	*Fimbristylis miliacea*	**Keya bon**	India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Throughout the area	-	-	National
25.	*Galinsoga parviflora*	Gallant soldier or yellow weed	Neotropical	-	-	-	-	Covers urban areas, trails, open rocky sites and pasture lands	-	-	National
26.	*Ichnocarpus frutescens*	**Black creeper, dudh lota, dudh koori**	India	-	-	Through man, cattle, other animals and air.	Through man, animals, cattle and air	Throughout the area	-	-	National
27.	*Mimosa pigra*		Mexico, Central and South America	-	-	Transported through seeds	-	It makes infested areas inaccessible to animals and people, and interferes with stock watering, irrigation and recreational use of waterways	It invades watercourses and seasonally flooded wetlands in tropical and sub-tropical regions	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
28.	*Imperata cylindrica*	**Thatch grass, alang alang, cogon grass, Ulu, kher**	Philippines, India	-	1940	Fodder, forage, wind, birds and water run off,	Cattle, animals, birds and man.	Swamps, floodplains, dry scrubs, and sand dunes, as well as the sand hills, roadsides, pastures, utility rights-of-way, and mined lands.Throughout the area, not uncommon	-	-	National
29.	*Ipomoea carnea*	Bahaya, Sada suhagan	South America	Intentionally introduced as flowering plants, cuttings	Early 20th century	Cutting, aggressive colonizer of riparian zone, transported through seed, escapes from gardens and aquariums	Animal, nursery raised cuttings, fuel wood collectors, planting for decoration	It is perennial diffuse or straggling shrub and comes up in water logged areas and is resistant to drought, causes hindrance in navigation and chokes irrigation systems	They are widely seen in roadside and farm ditches, shoreline and river-sides. It has become an obnoxious aquatic weed	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
30.	*Ipomoea fistulosa*	**Besharam, behaya**	Tropical America, naturalized in India	Accidental or perhaps introduced.	-	Cattle, water run off, wind, garden waste and man	Water channels and disturbed areas in forests, wastelands, fringes of villages etc., throughout the region	Forest areas, water channels and hedges.	-	-	National
31.	*Lantana camara L*	**Lantana, large leaved lantana, podina ghas Kurri Ghaneri (Mar); Pulikampa (Tel); Unnichedi (Tam); Hesike (Kan); Arippu (Mal)**	Tropical America, naturalized throughout India	Introduced as an ornamental plant	1809	Nursery, trade, animal excretion, garden waste,	Animals, birds and human agencies, transport networks, commercial nurseries, etc.	Common throughout the country in the forests, plantations, agricultural land, disturbed areas, grass lands, wetlands, riparian and urban areas	Areas under Lantana increasing by 700 ha per year (approx.)	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
32.	*Leucaena leucocephala*	Subabul, Ipil-ipil	Mexico, Central America and West Indies	Forage production and afforestation programmes	1960	Transported through seeds, animals, water	Animals, transport network, humans	Invades cleared areas, wastelends and forms dense thickets	It forms dense thickets and difficult to eradicate, rendering extensive areas unusable and threaten-ing native plants in most areas.	-	National
33.	*Melochia corchorifolia*	**Bon mora**	India	Accidental	-	Fodder, forage, wind water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operation s	Common throughout the area	-	-	National
34.	*Microcystis*	-	China	Introduced for fertility induction	-	Spores spread through water and aquatic animals	-	Invasive weed causing extensive damage to the aquatic ecosystems and affect aquatic biodiversity	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
35.	*Mikania micrantha*	Silver bullet, Mile-a-minute weed	Tropical and subtropical zones of North and South America	Introduced as ground cover an air force runway, camouflage during World Wars and cover crop for tea plantations	Early 1900	Air, water, nursery, trade	Wildlife, animal transport network and nurseries	Major menace in natural forests, plantations, agricultural systems in northeast and southwest India, disturbed areas	Spreading fast in South-west and North-east India	*Puccinia spegazzinii* fungus.	National
36.	*Parthenium hysterophorus L*	**Carrot weed, congress grass,white top grass, gajarghas Chatakchandani**	Mexico, Argentina, Tropical America, invaded large areas in India.	Commercial trade from USA, believed to have come with Mexican wheat consignment	1950	Wind, water run off, transport of grains and vegetables, garden waste etc.	By air, cattle, nurseries animals and man.	Agricultural fields, forest areas, grass lands & urban areas, aggressive colonizer of degraded areas with poor ground cover and exposed soil such as fallow wastelands, roadsides and overgrazed pastures between existing plant cover and native weed density	Spreads very fast, it infests about 5 million hectares area	*Epiblema strenuana*	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
37.	*Prosopis chilensis* (Molina) Stuntz	Vilayati kikkar, Kabuli kikkar (*H*); Velikaruvel delli mullu (*Tam*)	Native of south and central America			Animal excretion; garden waste	Animal excretion	The species is commonly found in plains of Tamil Nadu and Andhra Pradesh and has spread to dry deciduous forest areas.			National
38.	*Prosopis juliflora*	Vilayati Babool	Central and South America	Intentionally introduced for greening dry area and for fuelwood purposes	1915	Nursery trade; animal excretion; garden waste	Animal, commercial nurseries	Affecting agricultural areas, coastlands, disturbed areas, roadside, railway tracts, planted forests, range/grassland, riparian zones, scrublands, urban areas and wet lands.	-	-	National
39.	*Saccharum spontaneum*	**Kans grass, wild cane, kohua**	India	-	-	Fodder, forage, wind and water run off	Cattle, animals, birds and man.	Not uncommon throughout the area.	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
40.	*Salvinia molesta*		South America	-	-	Water transport, spread through stolones	Animals	Nuisance for aquatic ecosystems and reduces aesthetic value of water bodies	-	-	National
41.	*Sida acuta*	**Snake's tongue, Sonbrial, boriala**	Pantropical . invaded throughout India	Accidental	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations.	Common throughout the area	-	-	National
42.	*Sida orientalis*	**Paroquet bur, sida hemp,broom jute sida, soru sonbrial**	Pantropical . invaded throughout India	Accidental	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations	Common throughout the area	-	-	National
43.	*Solanum elaeagnifolium*	Silver leaf night shade, Whiteweed	South west United States and northern Mexico	Ornamental	-	Nursery trade, animal excretion, garden waste	Seeds, creeping rhizomes and root fragments through agricultural operations	It attacks agricultural crops	It is damaging adjoining forest areas or plants of agricultural crops	-	National
44.	*Solanum viarum*		South America	-	-	Seeds	Livestock (cattle) and wildlife	It is an aggressive perennial of most of the areas	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
45.	*Tridax procumbens*	-	Tropical America, naturalized in India	Accidental	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations	Common throughout the area	-	-	National
46.	*Triumfetta rhomboidea*	**Champadang, spiny cocklebur, Bon ogora**	India	-	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals, birds, man and nursery operations.	Common throughout the area	-	-	National
47.	*Ulex europaeus*	Gorse	Europe	Introduced intentionally as an ornamental plant		Seeds, insects, it regenerates rapidly after fire both by re-sprouting and by growing from a persistent soil seed-bank	Wild animals	Covers open areas and forms dense monospecific thickets.		-	National
48.	*Urena lobata*	**Aramina, Cadilla, bor sonobrial**	India	-	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals, birds, man and nursery operations.	Common throughout the area	-	-	National

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
49.	*Xanthium strumarium*	**Clot bur, cockle bur, bur weed, Ogora**	Cosmopolitan. naturalised throughout India.	-	-	Fodder, forage, wind, water run off, transportation of grains and vegetables, etc.	Cattle, animals, man and nursery operations.	Common throughout the area	-	-	National

2. Entomological FIS (Insects)

SN	Scientific Name	Common Name	Origin	Introduction		Likely pathways of Spread	Vectors	Distribution	Rate of change	Major host	Threat level
				Method	Year						
1.	*Aleurodicus dispersus*	Spiraling white fly	Central America	Unintention-ally introduced	1993	Planting materials	Plantin g stock	Spreading gradually to southern states	-	253 host plants, out of which 34 forest tree Tectona grandis species including teak	National
2.	*Anoplolepis Gracilipes*	Yellow crazy ant	West Africa	Unintention-ally introduced across the tropics as a byproduct of commerce	-	Nurseries, planted and natural forests	Byprod uct of comme rce	Distributed in the tropics and subtropics especially in nurseries, planted and natural forests.	-	No specific to particular host plants but has significant associations with cocoa, coconut, and coffee	National
3.	*Curculio sikkimensis*	Weevil beetle	-	Endemic	2002	-	-	India, Nepal, Japan, China, Burma and South-East Asia India in Chengalpatu, Tamil Nadu	-	1. *Quercus leucotrichophora* 2. *Q. dilatata* 3. *Q. glauca*	
4.	*Ectropis deodarae* Prout	Deodar defoliator	-	Sporadic and frequent outbreak of the pest in deodar forests	2001	Accidental introductio n	---	It distributed all along North-Western part of India in outer as well inner ranges of Himalayas	-	1. *Cedrus deodara* 2. *Abies pindrow* 3. *Pinus wallichiana* 4. *Pinus gerardiana*	

SN	Scientific Name	Common Name	Origin	Introduction		Likely pathways of Spread	Vectors	Distribution	Rate of change	Major host	Threat level
				Method	Year						
5.	*Heteropsylla cubana*	Jumping lice of Leucaena	Cuba, Central and South America	Unintentionally introduced with *Leucaena leucocephala*	1988	Accidental introduction, Planting material	Planting stock	Well established all over India	-	Subabool, *Leucaena leucocephala*	National
6.	*Icerya purchasi*	Cottony cushion scale	Australia	Unintention-ally introduced	1921	Accidental introduction, planting material	Planting stock	Nilgiris, Anamalai hills, Karnataka, Kerala Tamil Nadu and all parts of India	Spreading rapidly throughout humid regions of India	*Acacia dealbata, A.melanoxylon, A. decurrens, Albizia spp. Cassia spp., Causarina equisitifolia, juglans regia, Morus alba, Pinus roxburghii*	National

SN	Scientific Name	Common Name	Origin	Introduction		Likely pathways of Spread	Vectors	Distribution	Rate of change	Major host	Threat level
				Method	Year						
7.	Insect stem borers complex: a) *Sphaenoptera aterrima* Kerremens (Coleoptera: Buprestidae) b) *Crytorhynchus rufescens* Roelofs (Coleoptera: Curculionidae) c)*Platypus biformis* Chapuis (Coleoptera: Platypodidae) d) *Polygraphus longifolia* Stebbing (Coleoptera: Scolytidae)	Beetles	-	Accidental and their population remains in Chir Pine forests	2000	Accidental introduction	-	Throughout the Chir Pine forests in Himachal Pradesh, Jammu & Kashmir and Uttaranchal	-	Chir Pine trees and associated conifers trees	
8.	*Lymantria obfuscata*	Indian Gypsy Moth		Accidental and epidemic form	June, 2004	-	-	North West Himalayas	N.A	1. *otricophora* 2. *Quercus dialatata* 3. *Alnus nitida* 4. *Salix alba* 5. *Salix fragilis* Oaks	
9.	*Pineus laevis*	Adalgid	Europe	Inadvertently	1966	Accidental introduction	-	Arambi, Ootacamund, Topslip		*Pinus patula,, P. Kesiya, P.caribaea, P.moltezumae*	National

SN	Scientific Name	Common Name	Origin	Introduction		Likely pathways of Spread	Vectors	Distribution	Rate of change	Major host	Threat level
				Method	Year						
10.	*Pitogenes scitus* Blanford	Scolitid beetle	-	Accidental and in epidemic form	2001	Accidental introduction	-	Himachal Pradesh and Jammu & Kashmir	-	1. *Pinus wallichiana* 2. *Cedrus deodara* 3. *Picea morinda* 4. *Pinus gerardiana* 5. *Pinuslongifolia*	
11.	*Quadraspidiotus perniciosus*	San Jose Scale	China	Unintention-ally introduced	1911	Accidental introduction, planting materials	Plantin g stock	All over India		*Aesculus, Alnus, Betula celtis, Fagus, Fraxinus, Morus, Populus, Salix*, Apple, apricot, Loquat, Peach, Pear, Plum, currant, Walnut, fig	National
12.	*Solenopsis geminate*	Fire ant	Central America	Unintention -ally introduced through commerce	-	Nurseries, planted and natural forests	Commer ce	Distributed throughout New and Old World Tropics and became a pest in India	-	No specific to particular host plants but has significant associations with cocoa and coffee	National
13.	*Teleonemia scrupulosa* Stal	Lantana lace bug	Mexico	Intentionally introduced for control of lantana	1941	Planting materials	Plantin g stock	Distributed all over India	-	*Tectona grandis. Sesamum indicum, Lantana* spp, *Leucophyllum* spp.	National

SN	Scientific Name	Common Name	Origin	Introduction		Likely pathways of Spread	Vectors	Distribution	Rate of change	Major host	Threat level
				Method	Year						
14.	*Tuberolachnus salignus*	Giant Willow Aphid		Introduced, and in epidemic form	2001	-	-	Gharwal range, Kumaon range, Kashmir valley, Lahaul and Spiti valley of Western Himalaya	N.A	1. *Salix alba* 2. *Salix correalua* 3. *Salix babilonica*	

3. Pathogenic FIS (Fungi)

SN	Scientific name	Common name	Origin	Introduction		Likely pathway of spread	Vectors	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
1.	*Ceratocystis* sp.	-	Europe, USA	Introduced	2000	Import	Cuttings	Uttaranchal	-	*Populus deltoides* G 48	National
2.	*Cercospora pini* densiflorae	Cercospora needle cast of radiata and chir pines.	Japan	Accidental occurrence	1913	Infected needles & seed husk	Planting stock, seeds & infected needles	Affecting all exotic pine nurseries.	Spreading throughout hilly areas of India	*Pinus radiata, P. caribaea, P. oocarpa, P.kesiya, P. roxburghii*	National
3.	*Cryphonectria cubensis*	Cryphonectria stem canker	Cuba	Accidental occurrence	1917	Planting material	Diseased planting stock	Distributed Eucalyptus plantations of Kerala (High rainfall area)	Spreading high rainfall areas of Kerala (Eucalyptus plantations)	*E. grandis, E. teretornis, E. citriodora, E.torelliana*	National
4.	*Diplodia pinea*	Diplodia die back, Whorl canker	South Africa Cape Region, Europe, USA	Un intentionally introduced	1900	Planting material	Planting stock, seeds & infected needles	Affecting exotic pines of Uttaranchal	Spreading throughout hilly areas of India	*P. patula, P. pseudostrobus*	National
5.	*Dothistroma pini*	Dothistroma Blight, Red Band	USSR Australia, New Zealand	Un intentionally introduced	1911	Planting material (seed husk)	Infected needles & seeds	Affecting Uttaranchal, J&K and southern provenances in nursery and plantations.	Spreading throughout hilly areas of India	*Pinus radiata, P. walliachiana* & *P. roxburghii*	National
6.	*Fusarium moniliforme*		Japan	Introduced through rice import		Spores spread through air and insects		Cause 'Foot rot' disease and destroys rice fields in many of the areas		-	National
7.	*Hemileia vastatrix*			Introduced through coffee import		Spores spread through air and insects		These cause Rust disease in Coffee plants in north western and southern India		-	National

SN	Scientific name	Common name	Origin	Introduction		Likely pathway of spread	Vectors	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
8.	*Lophodermium pinastri*	Lophodermium needle cast	America, Mexico, South Africa	Accidental occurrence	1962	Infected needles & seed husk	Planting stock, seeds & infected needles	Affecting all exotic pine nurseries.	Spreading throughout hilly areas of India	*Pinus radiata, P. caribaea, P. elliotti, P.kesiya, P. roxburghii*	National
9.	*Monochaetia unicornis*	Monochaetia canker of Cupressus and Junipers	USA, Kenya, Tanzania	Accidental occurrence	1940	Infected needles & seed husk	Planting stock, seeds & infected needles	Affecting all exotic pine nurseries.	Major pathogen of cupressus plantations of UP	*Cupressus arizonica, C. lusitanica, C.macrocarpa*	National
10.	*Oidium heveae*		Brazil/ Cuba	Introduced through coffee import		Spores spread through air and insects		Forms disease named "Powdery Mildew" and destroy seedlings and crops		-	National
11.	*Peniophora gigantea*	-	New Zealand	Introduced	2002	Import	Wood logs, planks	Throughout the country	-	*Pinus* spp.	National
12.	*Pseudoperonospora cubensis, Berk.*		Brazil/ Cuba	Introduced through rubber import		Spores spread through air and insects		Forms Downy Mildews' disease and destroy grapewine, cucurbita and maize crops		-	National

Checklist of Forest Invasive Species having Regional Distribution

1. Floral FIS (Weeds and Plants)

2.

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
1.	*Argyreia speciosa*	**Elephant creeper, tokoria alu**	India, Java	-	-	Fodder, forage, water run off, etc.	Cattle, animals and man, nursery operations.	Common throughout the area.	-	-	Regional
2.	*Bidens pilosa*	**Beggers tick, Spanish needle**	Tropical America, Neotropics, naturalized throughout India	Accidental	-	Fodder, forage, water run off, transportation of grains and vegetables, animals, etc.	Cattle, animals and man, nursery operations, transport	Road sides coffee estates, not uncommon throughout the area	-	-	-
3.	*Cassia alata*	**Ringworm plant, khorpat**	India	-	-	Fodder, forage, water run off, transportation of grains and vegetables, etc.	Cattle, animals and man, nursery operations	Not uncommon throughout the area	-	-	Regional
4.	*Clerodendrum siphonanthus*	**Brahma josthi, akal bih**	India	-	-	Man and animals	Cattle, animals and man, nursery operations	Common throughout the area	-	-	-

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
5.	Clerodendrum viscosum	**Dophat tita, bhet tita**	India	-	-	Man and animals	Cattle, animals and man, nurseries	Common throughout the area	-	-	-
6.	*Commelina benghalensis*	**Day flower, konasimolu**	India	-	-	Through man, cattle, other animals and water	Through man, animals and cattle and water	Occurs in the aquatic habitats	-	-	-
7.	*Crotolaria striata*	**Jhunjhunia, ghonta koron**	India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Common throughout the area	-	-	-
8.	*Elephantopus scaber*	**Elephant's foot, hati khoje**	India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Common throughout the area	-	-	-
9.	*Erechthites valerianaefolia*	**Fire weed, pile wort, Bon kopah**	North-eastern India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Common throughout the area	-	-	Regional
10.	*Eupatorum adenophorum*	-	Central America	Seed	1960	Garden decor	Animals, transport	Along the outskirts of forest roads in hills	Over 20 ha per year		Regional
11.	*Floscopa scadens*	**Konasimola**	India	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Occurs in the aquatic habitats			-

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
12.	*Hyptis suaveolens*	Wilayati Tulsi	Tropical America	Medicinal importance	-	Nursery trade, animal excretion, garden waste		Densely populated in forest areas dominating ground vegetation	They are widely seen in forest areas inhibiting the growth of local forest vegetation in N.E and central India		Regional
13.	*Ipomoea hederifolia*	-	Tropical America, naturalized in India	Accidental. has ornamental appeal	-	Cattle, man, garden waste, etc	Agriculture, horticulture and nurseries, etc.	Forest areas, agricultural fields, orchards and hedges	-	-	-
14.	*Ipomoea pes tigridis*	**Tiger's foot,**	Topics. India	-	-	Cattle, man, garden waste, etc	Agriculture, horticulture, nursery operations, etc.	Forest areas, agricultural fields, orchards and hedges	-	-	-
15.	*Ipomoea quamoclit*	**Cypress vine, needle creeper, star glory, kunja lota**	Circumtropical. naturalized in India	-	-	Cattle, man, garden waste, etc	Agriculture, horticulture, nurseries, etc.	Forest areas, agricultural fields, orchards and hedges	-	-	-

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
16.	*Leea crispa*	**O'u lota**	India	-	-	Man, animals, birds and water run off	Human and animal agencies	Forest areas throughout the region	-	-	-
17.	*Melastoma malabathricum*	**Phutuka (Ronga)**	India	-	-	Man, animals, birds and water run off	Human and animal agencies	Forest areas throughout the region	-	-	-
18.	*Mikania cordata*	Mikania	Tropical Asia, Philippines, New Guinea and Tropical Africa.			By wind	By wind	Forest areas and forest plantations			Regional
19.	*Minosa invisa var invisa*	Giant sensitive plant	Tropical America	As a cover crop in rubber, teak, cashew plantations	1950	Animal, nursery trade	Animals commerce nurseries	Road sides moist waste lands	Spreads, fast, North-east and South-west India		
20.	*Mimosa pudica*	**Touch-me-not, sensitive plant, humble plant, lajuki bon, nilaji bon; chhui-muie**	Tropical America, naturalized throughout India	-	-	Wind, water run off, transport of grains and vegetables, etc.	Cattle, animals and man. Nurseries	Commonest aggressive weed throughout the area, wastelands lawns	Spreads very fast	-	Regional /Local

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
21.	*Monochoria hastata*	**Pani meteka**	India. Northeast Africa to Manchuria.	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Occurs in the aquatic habitats	-	-	Local
22.	*Monochoria vaginalis*	**Bhat meteka**	India. Northeast Africa to Manchuria.	-	-	Through man, cattle, other animals and water	Through man, animals, cattle and water	Occurs in the aquatic habitats	-	-	Local
23.	*Mucuna pruriens*	**Cowage plant, cowitch horse bean, bandor kekua**	India	-	-	Man, animals, cattle, birds, wind, water run off, etc.	Cattle, animals, man, nurseries, hairs on pod cause intense itching and allergy to men and cattle.	Common throughout the area.	-	-	-
24.	*Opuntia vulgaris* Mill.	Prickly Pear (*E*) Pattakalli, chapathikalli (*Tam*); Puchikalli (*Tel*); Mullugalli (*Kan*); Chattukalli (*Mal*) **	Native of America					Colonizing in dry deciduous forest areas and rain shadow portions of Western Ghats and Eastern Ghats			Regional

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
25.	*Passiflora foetida*	**Passion flower, jhunuka phool**	Brazil. naturalized in India	Accidental	-	Man, cattle, birds and water run off.	Human and animal agencies	Forest fringes, wastelands, agriculture fields, etc	-	-	-
26.	*Pothos scandens*	**Hati lota**	-	-	-	Man, animals and water run off	Human and animal agencies	Forests	-	-	-
27.	*Rubus moluccanus*	**Wild raspberry, black cherry, jutuli poka, jetuli poka**	India, mainly distributed in the Himalayas.	-	-	Man, animals, birds and water run off	Human and animal agencies	Forest areas throughout the region	-	-	-
28.	*Siegesbeckia orientalis*	**Katampam, lichkura**	Occurs throughout India.	Accidental	-	Cattle and human agency	Cattle, animals and man, nursery operations	Occurs throughout the area	-	-	-
29.	*Solanum hispidum* (Solanaceae)	-	Tropical America, naturalized throughout India.	Accidental	-	Fodder, food, forage, water run off, etc.	Cattle, animals, birds, man and nursery operations	Found throughout the area in the forests	-	-	-

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
30.	*Solanum indicum*	-	Palaeotropical	-	-	Fodder, food, forage, water run off, etc.	Cattle, animals, birds, man and nursery operations	Found throughout the area in the forests	-	-	-
31.	*Solanum torvum*	**Hati bhekuri**	Tropical America. naturalised in India.	Accidental	-	Fodder, food, forage, water run off, etc.	Cattle, animals, birds, man and nursery operations	Found throughout the area in the forests	-	-	-
32.	*Solanum viaram*	**Horse nettle, kotahi bengena, kotayen bengena**	India	-	-	Fodder, food, forage, water run off, etc.	Cattle, animals, birds, man and nursery operations	Found throughout the area in the forests	-	-	-
33.	*Spilanthes acmella*	**Karkara**	Tropical, occurs throughout India.	Accidental or for medicinal value.		Cattle, animals, birds and human agency	Cattle, animals, birds, man and nursery operations.	Extremely common in some areas, possesses medicinal properties	-	-	Regional
34.	*Stephania hernandifolia*	**Tabuki lota**	-	-	-	-	-	Common throughout the area	-	-	-

SN	Scientific Name	Common name	Origin	Introduction		Likely pathway of spread	Vector	Distribution pattern	Rate of change	Major hosts	Threat level
				Method	Year						
35.	*Tithonia diversifolia*	-	Mexico and Central America, almost naturalized in India.	Perhaps introduced as an ornamental plant	-	Fodder, forage, wind, water run off, etc.	Cattle, animals, man and nursery operations	Very common in some forest areas	-	-	-
36.	***Vitex negundo***	**Chaste tree, posotia**	India	-	-	Nursery, trade, animal excretion, garden waste, etc.	Animals, birds, human agencies, transport networks, commercial nurseries, etc.	Common throughout the area in the forests, plantations, fringe areas, field boundaries, disturbed areas, grass lands, wetlands, riparian and urban areas	-	-	Regional

Annexure II

A Case Study for investigation of bio-invasion

A study funded by **Technology Information, Forecasting & Assessment Council (**TIFAC (DST)**)** was conducted by IWST, Bangalore in 2003-2004 to investigate in detail the following issues related to bio-invasion during import of wood and wood products into the country

Scope of the study

The study was aimed at generating information on the following aspects.

1. Enumeration of the existing legal provisions for importing of wood and wood products in India
2. Investigation on the quarantine measures taken up by the exporting countries
3. Elucidation of the chances of pests introduction through import of wood and wood products and their invasive potential.
4. Looking into the feasibility of establishing post import quarantine facilities in India.

The primary surveys were conducted at the main entry points of wood import into the country, the major sea ports of India. For this, the following six ports were selected, for collecting samples for interception of insects / pathogens.

1. Mumbai Port, Mumbai, Maharastra
2. Kandla Port, Gujarat
3. Tuticorin Port, Tuticorin, Tamil Nadu
4. New Mangalore Port, Dakshin Kannada District, Karnataka
5. Kolkata Port, Kolkata, West Bengal
6. Andaman & Nicobar Port, Port Blair

In addition, surveys were also conducted at major timber depots to which the imported wood consignments reach, to assess further developments during transit and storage. Details of the timber logs stacked in the depots

including duration, physical conditions, infestation of fungi/insects etc., were recorded. Samples were collected for interception of insects / pathogens.

Field and Laboratory studies

Information was collected by devising suitable structured questionnaires including the details on timber species, country of export, quantity, physical condition of the material, duration of travel, stocking period etc. Information on sanitary and phytosanitary measures adopted by exporting countries, pests reported on timber at the country of export, their entry, colonization and spread were studied. The timber pests/fungi of important Indian tree species, which are also being imported to India, were enlisted from different books and papers so that the exotic pests can be distinguished as invasive species.

Damaged wood collected from port area and timber depots were brought to the laboratory and studied. Insects emerged were collected. Nature of damage and the stages were documented. The insects were identified upto family/ genus level. Some samples were processed as per standard procedures and sent to Indian experts for authentic identifications. Insects belonging to Coleoptera and Hymenoptera could be collected from different imported timbers at various ports Wood samples with fungal growth were collected in sterile polythene bags and brought to the laboratory for further culture and identification.

From the ports of Mangalore, Tuticorin, Mumbai, Kandla, Kolkata, as many as 55 species of insects (including several new records) and 22 types of fungi could be collected from the timber imported.

Invasive species identified in the study

Aleurodicus dispersus: an invasive species to India

The spiralling whitefly *Aleurodicus dispersus,* Russell, is reported on diverse plants of economic importance in the USA (Russell, 1965). Mound and Halsey (1978) indicated its distribution in USA (Florida), Cuba, Haiti, Dominica, Martinique, Barbados, Costa Rica, Panama, Ecuador, Peru, Brazil and Canary islands. It was reported as an invasive species to India in 1995 on a wide variety of plants in Western Ghats of Kerala and Tamilnadu where nymphs and

adults were found to feed on under surface of leaves resulting in premature shedding. Nearly 72 host plant species of this whitefly have been recorded from different parts of Kerala. Later, it was observed to infest guava around Bangalore and mulberry in Tamilnadu. It is reported to breed on 481 host plants throughout the world of which it is known to attack 253 plant species constituting 52.3% of its known host plant species in India.

Economic importance

Both nymphs and adults suck the plant sap, and production of honey-dew leading to the development of mould on leaves, adversely affecting photosynthesis. Severe infestation results in death of seedlings and young plants.

Study on developmental stages

1. A female lays up to 100 eggs generally at right angles to the midrib mainly on the ventral surface of leaf typically forming a spiraling pattern. The pedicel of the egg is inserted into the stomata of host plant during oviposition and the eggs are covered with waxy secretion that takes the form of white flocculence. There are four nymphal stages; the fourth stage is pupa which bears conspicuous amount of white cottony secretion. Adults are white, coated with fine dust-like waxy secretion. The following studies were undertaken on the pest.

(a) Survey was undertaken to assess the intensity of *A. dispersus* infesting the leaves of variety of important avenue and forest tree species. The findings were published in *Indian Journal of Forestry* 23(3): 319-321

(b) Extensive survey was conducted to assess the host range of *A. dispersus* in south Western Ghats: The findings were published in *Indian Journal of Forestry* 27(1): 63-65.

(c) Neem products were evaluated against *A. dispersus* on *Bauhinia variegata* and *Michelia champaca:* The findings were published in *Indian Journal of Plant Protection* 32(2): 126-128

Annexure - III

List of Quarantine Weed Species

(SCHEDULE-VIII of Plant Quarantine Order 2003)

1. *Abutilon theophrasti*	32. *Echium plantagineum*
2. *Agrostemma githago*	33. *Emex australis*
3. *Alectra sp.*	34. *Emex spinosa*
4. *Allium vineale*	35. *Froelichia floridana*
5 *Ambrosia artemisiifolia*	36. *Helianthus californicus*
6. *Ambrosia maritima*	37. *H. ciliaris*
7. *Ambrosia psilostachya*	38. *H. petiolaris*
8. *Ambrosia trifida*	39. *H. scaberrimus*
9. *Ammi visnaga*	40. *Heliotropium amplexicaule*
10, *Apera-spica-venti*	41. *Ipomoea coccinea*
11. *Arceuthobiumoxycedri*	42. *Leersia japonica*
12. *Avena sterilis*	43. *Lolium rigidum*
13. *Baccharis halimifolia*	44. *Matricaria perforatum*
14. *Bromus diandrus*	45. *Mimosa pigra*
15. *Bromus rigidus*	46. *Orobanche cumana*
16. *Bromus secalinus*	47. *Phalaris paradoxa*
17. *Cardus pycnocephalus*	48. *Polygonum cuspidatum*
18. *Cenchrus tribuloides*	49. *P. perfoliatum*
19.*Centaurea diffusa*	50. *Proboscidea lovisianica*
20. *C. maculosa*	51. *Raphanus raphanistrum*
21. *C. melitensis*	52. *Rumex crispus*
22. *C. solstitialis*	53. *Salsola vermiculata*
23. *Chondrilla juncea*	54. *Senecio jacobaea*
24. *Cichorium endivia*	55. *Solanum carolinense*
25. *C. pumilum*	56. *Striga hermonthica*
26. *C. spinosum*	57. *Thesium australe*
27. *Cordia curassavica*	58. *T.humiale*
28. *Cuscuta australis*	59. *Vicia villosa*
29. *Cynoglossum officinale*	60. *Viola arvensis*
30. *Desmodium tortuosum*	61. *Xanthium spinosum*
31. *Echinochloa crus-pavonis*	

Annexure - IV

List of Inspection Authorities for Certification of Post-entry Quarantine Facilities and Inspection of Growing Plants

(SCHEDULE-XI of Plant Quarantine Order 2003)

S. No. (1)	State/Union Territory (2)	Jurisdiction (3)	Designated Inspection Authorities. (4)
1.	Andaman & Nicobar Islands	Entire Union Territory	Officer- in-charge, Indian Council of Agricultural Research, Research Complex, Port Blair.
2.	Andhra Pradesh	Entire State	Head, Division of Plant Pathology, Andhra Pradesh Agricultural University, Hyderabad.
3.	Arunachal Pradesh	Entire State	Joint Director, Indian Council of Agricultural Research, Research Complex for North-Eastern Hill Region, Arunachal Pradesh Center, Basar, Arunachal Pradesh.
4.	Assam	Entire State	Head, Division of Plant Pathology, Assam Agricultural University, Jorhat.
5.	Bihar	Except North and South Chota Nagpur, Santhal Region	Head, Division of Plant Pathology, Rajendra Prasad Agricultural University, Pusa, Bihar.
6.	Bihar	North and South Chota Nagpur, Santhal Region.	Head, Division of Plant Pathology, Bisra Agricultural University, Ranchi, Jharkhand.
7.	Chandigarh	Entire Union Territory	Head, Division of Plant Pathology, Punjab Agricultural Universitgy, Ludhiana..
8.	Daman & Diu	Entire Union Territory	Head, Division of Plant Pathology, Gujarat Agricultural Universitty, Banaskantha.
9.	Delhi Entire Union	Territory	Head, Division of Plant Pathology and Mycology, Indian Agricultural Research Institute, New Delhi –110012.
10.	Goa	Entire State	Officer- in-charge, Indian Council of Agricultural Research, Research Complex for Goa, Ele Farm, Ele, Old Goa-403 402.
11.	Gujarat	Entire State	Head, Division of Plant Pathology, Gujarat Agricultural University, Dantiwada.
12.	Haryana	Entire State	Head, Division of Plant Pathology, Haryana Agricultural University, Hissar.
13.	Himachal Pradesh	Entire State(Agriculture)	Head, Division of Plant Pathology, Himachal Pradesh Krishi Vishva Vidyalaya, Palampur.
14.	Himachal Pradesh	Entire State (Horticulture and Forestry)	Head, Division of Plant Pathology, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan.
15.	Jammu & Kashmir	Entire State	Head, Division of Plant Pathology, Sher-e-Kashmir Agricultural University of Science and Technology, Srinagar/Jammu

16.	Karnataka	Shimoga, Chitterdurga, South Kanada, Chickmaglur, Kolar, Bangalore, Hassan, Coorg, Mandya, Mysore	Head, Division of Plant Pathology, University of Agricultural Sciences, Bangalore 560067.
17.	Karnataka	Belgaon, Bellary, Bidar, Bijapur, Dharwar, Gulbarga, Raichur and Uttar Kannada	Head, Division of Plant Pathology, Dharwar University of Agricultural Sciences, Dharwar.
18.	Kerala	Entire State	Head, Division of Plant Pathology, Kerala Agricultural University, Trissur.
19.	Laskshadweep	Entire Union Territory	Head, Division of Plant Pathology, Kerala Agricultural University, Trissur.
20.	Madhya Pradesh	All districts of state except Raipur, Durg, Rajnandgaon, Bilaspur, Rajgarh, Surguja and Bastar	Head, Division of Plant Pathology, Jawahar Lal Nehru Krishi Vishva Vidyala, Jabalpur.
21.	Madhya Pradesh	Raipur, Durg, Rajnandgaon, Bilaspur, Rajgarh, Surguja and Bastar Raipur.	Head, Division of Plant Pathology, Indira Gandhi Krishi Vishva Vidyalaya
22.	Maharashtra	Konkan and Revenue Division of Bombay	Head, Division of Plant Pathology, Konkan Krishi Vidyapeeth, Dapoli.
23.	Maharashtra	Revenue Division of Pune and Nasik	Head, Division of Plant Pathology, Mahatma Phule Agricultural University, Rahuri.
24.	Maharashtra	Revenue Division of Aurangabad (7 districts)	Head, Division of Plant Pathology, Marathwada Agricultural University, Parbhani.
25.	Maharashtra	Revenue Division of Nagpur and Amravati	Head, Division of Plant Pathology, Krishi Vidyapeeth, Akola.
26.	Manipur	Entire State	Indian Council of Agricultural Research, Research Complex for North-Eastern Hill Region, Manipur Center, Lamphelpat, Manipur.
27.	Meghalaya	Entire State	Indian Council of Agricultural Research, Research Complex, Meghalaya.
28.	Mizoram	Entire State	Indian Council of Agricultural Research, Research Complex for North-Eastern Hill Region, Mizoram Center, Kelasib, Mizoram.
29.	Nagaland	Entire State	Indian Council of Agricultural Research, Research Complex for North-Eastern Hill Region, Nagaland Center, Jharnapani, Nagaland.
30.	Orissa	Entire State	Head, Division of Plant Pathology, Orissa University of Agriculture and Technology, Bhubaneswar.
31.	Pondicherry	Entire Union Territory	Head, Division of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
32.	Punjab	Entire State	Head, Division of Plant Pathology, Punjab Agricultural University, Ludhiana.
33.	Rajasthan	Entire State	Head, Division of Plant Pathology, Rajasthan Agricultural University, Bikaner.

34.	Sikkim	Entire State	Head, Indian Council of Agricultural Research, Research Complex for North-Eastern Hill Region, Sikkim Center, Tadong, Gangtok, Sikkim.
35.	Tamil Nadu	Entire State	Head, Division of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.
36.	Tripura	Entire State	Officer- in-charge, Indian Council of Agricultural Research, Research Complex, Agartala, Tripura.
37.	Uttar Pradesh	Lucknow, Jhansi, Agra and Allahabad Division	Head, Division of Plant Pathology, Chandrasekhar Azad University of Agriculture and Technology, Kanpur.
38.	Uttar Pradesh	Kumaon, Garhwal, Rohilkhand, Meerut Division.	Head, Division of Plant Pathology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal.
39.	Uttar Pradesh	Faizabad, Gorakhpur and Varanasi Division	Head, Division of Plant Pathology, Narender Dev University of Agriculture and Technology, Faizabad.
40.	West Bengal	Entire State	Head, Division of Plant Pathology, Bidhan Chandra Krishi Vishva Vidyalaya, Kalyani, Mohanpur, Nadia (West Bengal).
41.	Karnataka	Entire State	Head, Division of Plant Pathology, IIHR, Hessarghata, Bangalore, Karnataka.

Annexure V

Mechanical, biological and chemical control measures taken for a few important FIS

Plant Species

1) *Lantana camara*

Biological control: A survey of its natural enemies found 148 species of insects but only *Lantanophaga (Platyptilia) pusillidactyla* (pterophorid) was of some importance. However, *L. pusillidactyla* has a number of natural enemies, which impaired its effectiveness. A polyphagus scale insect viz. *Orthezia insignis* (Brown) has been recorded suppressing the lantana population in many parts. But it cannot be used as it attacks a number of other economically important forest trees. Another insect *Teleonemia scrupulosa* was imported from Australia in 1941 by Forest Research Institute, Dehra Dun. After host specificity tests, the insect was declared unsafe owing to its feeding on teak (*Tectona grandis L.),* a valuable timber tree hence the whole culture was destroyed in 1943. However, in 1951 it was recorded from Dehra Dun and the subsequent surveys showed its presence up to the distance of 40 km from the point of the escape. It was further reported to kill lantana in Bhimtal, Nainital, UP. In 1976, *T. scrupulosa* was reported infesting lantana at various locations in Karnataka and Tamil Nadu, although no case of complete death was recorded. Subsequent observations have also shown that inspite of defoliation by this insect the plants were not killed. For biological suppression of lantana, *Diastema tigris*

Guenee, *Saliba* (Syngamia) *haemorrhoidalis* Guenee and *Uroplata girardi* Pic. (origin: Mexico) have also been introduced. Similarly *Epinotia lantanae* (Busck) has established in certain pockets of south India. *E. lantanae in* combination with *Octotoma lantanae* affects 95% of the fruits of lantana in Bangalore.

Chemical Control: Various methods viz. mechanical, culture, biological and chemical for control and eradication of weed have been tried in the past. All these methods have proved costly and partly successful. To eradicate *Lantana* a series of experiments with different chemicals were conducted. The experiment was conducted by R.C. Ghosh et.al, during 1978 at FRI, Dehradun. Twenty five treatments comprising of different concentrations of weedicides namely Tordon 10 K, Tordon 22k, Brush Killer 64, Weedone concentrate 48 and 2, 4, 5-T 20 percent Amine were tried in split plot designs with three replications for eradication. It was found from the results that application of different concentrations i.e. 10 lit/ha., 5 lit/ha and 3 lit/ha of Tordon 22k and 10 Kg. /ha of Tordon 10 K completely killed *Lantana* weed followed by Tordon 155 @ 10 lit/ha and Brush Killer 64 @ 10 lit/ ha.. Tordon 22K @ 3,5,10 lit/ha., Tordon 10 K @ 10 Kg/ ha. and Tordon 155 @ 10 lit/ha are recommended. The research findings were implemented in the various forest types of India and in plantations.

Mechanical Control: The Forest Operations Unit of Silviculture Division FRI has developed a series of tools for mechanical eradication of *Lantana*. The tools are Stalk light and heavy duty puller. The uprooting of *Lantana* by these tools was found to be efficient and economical which requires less labour. Various forestry personnel of the country were trained in handling of these tools.

2) *Parthenium hysterophorus*

Parthenium (Carrot weed) is another invasive species causing serious problem for almost all forest crops. It has spread to alarming proportions in India and is threatening human and cattle life.

Biological control: During the last few years much emphasis has been given to control parthenium through various biological agents like pathogens, insects and plants.

i) **By pathogens**: In India, some pathogens have been reported to attack parthenium. A leaf spot disease caused by *Colletotrichum gloeosporiode* (Penz.) was recorded in 1976. In 1979, a few plants of parthenium were found in the stage of advanced wilting in Tamilnadu caused by *Rhizoctonia solani*. Powdery mildew caused by *Oidium parthenii* was reported in 1981, in Hyderabad. *Selerotium rolfsii* Sacc. was observed causing wilting and death of parthenium plants in Dharwad, in the year 1984.

Fusarium oxyporum and *Rhizoctonia solani* were evaluated. Both the pathogens were found effective, causing severe infection and significant damage to the weed. They could obtain 90-95% and 35-40% mortality of parthenium seedlings in greenhouse and field trials.

In 1997, it was reported that *Fusarium pallido-roseum* (Cooke) Sacc. caused the reduction in the seed germination, seedling vigour and height of plants, number of branches and number of flowers. Spray of *Trichoderma viride* Pers. could also reduce the growth of parthenium.

ii) By insects:

Indigenous insects

Many insects like, mealy bugs, aphids and grasshoppers have been reported feeding on parthenium as an alternate host. A stem boring scolytid beetel, *Hypothenamus erudistus* was reported to cause widespread damage to parthenium in 1979. *Oberea* spp. has also been found to kill this weed significantly. Severe attack of a cerambycid *Leptrocentrus taurus* (F.) and a scale insect *Orthezia insignis* (Brown) were reported from Mysore and Bangalore, respectively.

Exotic insects

In 1983 a chrysomelid beetel *Zygogramma bicolorata* was imported from Mexico. Both the larvae and adults caused severe defoliation of

parthenium and encouraged the growth of vegetation formerly suppressed by this weed. The beetle has spread in Haryana, Punjab, Karnataka, Madhya Pradesh, Tamil Nadu, Himachal Pradesh and Andhra Pradesh.

iii) By plants: This approach has also gained momentum after reports that *Cassia uniflora* Mill can be used to control parthenium. *Abutilon indicum* (G.Don) was found to reduce 52% of the population of partehnium. In Jabalpur suppression of parthenium by marigold showed encouraging results in 1999.

Manual control: Recently, Silviculture Division FRI has conducted experiments on preparation of compost from *Parthenium* weed. The compost was prepared by Barkley & Indore process and it was proved to be successful in eradicating carrot weed from the area.

Chemical Control: The following chemicals were tried to eradicate Parthenium.

i. Gramoxone: Parthenium can be killed by application of 2-3 litres/ha.

ii. 2-4 D Ethyl Easter: The chemical spray @ 0.2% in water proved to be the best treatment for killing of carrot weed. This application proved to be most effective.

iii. Ammonium Sulphate: It was found that spray of 20% of chemical in water has killed the carrot weed.

Control by utilization: Parthenium has been well documented for its insecticidal, nematicidal and herbicidal properties and biogas production. It increases the rate of decomposition of cowdung. Methane production is possible from sodium hydroxide (NaOH) treated parthenium. Parthenium can be potentially used for paper making. It contains lactone parthenin, one of the

major toxins in parthenium, which can be utilized for control of several weeds like, pistia, water hyacinth and *Salvinia molesta*.

3) Water hyacinth, *Eichornia crassipes* (C. Martius)

Biological control: Biological control efforts were initiated in 1982 when two curculionid weevils *Neochentia eichhorniae* and *N. bruchi* and galumnid mite *Orthogalumna terebrantis* of Argentinean origin, were imported from USA. The results of the studies conducted in Bangalore indicate that with sustained efforts biological control of water hyacinth can be achieved throughout the country. With this in view, over 1,30,000 weevils have already been supplied to 15 states. The most spectacular results has been achieved within four years by releasing 12,000 adults of *N. eichhorniae* and 5,500 adults of *N. bruchi* in the 286 sq. km Loktak lake in Manipur, 75% of which was infested by water hyacinth. During 1999, the Project Director of Biological Control, Bangalore released over 0.3 million weevils and 0.8 million mites in Bhindawas lake (Haryana) for the management of water hyacinth. In 1987, *N. eichhorniae* and N. *bruchi* were released over a period of three years in an eight ha tank at Nacharam in Hyderabad. Ninty eight percent reduction in the density of water hyacinth was recorded. *Neochentia eichhorniae* and *N. bruchiwere* were released through 28,545 weevil infested plants at Ramgarh lake near Gorakhpur (U.P) in 1988. In 1989, the weevils had spread throughout the 688 ha Ramgarh lake (44.92 individuals/plant) and complete defoliation was achieved. The ratio of *N. eichhorniae* and *N. bruchiwere* 5:1.

Chemical control: Diquat, 2, 4-D, paraquat, temephos and phentoate are relatively safe to the curculionids N.*eichhorniae* and *N. bruchiwere* and could be used in integrated management of water hyacinth.

4) *Salvinia molesta* Mitchell

Biological control: In 1982, a culture of the weevil *Crytobagous salvineae* was obtained from Australia, where it had demonstrated potential of an effective control agent. In demonstration trials in a 200 sq. m lily pond, release of

Crytobagous salvineae resulted in collapse of *S. molesta* and lily growth which was suppressed by competition from *S. molesta,* was resurrected.

Chemical control: Herbicides like 2, 4-D, paraquat, and glyphosate are found to be effective for killing the weed. However, large-scale application of herbicides is not feasible due to high costs involved in spraying the extensive areas and also due to environmental concerns.

5) *Opuntia* spp.

Biological control: The first outstanding success in biological control in India was achieved when *O. vulgaris* was controlled in central and north India by introduction of the mealybug (*Dactylopius ceylonicus*) from Brazil. This, of course, was not a deliberate attempt as *D. ceylolicus* was mistaken for the true cochineal insect *D. coccus* Costa and was introduced for commercial production of cochineal dye. But the potential of classical biological suppression was established by using an insect to control a weed. The area became fit for cultivation within five to six years. *D. ceylonicus* being restricted to *O. vulgaris* proved a failure when introduced and distributed in south India to suppress *O. stricta* (*O. dillenii* (Ker-Gawl.) Haw). In 1926, *D.opuntiae* (a north American spp.) was imported from Sri Lanka and its colonization resulted in spectacular suppression of *O. stricta* and related *O.elatior* Mill. More than 40,000 ha area was thus cleared.

6) *Leucaena leucocephala, Benth.*

Biological control: A tiny insect known as the *Leucaena psyllid* (jumping plant lice), has spread to most regions of the world where *Leucaena* is cultivated. Psyllids have caused severe damage since late 1982 to *Leucaena* in tropical and subtropical areas outside their native range. Psyllid damage is greatest when juvenile foliage development is rapid, as on hedges managed for green manure and/or fodder. Nymphs cause the primary damage by sucking sap from young foliage. Leaflets turn yellow, curl, and wilt. The deposition of honeydew encourages the growth of sooty molds. Complete defoliation of terminal shoots can occur under heavy psyllid infestation. Trees usually survive unless they are subject to other severe stresses, such as a drought. Damage

usually has been the most severe just after the psyllids invade an area. Trees were almost bare in Hawaii during the first year of attack, which coincided with a severe drought. Defoliation has occurred rather cyclically since then.

Chemical control: Chemical control has generally proven uneconomical and also eliminates predators and parasites.

7) Mikania micrantha (L.) Kunth.

Biological control: Biological control causing a host specific thrips, Liothrips mikaniae from Trininad was tried without much success.

Chemical control: The treatments of 1.2 kg gramaxone, 0.8 kg gramaxone+1 kg 2, 4-D amine /ha significantly reduced the growth of Mikania. Control of 50-60% weed was noticed 2-3 days after spraying of gramaxone and 2, 4-D amine. There was no further growth of weed up to 80 days after spraying.

8) Alternanthera philoxeroides (mart.) griseb

Biological control: An indigenous turtle beetel (Cassida sp. Nr, enervis Boh) was found to severely attack this weed at Jabalpur and adjoining areas.

Chemical control: 2, 4-D, glyphosate and metsulfuron-methyl were found effective against alligator weed in aquatic and terrestrial situations.

9) Cuscuta spp.

Chemical control: Herbicides like, pendimethalian, paraquat, lower doses of glyphosate, pronamide, imazaquin and trifluralin may provide only partial control of cuscuta. Further research to identify more promising and appropriate selective herbicide formulations to control dodder in different fields is needed.

10) Ipomoea carnea, Jacq

Chemical control: Some recommended packages for the management of I. Carnea are foliar spray of 2, 4-D Na salt 0.2%+urea 0.1% +soap oil 1ml/l of water on weeds and then removal and burning of dried weeds, manual and mechanical removal of grown up plants in channels during summer and composting Ipomoea plants and used as organic manure.

11) Solanum elaeagnifolium Cav. W.

Chemical control: Application of 2, 4-D, triisopropanolamine salt+picloram, 2, 4-D ethyle ester, 2, 4-D isobutyl ester, glyphosate isopropylamine salt and oryzalin may need to be repeated over several years to achieve total eradication of silver leaf night shade.

12) *Hyptis suaveolens* (L.) Poit.

Chemical control: Use an overall spray of amine or ester 2,4-D, spot spraying where applicable. All sprays should be applied before flowering begins. Other herbicides such as dicamba, clopyralid and picloram based mixtures also are effective but more expensive.

Insects/Pathogens

Common methods of Insect and pathogen control adopted are given below.

Integrated Management of *A. disperses :* The following recommendations are made for control of this pest. Basal application of neem cake (1gm/Kg soil mixture) along with pongam cake (1gm/Kg soil mixture) and vam (1gm/Kg soil mixture); foliar spray of neem seed oil alone (5ml/litre) or in combination with synthetic insecticides like chlorpyriphos 20 EC (2ml/litre) and monocrotophos 36 WSC; application of Biomite (a plant product) (o0.05%), dimethoate (0.045%) and profenphos (0.05%); augmentation of natural enemies (Coccinellids, lacewing insects and aphelinids).

1. Seeds and planting material being exported by the exporters when routed through Forest Research Institute are always checked for infection and suitably treated or destroyed before issuing phytosanitary certificate.
2. Directorate of Plant Protection, Quarantine & Storage has been requested to adhere to strict guidelines in importing wood, as many pathogenic fungi are likely to come associated with it.

3. The issues regarding threats of new pathogens are raised in the National Plant Quarantine Advisory Committee Meetings conducted regularly by the Directorate of Plant Protection, Quarantine & Storage, Faridabad

In many countries the susceptible tree species were replaced by resistant species or clones. In India, long back in 1929, predatory beetles were introduced for the control of cottony scale, *Icerya purchasi* in Southern India, which was successful. There is no planned programme or mechanism for reporting or recording FIS.

Annexure VI

LIST OF SCIENTISTS/EXPERTS IN THE FIELD

KERALA FOREST RESEARCH INSTITUTE, PEECHI, KERALA

1 Curricula vitae

Name : Dr. K.V. Sankaran

Date of birth : 26 October 1952

Present position : Scientist E1 (Forest Pathology), Division of Forest Protection, Kerala Forest Research Institute

Academic record : B.Sc. 1973 (Botany), University of Calicut, Kerala
M.Sc. 1975(Botany), University of Calicut, Kerala
Ph.D. 1983 (Mycology)University of Calicut

Contact Address

Kerala Forest Research Institute, Peechi- 680 653,
Kerala, India
e-mail : sankaran@kfri.org
Ph: 0487 2699061 (O) 04662 223366 (R)
Fax : 0487 2699249

Awards/ honours/fellowships

was awarded

1) Commonwealth Fund for Technical Cooperation to attend a training programme on Identification of Fungi and Bacteria of Agricultural Importance at the International Mycological Institute (IMI), U.K. (1989).
2) Fellowship by International Tropical Timber Organization (ITTO), Japan to attend International Symposium on Mycorrhizae held at Perth, Western Australia (1992)
3) Darwin Fellowship in Biosystematics by the U.K. Department of Environment to do post-doctoral research in Mycology at the International Mycological Institute, U.K. (1994-1995).
4) The Crawford Fund for International Agricultural Research by the Australian Academy of Technological Sciences and Engineering to do post-doctoral research on soil microbiology at CSIRO Laboratories, Perth, W. Australia (1996)
5) Fellowship by ITTO, Japan to do post-doctoral work on soil microbiology at CSIRO Laboratories, Perth, W. Australia (1996)

Training received

Identification of Fungi and Bacteria of Agricultural Importance, IMI, U.K. (1989)

Biodeterioration of Materials, IMI, U.K. (1990)

Modern Techniques in the Identification of Bacteria and Filamentous Fungi, IMI, U.K (1994)

Soil Microbiology and Tree Nutrition, CSIRO Laboratories, Perth, W. Australia (1996)

Development of Mycoherbicides to Control Exotic Weeds, CABI Bioscience (Ascot), U.K. (1998).

Specialization: Plant Pathology, Fungal Diversity Studies, Ecology and Control of Exotic Weeds.

Research Experience: 1976- to date (28 yrs). Taxonomy and ecology of soil micro fungi; forest pathology; ecology, distribution and control of invasive weeds; nutrient cycling in forest plantations.

Post doctoral work outside India :

Taxonomy of fungi - International Mycological Institute, UK. 1989-1990; 1994-1995
Soil microbiology and tree nutrition - CSIRO Forestry and Forest Products Perth, W. Australia
(1996)

Current research interests

ECOLOGY, DISTRIBUTION AND CONTROL OF ALIEN WEEDS, BIODIVERSITY OF FUNGI IN FOREST ECOSYSTEMS, EPIDEMIOLOGY AND CHEMICAL CONTROL OF DISEASES OF FOREST TREES, MYCORRHIZAL ASSOCIATIONS IN FOREST PLANTATIONS, NUTRIENT CYCLING IN FOREST PLANTATIONS.

RESEARCH PROJECTS AND PUBLICATIONS PERTAINING TO FOREST INVASIVE SPECIES

RESEARCH PROJECTS HANDLED

1. INTEGRATED MANAGEMENT OF THE ALIEN INVASIVE WEED *MIKANIA MICRANTHA* IN THE WESTERN GHATS. COLLABORATIVE PROJECT WITH CABI BIOSCIENCE, UK. (1997-1999) - FUNDED BY DFID, UK.

2. Field trials for controlling Mikania infestation in forest plantations and natural forests in Kerala (1999-2003) - Funded by Kerala Forest Dept.
3. CLASSICAL BIOLOGICAL CONTROL OF *MIKANIA MICRANTHA* WITH *PUCCINIA SPEGAZZINII*. COLLABORATIVE PROJECT WITH CABI BIOSCIENCE, UK AND ICAR. (2003- 2005) - FUNDED BY DFID, UK.

Book

Sankaran, K.V., Murphy, S.T. and Evans, H.C. (Eds.) 2001. Alien weeds in moist tropical zones: Banes and benefits. Kerala Forest Research Institute and CABI Bioscience, U.K. 172 p.

RESEARCH REPORTS

Murphy, S.T., Ellison, C.A. and Sankaran, K.V. 2000. The development of a biocontrol strategy for the management of the alien perennial weed, *Mikania micrantha* HBK' (Asteraceae) in tree crop based farming Systems in India. RNRRS Project Final Technical Report, DFID , UK, 78p.

Sankaran, K.V., Muraleedharan, P.K. and Anitha, V. 2001. Integrated management of the alien invasive weed *Mikania micrantha* in the Western Ghats. KFRI Res. Rep. No.202, 51p.

Sankaran, K.V. and Pandalai, R.C. 2004. Field trials for controlling Mikania infestation in forest plantations and natural forests in Kerala. KFRI Res. Rep. under preparation.

Research papers and papers presented in Conferences

Sankaran, K.V. 2000. Effect of weeds on the productivity of forest plantations in Kerala. Paper presented at the Silver Jubilee Celebrations of the Kerala Forest Development Corporation and Symposium 'Prospects of Forest Development Corporation in the new millennium'. 24-25 January 2000, Kumily, Kerala.

Sankaran, K.V. and Sreenivasan, M.A 2001. Status of *Mikania* infestation in the Western Ghats. In: Proceedings of Workshop on Alien weeds in moist tropical zones: Banes and benfits, K.V. Sankaran *et al.*, (Eds.), Kerala Forest Research Institute and CABI Bioscience, U.K. pp. 67-76.

Sreenivasan, M.A. and Sankaran, K.V. 2001. Management of *Mikania micrantha* in Kerala - Potential of biological and chemical methods. In: Proceedings of Workshop on Alien weeds in moist tropical zones: Banes and benefits, , K.V. Sankaran *et al,* (Eds), Kerala Forest Research Institute and CABI Bioscience, U.K. pp. 122-130.

Sankaran, K.V. 2001. *Mimosa invisa*: a growing menace in South India. Biocontrol News and Information 22: 4-5 N.

Sankaran, K.V. 2001. Mikania management calls for biocontrol. Biocontrol News and Information 22(3): 61 N.

Sankaran, K.V. 2002. Black wattle problem emerges in Indian forests. Biocontrol News and Information 23: 5 N.

Sankaran, K.V. 2003. Biology, distribution and management of the weed *Mikania micrantha* in southwest India. In: Proceedings of the Inception Workshop of the ICAR-CABI Collaborative Project " Classical Biological Control of *Mikania micrantha* with *Puccinia spegazzinii"*, 27-28 June 2003, National Bureau of Plant Genetic Resources, New Delhi.

Sankaran, K.V., Murphy, S.T. and. Sreenivasan, M.A 2003. When good trees turn bad- the unintended spread of introduced plantation tree species in India. Proceedings of the Asia-Pacific Forest Invasive Species Conference, 17-22 August 2003, Kunming, China, FAO Regional Office, Bangkok (in press).

Sankaran, K.V., Murphy, S.T. and Sreenivasan, M.A. 2004. Invasion dynamics and impact of *Mikania micrantha* in the Western Ghats of India. Biological Invasions (Communicated).

Sreenivasan, M.A., Murphy, S.T and Sankaran, K.V. 2004. Growth and performance of *Mikania micrantha* in relation to soil types and other factors in the Western Ghats of India. Forest Ecology and Management (Communicated).

Sreenivasan, M.A. and Sankaran, K.V. 2004. Herbicidal control of the weed mikania in Kerala. Indian Journal of Forestry (to be communicated soon).

Sreenivasan, M.A. and Sankaran, K.V. 2004. Pathogenic mycobiota of the alien invasive weed *Mikania micrantha* in Kerala- search for potential biocontrol agents. Indian Phytopathology (to be communicated soon)

Little, K., ... Sankaran, K.V. et al. 2004. Reducing herbicide use through integrated forest vegetation management practices. Paper for presentation at the International Weed Science Congress, 2025 June, 2004. Durban, South Africa.

Popular article

Sreenivasan, M.A.& Sankaran, K.V. 2002. *Acacia mearnsii*- a cultivated weed? Evergreen 48: 2.

Curriculum Vitae

Name **S. S. JAIN**
Date of Birth : 11th April 1952

Present Address : Shifting Cultivation Division
Rain Forest Research Institute (RFRI)
(Indian Council of Forestry Research and Education)
P.O: Box No. 136, Jorhat – 785001, Assam, India

E-mail:jainss_84@yahoo.com
Tel: 0376 – 2395157; 2350274
Fax: 0376 – 2350273

Professional Skills and Work Experience

Post Held : **Present:** Scientist – C

Work Experience : 28 years experience of Research and Teaching in Taxonomy, Biodiversity Conservation and Ethno Botany.

Management of Herbarium, Arboretum and Botanical Garden at the Forest Research Institute, Dehra Dun.

Books / Publications : Books – 2

Papers – 70

Specialization : Taxonomy and Biodiversity Conservation of higher vascular plants with special reference to the forest flora.

Formal Education

- **M. Sc. Botany (1975)**
- **B. Sc. (Botany, Zoology, Chemistry) (1973)**

Curriculum Vitae

Personal Details

Name **DR. C. KUNHIKANNAN**

Date of Birth : 23rd March 1965

Present Address : Division of Biodiversity
Institute of Forest Genetics and Tree Breeding (IFGTB)
P.B. No. 1061, R.S. Puram
Coimbatore – 641002, TamilNadu, India

E-mail: kunhikannan@ifgtb.res.in

Professional Skills and Work Experience

Posts Held : **January 2003 to Present:** Scientist – D, ICFRE, Dehra Dun

Work Experience : 14 years of experience in Forest Botany, Forest Ecology, Medicinal Plant Survey, Documentation and Conservation

Books / Publications : Books – 2
Papers – 17

Specialization : Forest Ecology and Taxonomy

Formal Education

- **PH. D ON "STUDIES ON VEGETATION ECOLOGY OF TADOBA NATIONAL PARK, CHANDRAPUR, MAHARASHTRA"**
- **M. Sc. Botany**

Curriculum Vitae

Personal Details

Name		**Dr. N. VENKATASUBRAMANIAN**
Date of Birth	:	14th June 1951
Present Address	:	Division of Biodiversity Institute of Forest Genetics and Tree Breeding (IFGTB) P.B. No. 1061, R.S. Puram Coimbatore – 641002, TamilNadu, India

Professional Skills and Work Experience

Post Held	:	**Present:** Research Assistant Gr. I
Work Experience	:	28 years of experience in Forest Botany of Western Ghats and Eastern Ghats, with particular reference to Plant Taxonomy.
Books / Publications	:	Book – 1 Papers published in journals – 15 Papers presented in seminars – 10
Specialization	:	Plant Taxonomy

Formal Education

- **Ph. D**
- **M. Sc.**

Curriculum Vitae

Personal Details

Name		**RANJEET SINGH**
Date of Birth	:	19th November 1962
Present Address	:	Forest Protection Division Himalayan Forest Research Institute Conifer Campus, Panthaghati, Shimla – 171009 (HP) India

Professional Skills and Work Experience

Post Held	:	**Present:**	Head Forest Protection Division
Work Experience	:	14 years work experience in the field of Forest Entomology	
Publications	:	Papers – 42 papers	(Research papers, Technical Notes, Status and Research Reports)
Specialization	:	Economic Entomology	

Formal Education

- **Ph. D (Forest Entomology)**
- **M. Sc. (Entomology)**
- **B. Sc. Agri. (Honrs.)**

Curriculum Vitae

Personal Details

Name		**Dr. RAJ KUMAR VERMA**
Date of Birth	:	5th August 1966
Present Address	:	Division of Ecology & Biodiversity Conservation Himalayan Forest Research Institute Conifer Campus, Panthaghati, Shimla – 171009 (HP) India

Professional Skills and Work Experience

Post Held	:	**Present:** Scientist – D
Work Experience	:	12 years work experience in the field of Forestry Research
Publications	:	Papers – 40 (Research papers, Technical Notes, Status papers, Research Reports and booklets etc.)
Specialization	:	Forest Ecology and Biodiversity Conservation

Formal Education

- **Ph. D (Forestry)**
- **M. Sc. (Forestry)**
- **B. Sc. Agri. (Forestry)**

Curriculum Vitae

Personal Details

Name		**S. P. SUBRAMANI**
Date of Birth	**:**	9th June 1971
Present Address	**:**	Himalayan Forest Research Institute, Shimla Conifer Campus, Panthaghati, Shimla – 171009 (HP) India

Professional Skills and Work Experience

Post Held	**:**	**Present:** Research Assistant Gr. I
Work Experience	**:**	10 years work experience in Angiosperm Taxonomy
Publications	**:**	Papers – 11
Specialization	**:**	Plant Taxonomy

Formal Education

- **Ph. D (continuing in Angiosperm Taxonomy)**
- **M. Sc. (Botany)**
- **B. Sc. (Botany)**

Curriculum Vitae

Personal Details

Name		**R. S. BHANDARI**
Date of Birth	:	30th June 1949
Present Address	:	Forest Research Institute P.O: New Forest, Dehra Dun – 248006, Uttaranchal, India

Professional Skills and Work Experience

Post Held	:	**Present:** Scientist – F
Work Experience	:	34 years of Research experience
Books / Publications	:	Papers – 69 Reports – 7
Specialization	:	Forest Entomology

Formal Education

- **M. Sc. (Zoology) (1969)**

Other Education

- One month Training in 'FOXPRO', TULEC Computer Education, Dehradun (1999)
- 3 months Diploma Course in Insect Entomology from Swedish University of Agricultural Science, Uppsala, Sweden (1996)

Curriculum Vitae

Personal Details

Name **Dr. SUDHIR SINGH**

Date of Birth : 2nd March 1962

Present Address : Division of Forest Entomology
Forest Research Institute
P.O: New Forest, Dehra Dun – 248006, Uttaranchal, India

Professional Skills and Work Experience

Post Held : **Present:** Scientist – D

Work Experience : 20 years of Research experience in Taxonomy of parasitic Hymenoptera. Bio-ecology, microbial entomopathogens and biological control of forest insect pests. Involved in upgradation and computerization of National Forest Insect Collection at Entomology Division, Forest Research Institute, Dehradun

Publications : Papers – 29
Monograph – 1

Specialization : Taxonomy of parasitic species and their biological control

Formal Education

- **Ph. D (Zool., Entomology) on "Taxonomic Studies on Parisitic Micro-Hymenoptera (Chalcidoidea) (1991)**
- **M. Phil. (Zool. Specialization in Entomology) (1987)**
- **M. Sc. (Zool. Specialization in Entomology) (1984)**
- **B. Sc. (Bot., Chem., Eng., Zool.) (1982)**

Other Education

- Diploma in Proficiency of German Language (1990)
- Certificate in Proficiency of German Language (1988)
- Diploma in Statistics (1986)

Curriculum Vitae

Personal Details

Name		**Dr. A. N. Shukla**
Date of Birth	:	1st June 1949
Present Address	:	Forest Pathology Division Forest Research Institute P.O: New Forest, Dehra Dun – 248006, Uttaranchal, India

Professional Skills and Work Experience

Post Held	:	**Present:** Scientist – F and Head, Forest Pathology Division, FRI
Work Experience	:	34 years of experience in the field of Forest Pathology with emphasis on pathogenic diseases caused by fungi and their control measures
Publications	:	45
Specialization	:	Forest Pathology

Formal Education

- **Ph. D (1976)**
- **M. Sc. (1971)**

Membership in Professional Societies

- Mushroom Society of India, Solan, Himachal Pradesh
- Indian Society of Mycology and Plant Pathology, Udaipur, Rajasthan

Curriculum Vitae

Personal Details

Name **Dr. NIRMAL SUDHIR KUMAR HARSH**

Date of Birth : 3rd April 1957

Present Address : Forest Pathology Division
Forest Research Institute,
P.O: New Forest, Dehra Dun – 248006, Uttaranchal, India

E-mail:harshnsk@icfre.org
Tel: 0135 – 2752672 (O); 2771937 (R)

Professional Skills and Work Experience

Post Held : **Present:** Scientist – E

Work Experience : 25 years of Research and Teaching experience in the field of Forest Pathology

Publications : Articles – 8
Research Reports – 6
Research Reports – 2
Papers published in journals – 93
Papers presented in seminars – 49

Specialization : Forest Pathology, Control of forestry diseases including biological control, Taxonomy of higher fungi

Formal Education

- **Ph. D (Mycology – Forest Pathology) on "Studies on the wood-decaying fungi of Kumaon Hills" (1976)**
- **M. Sc. (Botany – Specialization in Plant Pathology) (1971)**
- **B. Sc. (Botany, Zoology, Chemistry) (1976)**

Membership in Professional Societies

- Fellow of Phytopathological Society of India
- Member of New York Academy of Sciences, U.S.A.
- Honorary Appointment to the Research Board of Advisors for 1999 by American Biographical Institute Inc., North Carolina, U.S.A.

Curriculum Vitae

Name	**Dr. Rajendra Kumar Pandey**
Date of Birth	1st April 1957
Nationality	Indian

Educational Qualifications:

Degree	University / Institutions	Year
B.Sc	Saugar University	1976
M.Sc	Saugar University	1978
Ph.D.	Saugar University	1983
L.L.B.	R.D.University, Jabalpur	2000

Present working position:	Senior Scientist and Head Ecology & Environment State Forest Research Institute, (Govt. of M.P.) Jabalpur, Madhya Pradesh
Research Experience:	22 years of experience in various disciplines of environmental services and sustainable use of forest, embracing forest ecology, wildlife management, systematic botany, biodiversity conservation and their sustainable development, EIA etc.