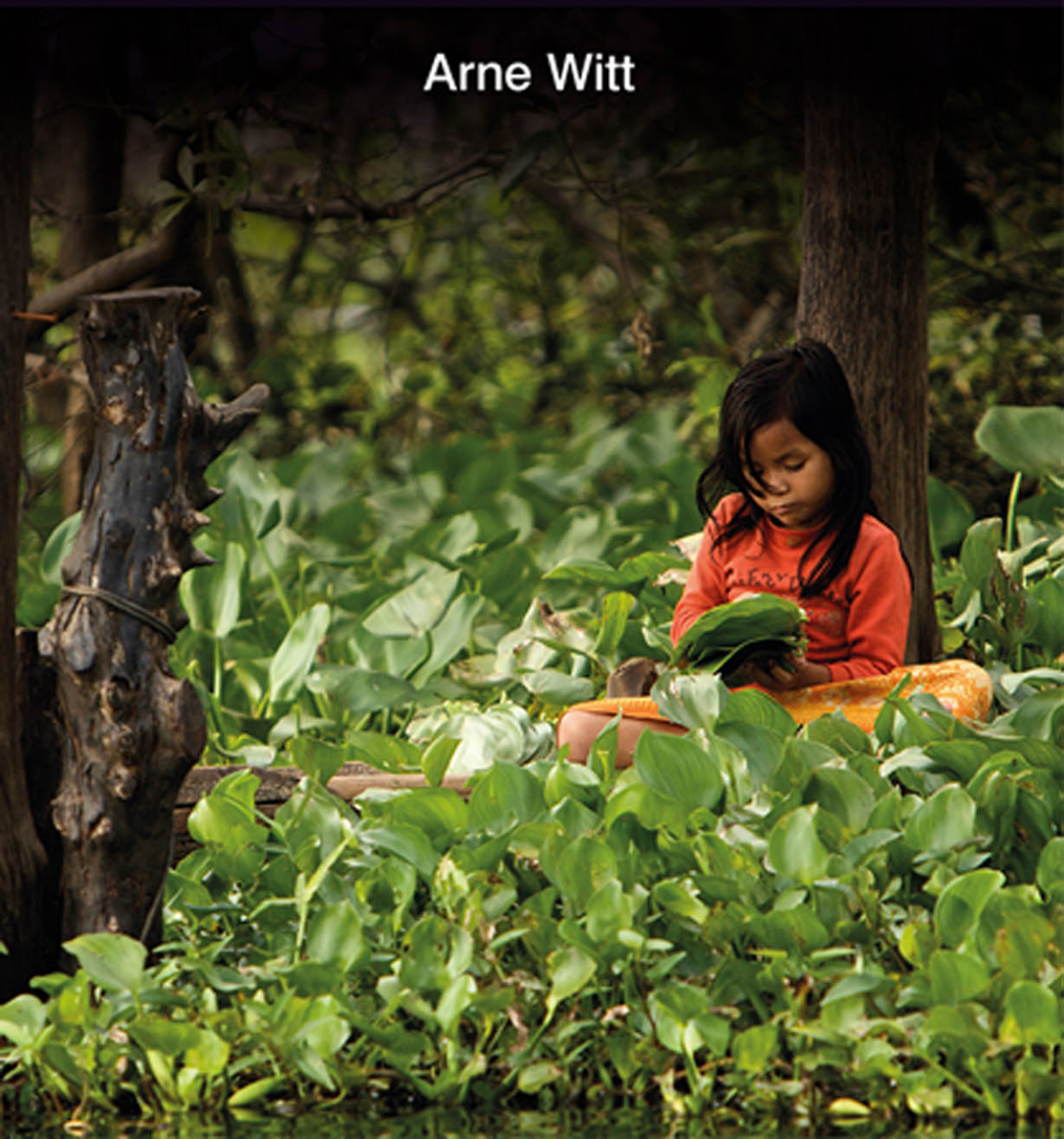
GUIDE TO THE NATURALIZED AND INVASIVE PLANTS OF

SOUTHEAST ASIA

Arne Witt



GUIDE TO THE NATURALIZED AND INVASIVE PLANTS OF

SOUTHEAST ASIA

This page intentionally left blank

GUIDE TO THE NATURALIZED AND INVASIVE PLANTS OF

SOUTHEAST ASIA

Arne Witt, CABI

First published in 2017

CABI is a trading name of CAB International

CABI
Nosworthy Way
Wallingford
Oxfordshire OX10 8DE
UK

T: +44 (0)1491 832111
F: +44 (0)1491 833508
E: info@cabi.org
www.cabi.org

A catalogue record for this book is available from the British Library, London, UK.

ISBN-13: 978 1 78639 210 7

Front cover image: Jus Medic, www.jusmedic.com

Design and typesetting by Sarah Hilliar, CABI

Production Editor: Tracy Head, CABI

Line drawings: Elijah Njoroge

Printed and bound by Gutenberg Press Ltd., Tarxien, Malta

Contents

Arne Witt is currently the Regional (Africa and Asia) Coordinator for Invasive Species for CABI, based in Nairobi, Kenya. He has been, and still is, actively involved in a number of UN Environment-GEF IAS Projects in Africa, Asia and the Caribbean dealing with issues pertaining to policy development, capacity building, awareness creation and development and implementation of best management practices. He is also involved in a number of other IAS projects in Africa and Asia.

Arne has a PhD from the University of the Witwatersrand. He also has Master of Science degrees in Entomology and Conservation Biology. This is the first of a series of Field Guides he is authoring on invasive plants in Africa and Asia and follows on from his recently co-authored book *Invasive Alien Plants and their Management in Africa*.

Foreword

The nations of Southeast Asia have embarked on a major new initiative aimed at better conserving their natural heritage resources. Under this initiative, steps are being taken to protect biodiversity in forests, wetlands and other natural ecosystems. The measures are expected to deliver important gains, boosting Natural Capital – both in individual countries and across the region as a whole. Present and future generations of people in Southeast Asia stand to benefit from this investment.

These efforts are being driven by unprecedented levels of commitment on the part of national institutions in the member states of ASEAN (the Association of Southeast Asian Nations), and by newly-forged cooperation at the regional level between the member states. The more effective stewardship of natural resources is recognized as critical in enabling the ASEAN countries to meet their obligations under a number of important global treaties and agreements, with respect to both biodiversity protection and sustainable development.

Such agreements include those of the Environment Assembly (UNEA), the Convention on Biological Diversity (CBD), and the International Plant Protection Convention (IPPC), as well as undertakings made under the three main pillars – *Environmental*, *Economic*, and *Social* – of the Sustainable Development Goals (SDGs).

Progress under the second of the major SDG components, that of Economic Sustainable Development, is essential, here as in other regions with a burgeoning human population, in underpinning basic food security. To this end, continual improvements are needed, in the management and productivity of farmlands and of pastures, as well as in aquaculture and in other aspects of food production and agribusiness. Such improvements depend on nations' being able, in the long term, to safeguard their water supplies and access to vital ecosystem services, while at the same time ensuring that threats, in the shape of invasive 'pest' species for example, can be minimized.

Gains under the third major SDG component, that of *Social Sustainable Development*, are likewise dependent on healthy, productive and resilient natural ecosystems. Only such environments can deliver stable and secure livelihoods and living conditions. By contrast, the social consequences for those living in degraded environments, beset by water scarcity and by famine, poverty and disease, can be devastating.

One of the gravest threats, to the healthy function of any ecosystem, natural or human-made, is the menace posed by invasive alien species (IAS). These are species of plants and of animals which, on having been introduced into new environments outside their natural home ranges, go on to proliferate and to become destructive to the native ecology of their adopted environments, impacting negatively on biological diversity, on human health and food security, and on livelihoods – often with dire socio-economic consequences.

For Southeast Asia as a whole, annual losses attributed to IAS have been estimated at some US$ 33.5 billion. This includes biodiversity losses and lost crop-production, as well as costs to human health and well-being. Losses within the agricultural sector alone, both through lost production and through increased management costs, amount to an estimated 90 % of this total. The annual costs associated with IAS impacts on human health and on environmental degradation are put at US$ 1.85 billion and US$ 2.1 billion, respectively.

The unbridled spread of IAS, including that of destructive crop pests, has significantly reduced farm yields, while forcing farmers into using ever greater quantities of expensive and toxic pesticides. Many pathogens, too, including the vectors of diseases such as Zika and Dengue Fever, are invasive species, which are adversely affecting human health and productivity. Invasive plant species, meanwhile, in watersheds, are limiting the availability of potable water – now an increasingly grave concern, especially against the backdrop of a changing global climate.

Infestations of invasive plant species, many of which are toxic, are also damaging to animal health, while at the same time displacing native forage plants and so reducing the carrying capacities of pastures, for domestic livestock and wild animals alike. Increasingly, in the wildlife habitats of Protected Areas in Southeast Asia, infestations of invasive plant species are threatening to disrupt the native ecology that sustains threatened populations of mammals of iconic flagship species, such as elephants, rhinos and tigers.

Collectively, IAS are now universally regarded as posing one of the most serious of all threats to global biodiversity, to agriculture and food production, to sustainable economic development, and to human health and livelihoods. In magnitude, the damaging impacts of IAS on natural ecosystems are eclipsed only by those of outright habitat destruction. The IAS threat extends to multiple sectors, moreover, impacting negatively all aspects of socio-economic activity. This is true of the ASEAN region, as it is for every other region on the planet.

Yet, despite the known magnitude and extent of this threat, and despite the ever rising economic costs associated with IAS, decision-makers and policy formulators around the world remain reluctant to act upon the need to manage these costly IAS infestations. This amounts to a serious failing, both in market-driven economic terms and in terms of governance, particularly given that world leaders – both in governments and in commerce and industry – are fully aware of how the IAS menace may prevent the full attainment of at least three important targets agreed to under the Sustainable Development Goals.

In a bid to overcome this problem of inaction with regard to IAS, CAB International – with support from the UN Environment – has been working with the ASEAN Centre for Biodiversity (ACB), and with national executing agencies in Indonesia, Cambodia, Vietnam, and the Philippines, on a GEF-funded project called ‘Removing Barriers to Invasive Species Management in

Production and Protected Forests in Southeast Asia' – otherwise known as the FORIS Project.

One of the principal goals of the FORIS Project is to strengthen IAS awareness in the ASEAN countries, and to facilitate action on the ground, as well as at the level of national policy, so enabling the ASEAN countries to act now and to invest more in IAS prevention and control measures. To this end, the critical first step lies in providing information that will enable people in the region to identify plant species that are invasive already, or which have the potential to become invasive – so that potentially serious impacts can be averted through the initiation of timely management interventions.

We therefore welcome the production, and the dissemination in ASEAN member states, of this Field Guide to some of the naturalized and invasive alien plant species in the region. The Guide will serve as an invaluable aid in the identification, mapping, monitoring, and management of invasive alien plant species that are already present in member states, or which may become problematic in the future, due to increased trade and travel, economic development and climate change.

Max Zieren, UN Environment–GEF Regional Focal Point & FORIS Task Manager, UN Environment Regional Office, Asia Pacific, Bangkok, Thailand

Foreword

There are 25 'biodiversity hotspots' in the world and Southeast Asia overlaps or includes within its geographic boundaries four of these (Indo-Burma, Sundaland, Wallacea and the Philippines). Despite occupying only 3% of the earth's surface, the Association of Southeast Asian Nations (ASEAN) region hosts 20% of all known species. For example, the Philippines harbours some 8,000 and 6,490 species of flowering and non-flowering plants, respectively. Up to 40% of these are thought to be endemic.The Sundaland hotspot, with its core in Indonesia, has about 25,000 vascular plant species, of which 15,000 are endemic; approximately 770 bird species of which nearly 150 are endemic; more than 170 endemic mammal species; and over 450 species of reptiles of which roughly 250 are endemic. The Indo-Burma hotspot, which includes Vietnam and Cambodia, has 7,000 endemic vascular plant species, 520 reptile species of which 200 species are endemic, and the highest diversity of freshwater turtles in the world with 53 species. Out of the 64,800 species found in Southeast Asia, 1,312 are endangered by a host of factors including invasive alien species (IAS).

These IAS are exotic, non-native, non-indigenous or foreign plants or animal species that have been introduced by people, either intentionally or unintentionally, outside of their natural range and outside of their natural dispersal potential. In their new environment they establish and proliferate to the detriment of biodiversity, livelihoods, human and animal health, and the environment. In fact IAS are considered to have one of the biggest impacts on biodiversity, second only to habitat destruction. The total annual loss to agriculture, human health and the environment in Southeast Asia as a result of IAS is estimated to be more than US$ 33 billion. These impacts will be exacerbated as a result of increased trade, travel and transport, and climate change.

Despite the significant impacts of IAS, there has not been a concerted effort to tackle the problem across the region. This can mainly be ascribed to a lack of policy, little awareness and limited capacity at a national and regional level. The UN Environment-GEF project, 'Removing Barriers to Invasive Species Management in Production and Protection Forests in SE Asia', which was active in Cambodia, Indonesia, the Philippines and Vietnam, identified these barriers and produced this Guide which will go a long way to creating awareness about invasive plants, their impacts and how best to manage them. As such the author of this Guide, Arne Witt, should be commended as well as all of the other contributors. It is hoped that this Guide would trigger similar efforts in other countries in Southeast Asia as the region moves toward socio-economic integration.

Dr. Ir. Irdika Mansur, Director SEAMEO BIOTROP (Southeast Asian Regional Centre for Tropical Biology)

Introduction

The main aim of this Identification Guide is to enable individuals to identify some of the naturalized and invasive alien plants in Southeast Asia and to learn more about their impacts and options for their management and control. The plants described in this Guide are all naturalized and/or invasive in one or more of the countries in the region such as Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. It is by no means a complete Field Guide, only covering 55 introduced and problematic plant species. These species are also not necessarily all of the worst 'offenders', but have been included based on some literature reviews and feedback from project partners and others.

The book is sub-divided into seven main sections: Aquatics, Grasses, Climbers (includes vines and/or creepers), Herbs (includes spreading or flat-growing herbs), Shrubs, Succulents, and Trees. Some species may be considered as both shrubs and small trees, or as both small and large trees, or as both shrubs and climbers, but have been included in only one of the sections or categories in order to avoid duplication. The species appear in alphabetical order within each section based on their scientific names.

Where two or more species are very similar, based on their external morphology, only one species is illustrated and the differences between them provided in the text. The text includes the scientific name of the species, together with its common English name and local names most frequently used in some of the countries. Unfortunately we were unable to get common names for all species but hope that this will be rectified in future editions. There is a brief description of the species, together with line drawings and colour photographs and information on their origin, reasons for introduction, habitats invaded and impacts. Information on impacts have been obtained from multiple sources, often from studies undertaken outside of Southeast Asia, but are considered to be generic, and at the very least the assumption can be made that the impacts of a particular invasive plant are similar, irrespective of where it is adventive. Information on management practices is also provided. We have included information on herbicides used elsewhere to control these naturalized and invasive plants. These herbicides may not be available or registered for use in countries within the region, but could be considered for future use, provided that all required national regulations are fulfilled. Ultimately it is the responsibility of the user to ensure that he/she abides by all national regulations pertaining to herbicide use.

What is an alien plant?

An alien plant is an exotic, non-native, non-indigenous or foreign plant species that has been introduced by people, either intentionally or unintentionally, outside of its natural range and outside of its natural dispersal potential. Plants that have been introduced into an area without the help or involvement of people, from an area in which they are already exotic, are also regarded as alien. In other words a species which does not belong to the native flora is alien. This includes most of our crops (wheat, maize, rice, potatoes, etc.) and many of our ornamental plants.

What is an invasive alien plant?

An invasive alien plant is a species of plant that is both alien, as described above, and is destructive to the environment in which it grows. As such invasive plants can have negative impacts on biodiversity and/or livelihoods. It should be noted that most alien species are useful and are not invasive.

What is a naturalized plant?

In the context of this Guide, a naturalized plant is an alien plant that has established self-perpetuating populations without any human intervention, but which is not yet considered to be invasive in terms of being widespread, abundant or destructive in areas where it is found. Most plants that are considered to be naturalized go on to become invasive, but in many cases they do not.

What is a weed?

A weed is a plant that is out of place and which has not been sown intentionally, or it is a plant growing where it is not wanted. A weed has a negative impact on, among others, crop or pasture production, on human or animal health, or other aspects of economic activity and development, and may be either native or introduced. Yet while some native weeds may be problematic, in crop production systems, for example, those very same species, often referred to as pioneers, may play an important role in plant successions, say, in degraded forests. Pioneers, because they do not persist, allow natural succession to take place, unlike invasive alien species (IAS), which do persist and inhibit or prevent natural succession processes. The definition of a weed is therefore context dependent, but in the final analysis, while all invasive alien plant species are weeds, not all weeds are invasive alien plants, because many of them are native to a particular country or region.

Attributes that enable alien plants to become invasive:

- have no natural enemies in the area to which they have been introduced. In other words, there are no diseases or herbivores that have the ability to attack the alien plant, and so reduce its growth rate, reproductive capacity and competitive ability;
- are adaptable in that they are capable of growing in a wide range of habitats and soil types and under various climatic conditions;

- are often plants that have the ability to spread vegetatively (cladodes, tubers, bulbs, etc.) as well as by seed;
- may be plants that are popular as ornamentals or which are used in agro-forestry, as these plants are more likely to be moved around and are grown in large numbers, contributing to increased propagule pressure;
- are often hardy, having the ability to withstand adverse growing conditions;
- have the ability to grow rapidly and can regenerate quickly after being damaged;
- establish easily, often in nutrient-poor or water-limited environments;
- can make very efficient use of limited resources such as water, nutrients and light;
- mature very rapidly and thus produce seeds early, often in large quantities;
- possess efficient and effective modes of dispersal;
- do not require specialized pollinators, so they are not dependent on one species of insect or bird to pollinate their flowers; and
- have seeds that can remain dormant for long periods allowing the plant to persist during periods that are not suitable for active growth.

Invasive alien plants may:

- interfere with crop and pasture production and native plants through competition for available light, water and nutrients;
- physically interfere with the growth of a crop or native plant species;
- displace crops, pasture and native plant species through the production of toxins that inhibit the growth of other plants (allelopathy);
- permanently alter natural ecosystems and the services and benefits they provide in nature and to people;
- impact on soil nutrient cycling (e.g. nitrogen-fixing plants);
- contaminate harvested crops with weed seeds or by tainting (e.g. some weed seeds are toxic and may result in poisoning when consumed);
- act as secondary hosts for crop pests (i.e. harbour insects, pests or diseases which attack crops);
- provide suitable habitats for organisms that may pose a threat to human or animal health (e.g. waterweeds provide ideal habitats for vectors of human and animal diseases);
- increase shading (e.g. caused by invasive shrubs or trees), which can alter soil temperatures, affecting the growth, reproduction and/or survival of organisms residing in the soil;
- have a negative impact on human and animal health (e.g. pollen from invasive plants may contribute to respiratory ailments in people);
- interfere with the harvesting of crops or forage (e.g. thorny or woody weeds can make it difficult to harvest crops);

- lead to the need for additional cleaning and processing (e.g. weeds with burs may lodge in sheep's wool);
- reduce the amount of available pasture (i.e. weeds may displace valuable pasture species or prevent access to valuable forage);
- be poisonous to people, livestock or wildlife;
- cause physical injuries to people, livestock or wildlife (e.g. weeds with spines, such as cactus species, can cause serious injuries);
- reduce the quality of animal products such as meat, milk, fleeces or hides (e.g. consumption of some weeds, such as parthenium, by livestock, may make their milk and meat unpalatable);
- invade water bodies, affecting water quality and quantity (e.g. waterweeds can dramatically increase water loss through evapotranspiration);
- inhibit water transport (e.g. waterweeds can inhibit or prevent the movement of boats);
- inhibit or prevent hydroelectricity generation (e.g. waterweeds block turbines);
- block water courses (e.g. aquatic or semi-aquatic weeds) including irrigation canals, leading to flooding;
- inhibit the ability of people to catch fish (e.g. waterweeds, such as water hyacinth, can cover a whole water surface making it impossible to fish);
- alter river flows and contribute to riverbank erosion (e.g. semi-aquatic weeds, such as giant sensitive plant, can reduce water flow rates);
- contribute to erosion of sand from beaches (i.e. weeds used to stabilize coastal dunes can alter soil movement dynamics reducing sand deposition on beaches);
- interfere with the recreational use of certain areas, especially water bodies;
- reduce tourism potential (i.e. unpalatable weeds can reduce the abundance of wildlife);
- increase the frequency and intensity of fire (e.g. weeds, such as chromolaena, are highly flammable);
- provide cover for dangerous animals and in many instances also poachers;
- prevent access to natural resources (i.e. weeds forming dense impenetrable thickets can prevent access to water and grazing);
- encroach on roads, paths and villages;
- contribute to the abandonment of homes and villages (i.e. a reduction in crop yields and pasture production has forced people to move elsewhere);
- are drivers of human conflict (i.e. invasive plants, by eroding the natural resource base on which millions of people depend, may spark conflict, especially over access to water and grazing); and
- reduce visibility along transport corridors.

It has been estimated that weeds in general cause a yield loss of about 10% in less developed countries and approximately 25% in the least developed countries (Akobundu, 1987). In the USA, crop losses to the value of approximately US$ 27.9 billion can be attributed to exotic weeds (Pimentel *et al*., 2001). In India, weeds are estimated to cause a 30% loss in potential crop production, worth about US$ 90 billion per year in reduced crop yields (Singh, 1996). In Southeast Asia, 44% of weeds are considered to be introduced (Nghiem *et al*., 2013). It is estimated that invasive plants and animals contribute to losses and costs to agriculture, human health and the environment of US$ 33.5 billion (Nghiem *et al*., 2013). The importance of weeds can probably be best illustrated from a survey conducted by Arraudeau (1986) in 36 countries, representing approximately 90% of the upland rice area in the world, where weeds were reported to be the major biological constraint to rice production in 25 countries. In fact, more than 1,800 weed species grow in association with rice in South and Southeast Asia alone, more than are recorded for any other crop. In upland rice, losses caused by uncontrolled weed growth can range from 40% to 100%. Upland rice farmers in Laos mentioned that weeds were the major constraint to production, with up to 50% of farmer's time (150–200 days per hectare) spent on weed control (Roder *et al*., 1995). Clearly not all of these weeds are introduced but in most regions almost 50% are considered to be alien.

Invasive plant species can also have a dramatic impact on livestock production. Approximately 45% of the weed species in US pastures are introduced species, which account for a loss of about US$ 1 billion in pasture production per year (Pimentel *et al*., 2001). Most of the pasturelands in India have been invaded by the invasive shrub *Lantana camara* L. (Verbenaceae) to some or other degree, resulting in lost productivity and management costs of almost US$ 1 billion per year (Pimentel *et al*., 2001). It is also toxic to livestock with pastoral losses in Queensland, Australia, in 1985, estimated to be A$ 7.7 million, as a result of 1,500 animal deaths, reductions in productivity, loss of pasture, and control costs (van Oosterhout, 2004). Annual losses caused by *Parthenium hysterophorus* L. (Asteraceae) in Australia were approximately A$ 16.5 million, due to reduced livestock numbers, reduced live-weight gains, and control costs (Chippendale and Panetta, 1994). In South Africa, *Chromolaena odorata* (L.) King & Rob. (Asteraceae) can reduce pasture carrying capacities from approximately six hectares per livestock unit (LSU) to more than 15 hectares per LSU (Goodall and Morley, 1995). A recent study indicated that without any management of invasive plants there would be a 71% reduction in natural grazing capacity in South Africa (van Wilgen *et al*., 2008). It is estimated that introduced weeds in crops and pastures in South Africa, the USA, the UK, India, and Brazil result in economic losses of almost US$ 95 billion per annum (Pimentel *et al*., 2001).

Many invasive plants also have a dramatic impact on water resources. In South Africa, invasive alien plants reduce surface water run-off by approximately 3,300 million m^3 (about 7% of the national total) (Le Maitre *et al*., 2000). If invasive plants were left to expand their distribution and occupy their full potential range, water reductions in South Africa would be more

than eight times greater (about 56% of the national total) (van Wilgen *et al*., 2008). Water hyacinth [*Eichhornia crassipes* (Mart.) Solms; Pontederiaceae] and other waterweeds can also dramatically increase water loss through evapotranspiration and impact on a host of other sectors. For example, rates of water loss as a result of water hyacinth infestations have been reported to be up to 13 times that from a free water surface (Gopal, 1987). Water flow can also be reduced by 40–95% in irrigation channels as a result of infestations, sometimes leading to flooding in Malaysia and Guyana (Gopal, 1987). *E. crassipes* may also reduce water quality in various ways and encourage mosquitoes, snails and other organisms associated with human illnesses, including malaria, schistosomiasis, encephalitis, filariasis and cholera (Gopal, 1987). Costs of controlling water hyacinth in Malaysia have been estimated at M$ 10 million per year (Mohamed *et al*., 1992).

Invasive plants also impact human and animal health. For example, parthenium weed can cause severe allergic reactions in people who come into contact with the plant on a regular basis (McFadyen, 1995). Paper mulberry [*Broussonetia papyrifera* (L.) Vent.; Moraceae] produces considerable amounts of allergenic pollen which has been shown to exacerbate asthma in sufferers. In Islamabad, Pakistan, paper mulberry can account for 75% of the total pollen count contributing to ill health and even death in the old and infirm. Parthenium weed, like so many other invasive plants, is also toxic to livestock. This weed has been shown to cause severe dermatitis, anorexia and intestinal damage, which can lead to the death of buffalo, cattle and sheep, and 10–50% of the weed in the diet can kill these animals within 30 days (Narasimhan *et al*., 1977). In South Africa, *L. camara* poisoning accounts for about 25% of all reported livestock poisoning by plants (Wells and Stirton, 1988).

Biodiversity is also dramatically reduced as a result of the presence of invasive plants. In fact many consider IAS to pose the second biggest threat to biodiversity after habitat destruction. In Australia, 275 native plant and 24 native animal species are threatened by the presence of *L. camara* alone (Turner and Downey, 2010). In Tram Chim National Park, Vietnam, *Mimosa pigra* L. (Fabaceae) has reduced the density of native plant species, threatening the sarus crane (Triet and Dung, 2001), which is already listed as vulnerable. *M. pigra* thickets in Australia had fewer birds and lizards, less herbaceous vegetation and fewer tree seedlings than native vegetation (Braithwaite *et al*., 1989). In Lochinvar National Park, Zambia, mimosa infestations reduced bird diversity by almost 50% and abundance by more than 95% (Shanungu, 2009). In South Africa, *Prosopis* spp. (Fabaceae) infestations reduced bird species diversity in some guilds by more than 50% (Dean *et al*., 2002). In Nepal, plant invasions pose the second biggest threat to the endangered one-horned rhino after poaching. In Ethiopia, *Prosopis juliflora* reduced understorey basal cover for perennial grasses from 68% to 2% and, the number of grass species from seven to two (Kebede and Coppock, 2015). The total transformation of the habitat and reduction in pasture species threatens the survival of Grévy's zebra (*Equus grevyi* Oustalet; Equidae) in invaded areas (Kebede and Coppock, 2015). The

banteng (*Bos javanicus* d'Alton; Bovidae) is threatened with extinction in Baluran National Park, Indonesia, as a result of *Vachellia nilotica* (L.) Hunter & Mabb (Fabaceae) [previously *Acacia nilotica* (L.)] infestations, which are displacing valuable pasture species. More than 50% of protected areas in Indonesia are already known to be invaded by one or more invasive plant species, but the figure is probably significantly higher. It is highly likely that the majority of protected areas throughout Southeast Asia are invaded to some extent.

It is obvious that unlike many invasive species, such as insect pests of crops, introduced plants generally have a cross-cutting impact affecting various sectors from biodiversity to agriculture to water resources, and human and animal health. Once an invasive plant has established, and is widespread and abundant, it is virtually impossible to eradicate and as such, impacts on natural or man-made ecosystems are permanent. This is why invasive alien plants pose such a significant threat to economic development and livelihoods, especially in the developing world, where most people are dependent on natural resources for their survival. It is therefore critical that we pool our efforts to manage this scourge at the national, regional and global level.

Types of invasive plants

Invasive plants come in various growth forms, shapes and sizes. As mentioned in the Introduction, invasive plants in the context of this Field Guide have been grouped into Aquatics, Grasses, Climbers, Herbs, Shrubs, Succulents, and Trees. Although many of the invasive plants included in this Guide could be considered to be benign, others, if consumed by wildlife, livestock or people, are extremely toxic. The symbols used in this Guide provide users with a quick reference to the various growth forms and toxicity.

Toxic: These plants are poisonous and can have a negative impact on human or animal health and may even result in death, if consumed. Species which are toxic include parthenium weed (*Parthenium hysterophorus* L.; Asteraceae), lantana (*Lantana camara* L.; Verbenaceae) and common thorn apple (*Datura stramonium* L.; Solanaceae), among others.

Grasses: Herbaceous plants with jointed stems, long and narrow leaves growing from the base, with spikes of small wind-pollinated flowers. These include species such as torpedograss (*Panicum repens* L.), para grass [*Brachiaria mutica* (Forssk.) Stapf.], and Mossman river grass (*Cenchrus echinatus* L.).

Aquatics: Plants capable of growing in aquatic or semi-aquatic environments. These include species such as water hyacinth [*Eichhornia crassipes* (Mart.) Solms; Pontederiaceae] and water lettuce (*Pistia stratiotes* L.; Araceae). Some shrubs or small trees, such as the giant sensitive plant (*Mimosa pigra* L.; Fabaceae), may also be regarded as semi-aquatic, although they have been included under the 'Trees' section in this Guide.

Climbers: Plants which can grow over and smother other vegetation. These include species such as coral creeper (*Antigonon leptopus* Hook. & Arn.; Polygonaceae), mile-a-minute (*Mikania micrantha* Kunth; Asteraceae) and lesser balloon vine (*Cardiospermum halicacabum* L.; Sapindaceae). It should be noted that some large shrubs such as *Chromolaena odorata* (L.) R.M. King & H. Robw (Asteraceae), yellow cestrum (*Cestrum aurantiacum* Lindl.; Solanaceae) and even *Lantana camara* may also be considered to be climbers as they have the ability to grow over other vegetation and 'climb' into trees. However, in this Guide the latter species are included under the 'Shrub' section.

Herbs: Small non-woody plants, usually no more than about 1 m tall, with generally green, soft, often single stems. These include species such as black jack (*Bidens pilosa* L.; Asteraceae), Mexican poppies (*Argemone* spp.; Papaveraceae) and *Parthenium hysterophorus*.

Spreading or Flat-growing Herbs or Ground Covers: Plants with green, soft and horizontal stems that root whenever they come into contact with the ground. Examples include species such as Singapore daisy [*Sphagneticola trilobata* (L.) Pruski; Asteraceae] and creeping sensitive plant (*Mimosa pudica* L.; Fabaceae). The latter is sometimes also considered to be a small shrub.

Small Shrubs: Woody plants that are smaller than large shrubs and trees, as described below. Often multi-stemmed and reaching heights of 1 m or less, these include species such as crofton weed [*Ageratina adenophora* (Spreng.) King & Rob.; Asteraceae] and Koster's curse [*Clidemia hirta* L. (Don.); Melastomataceae].

Large Shrubs: Woody plants that are smaller than trees and often multi-stemmed, reaching heights of 2 m or more. They form dense impenetrable stands such as *Lantana camara*, *Chromolaena odorata* and others. Some species, such as *Cestrum aurantiacum*, which are classified as large shrubs also have the ability to climb over or into other vegetation and as such may also be considered as climbers. However, in this Guide the latter is included under the 'Large shrub' section.

Succulents: Plants with thick fleshy leaves or stems for storing water. Usually found in arid or semi-arid regions, these include species such as *Opuntia* species. Many of these could also be considered to be shrubs or even small trees such as sweet prickly pear [*Opuntia ficus-indica* (L.) Mill.; Cactaceae].

Small Trees: Woody plants that are larger than shrubs and which usually have only one erect perennial stem or trunk. Generally reaching heights of a few metres (less tall than in the 'Large trees' category below), these plants have wide crowns and in many cases form dense impenetrable thickets. Examples include calliandra (*Calliandra calothyrsus* Meissn.; Fabaceae) and pigeon berry (*Duranta erecta* L.; Verbenaceae) although some may consider the latter to be a large shrub.

Large Trees: Woody plants that are larger than shrubs and which usually have only one erect perennial stem or trunk and a wide crown, but which (unlike small trees) may reach several metres in height. Examples include mangium (*Acacia mangium* Willd.; Fabaceae) and *Prosopis juliflora* (Sw.) DC. (Fabaceae), although the latter is sometimes also regarded as a large shrub.

What can we do to manage invasive alien plants?

In order to be effective, all invasive alien plant management strategies need to consider activities related to: (i) prevention; (ii) early detection and rapid response (EDRR); and (iii) control.

Prevention: As most of the invasive plants present in Southeast Asia were intentionally introduced, the most effective way to prevent further introductions is to prevent their introduction in the first place. To that end it is important to evaluate the potential of an introduced plant to become invasive prior to introduction. This can largely be determined by undertaking a Risk Assessment (RA) which, amongst other factors, considers the biology of the species, characteristics of the environment to which it is being introduced and if it has been recorded as being invasive elsewhere. Undertaking RA on exotic species which are already present should also be encouraged, so that those plant species which show a high risk of becoming invasive in the future can be eradicated. It should be noted that climate change, increased disturbance and propagule pressure are all factors that may drive an exotic species, which may appear to be benign now, to become invasive in the future. Prevention is the most cost-effective activity within a holistic invasive species management strategy. As the saying goes 'an ounce of prevention is worth a pound of cure'.

Early detection and rapid response (EDRR): If authorities, competent bodies or even landowners have failed to prevent the introduction of an invasive or potentially invasive species, and it has established in the field, it is critical that it be detected early and eradicated, before it becomes widespread and abundant. To that end it is important that a surveillance strategy be developed and implemented. If an invasive or potentially invasive species is detected, but it is already abundant and widespread, a containment strategy needs to be implemented to prevent its further spread and action taken to mitigate its negative impacts.

Control: If surveillance did not result in the early detection of a potentially problematic plant, and eradication is no longer feasible because it is already widespread and abundant, it is essential to implement a control strategy. A control strategy could include the use of cultural, physical or chemical methods or a combination of some or all of these measures, followed by rehabilitation or restoration. However, before any control is implemented it may be wise to consider these points:

- If possible, undertake a socio-economic survey among communities and/or other target groups to determine the impacts of the invasive plant species on livelihoods or other economic sectors. If there is disagreement among the community as to the costs and benefits of the target species it is recommended that a cost–benefit analysis (CBA) be undertaken. To acquire sufficient information to undertake a CBA it may be necessary to undertake additional field trials/surveys to support or refute the findings of the socio-economic assessment.

- It is critical that action be taken in order to garner support for control of the target species from government officials and local communities. This may take the form of meetings, workshops and/or the development and dissemination of awareness material.
- Inform all stakeholders as to the identity of the target species, its impacts and management options. A lack of support from communities will be a major barrier to the long-term success of any management activities.
- Demarcate and map the area targeted for control and calculate the costs associated with any control activities – these should include the costs of equipment, transport, labour, herbicides, nurseries to grow plants for restoration activities, etc. Note should be taken of the presence of other invasive plants which may invade the area once the target species has been removed. Costs associated with their control also need to be included.
- Develop baseline data on the density, distribution and impacts of the target species in order to measure the efficacy of control operations and benefits to local communities.
- Ensure that you have sufficient resources to undertake initial control, for follow-up activities and if required rehabilitation or restoration.
- If best management practices are not known, or there is resistance from the community to the implementation of particular control activities, it is suggested that demonstration trials or similar be established to reassure communities about the efficacy and safety of selected methodologies.
- The most cost-effective way of managing infestations is to initially contain the current infestation and then initiate control of the less dense or isolated populations first before moving onto the densest stands. In other words management strategies should work from 'outside-in', clearing less dense infestations on the periphery of larger and denser infestations first.
- If clearing invasive plants in mountain catchments or similar it is recommended that invaded areas in higher lying areas be cleared first before moving onto lower lying areas because plant propagules (seeds or vegetative material) are more likely to move 'downhill'. This is especially relevant when controlling invasive plants that have invaded riparian zones because most propagules move downstream along with the water flow.
- Try to remove invasive plants before they flower and produce seeds. This is especially relevant and applicable to new infestations detected during surveillance activities.
- It is not advisable to transport plant parts, especially seeds, rhizomes, tubers, bulbs or other vegetative material (e.g. cactus cladodes) from areas where they have been removed for disposal elsewhere. This will most likely contribute to the further spread of the target species. Ideally plants that have been removed should be destroyed on site or remain on site to avoid further spread.

Example of control methods

Invasive plants can be controlled using **physical** (manual or mechanical), **chemical** or **biological** means (see below for more details). **Cultural** control, which is the use of fire, flooding or grazing to reduce the abundance of invasive plants, can also be used in conjunction with other control methods. Cultural control in crop production systems can include crop rotation, the use of catch crops, winter ploughing, and irrigation management can also be helpful in controlling problem plants. Overgrazing often facilitates plant invasions by reducing native plant cover, allowing exotic plants to establish and spread – most invasive species thrive on disturbance. Overgrazing can lead to a reduction in fire frequency and intensity. An absence of fires can facilitate the establishment and proliferation of many invasive plants, especially succulents such as cacti, which are sensitive to fires. Livestock owners should therefore practise rotational grazing and apply the correct stocking rates.

A critical component of invasive species management, which is often not implemented, is that of **rehabilitation or restoration**. Rehabilitation involves activities which convert a cleared piece of land into land suitable for use in terms of habitation, cultivation or even livestock production. The objective of restoration, on the other hand, is to restore land cleared of invasive species to a situation where it matches, as closely as possible, the original condition. The latter may involve activities to restore various ecological processes. Cleared areas are very prone to re-invasion, while restored areas are more resistant to invasive plant regeneration and invasion. Restored areas generally also require fewer follow-up activities to remove emerging seedlings and to clear novel plant invaders, and as such can result in significant long-term cost savings.

In areas where degradation is not severe, restoration can be achieved through accelerated natural regeneration (ANR), which relies largely on activities or actions that facilitate natural processes such as seed germination of native species from the soil seed bank. Factors such as overgrazing and fire, which may harm the regeneration of native plants, can be limited through judicious management. Livestock may be excluded during the regeneration process, while weeding, along with the application of fertilizers and of mulching around regenerating native plants, coupled with direct seeding and steps that will attract seed dispersers, are encouraged (FORRU, 2006).

ANR can be facilitated by enrichment planting or framework forestry. Enrichment planting simply means planting more trees or shrubs of the existing native species, in order to boost their population densities, or else planting trees and shrubs of other native species, in order to enhance overall species richness. Framework forestry involves planting the minimum number of tree species required to reinstate the natural processes of forest regeneration and biodiversity recovery. Framework species include indigenous, non-domesticated forest trees which, on being planted in cleared areas 'rapidly re-establish forest structure and ecological functioning' (Elliott *et al*., 2003). The principles for grassland or savannah restoration are similar.

The most cost-effective way of controlling invasive plants is by combining two or more of the methods mentioned above – as in, for example, manual control applied in conjunction with chemical and/or biological control. This is commonly known as **integrated pest management (IPM)** and should be implemented whenever possible in order to reduce costs and improve the efficacy of control across a landscape.

The benefits of weed or invasive alien plant management or control are significant, and are well understood in crop production systems. However, few studies have looked at the costs and benefits of an integrated management strategy across a range of sectors, with the possible exception of biological control, which in almost all cases has shown a positive return on investments. Those few studies that have looked at the benefits of an integrated approach to invasive plant management across a range of sectors have also found it to be a wise investment:

- Brown and Daigneault (2014) found that an integrated approach to the control of the invasive tree *Spathodea campanulata* Beauv. (Bignoniaceae) in Fiji, derived monetized benefits of US$ 3.7 for each US$ 1 spent even without explicitly considering biodiversity, culture and other non-monetized benefits of control.
- Costs of aquatic weed control in Florida in the late 1960s were estimated to be US$ 6 million annually and benefits were reported as US$ 82 million, with the largest benefits coming from increased land use (due to drainage) and prevented flood damages (Lovell and Stone, 2005).
- An analysis of the costs and benefits of the invasive Australian tree, *Acacia mearnsii*, in South Africa, suggest that a 'do nothing' scenario (with no attempts being made to control the spread of the species beyond the limits of plantations) is not sustainable, as the cost:benefit ratio is around 0.4 (de Wit *et al*., 2001). The most attractive control option will be a combination of biological control of the whole plant (flowers, seed pods, leaves and stems) and physical clearing, assuming commercial growers can protect plantations at a low cost (cost:benefit ratio of 7.5) (de Wit *et al*., 2001).
- Based on current values, if the invasive tree *Miconia calvescens* DC. (Melastomataceae) is allowed to expand and reach its full distribution in Hawaii, its impacts on forest ecosystems will amount to US$ 3.08 and US$ 4.6 billion on Oahu and Maui, respectively (Burnett *et al*., 2007). To retain the current population into perpetuity will cost US$ 10.5 and US$ 73.5 million for Oahu and Maui, respectively. However, if Oahu switches to the optimal policy of population reduction, instead of spending US$ 321,000 per year from today into the future, a present value benefit of US$ 6.5 million can be realized. If Maui switches to an optimal policy of population reduction, a net present value benefit of US$ 34.5 million is possible (Burnett *et al*., 2007).

- Under a dynamic simulation of an ecological-economic model of alien plant control, in a mountain fynbos ecosystem in South Africa, it was found that the cost of proactive clearing would range from 0.6% to 4.76% of the economic value of ecosystem services, but increases the value of these services between 138% and 149%, depending on the assumptions of the model (Higgins *et al*., 1997).
- De Lange and van Wilgen (2010) estimated the value of ecosystem services in South Africa at ZAR 152 billion (presently, about US$ 19.7 billion) annually of which an estimated ZAR 6.5 billion was lost every year due to invasive alien plants. However, the loss would have been an estimated additional ZAR 41.7 billion had no invasive plant control been carried out. Between 5% and 75% of this protection was due to biological control.

Cultural control

Cultural control of invasive plants can include the use of grazing, flooding, and fire. Grazing can either promote or reduce weed abundance at a particular site. Increased disturbance as a result of the presence of livestock or other grazers can actually facilitate densification and the spread of some invasive plant species. However, if grazing treatments can be combined with other control techniques, such as herbicides or biocontrol, severe infestations can be reduced. Flooding can also be effective in controlling some invasive plant species, but is very difficult to implement in natural environments, and as such, rarely used. Fire is more widely used to control unwanted plants in the natural environment and when combined with other control methodologies can be effective.

Fire can be a very cheap and effective way of controlling specific invasive plant species but its efficacy largely depends on the target species, the ecosystem in which it occurs, the intensity of the fire and the amount of times (frequency) it can be applied. For example, fires may actually stimulate seed germination of some plant species and as a result contribute to their densification, while species, which are usually susceptible to fires, may actually benefit from a controlled burn if it is implemented at the wrong time of the year. For susceptible species, the efficacy of a controlled burn can be further enhanced if used in combination with other control techniques, such as herbicides and biocontrol.

Fire: Especially effective for controlling succulents such as species in the Cactaceae and Crassulaceae. Can also be used to reduce the abundance of young seedlings or saplings of other invasive plants and can be used to control invasive grasses. Control efficacy is enhanced if used in combination with herbicides. For example, the significant biomass of clump grasses can be reduced using fire, and herbicide can then be applied to the emerging shoots, reducing the amount of herbicide that would normally have to be used in the absence of fire. However, before using fire it is critical to understand the ecology and phenology of the target species, when it is most susceptible to fire, and if there is sufficient combustible material in the system to carry an "effective" fire. Precautions should also be taken to prevent the fire from spreading to areas outside of the target area.

Physical control

Manual and mechanical: Manual control involves the direct removal of the above-ground parts of a plant with an axe or a slasher, or the uprooting of plants using a hoe, a garden fork or a spade, or by hand pulling. It may also include ring- and strip-barking. Mechanical control may involve the use of machinery or equipment (e.g. bulldozers or tractors and can, among others, involve pushing, stick-raking, blade ploughing and/or chaining of larger plants or medium density infestations) to remove a target species. Mechanical control is often used to remove dense stands of woody weeds but can be expensive and may leave soils bare and so susceptible to erosion and re-invasion by invasive plants of the same species or of other species. Soil disturbance associated with manual control may stimulate the germination of weed seeds in the soil seed bank.

Uprooting: Physically removing a weed from the ground using tools such as hand-hoes, picks, garden forks or mattocks. Not suitable for weeds with deep root systems or which produce suckers. All below-ground plant parts, which can result in the res-establishment of the target species, need to be removed and disposed of in a safe and effective manner.

Hand pulling: Similar to uprooting and widely used to remove seedlings and young plants of most invasive plant species; works best when the soil is moist. Take hold of the stem at ground level and pull out vertically. Try to remove plants when they are not fruiting in order to limit the spread of seeds. All below-ground parts of target species, which have rhizomes, tubers or other regenerating vegetative structures, need to be removed and disposed of to prevent their re-establishment.

Slashing or felling: A mower, slasher, machete, axe, saw or other tool is used to cut down a plant just above the soil surface. Only suitable for use against weeds that do not coppice or regrow from the rootstock (e.g. *Pinus* species). However, some species, such as *Acacia mearnsii*, will coppice readily from cut stems less than 10 cm in diameter, but larger trees will not do so. Felling can also be used in combination with foliar herbicide application for species that coppice or regrow. For example, large shrubs can be cut down at ground level and herbicide applied to the coppice or regrowth.

Ring barking: Removing a 30 cm band or strip around the stem or trunk of a shrub or tree at a height of about 50 cm. It is important to remove all of the bark and cambium. Not suitable for use on multi-stemmed plants, or on plants that coppice or produce root suckers. Hardwood species generally die after ringbarking, whereas most softwood species can survive ringbarking.

Strip barking: Stripping all of the bark from the stem or trunk from about 75 cm to below the soil surface using an axe or similar tool. Only suitable for species with bark that strips easily (e.g. Australian *Acacia* species).

Mechanical: The use of heavy machinery, such as tractors or bulldozers, in conjunction with ploughs or similar equipment. For example, blade ploughing, grubbing and chaining are utilized in Australia to control invasive *Prosopis* species. Ploughing can also be used to control herbaceous plants, although this is largely limited to crop production systems.

Advantages of manual control

- In most cases, little training or supervision is required.
- Tools are simple, cheap and easily obtainable in all countries – and with hand pulling no tools are required.
- In most cases, little or no harm is caused to the environment – desirable vegetation is not damaged by the hand pulling or uprooting of weeds.
- It can be used in countries where no herbicides are registered for use against a particular weed species.

Disadvantages of manual control

- Procedures are labour intensive, and can be expensive in countries with high labour costs.
- It is physically demanding and slow, and it usually requires repeated follow-up operations.
- Where machinery is used, manual control can be expensive – incurring fuel and maintenance costs.
- Soil disturbance may stimulate seed germination among weeds, and on steep slopes or on riverbanks this may also exacerbate soil erosion.
- In dense infestations, native species are often inadvertently damaged or removed.

Chemical control (adapted from Bromilow, 2001)

Chemical control is the use of herbicides, applied alone or in combination with other methods.

A herbicide is a naturally occurring or man-made substance that alters the metabolic processes of a plant, so the plant is either killed or suppressed, or its growth habit altered. Herbicides can be divided into groups according to their modes of action. Non-selective herbicides will affect any plant they come into contact with, whereas selective herbicides can, for example, be used in crop production systems to kill weeds without impacting on the crop itself. However, it is important to recognize that non-selective herbicides can be applied selectively. For example, tree stumps can be treated with little risk to other plants growing nearby. Non-selective herbicides can also be injected into target species without affecting nearby plants.

Contact herbicides affect only the plant tissue they come into contact with, whereas systemic herbicides are translocated or moved throughout the plant from the initial point of application. So, for example, a chemical applied to the stem can be translocated to the roots and leaves, eventually killing the whole plant. Translocated herbicides may move either through the phloem (the living tissue which transports carbohydrates from the leaves or storage organs) or the xylem (non-living tissue that moves water and minerals from the roots to the shoots). Translocated herbicides can be selective or non-selective.

Pre-emergence herbicides, applied to the soil before weeds emerge, are often used in crop production systems, but are rarely used to control invasive plants in natural environments. Post-emergence herbicides, applied to weeds after they have emerged, are most frequently used to control environmental weeds.

It is important, in many cases, that herbicides are applied together with an adjuvant or adjuvants. Adjuvants are substances added to spray mixtures to enhance the efficacy of herbicide applications or application characteristics. They may include buffers and acidifiers, compatibility agents, de-foaming agents, deposition aids, dyes, stickers and surfactants. In some cases, the addition of an adjuvant is recommended, but in others it is important they are not used. Surfactants are the most important adjuvants because they facilitate the movement of the active ingredient into the plant. They include 'surface-active' chemicals such as penetrators, wetters, stickers and spreaders. These chemicals change the surface tension of the spray droplets, enhancing the spreading of droplets and their adherence to leaf surfaces.

- **Wetters** reduce the surface tension of spray droplets, facilitating their spread over the leaf surface. This also makes it easier for spray droplets to adhere to a waxy or hairy leaf surface. Many of these products are based on soaps or detergents.
- **Stickers** improve the retention of spray droplets on the plant once good wetting and coverage have been achieved.
- **Penetrants**, as the name implies, increase the penetration potential of the applied chemical into the plant.
- **Carriers** are used to dilute or suspend a herbicide formulation during its application – water and diesel are the most commonly used. Diesel can also assist in penetration.

- **Anti-foam agents** prevent the formation of foam in the spray tank, preventing the loss of active ingredients in the foam.
- **Anti-evaporants** are added to slow the evaporation of droplets of volatile herbicides, giving the herbicide more time to penetrate the target plant.
- **Emulsifiers** promote the suspension of one liquid in another, allowing the product to mix with water or oils such as diesel.
- **Solvents** are used in liquid formulations to disperse the active ingredient uniformly in the medium.
- **Stabilizers**, already present in most herbicide formulations, promote and maintain a uniform distribution of active ingredient throughout the spray tank, while prolonging the shelf life of the active ingredient(s). Products are available which can be added to enhance the effect described.
- **Buffers** maintain the desired pH (acid or alkaline) of spray mixtures in the tank.
- **Drift control agents** control the size of spray droplets.
- **Dyes** are substances that stain areas where the herbicide has already been applied in order to show visually which plants have already been sprayed or treated and which have not.

A herbicide formulation will therefore include:

- the active ingredient(s);
- additives that enhance herbicide effectiveness, stability or ease of application, such as surfactants and adjuvants; and
- other additives such as solvents, carriers or dyes.

Factors that influence the efficacy of herbicides

- Seedlings are very sensitive to foliar applied herbicides – those of the contact type especially. On the other hand, systemic herbicides require both a large leaf area and active plant growth for efficient translocation.
- Stressed plants cannot absorb or translocate a herbicide efficiently.
- Rainfall or irrigation immediately after application can wash a chemical off the plant before it has been absorbed.
- Sometimes, if a mixture of products is used, one of the products may interfere with the action of another, reducing the overall efficacy of the application. Conversely, some chemicals can complement or enhance the efficacy of others.
- Insufficient coverage, resulting from the use of incorrect equipment, may reduce the efficacy of the application.
- Sediments, in the form of fine organic matter or clays in dirty water, may block spray nozzles. Active ingredients may bind with suspended solids and reduce their efficacy.

Advantages of chemical control

- In many cases, there are no other effective options.
- In most cases, chemical control is more cost-effective than other methods, especially manual control.
- Results are quicker than with manual control, especially when compared with ring-barking or stripping.
- Use of the correct herbicides, applied according to label recommendations, has little to no negative impacts on the environment.

Disadvantages of chemical control

- The purchase of specialized equipment and the training of those applying herbicides are essential, and can add to costs.
- Herbicides can be expensive – incorrect formulations can result in poor control, requiring repeated applications, which can add to costs.
- Target species must be 'healthy', and weather conditions suitable, at the time of a herbicide's application.
- Foliar application can affect non-target species.
- Herbicide misuse may cause environmental damage.
- Manual control of plants may be necessary before herbicide application (e.g. in cut-stump treatments) or in the spraying of re-growing or coppicing plants that were too tall to spray initially.

IMPORTANT NOTES

- Always read the product label and follow all instructions relating to safe and proper use of the product.
- Always wear protective/safety gear when applying herbicides.
- Only apply herbicides that are registered for use against a particular target species in your country.

1. Foliar applications:

Foliar spraying is the use of a herbicide, diluted with water, sprayed over the foliage (leaves and stems) of seedlings, shrubs, grasses or dense vine infestations to the 'point of runoff' (until every leaf is wet). Some herbicides will require the addition of stickers and wetters in order to improve efficacy. With plants that have been slashed or cut down, the coppice or regrowth should ideally have reached a height of 50–100 cm before spraying, if effective control is to be achieved. This method of control should generally be considered only for large and dense infestations where risks to non-target species are minimal. Efficacy may be influenced by: (i) the available surface area of the leaves; (ii) the position of the leaves; (iii) hair density on the leaves; and (iv) the thickness of the waxy layer on the leaves.

NB: Poor water quality may reduce a plant's herbicide uptake. Soil particles in water may also block spray nozzles. Active ingredients may bind with clay particles in the water, further reducing efficacy. As such, river water should not be used.

Advantages of foliar application

- Easy to apply.
- Large areas can be sprayed in a relatively short period of time.
- Small areas, or even individual plants, can be targeted.
- Ideal for follow-up work to kill seedlings or coppicing plants.
- Herbicides can be applied at lower concentrations than are needed for basal bark or cut-stump treatments.
- Minimal soil disturbance.
- Relatively cheap.
- Not labour intensive.

Disadvantages of foliar application

- Cost of spray equipment.
- Inconsistent or inadequate application rates, influenced by factors such as difficult terrain (steep slopes, rocky outcrops, etc.) and high plant densities, or by laxness on the part of operators.
- A herbicide's efficacy, as determined by its rate of uptake by targeted plants, may be affected by a host of environmental factors, as well as by the condition of the plants. For example, rainfall shortly after application will wash off the herbicide. Uptake will also be reduced in plants that are covered in dust, or thst are stressed (through high temperatures, drought, waterlogging or leaf damage caused by diseases or by insect attack).
- Can be undertaken only during the growing season of the plants.
- Cannot be applied in windy areas, while the wind is blowing.
- Potential spray drift may result in off-target damage.
- Large quantities of clean water are required at a spray site.

2. Stem applications:

No pre-treatment of the targeted plant is required. Herbicide is applied directly to the stem of the growing plant.

a. Basal stem application: Usually applied to thin-barked woody weeds, tree saplings, regrowth and multi-stemmed shrubs and trees with basal diameters of no more than 20 cm. The entire circumference of the trunk or stem from ground level to a height of 30–100 cm is sprayed or painted. To help bark penetration, an oil-soluble herbicide is mixed in diesel/kerosene/mineral turpentine/penetrating oil/mineral oil or in other formulated oil blends. The full circumference of every stem or trunk rising from the ground needs to be saturated with the herbicide solution. Trees with old or rough bark may require increased coverage. Application may be made at any time. Bark should not be cut or removed before a basal stem application. Herbicide uptake will be reduced in plants with trunks that have been scorched by previous fires.

b. Total frill: Using a hand-axe, a panga or machete, make horizontal cuts into the sapwood tissue of the stems or trunks of trees, vines or woody weeds, and then insert herbicide into the cuts. Cuts are made at waist height around the circumference of the trunk. While still in the cut, the axe or tomahawk is leaned out to make a downward angled pocket, to which 1–4 ml of herbicide solution is IMMEDIATELY applied (within 15 seconds of making the cut), using a syringe or hand-held sprayer. A partial frill requires a few large cuts on all sides of the tree (5–10 cm apart), while a total frill requires a complete ring of level downward slanting cuts near the base of the stem. DO NOT ringbark the tree, as this will decrease herbicide uptake into the plant.

c. Stem injection: Also called drill-and-frill. Using a battery-powered drill or similar tool, make holes (at a 45° downward angle) in the stems or trunks of trees, cacti, vines or woody weeds, and IMMEDIATELY (within 15 seconds of drilling the hole) apply herbicide in the drill hole, using a squeeze bottle or plastic syringe. This technique targets the sapwood (cambium growth) layer just under the bark, which will transport the chemical throughout the plant. Do not drill too deeply or you will get into the heartwood, which will not take up the herbicide. Drill four holes for smaller plants, and a maximum of 12 holes for large plants. Stem injection relies on the active uptake and growth of the plant to move the chemical through its tissues, so plants that are already stressed may not be killed.

Similar to this is the **tree spearing** method whereby a specifically designed tree spear is thrust into the base of the tree at an angle of 30–40° from vertical. A herbicide solution is applied IMMEDIATELY to the holes/cuts, which are spaced approximately 5 cm apart.

This page intentionally left blank

3. Stump applications:

These include procedures that involve cutting down a plant at the base of the stem, and then immediately applying herbicide to the stump.

a. Cut stump: Sever the plant completely at its base (no higher than 15 cm above the ground), preferably horizontally using a chainsaw, brush-cutter, machete or even secateurs or pruning loppers (tool selection will depend on ease of cut, as determined by the thickness of the stem/trunk), and IMMEDIATELY apply herbicide (with a paint brush, a squeeze bottle, a sponge-tipped bottle or a spray bottle). Application delays of more than 15 seconds for water-based herbicides and 1 minute for diesel-soluble herbicides, from cutting to chemical application, will give poor results. For trees with trunks of large circumference, the herbicide solution should be applied only around the edges of the stump, targeting only the cambium layer. Apply to the point of wetting, but not to the point of runoff. Treatments can be applied at any time of the year.

b. Total stump: Sever the plant completely at its base (no higher than 15 cm above the ground) using a chainsaw, axe, brush-cutter or machete. Once cut, the herbicide solution can be sprayed or painted on to the exposed cut surface and to the sides of the stump down to the root collar area, using a knapsack sprayer, a paint brush, a drench gun or a hand-held spray bottle. This method is generally used on trees with stems of small circumference. For vines with aerial tubers (e.g. *Anredera cordifolia*), both cut ends have to be treated with herbicide. Hold cut stems in a container of herbicide solution for 15 seconds after cutting, so that maximum translocation will occur.

Advantages of stump applications

- They are target specific, with negligible potential for herbicide drift (hence minimal non-target impacts).
- Tall foliage can be treated.
- They are relatively cost-effective in that only small amounts of herbicide are used.
- One application is usually enough to kill the target plant.
- Can be done in winter – outside of the growing season.
- There is no soil disturbance.

Disadvantages of stump applications

- Cutting down trees or shrubs is labour intensive.
- Can be time-consuming when dealing with large infestations.
- May require some training.
- Felling large trees can damage native vegetation.

This page intentionally left blank

4. Scrape and paint:

Scrape a very thin layer of bark, using a sharp knife, from a 10–30 cm section of stem (taking care not to cut through the vine), and IMMEDIATELY apply the herbicide to the exposed green underlying soft tissue (before the plant can seal). Removing a small portion of the bark will allow the herbicide to penetrate into the plant's sapwood. For large shrubs and vines, several scrapes, placed approximately 7.5 cm apart, may be required.

Advantages of scrape and paint

- It is effective because herbicide is placed directly on to the target plant, with the result that non-target impacts are negligible.
- It is relatively cost-effective in that only small amounts of herbicide are used.
- One application is usually enough to kill the target plant.
- Gradual defoliation of a target plant will allow plants of native species growing nearby to recover over time, while also preventing sudden exposure of the soil to erosion.
- There is no soil disturbance.

Disadvantages of scrape and paint

- It may require some training.
- Large standing trees that have been treated, and are dying, may fall suddenly or drop branches, and as such may be dangerous. They also pose an increased fire hazard.
- It is labour intensive.

NB: The herbicides and the modes of application recommended for controlling most (for some of the plants we could not find any relevant information pertaining to herbicide use) of the species included in this Field Guide are those that are used in Australia and/or South Africa (see **Appendices C & D**). The recommended herbicides may not be available or registered for use against the target species in Kenya. If legislation in Kenya prohibits the use of these herbicides, or they have not been registered for use against a particular target species, it is illegal to use them, unless authorization has been granted by a competent authority, in this case the Pest Control Products Board (PCPB), for experimental purposes. It should also be noted that the information contained in this book is a guideline only and that all herbicide-users read and strictly follow all label instructions when using a particular pesticide. The author of this Field Guide encourages those that choose to use herbicides to:

- purchase products that are registered and fit for purpose;
- obtain the correct advice from accredited advisers;
- ensure correct handling, transportation and storage of products;

- always use protective gear when applying herbicides;
- always read the product labels and follow all instructions relating to the safe and proper use of the product;
- always use the recommended product mixtures;
- always use the recommended equipment;
- take all necessary precautions to avoid non-target impacts; and
- dispose of all containers in a safe manner ensuring that they will not be used for other purposes subsequent to disposal or have a negative impact on the environment.

Biological control

The use of host-specific natural enemies (pathogens, mites and insects) to control invasive plants has been practised for many decades by a host of countries, especially the USA, Australia, South Africa, Canada and New Zealand. The main aims of biological control are to:

- suppress plant vigour;
- reduce seed production;
- slow plant growth; and
- reduce the density of the weed infestation.

Biological control agents include: (i) gall-forming insects; (ii) defoliators (e.g. leaf-feeding beetles); (iii) leafminers; (iv) sap-suckers such as insects and mites with piercing and sucking mouthparts; (v) flower-, bud- and seed-feeders; (vi) stem-borers; (vii) crown-feeders; (viii) root-feeders; and (ix) disease-causing microorganisms such as bacteria, viruses, fungi and nematodes. In some cases, only one introduced biocontrol agent has been needed for success in controlling an invasive plant infestation. In most cases, however, effective suppression of a target plant species has been achieved through the release of multiple biocontrol agents, which attack different parts of the plant.

Over a period of 150 years, until the end of 1996, more than 350 species of invertebrates and pathogens were deliberately released in 75 countries for the control of at least 133 weed species (Julien and Griffiths, 1998). It was estimated (Winston *et al*., 2014) that by the end of 2012, there were 1555 separate and intentional releases of 469 species of weed biological control agents against 175 species of non-native target weeds (when related taxa of unidentified plant species, such as some *Opuntia* species, are counted as single target weeds). These so-called 'classical' biocontrol projects have been conducted in a total of 90 countries (Winston *et al*., 2014). At a national level, biocontrol programmes have achieved success rates of 83%, 80%, 61%, 51% and 50%, respectively, in New Zealand (Fowler, 2000), Mauritius (Fowler *et al*., 2000), South Africa (Zimmermann *et al*., 2004), Australia (McFadyen, 2000) and Hawaii (Markin *et al*., 1992).

The main benefits of biocontrol (Greathead, 1995)

- Agents establish self-perpetuating populations, often throughout the range of a target weed, including areas that are not accessible using chemical or mechanical control methods.
- The control of a target weed is permanent.
- There are no negative impacts on the environment.
- The cost of biocontrol programmes is low, relative to other approaches, and requires only a one-off investment.
- Benefits can be reaped by many stakeholders, irrespective of their financial status or of whether they contributed to the initial research process.

An analysis of some biocontrol research programmes in South Africa found that benefit:cost ratios ranged from 34:1 for *Lantana camara* to 4,331:1 for golden wattle, *Acacia pycnantha* Benth. (van Wilgen *et al*., 2004). It is also estimated that biocontrol agents present in South Africa have reduced the financial costs of mechanical and chemical control by more than 19.8%, or ZAR 1.38 billion (Versfeld *et al*., 1998). It is further estimated that biocontrol programmes, if fully implemented in the future, may reduce control costs by an additional 41.4%, or ZAR 2.89 billion (Versfeld *et al*., 1998). These findings are supported by studies in Australia which have found that every dollar invested in the weed biocontrol effort yielded a return of A$ 23.10 (Page and Lacey, 2006). There, the benefit:cost ratio for agriculture alone (in terms of both cost savings on control and increased production) was 17.4. If current annual expenditures on biocontrol research continue into the future, it is expected that weed biocontrol projects in Australia may provide, on average, an annual net benefit of A$ 95.3 million, of which A$ 71.8 million is expected to flow into the agriculture sector (Page and Lacey, 2006).

In southern Benin, the reduction of water hyacinth as a result of biocontrol has been credited with an increase in income of US$ 30.5 million per year to a community of about 200,000 people (de Groote *et al*., 2003). If one assumes that the benefits stay constant over the next 20 years, the accumulated present value would be US$ 260 million – a benefit:cost ratio of 124:1 (de Groote *et al*., 2003).

The invasive plants which have been described in this Guide, and for which biological control agents are available, are listed in **Appendix B**. All of the agents listed have established in the identified countries, although a number have proved largely ineffective, owing to a range of factors.

Summary guidelines for managing Invasive Alien Plants

When developing and implementing an invasive alien plant management strategy it is recommended that the following steps be followed:

- Inspect the area/property which has been identified for management;
- Record/map the location of all target species in the designated area, the habitats in which they are growing, and the possible presence of biological control agents;
- Identify all available control options and determine associated costs and benefits, including those for follow-up operations, being aware of the fact that physical and chemical control operations may have a negative impact on any biological control agents that may be present;
- Ensure that sufficient resources are available to reduce and maintain infestations to levels which have been pre-determined and agreed upon by all stakeholders;
- Undertake Environmental Impact Assessment's for management options, if required;
- Design, document and implement the management strategy based on inputs from all interested and affected parties;
- Regularly monitor effectiveness, including costs, of the control strategy;
- Record and share the results of the strategy in order to evaluate success and provide lessons learnt;
- Design, document and implement a long-term programme to prevent re-establishment or re-invasion of the cleared area. Ideally this should also include restoration.

Acknowledgements

This project would not have been possible without the contributions of many individuals and organizations over a period of four years. There is not space enough, here, to acknowledge the contributions made by each and every individual or organization, but you can rest assured that we are deeply grateful to everyone who has contributed in whatever way.

The idea of a Field Guide was born after frequent requests from community members, protected area managers and rangers, farmers, researchers and others for a Guide in order to identify invasive plant species. This was largely based on my use of Identification Guides whenever I was working in the field and they were granted an opportunity to use one of many to identify invasive plant species. It is largely thanks to them that we now have a short Guide on the identification and management of naturalized and invasive plants of Southeast Asia.

This Guide is an output from the UN Environment – Global Environment Facility (GEF) Project, 'Removing Barriers to Invasive Species Management in Production and Protection Forests in SE Asia', which was active in Cambodia, Indonesia, the Philippines and Vietnam. As such all of those involved in this project have contributed in some or other way. All of the National Project Coordinators: Rathea Seng (Cambodia); Titiek Setyawati (Indonesia); Rheyda Hinlo, Marianne Saniano and Cynthia Layusa (the Philippines); and Duyen Nguyen and Ta Kieu Anh (Vietnam) have provided information on invasive plants and images. Hong Twu Chan from CABI's Malaysia office has provided administrative support while Sivapragasam Annamalai, as the International Project Coordinator, has coordinated all project activities. Max Zieren, as the UN Environment Task Manager for this project, has provided guidance and support. I am extremely grateful to everyone mentioned above for their support and assistance.

I am extremely grateful to colleagues Winnie Nunda and Julius Olumeh for their assistance with sourcing relevant information. Thanks also to Morris Akiri, CABI Regional Director, and Dennis Rangi, CABI Director General for International Development, for their support in this initiative. I am especially grateful to Sarah Hilliar (CABI) who provided the layout of the Field Guide. Joe Vitelli from Biosecurity Queensland, Department of Agriculture and Fisheries, Australia, kindly provided information on herbicide use, while Rachel Winston provided additional information for incorporation in the biological control table. Elijah Ngoroge produced all of the line drawings, for which I am extremely grateful, and to those that contributed images, many thanks. Gordon Boy kindly reviewed previous drafts of the Field Guide.

A number of references and source materials were used to glean information on various species and their impacts and management. I have unashamedly used a format similar to that used by the Kwazulu-Natal Branch of the Wildlife and Environment Society of South Africa in their Guide entitled *Invasive Alien Plants in Kwazulu-Natal – Management and Control*, as this was deemed to be the most popular format among potential users. The following additional sources of information were widely used and I would like to acknowledge all of them:

- The Field Guide *Alien Weeds and Invasive Plants* (2001) by Lesley Henderson was used to acquire additional information on the identification of some invasive plants.
- Guide to *Problem Plants of South Africa* (2001) by Clive Bromilow was largely used to glean information on herbicide use.
- Another Guide, *Naturalised and invasive succulents of southern Africa* by Walters *et al*. (2011) was useful in terms of the descriptions of succulent species.
- Sheldon Navie and Steve Adkins allowed me to use much of the information contained in the website *Environmental Weeds of Australia* (**http://keyserver.lucidcentral.org/weeds/data/media/Html/index.htm#A**).
- Information on the descriptions of some agroforestry species, known to invasive, was obtained from the World Agroforestry Centre website (**www.agroforestry.org**).
- Additional information of invasive plants was gleaned from the Global Invasive Species Database website (**www.iucngisd.org/gisd**).
- Information of invasive plant impacts in the Pacific was largely obtained from the Pacific Island Ecosystems at Risk (PIER) website (**www.hear.org/pier**).
- Comprehensive information on the origin, descriptions and impacts of invasive plants was obtained from CABI's Invasive Species Compendium (**www.cabi.org/isc**).

Other source material used has been listed in the references.

Ultimately none of this would have been possible without the financial support of the GEF, which not only contributed to the development of this Guide but to the project as a whole.

This page intentionally left blank

AQUATICS

PAGE 39

Aquatic plants are plants that have adapted to living in aquatic (Water) environments, e.g. *Eichhornia crassipes* (water hyacinth).

GRASSES

PAGE 51

Vegetation consisting of typically short plants with long, narrow leaves, growing wild or cultivated on lawns and pasture, and/or as a fodder crop., e.g. *Panicum repens* (torpedo grass).

CLIMBERS

PAGE 59

A weak-stemmed plant that derives its support from climbing, twining, or creeping along a surface, e.g. *Merremia peltata* (merremia).

HERBS

PAGE 79

Any seed-bearing plant which does not have a woody stem, e.g. *Ageratum conyzoides* (ageratum).

SHRUBS

PAGE 101

A woody plant which is smaller than a tree and has several main stems arising at or near the ground,e.g. *Lantana camara* (lantana).

SUCCULENTS

PAGE 129

Plants having some parts that are more than normally thickened and fleshy, usually to retain water in arid climates or soil conditions, e.g. *Opuntia stricta* (Australian pest pear).

TREES

PAGE 135

A woody plant, typically having a single stem or trunk growing to a considerable height and bearing branches at some distance from the ground, e.g. *Acacia decurrens* (green wattle).

This page intentionally left blank

PAGE 40

PAGE 42

PAGE 44

PAGE 46

PAGE 48

AQUATICS

Eichhornia crassipes

PICKEREL WEED FAMILY

Pontederiaceae

COMMON NAMES

English: lilac devil, Nile lily, pickerelweed, water hyacinth, water orchid

DESCRIPTION

Evergreen, free-floating, aquatic plant that may become anchored in shallow water; [10–20 (–100) cm high]; roots are long and feathery; runners (10 cm long) are produced across the water surface and give rise to new plants.

Leaves: Dark green, shiny, hairless, simple, oval to egg-shaped to almost rounded (2–25 cm long and 2–15 cm wide) with swollen bladder-like stems (30 cm long).

Flowers: Pale violet or blue (4–6 cm long and 3.5–5 cm wide), upper petal of each flower has a prominent yellow-centred patch; flowers in clusters of 8–10.

Fruits: Capsules (a dry fruit that opens at maturity) (10–15 mm long), containing very fine seeds.

ORIGIN

Brazil, French Guiana, Guyana, Suriname and Venezuela

REASON FOR INTRODUCTION

Ornament

INVADES

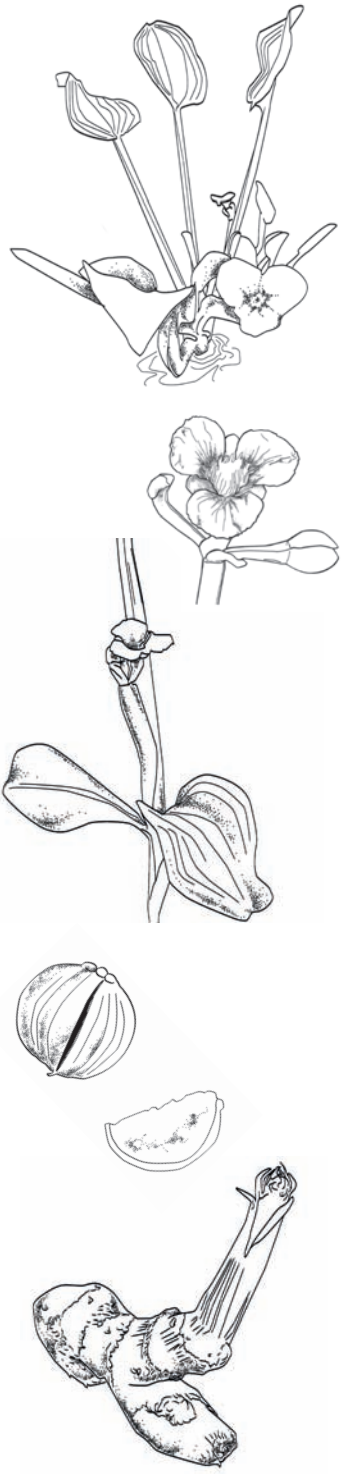
Irrigation channels, dams, ponds, floodplains, swamps, wetlands, lakes and slow-moving rivers.

IMPACTS

This aquatic weed has the ability to form thick mats which hamper water transport; inhibit or even prevent fishing-related activities; block waterways and canals; hamper hydroelectricity generation; and provide breeding sites for vectors of human and animal diseases, increasing the incidence of malaria, encephalitis, schistosomiasis, filariasis, river blindness and possibly cholera (Burton, 1960; Spira *et al*., 1981; Gopal, 1987; Viswam *et al*., 1989). The thick mats reduce light penetration into the water, causing declines in the concentrations of phytoplankton that support the zooplankton–fish food chain. Extensive mats of water hyacinth increase water loss through evapotranspiration, and impact rice production (Waterhouse, 1993). In southern Benin, an infestation of water hyacinth reduced the annual income of 200,000 people by about US $84 million (de Groote *et al*., 2003). Lost revenues for men were mostly fishing-related, while women experienced lost revenues in trade, primarily of food crops and fish.

Eichhornia crassipes (Mart.) Solms

Limnocharis flava



WATER POPPY FAMILY

Limnocharitaceae

COMMON NAMES

English: bur head, limnocharis, sawah lettuce, velvetleaf, yellow burrhead
Cambodia: trakiet paong
Indonesia: bangeng, eceng, enceng, berek, gunda, genjer
Lao PDR: kaanz choong
Malaysia: jinjir, paku rawan
Thailand: bon cheen, bonchin, nangkwak, talapatrusi, taalapat ruesee
Vietnam: cây cù nèo, kèo nèo

DESCRIPTION

Evergreen clump-forming, aquatic, herbaceous, rooted to the ground and emerges above the water surface (20–120 cm tall); large fleshy leaves borne in clusters along a short thick erect stem (about 3 cm long and 3 cm wide), contains a milky sap.

Leaves: Green, hairless, simple, triangular to rounded (5–30 cm long and 4–25 cm wide), margins entire or wavy, borne on long three-angled (triangular) stalks (5–90 cm long).

Flowers: Yellow, in clusters containing 2–15 flowers at the top of three-angled stalks (20–120 cm long).

Fruits: Rounded 'capsules' (15–20 mm across), that split up into several floating segments when mature.

ORIGIN

Argentina, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Grenada, Haiti, Mexico, Nicaragua, Panama, Paraguay, Peru and Venezuela.

REASON FOR INTRODUCTION

Ornament

INVADES

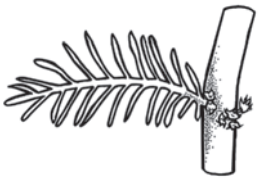
Drainage ditches, irrigation channels, dams, ponds, water courses, floodplains, swamps, wetlands and slow-moving rivers.

IMPACTS

Dominates invaded water bodies displacing other aquatic plant and animal species. It has become a serious weed in rice paddies and chokes irrigation and drainage canals (Waterhouse, 2003) facilitating siltation and reducing water discharge capacity (Kotalawala, 1976). In some cases, infestations are so severe leading to the abandonment of rice fields. Invaded areas also provide ideal breeding grounds for disease vectors such as mosquitoes, contributing to the spread of diseases such as Japanese encephalitis and dengue fever (Abhilash *et al*., 2008).

Limnocharis flava (L.) Buch.

Myriophyllum aquaticum



WATERMILFOIL FAMILY

Haloragaceae

COMMON NAMES

English: Brazilian water milfoil, parrot's feather, water feather
Indonesia: bulu burung, paris
Vietnam: rong xương cá, rong cỏ lông chim

DESCRIPTION

Evergreen, rooted aquatic plant with terminal, leafy shoots emerging 20–50 cm above the water surface; stems yellowish green (2–5 m long and 5 mm thick), roots forming at the joints.

Leaves: Pale green or bluish green, feather-like, finely divided, elongated or oval with deeply divided margins (30–45 mm long and 15 mm wide), arranged in groups of 4–6 at the tips of the stems.

Flowers: Inconspicuous, solitary in axis of leaves.

Fruits: None

ORIGIN

Argentina, Bolivia, Brazil, Chile, Ecuador, Peru and Paraguay

REASON FOR INTRODUCTION

Ornament

INVADES

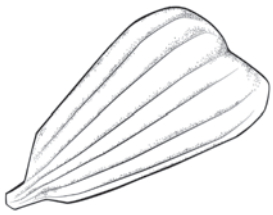
Drainage ditches, irrigation channels, dams, ponds, swamps, wetlands, lakes and slow-moving rivers or streams.

IMPACTS

Dense infestations exclude native plants and have multiple negative impacts on water transport, fisheries and recreation, and can increase the abundance of mosquitoes. The high tannin content also means that fish do not eat the plant. In California, control costs of this weed over a two-year period were US$ 215,000 (Anderson, 1993). Additional impacts would be similar to those of water hyacinth.

Myriophyllum aquaticum (Vell.) Verdc.

Pistia stratiotes



ARUM FAMILY

Araceae

COMMON NAMES

English: Nile cabbage, tropical duckweed, water cabbage, water lettuce
Cambodia: chark Thom
Indonesia: apon-apon, apu-apu, kiapu
Malaysia: kiambang
Thailand: chok, jawg
Vietnam: bèo cái

DESCRIPTION

Evergreen, mat-forming, usually free-floating aquatic plant; consists of a rosette of leaves (30 cm across) with a tuft of long, feathery roots (up to 80 cm long); plants develop runners (up to 60 cm long); resemble floating lettuces.

Leaves: Pale yellow-green or greyish-green, spongy, narrow at the base and rounded at the tips (2.5–15 cm long and 2–8 cm wide), margins with a series of curved projections, leaves ribbed with 6–15 longitudinal veins radiating from the base; soft white velvety hairs, that repel water, are found on the top and bottom of the leaf.

Flowers: Inconspicuous, pale green or white, arising from leaf forks.

Fruits: Capsules (dry fruits that open at maturity), small, green, egg-shaped or oval, (5–10 mm long).

ORIGIN

Brazil

REASON FOR INTRODUCTION

Ornament

INVADES

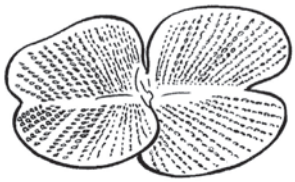
Irrigation channels, dams, ponds, floodplains, swamps, wetlands, lakes and slow-moving rivers.

IMPACTS

Water lettuce infestations contribute to increased rates of siltation, slowing of water flow rates, degradation of fish nesting sites, increased nutrient loading, thermal stratification, increased alkalinity, and fish and macro-invertebrate mortality (Dray and Center, 2002). Mats of water lettuce block waterways, making navigation difficult. Mats of the weed also hamper fishing activities, interfere with hydroelectricity generation and hinder flood control efforts. They provide habitats for vectors of disease, and can interfere with rice production (Holm *et al*., 1977; Waterhouse, 1993).

Pistia stratiotes L.

Salvinia molesta



WATERMOSS FAMILY

Salviniaceae

COMMON NAMES

English: aquarium water-moss, Australian azolla, butterfly fern, giant salvinia, kariba-weed, salvinia, velvet weed
Cambodia: chark toch
Indonesia: kiambang
Thailand: chawk hunu
Vietnam: bèo ong lớn

DESCRIPTION

Evergreen, mat-forming, free-floating fern, branching horizontal stems (up to 6–25 cm long and 1.2 cm thick), submerged feathery roots.

'Leaves': Green or yellowish-green fronds, in pairs, oval (2–6 cm long and 10–15 mm wide); almost impossible to wet due to a covering of fine egg-beater-shaped hairs (1–3 mm long) on upper surface; undersides covered in matted brown hairs.

Flowers: None

Fruits: None, reproduces from detached fragments.

ORIGIN

Brazil

REASON FOR INTRODUCTION

Ornament

INVADES

Drainage ditches, irrigation channels, dams, ponds, swamps, wetlands, lakes and slow-moving rivers.

IMPACTS

Thick mats reduce light penetration into water bodies, impacting negatively on submerged aquatic plants. Infestations also often out-compete rooted and submerged native plants and in so doing, reduce plant diversity (Sculthorpe, 1985). Benthic fauna is usually also reduced (Coates, 1982), while fish can also be impacted by changes in oxygen concentrations as *S. molesta* plants die and rot within water bodies (Sculthorpe, 1985). It is also a pest of rice paddies in India, where it competes for water, nutrients and space, resulting in poor crop production (Anonymous, 1987). Dense mats also provide habitats for many human disease vectors such as *Mansonia* spp. mosquitoes, which have been identified as vectors of West Nile virus, St. Louis encephalitis, Venezuelan equine encephalitis and rural elephantiasis (Pancho and Soerjani, 1978; Chow *et al*., 1955; Ramachandran, 1960; Lounibos *et al*., 1990). Mats also harbour snails that transmit schistosomiasis (Holm *et al*., 1977). Infestations also impact negatively on water transport and fishing. For example, entire villages, dependent on water transport were abandoned along the Sepik River in Papua New Guinea when infestations of *S. molesta* limited access to healthcare, education and food (Gewertz, 1983).

Salvinia molesta D.S. Mitch

This page intentionally left blank

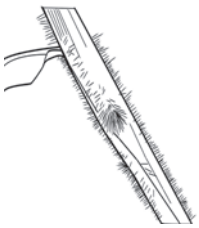
PAGE 52

PAGE 54

PAGE 56

GRASSES

Brachiaria mutica



GRASS FAMILY

Poaceae

COMMON NAMES

English: buffalo grass, Dutch grass, giant couch, Mauritius signal grass, para grass, Scotch grass
Cambodia: smau barang
Indonesia: jukut inggris, rumput malela, sukut kolonjono
Thailand: ya khon
Vietnam: cỏ lông tây, cỏ lông para

DESCRIPTION

Evergreen grass, stoloniferous [creeping or trailing stem (culm) that grows above ground for part of its length, rooting at the nodes], culms (grass stem) up to 5 m long with upright portion tall [0.9–2 (–3) m high], sheaths (tubular structure that clasps stem) are hairy.

Leaves: Green, moderately hairy (15–30 cm long and 3–20 mm wide).

Flowers: Inflorescence is a panicle or 'flowering spike' (10–25 cm long and 5–10 cm wide) with 5–20 branchlets (each 2–13 cm long), each with many almost hairless flower spikelets (2.5–3.5 mm long).

ORIGIN

Sub-Saharan Africa

REASON FOR INTRODUCTION

Fodder and erosion control

INVADES

Roadsides, disturbed land, drainage ditches, lowlands, swamps, wetlands.

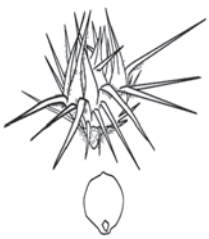
IMPACTS

Can form dense stands replacing native wetland plants and interfering with aquatic ecosystems. Para grass chokes streams and wetlands, slowing water flow and increasing sedimentation (Arthington *et al*., 1983; Humphries *et al*., 1994; Bunn *et al*., 1998). In North Queensland, Australia, infestations reduced channel discharge capacity by 85% (Bunn *et al*., 1998) increasing the frequency and intensity of floods. Poor drainage (excessive waterlogging) can also reduce sugarcane yields by up to A$ 100,000 per property per annum in coastal North Queensland, Australia. In the Babinda area, Australia, cane growers spend an estimated A$ 23,000 each year on herbicide to control para grass in drainage ditches (Fisk, 1991). Infestations can also affect nesting habits and feeding areas for waterfowl (Humphries *et al*., 1994). For example, it is destroying the breeding habitat of the magpie goose (*Anseranas semipalmata* Latham) and contributing to the decline of the endangered yellow chat (*Epthianura crocea tunneyi* Mathews) in the Alligator River floodplain in the Northern Territory, Australia. Infestations also increase the frequency and intensity of fires contributing to further biodiversity loss. Para grass is an alternative host for a number of agriculturally important pests and diseases (Holm *et al*., 1991).

Brachiaria mutica (Forsk.) Stapf

All images ©Siriporn Zungsontiporn

Cenchrus echinatus



GRASS FAMILY

Poaceae

COMMON NAMES

English: buffel grass, bur grass, field sandbur, hedgehog grass, Mossman river grass
Indonesia: rumput daratan
Philippines: agingay, madiyong-madiyong, sagisi, rukut-dukut
Thailand: yaa son krachap, ya-bung
Vietnam: cỏ echin

DESCRIPTION

Short-lived, tufted grass with often branched stems (culms) (25–60 cm tall), hairless nodes, roots occasionally produced at the lowest joints.

Leaves: Green, sheath (tubular structure that clasps stem) partially encloses stem, usually hairless but sometimes with a few hairs, reddish or purplish on young plants and lower stems; blades are linear (5–25 cm long and 3–12 mm wide), narrowing to a point, some hairs along margins.

Flowers: Inflorescence is a panicle or 'flowering spike' (3–10 cm long and 1–1.3 cm wide).

Fruits: Burr-like structures in inflorescence (4–10 mm long), each with many sharp spines (2–5 mm long), reddish or purplish-green when young turning straw-coloured or dark brown; 'burs' contain seeds which are brown and have a flattened tip.

ORIGIN

Mexico and southern USA

REASON FOR INTRODUCTION

Accidentally as a contaminant

INVADES

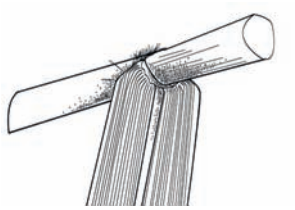
Roadsides, disturbed areas, fallow land, crops, managed pasture, gardens, grassland and sandy soils along the coast.

IMPACTS

Can readily establish large monocultures to the detriment of native plant species and the organisms that depend on them. On Laysan Island, Hawaii, it displaced the native bunchgrass, *Eragrostis variabilis* (Gaudich) Steud., and in so doing, reduced important breeding sites for two endemic, endangered land birds, the Laysan finch [*Telespiza cantans* (Wilson)], and the Laysan duck [*Anas laysanensis* Rothschild], as well as several species of indigenous seabirds and terrestrial arthropods (Flint and Rehkemper, 2002). The burs are apparently also dangerous for hatchlings of seabirds on the Northwestern Islands (Motooka *et al*., 2003). Burs in animal feed can also reduce their acceptability and palatability. Buffel grass is also a serious agricultural weed of orchards, vineyards, coffee, vegetables, bananas and coconuts. Crops competing for nutrients with *C. echinatus* typically have smaller leaf areas and lower growth rates and yields (Hammerton, 1981; Everaarts, 1993; Ramos and Pitelli, 1994). *C. echinatus* is also an alternative host for maize streak monogeminivirus and sugarcane streak monogeminivirus (Brunt *et al*., 1996).

Cenchrus echinatus L.

Panicum repens



GRASS FAMILY

Poaceae

COMMON NAMES

English: bullet grass, couch panicum, creeping panic grass, quack grass, torpedograss
Cambodia: smau phluk
Indonesia: rumput lampuyangan
Philippines: luya-luyahan, pagudpel, parayparay
Vietnam: cỏ gừng, cỏ cựa gà, cỏ ống

DESCRIPTION

Evergreen grass with culms (flowering stem) (1 m in height) arising from long, creeping rhizomes with sharp-pointed (torpedo-like) tips.

Leaves: Green, linear, flat or folded (7–25 cm long and 2–8 mm wide) with a whitish, waxy covering; leaf sheaths (tubular structure that clasps stem) hairless or hairy, with hairs usually restricted to the upper margins; ligule (thin outgrowth at junction of the leaf and leaf stalk) is membranous with short hairs.

Flowers: Branched, open inflorescences (7–22 cm long) with 1–3 branchlets per node.

ORIGIN

Botswana, Cameroon, Central African Republic, Egypt, Ethiopia, Ghana, Guinea, Kenya, Ivory Coast, Liberia, Mali, Morocco, Namibia, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Uganda, Zimbabwe, and Greece and Italy in Europe.

REASON FOR INTRODUCTION

Forage

INVADES

Roadsides, disturbed land, wasteland, crops, plantations, drainage ditches, irrigation channels, lowlands, floodplains, wetlands, gullies, lake and river edges.

IMPACTS

Displaces native vegetation, particularly in or near shallow waters. It is also a serious weed in a wide range of perennial crops including sugarcane in Taiwan and Hawaii; pineapple in West Africa; tea in India, Indonesia and Sri Lanka; various orchard crops in Thailand; rubber, coconut and oil palm in Malaysia; and rice in Indonesia and Sri Lanka (Holm *et al*., 1977). In Taiwan, rhizome density can reach 15 tons per hectare, while a density of 5 tons per hectare can result in a 50% reduction in sugarcane yield (Peng and Sze, 1974). *P. repens* may act as an alternative host to the rice leafhopper (Holm *et al*., 1977).

Panicum repens L.

This page intentionally left blank

CLIMBERS

Antigonon leptopus

KNOTWEED FAMILY

Polygonaceae

COMMON NAMES

English: bride's tears, chain of love, coral bells, coral creeper, love vine
Indonesia: bunga air mata pengantin
Malaysia: bunga berteh, bunga bonet
Philippines: cadena de amor, kantutay
Thailand: phuang-chomphuu
Vietnam: hoa ti-gôn

DESCRIPTION

Evergreen climber or vine with tendrils, angular stems [6–10 (–15) m long]; hairless or with young shoots covered in brownish or reddish hairs; older stems brown and woody near base; underground tubers.

Leaves: Light green on upper surface, pale green below, membranous, conspicuous network of veins, heart-shaped or triangular (2.5–15 cm long and 2–10 cm wide), margins entire, wavy or bluntly toothed with pointed tips, leaf stalks 1–5 cm long, slightly winged.

Flowers: Bright pink, sometimes white, in clusters (4–20 cm long) at the tips of branches, tips of clusters ending in a short tendril.

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity), brown, cone-shaped or three-angled (8–12 mm long and 4–7 mm wide), covered in the papery remains of the flower 'petals'.

ORIGIN

Mexico

REASON FOR INTRODUCTION

Ornament

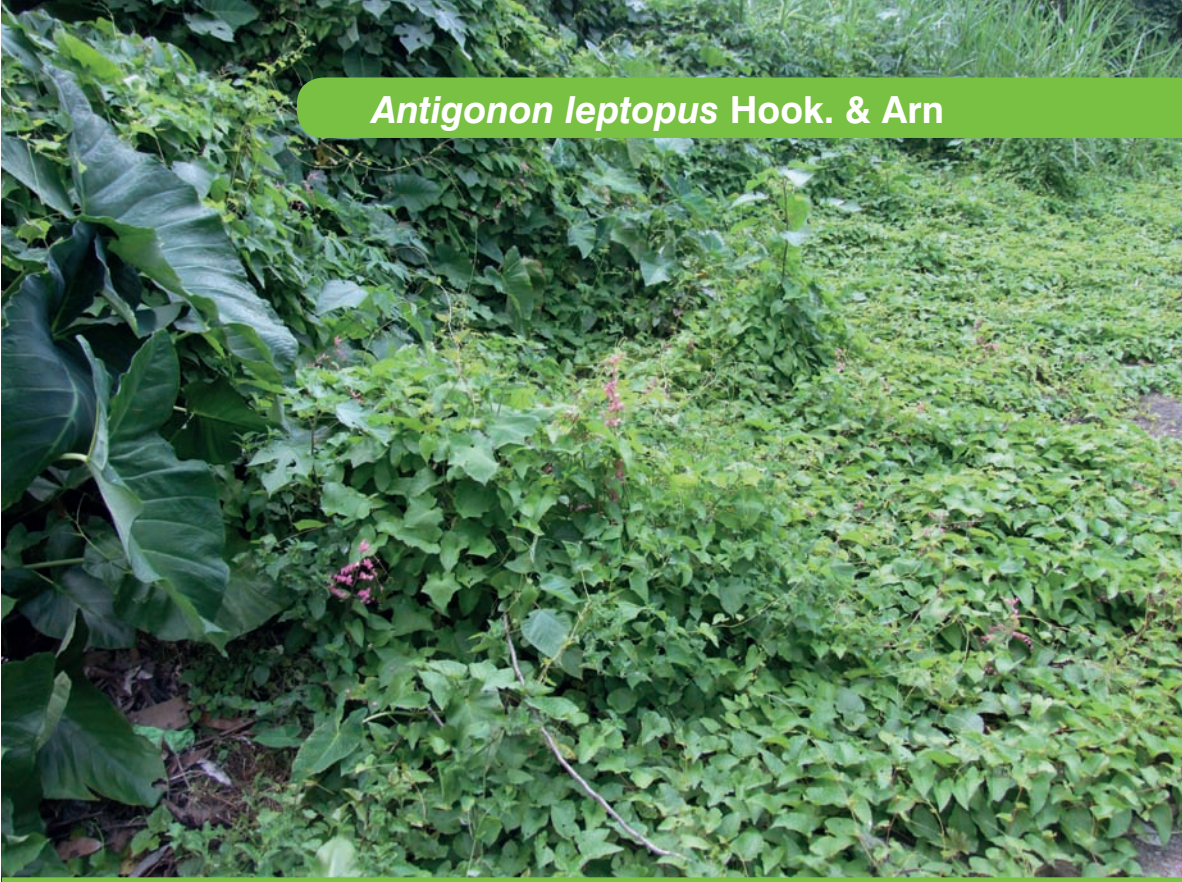
INVADES

Roadsides, disturbed areas, wastelands, urban open space, forest edges/gaps, riparian vegetation and coastal sand dunes.

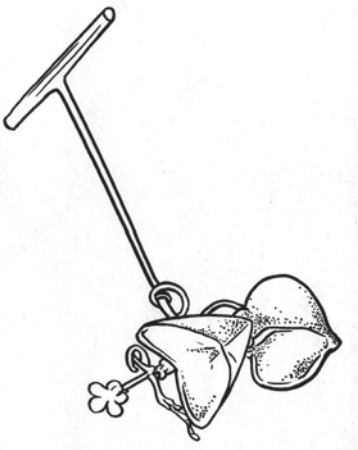
IMPACTS

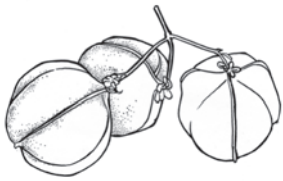
Smothers native trees, out-competes understorey plants and alters fire regimes (Langeland *et al*., 2008; USDA-NRCS, 2011). On Christmas Island (Indian Ocean), it is 'rampant on sea and inland cliffs and in previously mined areas where it may be hampering the annual migration of crabs and interfering with natural regeneration' (Swarbrick and Hart, 2000). It has been estimated to cover 20% of the island of Saint Eustatius (Caribbean) (Ernst and Ketner, 2007).

Antigonon leptopus Hook. & Arn



Cardiospermum halicacabum





SOAPBERRY FAMILY

Sapindaceae

COMMON NAMES

English: heart pea, heart seed, lesser balloon vine, love in a puff
Cambodia: am baeng baek, peng poh sraom, puos am baeng
Indonesia: paria gunung
Philippines: bangkolon, kana, paspalya
Vietnam: cây tam phỏng

DESCRIPTION

Herbaceous or slightly woody evergreen climber [up to 1–3 (–6) m high] with tendrils (slender, usually twisting structure which aids 'climbing'); grooved stems.

Leaves: Bright green, hairless or covered in minute hairs, compound, leaflets arranged in three sets of three, narrow and tapering to a point (3–5 cm long), side leaflets smaller, margins with deep and sharp forward-pointing projections or teeth.

Flowers: White or yellow (2–3 mm long), in a few-flowered, open clusters, on long stalks (5–10 cm long); two (2 cm long) paired tendrils just below inflorescence.

Fruits: Capsules (dry fruits that open at maturity), green turning brown as they mature, membranous inflated, nearly globular (25–30 mm long); seeds black, round, with a kidney-shaped white spot.

ORIGIN

Angola, Botswana, Cameroon, Ethiopia, Kenya, Malawi, Mozambique, Namibia, Somalia, South Africa, Tanzania, Uganda, Zambia and Zimbabwe in Africa; Argentina, Bolivia, Brazil, Chile, Paraguay, Peru, Uruguay and Venezuela in South America; and the Caribbean.

REASON FOR INTRODUCTION

Ornament

INVADES

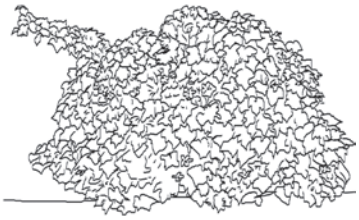
Roadsides, disturbed land, wasteland, urban open space, crops, plantations, gardens, forest edges/gaps, riparian areas, swamps and wetlands.

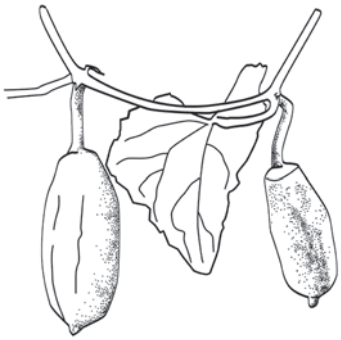
IMPACTS

Balloon vine smothers native vegetation, depriving it of sunlight and in so doing displaces native plant species. In Brazil, where *C. halicacabum* is considered to be native, it can reduce soybean crop yields by up to 26% (Brighenti *et al*., 2003; Dempsey, 2011). In Texas, there is also concern that it may contaminate certified soybean seeds since both seeds are similar in size and shape (Hurst, 1980). It is also considered to be a pest in sorghum, rice and oil palm plantations in Southeast Asia (Waterhouse, 1993).

Cardiospermum halicacabum L.

Coccinea grandis





GOURD FAMILY

Cucurbitaceae

COMMON NAMES

English: ivy gourd, kovai fruit, little gourd, scarlet gourd, tindora
Cambodia: slok bahs, voer bahs
Indonesia: timun kecil, timun jepang

DESCRIPTION

Evergreen, herbaceous vine (9–28 m long) with hairless stems, extensive tuberous root system and axillary tendrils.

Leaves: Green, hairless above and hairy below, simple, egg-shaped with broad and rounded base tapering towards the end or heart-shaped (5–9 cm long and 4–9 cm wide), sometimes with 3–7 shallow to deep lobes, margins finely to minutely toothed, held alternately on stem, leaf stalks 1–3 cm long.

Flowers: White, large, star-shaped with five petals.

Fruits: Berries (fleshy fruits that don't open at maturity), green turning bright red as they mature, smooth, egg-or oval-shaped (25–60 mm long and 14–35 mm wide); stalks are 10–40 mm long.

ORIGIN

Central African Republic, Chad, Ethiopia, Gambia, Ghana, Guinea-Bissau, Ivory Coast, Kenya, Mali, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo and Uganda.

REASON FOR INTRODUCTION

Food and ornament

INVADES

Roadsides, disturbed land, gardens, cropland, plantations, forests, forest edges/gaps and riparian vegetation.

IMPACTS

Very aggressive and can smother and kill other vegetation, including large trees. In Hawaii, it smothers trees and understorey vegetation (Muniappan *et al*., 2009). It has the potential to invade dry forest areas on Maui and out-compete rare native plants (Starr *et al*., 2003a). According to Medeiros *et al*. (1993) *C. grandis* 'would not only trigger the decline of much of the remaining biota but also transform the visual landscape to even the most casual of observers'. *C. grandis* is 'an aggressive alien vine that tends to out-compete all other plants' (Starr and Martz, 2000). It can also cover fences, power lines and other infrastructure causing economic damage. In the last two decades, *C. grandis* has emerged as an invasive weed in the islands of Guam and Saipan, where it is a problem plant both in managed gardens and natural areas (PIER, 2005). It is also a host for a number of crop pests in the family Cucurbitaceae including *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae), *Aulacophora* spp. (Coleoptera: Chrysomelidae), *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae), *Aphis gossypii* Glover (Hemiptera: Aphididae), *Liriomyza* spp. (Diptera: Agromyzidae), *Leptoglossus australis* (Fabricius) (Hemiptera: Coreidae) and *Bemisia* spp. (Hemiptera: Aleyrodidae).

Coccinea grandis (L.) Voigt

All images ©Siriporn Zungsontiporn

Merremia peltata

MORNING GLORY FAMILY

Convolvulaceae

COMMON NAMES

English: merremia
Indonesia: mantangan
Malaysia: akar sambaing

DESCRIPTION

Evergreen robust vine or climber, with large subterranean tubers; stems smooth (up to 30 m high) emitting a milky latex when damaged.

Leaves: Green, hairless above, purple veins below with scattered hairs, simple, almost round but abruptly tapering to a sharp point (7.5–30 cm long and 7–20 cm wide), held alternately on stems, leaf stalk attached to the underside of the leaf blade instead of at its base or margin (3–24 cm long).

Flowers: Usually white, funnel-shaped, large (5–6 cm wide), in clusters on stalks (15–30 cm long).

Fruits: Capsule (dry fruit that opens at maturity) (15 mm long), splitting into many valves; seeds brown.

ORIGIN

Uncertain but assumed to be native to Pemba, Madagascar, Mauritius, Reunion, Seychelles, Malaysia, Indonesia, the Philippines, northern Australia and eastwards into Polynesia to the Society Islands. Different biotype may be invasive in Bukit Barisan Selatan National Park in Indonesia.

REASON FOR INTRODUCTION

Medicine, land restoration and ornament.

INVADES

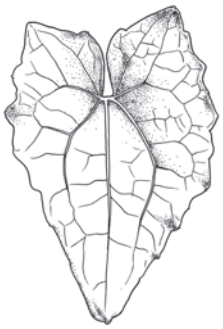
Roadsides, disturbed land, wasteland, urban open space, fallow land, plantations, forest edges/gaps and woodland edges/gaps.

IMPACTS

Smothers native vegetation to the detriment of plant and animal life. In Vanuatu, it is considered to be one of the most important weeds of plantation forestry and is one of two major species threatening natural regeneration in logged or disturbed areas (Bakeo and Qarani, 2005). In Indonesia, it also inhibits and/or prevents the movement of threatened and rare species such as elephants, rhinos and tigers.

Merremia peltata (L.) Merr.

Mikania micrantha



DAISY FAMILY

Asteraceae

COMMON NAMES

English: American rope, bitter vine, Chinese creeper, climbing hemp vine, mile-a-minute weed
Cambodia: voer tun trean khaet
Indonesia: caputuheun, mikania, sembung rambat
Malaysia: cheroma, ulam tikus
Vietnam: cây cúc leo

DESCRIPTION

A branched, scrambling, slender-stemmed, fast-growing, evergreen vine; stem slightly ribbed lengthwise, hairless or slightly hairy.

Leaves: Green, hairless, simple, heart-shaped or triangular with a pointed tip and a broad base (4–13cm long and 2–9 cm wide), 3–5 veined from base, margins are coarsely toothed; leaves held in opposite pairs along the stems with leaf stalks 2–8 cm long.

Flowers: Fluffy white to greenish-white, often with purple tinge (3–6 mm long), in dense clusters in the forks of the leaves or at the ends of the branches.

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity), black, linear to elongated with almost parallel sides, five-angled (1.2–2 mm long).

ORIGIN

Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominica, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Martinique, Mexico, Nicaragua, Panama, Peru, St. Lucia, Suriname and Venezuela.

REASON FOR INTRODUCTION

Ornament

INVADES

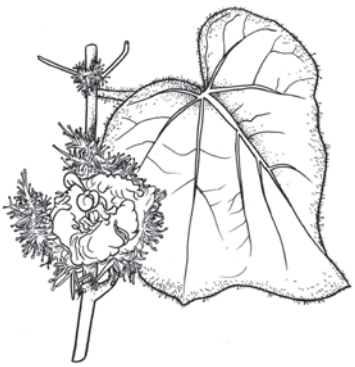
Roadsides, wastelands, disturbed land, crops, plantations, managed pasture, forest edges/gaps, woodland edges/gaps, riversides and wetlands.

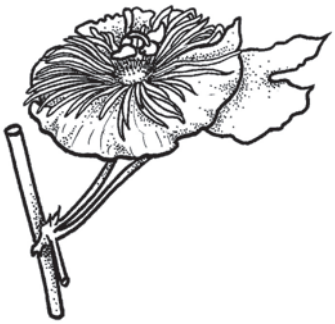
IMPACTS

Rapidly smothers native plants and crops. It is considered to be one of the worst weeds of plantation crops in India, Indonesia, Sri Lanka and Malaysia. In Southeast Asia, it affects yields of cocoa, coconut, orchards, rubber, oil palm, vegetables and rice (Waterhouse, 1993). The annual cost of controlling *M. micrantha* was estimated at US $9.8 million for rubber, oil palm and cocoa crops in Malaysia (Teoh *et al*., 1985). In Samoa, it has led to the abandonement of coconut plantations where it is also known to have killed large breadfruit trees. In Papua New Guinea, about 45% of all respondents estimated that *M. micrantha* causes yield losses in excess of 30% (Day *et al*., 2012). In summer, the dried aerial parts are also a fire hazard allowiing fires to penetrate deeper into forests and other natural vegetation.

Mikania micrantha Kunth

Passiflora foetida





PASSION-FLOWER FAMILY

Passifloraceae

COMMON NAMES

English: foetid passion flower, passion flower, stinking passion fruit, wild passionfruit
Cambodia: voer saw maw
Indonesia: buah tikus, ceplukan blunsun, katceprek, katjeprek, lemanas, permot, permot rajutan, rambaton blunsun
Lao PDR: nya ham ho
Malaysia: pokok lang bulu, timun dendang
Myanmar: chin-gya-thee-pin, su-ka
Philippines: belon-belon, kurunggut, lupok-lupok, masaflora, melon meleonan, taungan, pasionariang-mabaho, prutas taungan
Thailand: ka thok rok
Vietnam: chùm bao, nhãn lồng

DESCRIPTION

Evergreen, tendril climber; stems sometimes angular (up to 15 m high); tendril at the base of each leaf stalk together with a stipule (threadlike appendage) covered in sticky glands; stems have an unpleasant odour.

Leaves: Glossy dark-green above, simple, deeply three-lobed, but sometimes entire or five-lobed (3–10.5 cm long and 3–10 cm wide), margins with forward-pointing sharp projections or teeth; leaves held alternately on stems and borne on stalks (1–6 cm long).

Flowers: White or purplish (3–5 cm across), borne singly on stalks (2–4.5 cm long) arising from the leaf forks.

Fruits: Berries (fleshy fruits that don't open at maturity), greenish-yellow turning yellow/orange as it matures, round, dry, large (1.5–4 cm long), hairless, partially enclosed by the sticky bracts.

ORIGIN

Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay Peru, Suriname, Uruguay, USA and Venezuela.

REASON FOR INTRODUCTION

Medicine, edible fruit, ground cover and ornament.

INVADES

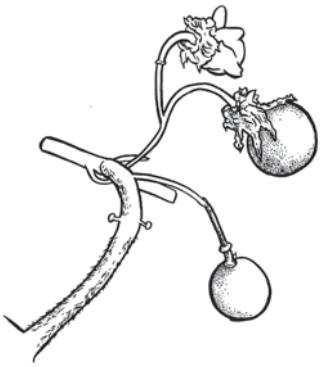
Roadsides, disturbed areas, crops, plantations, forest edges/gaps, savannah and riparian zones.

IMPACTS

In parts of Malaysia it is a serious weed of maize and rubber. It also impacts negatively on coconut production in the Pacific, on maize, sugarcane and cotton in Thailand, on oil palm in Indonesia, on taro in Samoa, and on various other crops in Sarawak (Holm *et al*., 1997). It is an alternative host for a number of diseases which affect cultivated passion fruit.

Passiflora foetida L.

Passiflora suberosa



PASSION-FLOWER FAMILY

Passifloraceae

COMMON NAMES

English: cork passion flower, small passion fruit, wild passionfruit
Vietnam: lạc tiên bần

DESCRIPTION

Evergreen, slender vine/climber or creeper, stems (up to 6 m in length) producing tendrils in the leaf forks, young stems are round or sometimes angular, becoming corky at the base with age.

Leaves: Dark green, simple (3–11 cm long and 4–12 cm wide), with three-pointed lobes, margins occasionally entire, leaves held alternately on the stems and borne on stalks (0.5–4 cm long).

Flowers: White to pale green, small (15–25 mm wide), on stalks (1.5–2.5 cm long) arising from the leaf forks.

Fruits: Berries (fleshy fruits that don't open at maturity), green turning bluish-black or purplish-black as it matures, rounded (1–1.5 cm wide), contain numerous wrinkled seeds (3–4 mm long).

ORIGIN

Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Panama, Paraguay, Peru, Suriname, Uruguay, USA and Venezuela.

REASON FOR INTRODUCTION

Ground cover and ornament.

INVADES

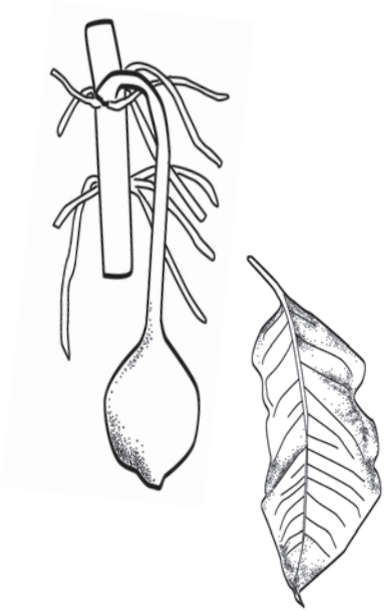
Roadsides, disturbed land, wasteland, plantations, forest edges/gaps, woodland edges/gaps, lowlands and riparian vegetation.

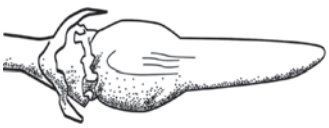
IMPACTS

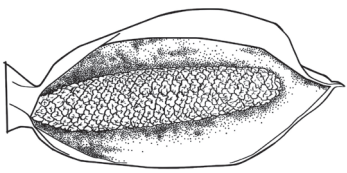
Smothers native vegetation reducing biodiversity. This climber, together with other invasive plant species, threatens *Platydesma cornuta* Hillebr. var. *decurrens* B.C. Stone (Rutaceae), a rare shrub endemic on Oahu of which only about 200 individual plants remain (Richardson, 2007). It also invades sugarcane fields and *Eucalyptus* spp. plantations in Mauritius (Seeruttun *et al*., 2005). Areas covered with dead and dying native plants become a fire hazard or increase the potential for erosion (Garrison *et al*., 2002). It is apparently toxic to cattle and ducks (Everist, 1974).

Passiflora suberosa L.

Syngonium podophyllum







ARUM FAMILY

Araceae

COMMON NAMES

English: arrowhead vine, African evergreen, goosefoot plant, American evergreen; Indonesia: Keladi-keladian; Philippines: kamay-Kastila; Vietnam: Tróc bạc, trầu bà trắng

DESCRIPTION

Rampant evergreen climber or creeping plant reaching 5-10 m when climbing over trees; young stems bluish-green, hairless, smooth, fleshy, contain milky sap, roots develop at stem joints; older stems pale brown, woody (1.5-2.5 cm thick) with aerial roots.

Leaves: Vary in colour with lower leaves dark green or with silvery-white veins and upper leaves light or dark green with no markings, all hairless with margins entire, paler undersides and on stalks (15-60 cm long) which are partly grooved; lower leaves are heart-shaped or shaped like an arrow-head (7-14 cm long) with pointed tips; intermediate leaves larger with spreading lobes; upper leaves (12-38 cm long and 16-17 cm wide) divided into three segments or leaflets.

Flowers: Whitish spikes (4-11) (5-9 cm long and 7-15 mm wide) partially enclosed in a white to greenish modified leaf (9-11 cm long), held in upper leaf forks on stalks (up to 13 cm long).

Fruits: Red to reddish-orange merging into one larger fruit, turning brown as they mature, egg-shaped (3.5-7 cm long and 1.5-3.5 cm wide), usually hidden.

ORIGIN

Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Trinidad and Tobago and Venezuela.

REASON FOR INTRODUCTION

Ornament

INVADES

Roadsides, wasteland, disturbed land, plantations, forests, forest edges/gaps, woodlands, woodland edges/gaps, riparian zones and wetlands.

IMPACTS

Climbs up into shrubs and tree shading out native vegetation and in so doing reducing native plant diversity and abundance. It has the ability to invade intact forests covering the forest floor and climbing into large and well established native trees, often causing canopy collapse due to the weight of the large stems (Space and Flynn, 2000; (Morgan *et al*., 2004). In Florida it is displacing a host of native plants including rare ferns (Possley, 2004). In Belize, it has invaded citrus orchards competing with trees for water and nutrients (Tzul, undated). The thick mats also harbour snakes endangering labourers working in orchards (Tzul, undated). *S. podophyllum* may also cause mild to severe poisoning if ingested (Morgan *et al*., 2004).

Syngonium podophyllum Schott

All images ©Danilo Tandang

Thunbergia grandiflora

ACANTHUS FAMILY

Acanthaceae

COMMON NAMES

English: Bengal trumpet vine, blue thunbergia, blue trumpet vine, Indian sky flower
Cambodia: voer thnort
Indonesia: keladi-keladian
Philippines: ag-agob, hagonoy, suga-suga, padawel, saromayag, kama-elaw
Vietnam: dây bông xanh, bông báo

DESCRIPTION

A vigorous evergreen climber with rope-like stems (up to 15 m in height) with tuberous roots; young stems are green, hairy, square in cross-section, becoming brown and more rounded with age.

Leaves: Dark green, somewhat hairy, simple, variable in shape from triangular with broad heart-shaped bases to egg-shaped with broad end at base (8–22 cm long and 3–15 cm wide), margins entire to irregularly toothed or with irregular pointed lobes, held opposite each other on stems.

Flowers: Pale-blue, violet or mauve with pale yellow or whitish throat, trumpet-shaped (3–8 cm long and 6–8 cm across), on elongated clusters; each flower on a stalk (4.5 cm long).

Fruits: Capsule (dry fruit that opens at maturity) with a rounded base (18 mm long and 13 mm wide) and a long tapered beak (2–5 cm long and about 7 mm wide).

ORIGIN

Bhutan, China, India, Myanmar and Nepal.

REASON FOR INTRODUCTION

Ornament

INVADES

Plantations, forest, forest edges/gaps, woodlands, woodland edges/gaps and riparian vegetation.

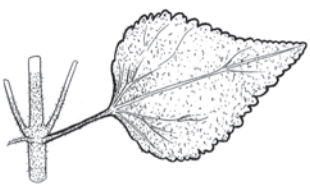
IMPACTS

This climber completely smothers other established plant species and prevents the regeneration of native species in invaded areas (Starr *et al*., 2003b). *T. grandiflora* has a heavy and extensive tuberous root system which can lead to riverbank destabilization and damage fences and building foundations (Motooka *et al*., 2003). In Queensland, Australia, it is having a negative impact on threatened lowland tropical rainforest that have been fragmented by agricultural and urban development (Queensland Department of Primary Industries and Fisheries, 2007). It also climbs on to power lines causing power outages.

Thunbergia grandiflora Roxb

This page intentionally left blank

HERBS



DAISY FAMILY

Asteraceae

COMMON NAMES

English: goatweed, invading ageratum, Mexican ageratum
Indonesia: badotan, wedusan
Lao PDR: nya khiu
Myanmar: kayin-ma-pau-poo, khwe-thay-paw
Philippines: baho-baho, bolas-bolas, budbuda, kanding-kanding, kolokong-kabayo, singilan, tuway-tuway
Thailand: saapraeng saapkaa, yaa suap raeng
Vietnam: cây cứt lợn

DESCRIPTION

Annual herb with fluffy flowerheads with green, purplish or reddish stems [0.3-1 (1.5) m tall] covered in short white hairs on young parts and nodes; shallow fibrous roots.

Leaves: Bright green, sparsely hairy, rough with prominent veins, triangular to egg-shaped (20-100 mm long and 5-50 mm wide) margins bluntly toothed with blunt or pointed tips, in opposite pairs, hairy petioles (5-75 mm); characteristic odour when crushed smelling like a male goat.

Flowers: Blue to lavender, sometimes with a white head in compact terminal flowerheads bearing 4–18 flowerheads (4–5mm across and 4–6 mm long), with slender, hardly exserted styles as opposed to its congener *A. houstonianum*, which has longer and thicker exserted styles in heads that are about 6–9 mm accross; slightly aromatic.

Fruits: Brown and one-seeded.

ORIGIN

Central and South America and West Indies.

REASON FOR INTRODUCTION

Ornament

INVADES

Roadsides, railways, wasteland, disturbed land, fallow land, croplands, plantations, managed pasture, drainage ditches, forest edges/gaps, grasslands, natural pasture, riparian areas, lowlands, wetlands and coastal dunes.

IMPACTS

This weed is allelopathic and as a result readily displaces native plant species. It excludes native grasses and medicinally important plants, reduces native plant abundance and creates homogenous monospecific stands (Dogra *et al*. 2009). In Hawaii in threatens the survival of native species including *Brighamia insignis* (Centre for Plant Conservation, 2004, in CABI, 2016). It causes yield reductions of major staple crops in India, and invades rangelands displacing native grasses and as a result reducing the amount of available forage. It also reduces crop yields, and is an important alternate host of a number of economically important crop pathogens and nematodes. In Tigray, Ethiopia, accidental consumption of the seeds with sorghum grains was implicated in the cause of liver disease resulting in the deaths of 27 people and numerous livestock.

A. conyzoides L.

Argemone mexicana

POPPY FAMILY

Papaveraceae

COMMON NAMES

English: Mexican poppy, Mexican thistle, prickly poppy
Indonesia: druju, celangkringan
Malaysia: chelang keriugan, pokok popi
Myanmar: kye-ja
Philippines: kachumba, kasubang-aso, diluariu
Thailand: fin naam
Vietnam: cà dại hoa vàng, gai cua, mùi cua

DESCRIPTION

Annual, very spiny herb (up to 0.9 m high); stems exude a yellow sap when cut.

Leaves: Grey or bluish-green, with prominent white veins and yellow-midvein (5–22 cm long and 3–7 cm wide), deep lobed with sharp spines; leaves of A. ochroleuca Sweet. are a darker shade of green.

Flowers: Bright yellow (2.5–5 cm across) as opposed to pale yellow or creamy white in *A. ochroleuca*.

Fruits: Capsules (dry fruits that open at maturity), spiny, green turning brown as they mature, egg-shaped (2.5–4 cm long), splitting into 3–6 lobes releasing small black seeds (1.5 mm across).

ORIGIN

Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Florida (USA), Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Accidentally as a contaminant.

INVADES

Roadsides, railway lines, disturbed land, wasteland, urban open space, fallow land, crops, managed pasture, riparian areas, gullies and dry river courses.

IMPACTS

Reduces plant diversity and has an inhibitory effect on the germination and seedling growth of vegetables (Hazarika and Sannigrahi, 2001). Weed residues may also affect the growth and development of bambara groundnut and sorghum (Karikari *et al*., 2000). Ingestion of seeds by poultry can result in death, and grazing animals can be poisoned if the seeds are consumed in hay or chaff. Harvesting of crops in the presence of this weed can also result in injuries. Edible vegetable oil, either accidentally contaminated with *A. mexicana*, or intentionally adulterated by unscrupulous traders, has resulted in epidemic dropsy in India. An epidemic also occurred in South Africa following the contamination of wheat flour (Sharma *et al*., 1999). *A. mexicana* has been identified as an important allergen in India (Singh and Kumar, 2004).

Argemone mexicana L.

Bidens pilosa

DAISY FAMILY

Asteraceae

COMMON NAMES

English: black jack, beggar's tick, broom stick, cobbler's pegs, Spanish needle
Indonesia: ajeran
Lao PDR: pak kwan cham
Myanmar: moat-so-ma-hlan, ta-se-urt
Philippines: borburtak, enwad, kaperek, nguwad, puriket, pisau-pisau, tubak-tubak
Thailand: puen nok sai
Vietnam: xuyến chi

DESCRIPTION

Annual or evergreen erect herb (up to 1 m tall), hairless stems, four-angled, purplish green in colour, simple or branched.

Leaves: Green, compound with 3–5 leaflets each; leaflets variable but usually egg-shaped with a broader and rounded base tapering towards the end to spear-shaped [3–7 (–10) cm long and 1–2 (–5) cm wide], margins with forward-pointing sharp projections or teeth, terminal leaflet always larger than lateral (side) ones.

Flowers: White petals, centre yellow (7–8 mm wide), usually borne singly on stalks (1 cm long).

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity), black, slender (1.5 mm long), ribbed, 2–4 barbed bristles or awns at terminal end.

ORIGIN

Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Uruguay, Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Accidentally as a contaminant.

INVADES

Roadsides, railway lines, disturbed land, wastelands, fallow land, crops, plantations, managed pasture, gardens, drainage ditches, forest edges/gaps, woodlands, riversides, lowlands, floodplains and gullies.

IMPACTS

Under favourable conditions a single plant can produce 3,000–6,000 seeds per year, with 3–4 generations annually. This, together with its allelopathic properties, allows it to form dense stands rapidly, displacing native vegetation. In Southeast Asia, this weed is problematic for those growing cabbage, pineapple, guava and plantation crops (Waterhouse, 1993). Densities of eight blackjack plants per square metre, in soybean fields in Argentina, reduced yields by 43% (Arce *et al*., 1995). Dry bean harvests in Uganda and Peru were reduced by 48% and 18–48%, respectively, as a result of the presence of *B. pilosa*. *B. pilosa* is also a host and vector to harmful parasites such as root knot nematodes and tomato spotted wilt virus (Mvere, 2004; DPI, 2008).

Bidens pilosa L.

Canna indica

CANNA FAMILY

Cannaceae

COMMON NAMES

English: African arrowroot, canna lily, edible canna, Indian shot, purple arrowroot
Cambodia: chek tehs
Indonesia: bunga kana, buah tasbeh, ganyong, ubi pikul
Lao PDR: kwàyz ké, kwàyz ph'uttha son
Malaysia: daun tasbeh, ganjong, pisang sebiak, pisang sebiak
Myanmar: adalut, butsarana
Philippines: batag-batag, balunsaying, korintas sa kalasan, kakuwintasan, tikas-tikas
Thailand:, bua lawong, phut, phuttaa-raksaa, phutthason, tharaksa
Vietnam: chuối hoa, ngải hoa

DESCRIPTION

Robust evergreen herb (1–2 m high) with a thick, branching, underground rhizome; leaves taper into slender petioles that form a sheath (tubular structure that clasps stem) around the main stem.

Leaves: Green, hairless, simple, elongated or oval (20–60 cm long and 10–30 cm wide), tapering to a point, margins entire, sheath clasping the stem similar to *Canna* × *generalis* Bailey, which also has purple-bronze leaves.

Flowers: Red or orange, usually yellow below, narrow (40–50 mm long), borne singly or in pairs at the tips of the flowering stems as opposed to *Canna* × *generalis*, which are yellow, red, orange, white or other colours, broad (80–90 mm long).

Fruits: Capsules (dry fruits that open at maturity), green turning brown as they mature, spiny, three-valved containing hard black seeds.

ORIGIN

Argentina, Belize, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay, Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Ornament

INVADES

Gardens, plantations, forest edges/gaps, drainage ditches, irrigation channels, dam/lake/river edges, ponds, lowlands, floodplains, swamps and wetlands.

IMPACTS

Forms dense clumps out-competing native plant species. It also restricts the flow of water contributing to increased sedimentation and flooding. Dense stands can also restrict access to water. It is also an alternative host of a number of crop pests, including banana bunchy top virus, cucumber mosaic virus and tomato spotted wilt virus, and a range of other pests that cause pathogenic diseases. Chemical extracts have a negative impact on snail species (Tripathi and Singh, 2000).

Canna indica L.

Hedychium coronarium

GINGER FAMILY

Zingiberaceae

COMMON NAMES

English: butterfly ginger, garland flower, garland lily, ginger lily, white butterfly ginger lily, white ginger, white ginger-lily, wild ginger
Indonesia: gondasuli, gandasoli, mandasuli
Malaysia: gandasuli, suli
Philippines: kamia, jing hua
Thailand: hanghong, hun kaeo, mahaahong, tha haan

DESCRIPTION

Evergreen herbaceous plant [1–2.5 (–2.5) m tall] which produces a thick mat of creeping underground stems (2.5–5 cm across) close to the soil surface, stems are reddish at base and covered by leaf sheaths (tubular structure that clasp stem).

Leaves: Green, glossy, smooth, hairless, simple, sword-shaped or somewhat elongated with almost parallel sides narrowed to a slender point (50–60 cm long and 10–15 cm wide), margins entire with prominent midvein; leaves held alternately on stem.

Flowers: White, at the tip of each unbranched stem, showy, fragrant.

Fruits: Capsule (a dry fruit that opens at maturity), orange-yellow, dry, smooth, somewhat elongated with almost parallel sides (2.5–3.5 cm long) containing many seeds (6 mm long and 4 mm wide).

ORIGIN

China, India, Myanmar, Nepal and Taiwan.

REASON FOR INTRODUCTION

Ornament

INVADES

Roadsides, disturbed areas, plantations, drainage ditches, irrigation channels, dam edges, ponds, forests, forest edges/gaps, riparian vegetation, lowlands, floodplains, swamps, wetlands, lake and river edges.

IMPACTS

Forms extensive thickets which disrupt water flow in channels and displace and suppress the regeneration of native wetland plants. In Brazil, dense infestations have caused the localized extinction of *Peripatus acacioi* Marcus and Marcus (Onychophora), a rare invertebrate, in a nature reserve established to protect it (Soares and Barreto, 2008). White ginger is a threat to *Clermontia samuelii* Forbes (Campanulaceae) and *Labordia tinifolia* A. Gray var. *lanaiensis* Sherff. (Loganiaceae), two endemic plant species on the Maui Nui group of islands in the Hawaiian Islands (USFWS, 1999). In St Lucia it may be replacing the rare indigenous orchid *Habenaria monorrhiza* [Sw] Rchb.f (Orchidaceae) (Krauss, 2012). The plant is also toxic.

Hedychium coronarium J. Koenig

Hedychium gardnerianum

GINGER FAMILY

Zingiberaceae

COMMON NAMES

English: kahili garland lily, kahili ginger, red ginger lily, wild ginger
Vietnam: gừng dại

DESCRIPTION

Robust, evergreen, with creeping underground stems or rhizomes [1–2 (–2.5) m high], branching surface rhizomes that can form dense mats up to 1 m thick.

Leaves: Bright green or greyish-green, glossy, upper surface hairless, lower surface sparsely hairy, narrow, tapering with pointed tips (20–45 cm long and 10–15 cm wide), margins entire; leaves held alternately on stem with a long base that sheaths the stem.

Flowers: Yellow in large clusters (15–45 cm long and 15–20 cm wide) at tips of stems; each flower has a slender red tube.

Fruits: Capsules (dry fruits that open at maturity), thin-walled (about 1.5 cm long) with three compartments.

ORIGIN

Bhutan, India and Nepal.

REASON FOR INTRODUCTION

Medicine and ornament.

INVADES

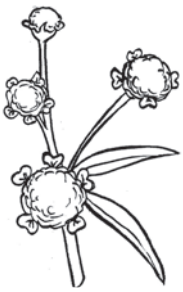
Roadsides, disturbed areas, plantations, forests, forest edges/gaps, riverbanks and damp areas.

IMPACTS

Forms dense stands out-competing native species for light, space, nutrients and moisture, and its shade tolerance makes it able to thrive in forests. The thick rhizome mats also prevent the establishment of other species. Populations are now found on all islands in Hawaii (Smith, 1985). Its aggressive growth and shade tolerance means that it can form dense thickets in the understorey of open- and closed-canopy *Metrosideros polymorpha* Gaud. (Myrtaceae) rainforests as well as in open habitats and forest edges around the Hawaii Volcanoes National Park (Anderson and Gardner, 1999). It threatens primary forest remnants in La Réunion and continuous expansion of large stands may endanger endemic lichens, vascular plants, molluscs and arthropods in the Azores. Infestations on Sao Miguel Island also threaten the Azores bullfinch. During rains, large infestations growing on steep slopes often become heavy with absorbed water and slip down slopes, contributing to erosion and gully formation.

Hedychium gardnerianum Sheppard ex Ker Gawl.

Parthenium hysterophorus



DAISY FAMILY

Asteraceae

COMMON NAMES

English: carrot weed, carrot grass, congress weed, famine weed, ragweed, white top.

DESCRIPTION

Annual erect herb, much branched [0.5–1.5 (–2) m high], forms a basal rosette of leaves when young, green stems are longitudinally grooved or ribbed and covered in short hairs.

Leaves: Pale green, covered with short stiff hairs; rosette and lower stem leaves are deeply divided and large (3–30cm long and 2–12 cm wide); upper stem leaves are shorter and less divided

Flowers: White, in small compact heads (5 mm across), clustered at the tips of branches, each flowerhead has five distinctive petals.

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity), (1.5–2.5 mm long), five in each flowerhead.

ORIGIN

Argentina, Bahamas, Barbados, Belize, Bolivia, Cuba, Dominica, Grenada, Grenadines, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Paraguay, Puerto Rico, St. Vincent, Trinidad and Tobago, Uruguay, Virgin Islands and Venezuela.

REASON FOR INTRODUCTION

Medicine, ornament and accidentally as a contaminant.

INVADES

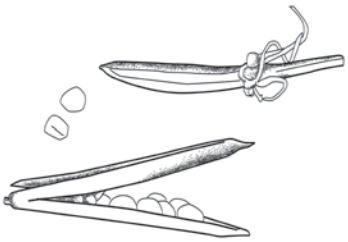
Roadsides, railways, wasteland, disturbed land, fallow land, crops, plantations, managed pasture, gardens drainage ditches, forest edges/gaps, woodland edges/gaps, grassland, savannah, riversides, lowlands and gullies.

IMPACTS

Parthenium disrupts grasslands, invades woodlands and generally disturbs native vegetation through aggressive competition (Evans, 1997). Parthenium is allelopathic, reducing crop yields, and displacing palatable species in natural and improved pasture. In India, parthenium infestations have resulted in yield losses of up to 40% in several crops (Khosla and Sobti, 1979). Parthenium is also a secondary host for a range of crop pests. In terms of pasture production, this noxious weed has been found to reduce livestock carrying capacities by as much as 90% (Jayachandra, 1971). It also poses serious health hazards to livestock, and can cause severe allergenic reactions in people who regularly come into contact with the weed.

Parthenium hysterophorus L.

Ruellia tuberosa



ACANTHUS FAMILY

Acanthaceae

COMMON NAMES

English: bluebell, iron root, large bell-flower, minnieroot, popping pod, ruellia, sheep potato, spearpod
Cambodia: phka arch kok, phka smau, smau leach phtoush
Indonesia: pletekan
Vietnam: cây Quả nổ

DESCRIPTION

Biennial (lives for 1–2 years) herb, creeping or upright [60 (–70) cm tall], stems four-sided and hairy, swollen and purplish at the nodes with thick, elongated spindle-shaped tuberous roots.

Leaves: Green, glossy, almost hairless, simple, oval to egg-shaped [5–9 (–18) cm long and 2–4 (–9) cm wide], margins entire, leaf stalk is 5–7 mm long.

Flowers: Mauve to blue-violet, solitary, tubular (5–5.5 cm long and 3.5 cm across), showy.

Fruits: Capsule, hairless, elongated with almost parallel sides (2.2–3 cm long), containing 24–28 seeds.

ORIGIN

Colombia, French Guiana, Guyana, Peru, Suriname, Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Medicine and ornament.

INVADES

Roadsides, railway lines, disturbed land, drainage ditches and lowlands.

IMPACTS

Forms dense stands displacing native plants and the organisms associated with them.

Ruellia tuberosa L.

Sphagneticola trilobata

DAISY FAMILY

Asteraceae

COMMON NAMES

English: creeping oxeye, creeping daisy, creeping wedelia, Singapore daisy
Indonesia: seruni, widelia, wedelia
Malaysia: panchut-panchut
Philippines: imelda
Vietnam: sơn cúc ba thùy

DESCRIPTION

Creeping, mat-forming evergreen herb with scrambling or climbing habit [15–30 (–70) cm tall]; stems green or reddish (up to 2 m long), slightly hairy, rounded, rooting at the joints.

Leaves: Dark green, glossy, almost hairless, simple, fleshy (40–180 mm long and 15–80 mm wide), three-lobed, margins toothed, held in opposite pairs on stem, stalkless or on short stalks.

Flowers: Bright yellow to orange, daisy-like (20–35 mm across), borne singly on upright stalks (3–15 cm long).

Fruits: Achene (small, dry, one-seeded fruit that does not open at maturity), brown, elongate (4–5 mm long).

ORIGIN

Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Medicine, erosion control and ornament.

INVADES

Roadsides, disturbed areas, wasteland, drainage ditches, forest edges/gaps, woodland edges/gaps and lowlands.

IMPACTS

Forms a dense ground cover to the detriment of other plant species. It is also allelopathic enhancing its competitiveness (Zhang *et al*., 2004). Even low infestation levels have a negative impact on plant diversity. In a study on Hainan Island, China, *S. trilobata* already starts decreasing plant community diversity at 10% cover (Qi *et al*., 2014). In south-east Viti Levu and Taveuni Island, Fiji, it has invaded taro [*Colocasia esculenta* (L.) Schott; Araceae] fields (Macanawai, 2013).

Sphagneticola trilobata (L.) Pruski

Xanthium strumarium

DAISY FAMILY

Asteraceae

COMMON NAMES

English: large cocklebur, noogoora bur, sheep bur
Cambodia: kropeatt chrouk
Malaysia: buah anjang
Thailand: kachab
Vietnam: cây ké đầu ngựa

DESCRIPTION

Annual, much-branched herb with erect stems (20–150 cm high) without spines; stems stout, green, brownish or reddish-brown, roughly hairy.

Leaves: Green, paler below, hairy on both surfaces, broadly egg-shaped to triangular (2–8 cm long), margins irregularly toothed or lobed, on long leaf stalks (2–8 cm), held alternately on stems.

Flowers: Green, inconspicuous, in the leaf axils.

Fruits: Burrs, green turning yellowish then brown as they mature (1.5–2.5 cm long), covered with hooked spines (up to 20 mm long) and two terminal beaks.

ORIGIN

Uncertain, but probably Central and South America.

REASON FOR INTRODUCTION

Bee forage and accidentally as a contaminant.

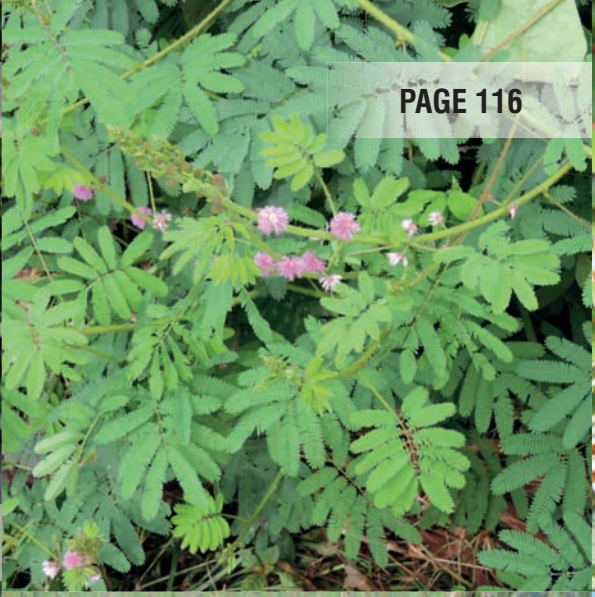
INVADES

Roadsides, wasteland, disturbed land, fallow land, crops, plantations, drainage ditches, savannah, water courses, lowlands, floodplains and sandy and dry riverbeds.

IMPACTS

Rapidly forms large stands, displacing other plant species. *X. strumarium* is a major weed of row crops such as soya beans, cotton, maize and groundnuts in many parts of the world, including North America, southern Europe, the Middle East, South Africa, India and Japan (Webster and Coble, 1997). It also has a damaging impact on rice production in South-east Asia (Waterhouse, 1993). In the USA, high-density cocklebur infestations have resulted in soya bean yield losses of as much as 80% (Stoller *et al*., 1987; Rushing and Oliver, 1998). Infestations can also decrease soya bean seed quality and harvesting efficiency (Ellis *et al*., 1998). Even low-density cocklebur infestations in cotton fields in the USA have contributed to seed yield losses of 60–90 kg per hectare, or approximately 5% (Snipes *et al*., 1982). Cocklebur has also caused yield losses in groundnuts of 31–39% and 88% at low and high densities, respectively, in the southern USA (Royal *et al*., 1997). *X. strumarium* burs lodge in animal hair and in sheep's wool, reducing the quality and increasing treatment costs (Wapshere, 1974; Hocking and Liddle, 1986). The plants are toxic to livestock and can lead to death if eaten (Weaver and Lechowicz, 1983). Cocklebur is also an alternative host for a number of crop pests (Hocking and Liddle, 1986).

Xanthium strumarium L.



Ageratina adenophora

DAISY FAMILY

Asteraceae

COMMON NAMES

English: cat weed, crofton weed, hemp agrimony, Mexican devil.

DESCRIPTION

A multi-stemmed evergreen herb or soft shrub [1–2 (–3) m high], young stems green, reddish or purplish covered in sticky hairs becoming woody and brownish-green or brown when mature.

Leaves: Dark green, simple, diamond-shaped or almost triangular (4–15 cm long and 3–9 cm wide) with toothed margins, three-veined from the base, held opposite each other on the stem on long stalks (about 1–6 cm long), non-aromatic.

Flowers: White flowerheads (5–8 mm across) in terminal clusters at the tips of branches.

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity), bristly (about 2 mm long and 0.3–0.5 mm wide).

ORIGIN

Mexico

REASON FOR INTRODUCTION

Ornament

INVADES

Roadsides, railway lines, disturbed areas, wastelands, urban open space, plantations, forests, forest edges/gaps, riparian vegetation and lowlands.

IMPACTS

Trailing branches easily root at the nodes on contact with the soil, forming dense impenetrable stands resulting in the loss of biodiversity. In Australia, infestations pose a threat to rare and endangered species. It also reduces crop yields, reduces livestock-carrying capacities and restricts movement of livestock and machinery. In Australia, it spreads so fast that dairy farmers and banana growers abandoned their land (Auld, 1969, 1970; Holm *et al*., 1991; Parsons and Cuthbertson, 1992). It is unpalatable to cattle and toxic to horses, who readily consume it if present.

Ageratina adenophora (Spreng.) R.M. King & H. Rob

Austroeupatorium inulifolium

DAISY FAMILY

Asteraceae

COMMON NAMES

English: austroeupatorium
Indonesia: kirinyuh, babanjaran

DESCRIPTION

Evergreen spreading, scrambling shrub [1–2.8 (–5) m tall]; stems covered with dense short hairs.

Leaves: Dark green above, pale green and covered with short fine hairs below; spear-shaped (7–18 cm long and 2.5–8 cm wide), leaves held opposite each other on stem on wedge-shaped leaf stalks (0.5–3 cm long).

Flowers: White in terminal, cylindrical heads (5–6 mm long and 2–3 mm wide), 8–15 flowers in each head, fragrant.

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity) brown, somewhat elongated with almost parallel sides, angular (1.5 mm long), with a whitish ring of hairs (pappus) (4 mm long) on the top of the fruit.

ORIGIN

Argentina, Bolivia, Brazil, Colombia, Ecuador, Panama, Peru, Uruguay and Venezuela.

REASON FOR INTRODUCTION

Ornament

INVADES

Roadsides, wastelands, disturbed areas, wastelands, urban open space, perennial crops, plantations, forest edges/gaps, grasslands, savannah, riparian zones and wetlands.

IMPACTS

Displaces native plant species and invades areas planted with perennial crops reducing yields and increasing management costs. In the Philippines, it forms dense thickets in rubber, tea and rosella plantations, upland rice plantations and in clearings of secondary forests (Waterhouse and Mitchell, 1998). In Sri Lanka, *A. inulifolium* has spread into the Knuckles Conservation Area, and has invaded many ecosystems such as grasslands, plantations and roadsides. It is unpalatable to livestock and reduces livestock-carrying capacities.

Austroeupatorium inulifolium (Kunth) R. M. King & H. Rob

Cestrum aurantiacum

TOMATO FAMILY

Solanaceae

COMMON NAMES

English: orange cestrum, orange jessamine, yellow cestrum.

DESCRIPTION

Evergreen, much-branched, half-climbing shrub [1–2 (–6m) high], sparsely hairy stems and leaves; stems and leaves bruise easily, emitting an unpleasant smell.

Leaves: Light green, hairless, oval to egg-shaped (7–13 cm long and 2.5–7 cm wide), leaf stalk 1–4 cm long.

Flowers: Orange-yellow, tubular (17–21 mm long), 10–15 in axillary and terminal clusters.

Fruits: Berries (fleshy fruits that don't open at maturity), white, spongy, round, small (10 mm across).

ORIGIN

Guatemala and probably elsewhere in Central America.

REASON FOR INTRODUCTION

Hedge/barrier and ornament.

INVADES

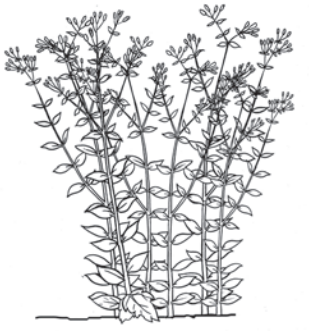
Roadsides, disturbed land, plantations, drainage ditches, forest edges/gaps, woodlands, savannah, riversides and gullies.

IMPACTS

Readily 'climbs' into trees and over shrubs, smothering native vegetation and impoverishing biodiversity. In Kenya, *C. aurantiacum* has invaded over 4,000 hectares of the Cherangany Forest displacing valuable forage species. It is toxic to people and to livestock and has caused numerous cattle deaths. Cattle that have consumed the plant become tetchy, before becoming paralysed and dying. The unripe berries are also fatal if consumed by sheep, and its leaves lead to non-fatal poisoning (Bizimana, 1994). According to the community in Cherangany Forest, the species has also had a negative impact on bee populations.

Cestrum aurantiacum Lindl.

Chromolaena odorata



DAISY FAMILY

Asteraceae

COMMON NAMES

English: chromolaena, devil weed, paraffin bush, Siam weed, triffid weed, turpentine weed; Cambodia: tuntrien khaet; Indonesia: kerinyu, tekelan; Lao PDR: nya khi law; Myanmar: kone-be-da, ne-da-ban, za-ma-ni; Philippines: dalayday, gonoy, hagonoy, talpus-palad; Thailand: saap suea; Vietnam: cỏ lào

DESCRIPTION

Evergreen shrub, which may take the form of a scrambler when growing among trees (3–7 m high), often forming dense thickets; stems yellowish-green and somewhat hairy, woody towards the base with wide-spreading branches; deep taproot.

Leaves: Light green, hairy, simple, triangular (5–12 cm long and 3–7 cm wide), pointed, margins toothed, three conspicuous veins from the base; leaves held opposite each other on stem, smell strongly of turpentine when crushed.

Flowers: Mauve, in cylindrical heads (about 10 mm long and 3 mm wide) clustered at the ends of stems.

Fruits: Achene (small, dry, one-seeded fruit that doesn't open at maturity), straw-coloured, bristly (4–5 mm long).

ORIGIN

Argentina, Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Mexico, Paraguay, Peru, Suriname, USA, Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Ornament

INVADES

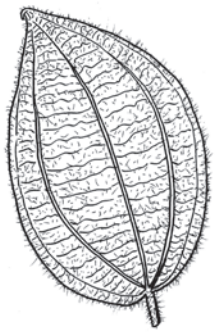
Roadsides, disturbed land, wastelands, urban open space, fallow land, plantation crops, managed pastures, drainage ditches, forest edges/gaps, savannah, natural pasture, riparian vegetation, lowlands and floodplains.

IMPACTS

One mature plant can produce approximately one million seeds per year. Its ability to form dense impenetrable thickets leads to the displacement of native plant species and the dry stems and leaves, which are rich in oils, also increase fire intensities (McFadyen, 2004) contributing to additional biodiversity loss. In South Africa, infestations have a negative impact on the breeding biology of the Nile crocodile (Leslie and Spotila, 2001), while in Cameroon, it displaces native species in the family Zingiberaceae, a major food source for the endangered western lowland gorilla (van der Hoeven and Prins, 2007). In Southeast Asia, it is also a serious weed of oil palm, rubber, coffee, cashew, fruit and forestry (Waterhouse, 1993). In fact 'some agricultural areas in Southeast Asia have been abandoned because Siam weed has taken over pasture and crops' (CRC for Weed Management, 2003). It also causes serious health problems in livestock and people (Soerohaldoko, 1971; Sajise *et al*., 1974) and significantly reduces livestock-carrying capacities.

Chromolaena odorata (L.) R.M.King & H.Rob

Clidemia hirta



TIBOUCHINA FAMILY

Melastomataceae

COMMON NAMES

English: Koster's curse, soap bush
Indonesia: harendong bulu
Vietnam: cỏ saphony

DESCRIPTION

Evergreen shrub [0.5–3 (–5) m tall], branchlets rounded, covered with large reddish-brown hairs/bristles.

Leaves: Light green, upper surfaces with a few hairs, lower surfaces more densely hairy, simple, oval or egg-shaped (5–18 cm long and 3–8 cm wide) with pointed tips, 5–7 prominent veins from the base running almost parallel; margins finely toothed, leaves appear wrinkled or pleated, leaves held opposite each other on stem.

Flowers: White or sometimes pale pink, in clusters in the leaf forks or tips of branches, on a short flower stalk (0.5–1 mm long); base of flower is swollen into a cup-shaped structure.

Fruits: Berries (fleshy fruits that don't open at maturity), dark blue, purplish or blackish, globular (4–9 mm across), covered in hairs/bristles; seeds are light brown (0.5–0.75 mm long).

ORIGIN

Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru and the Caribbean.

REASON FOR INTRODUCTION

Ornament

INVADES

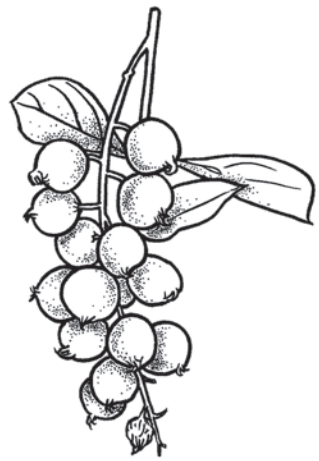
Roadsides, disturbed land, plantations, pasture, forests, forest edges/gaps, woodlands, woodland edges/gaps and riversides.

IMPACTS

This invasive plant has the ability to form dense stands displacing native plant species. Smith (1985) characterized the impacts of *C. hirta* as 'devastating' in Hawaii, where it threatens the extinction of endemic species. In Tanzania, it suppresses native herbs (Pocs, 1989), while in Fiji, it renders grazing land useless and retards the development of rubber and cocoa plantations. In Southeast Asia, it invades orchards and rubber and oil palm plantations where it reduces yields and increases management costs (Waterhouse, 1993). It came to be known as 'Koster's curse' after being accidentally introduced to Fiji by Koster and its subsequent impacts (curse) on plantation crops. It is also toxic to livestock (Francis, 2004).

Clidemia hirta (L.) Don

Duranta erecta



VERBENA FAMILY

Verbenaceae

COMMON NAMES

English: Brazilian skyflower, forget-me-not tree, golden dew drop, golden tears
Indonesia: sinyo nakal
Vietnam: thanh quan

DESCRIPTION

Usually evergreen, multi-stemmed, shrub or small tree [2–4 (–7) m high]; sometimes scrambling, branches with a drooping habit; sometimes with spines in the leaf stalks; branches four-angled.

Leaves: Dark to light green, sparsely hairy to hairless, simple, oval to egg-shaped (15–90 mm long and 12–60 mm wide), margins usually entire but sometimes toothed towards the leaf tips, held opposite each other on stem or occasionally in whorls of three.

Flowers: Lilac, light blue, pale purple or white, tubular-shaped (9–18 mm long), in elongated clusters or sprays up to 30 cm long at the ends of branches.

Fruits: Berries (fleshy fruits that don't open at maturity), initially green turning orange-yellow as they mature, round or almost round (5–14 mm wide), shiny, with a curved beak at one end, borne in large clusters.

ORIGIN

Argentina, Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Southern USA, Venezuela and the Caribbean.

REASON FOR INTRODUCTION

Hedge/barrier and ornament.

INVADES

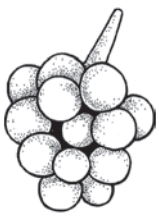
Roadsides, disturbed areas, plantations, forest edges/gaps, woodland edges/gaps and riparian vegetation.

IMPACTS

D. erecta has the ability to form dense stands displacing native plants, and the organisms associated with them. It is allelopathic and also has the ability to climb into woodland or forest canopies. Its toxicity has been known for over 100 years when the ingestion of fruit was inferred to have killed a two-year-old boy in Queensland, Australia, in the late 19th century (Wheeler, 1895). It has also caused the death of numerous pets (Scanlan *et al*., 2006) and poisoned cattle (Sutherland, 1953).

Duranta erecta L.

Lantana camara



VERBENA FAMILY

Verbenaceae

COMMON NAMES

English: curse of India, lantana, Spanish flag, tickberry, prickly lantana, white sage; Cambodia: phka chenh chien, phka kang, phka arch meann; Indonesia: kembang telek, tembelekan, tahi ayam Lao PDR: dok mai khiu; Myanmar: sein-na-ban; Philippines: asin-asin, bahu-bahu, sapinit, sapor, sari-sari, sibsibit; Thailand: pagaknong; Vietnam: bông ổi, cây ngũ sắc

DESCRIPTION

Compact, untidy long-lived shrub/scrambler (up to 2 m or higher), forming dense thickets; stems are usually green turning grey or brown with age, square in cross-section with short hairs and hooked/recurved prickles/thorns.

Leaves: Dark green, rough hairy, simple, egg-shaped (2–13 cm long and 1.5–7 cm wide) with pointed tips, margins toothed/rough, wrinkled appearance, held opposite each other on stems, smell strongly when crushed.

Flowers: Small red, pink, crimson, orange, yellow or white flowers borne in dense clusters (2–4 cm across), with each cluster containing about 20–40 flowers; clusters on stalks (2–10 cm long); individual flowers are tubular (9–14 mm long and 4–10 mm across).

Fruits: Berries (fleshy fruits that don't open at maturity), initially shiny green turning purplish-black when mature (5–8 mm across), one-seeded.

ORIGIN

Bahamas, Colombia, Costa Rica, Cuba, Hispaniola, Jamaica, Mexico and Venezuela.

REASON FOR INTRODUCTION

Hedging/barrier and ornament.

INVADES

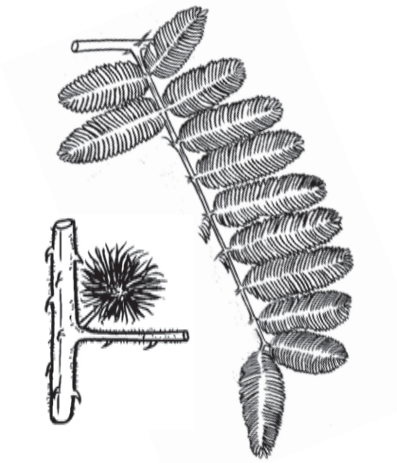
Roadsides, railways, disturbed land, wasteland, plantations, managed pasture, drainage ditches, forest edges/gaps, woodland edges/gaps, grassland, savannah, water courses, lowlands and gullies.

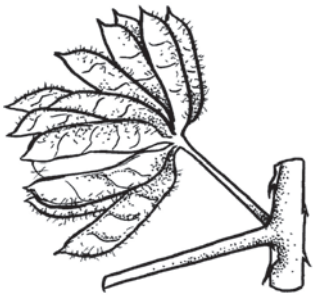
IMPACTS

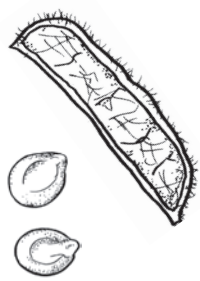
Lantana forms dense impenetrable thickets reducing biodiversity and threatening the continued existence of a host of rare and endangered species. Turner and Downey (2010) identified 275 plant and 24 native animal species in Australia that are threatened by the presence of lantana. In crop production systems in Southeast Asia, it reduces yields and increases management costs for those growing durian, pineapple, banana and rubber (Waterhouse, 1993). It is also toxic to livestock with pastoral losses in Queensland in 1985, estimated to be A$ 7.7 million, as a result of 1,500 animal deaths, reductions in productivity, loss of pasture and control costs (van Oosterhout, 2004). In South Africa, lantana poisoning accounts for about 25% of all reported livestock poisoning by plants (Wells and Stirton, 1988). There have also been some recorded fatalities in people, after consumption of the green fruit. Lantana can also alter fire regimes, allowing fires to penetrate into forests and woodlands.

Lantana camara L.

Mimosa diplotricha







PEA FAMILY

Fabaceae; subfamily: Mimosaceae

COMMON NAMES

English: creeping sensitive plant, nila grass, tropical blackberry; Cambodia: preah khlab damrei; Indonesia: jukut boring, putri malu, simeduri-dura; Lao PDR: nya nahm; Myanmar: tee-ka-yone-gyi; Philippines: aroma, hibi-hibi, kamit-kabag, makahiyang lalake; Thailand: maiyaraap luei; Vietnam: trinh nữ móc

DESCRIPTION

Annual, biennial (living for longer than one year but less than two) or evergreen, scrambling, climbing, strongly branched shrub, forming dense thickets [2–3 (–6) m tall], woody at the base with age; stems green or purplish tinged, 4–5-angled in cross-section, covered with sharp, recurved, yellowish spines (3–6 mm long).

Leaves: Bright-green, twice-divided (10–20 cm long), 4–9 pairs of leaflet branchlets each with 12–30 pairs of small elongated leaflets (6–12 mm long and 1.5 mm wide) with pointed tips, leaves fold together at night or when touched.

Flowers: Pinkish-violet or purplish, round heads (12 mm across), borne singly or in small groups on hairy stalks (3.5–16 mm long).

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature, flat, softly spiny on edges, elongated (8–35 mm long and 3–10 mm wide); occur in clusters which break into one-seeded joints; seeds are light brown (1.9 mm long and 2.7 mm wide).

ORIGIN

Bolivia, Brazil, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Panama, Paraguay, Peru, Puerto Rico and Venezuela.

REASON FOR INTRODUCTION

Erosion control, nitrogen fixation, forage for bees, hedge/barrier and ornament.

INVADES

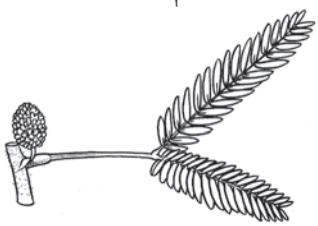
Roadsides, disturbed areas, wastelands, urban open space, crops, plantations, managed pasture, drainage ditches, woodland edges/gaps, forest edges/gaps, woodland edges/gaps, savannah, lowlands, wetlands and gullies.

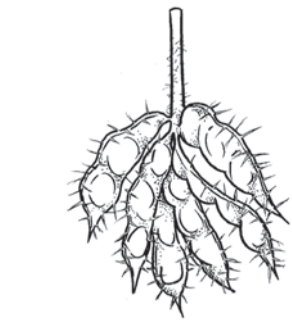
IMPACTS

Smothers other plants and prevents their natural regeneration. Dense stands also prevent or inhibit the movement of livestock and wildlife. In Nigeria, when *M. diplotricha* density reached 630,000 plants per hectare, cassava root yield, 12 months after planting, was reduced by 80% (Alabi *et al*., 2001). It readily invades orchards and rice paddies reducing yields and increasing management costs (Waterhouse, 1993). On cattle ranches in Papua New Guinea, up to US$ 130,000 is spent annually on chemical control (Kuniata, 1994). In Thailand, 22 swamp buffaloes died 18–36 hours after eating *M. diplotricha* (Tungtrakanpoung and Rhienpanish, 1992). Trials in Queensland, Australia, indicated toxicity to sheep, and a report from Flores, Indonesia, suggests that it is toxic to pigs (Parsons and Cuthbertson, 1992).

Mimosa diplotricha Sauvalle

Mimosa pudica





PEA FAMILY

Fabaceae; subfamily: Mimosaceae

COMMON NAMES

English: common sensitive plant, shame plant, sleeping grass, touch-me-not; Cambodia: preah klab sampeahs, preah khlab, sampeahs Indonesia: putri malu, sikejut; Lao PDR: nya nyoub; Myanmar: tee-ka-yone; Philippines: babain, bain-bain, hibi-hibi, torog-torog;Thailand: yaa pan yot; Vietnam: cây xấu hổ, cỏ trinh nữ

DESCRIPTION

Evergreen prickly herbaceous plant or small shrub, creeping or sprawling [15–50 (–100) cm high]; stems reddish-brown to purplish, round, sparse prickles (2–2.5 mm long).

Leaves: Yellowish-green, sparsely hairy, twice-divided, 1–2 pairs of leaflet branchlets (2.5–8 cm long) each bearing 10–25 pairs of elongated leaflets with almost parallel sides (6–15 mm long and 1–3 mm wide), margins entire, borne on stalks (1.5–6 cm long), leaves fold together at night or when touched.

Flowers: Lilac or pink in fluffy round heads or clusters (9–15 mm across) held on bristly stalks (1–4 cm long).

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature, elongated with almost parallel sides, flattened (1–2.5 cm long and 3–6 mm wide), held in clusters covered in bristles, prickles along their margins, break transversely into segments; seeds are light brown, flattened (2.5–3 mm long).

ORIGIN

Barbados, Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Puerto Rico, Suriname, Trinidad and Tobago and Venezuela.

REASON FOR INTRODUCTION

Medicine, tannins, forage for bees, ground cover and ornament.

INVADES

Roadsides, railway lines, disturbed land, wasteland, urban open space, gardens, fallow land, crops, plantations, managed pasture, drainage ditches, savannah, lowlands, wetlands and gullies.

IMPACTS

Is a fire hazard and poses a significant threat to native flora. It is a serious pest of crops and pastures throughout the tropics (Holm *et al*., 1979). Infestations of *M. pudica* can lead to a 10–70% reduction in upland rice yields in Kerala, India (Joseph and Bridgit, 1993). It is also considered a serious weed of sugarcane, sorghum, maize, soybean (Holm *et al*., 1977), tomatoes, pineapples, cotton (Lee Soo Ann, 1976; Waterhouse and Norris, 1987), rubber, tea, coffee, coconut, oil palm, banana, mango, papaya, citrus and even *Acacia mangium* plantations in Indonesia (Nazif, 1993). Mimosa also invades pasture and can be toxic to livestock. It is suspected of poisoning cattle in Papua New Guinea (Henty and Pritchard, 1975) and has caused stunted growth in chickens in Indonesia (Kostermans *et al*., 1987).

Mimosa pudica L.

Senna occidentalis

PEA FAMILY

Fabaceae; subfamily: Caesalpiniaceae

COMMON NAMES

English: ant bush, arsenic bush, coffee senna, sicklepod, stinkweed.

DESCRIPTION

Annual or lives for more than one year but less that two, erect herb or shrub (0.5–2.5 m tall); stems reddish-purple, smooth, hairless or sparsely hairy, four-angled or grooved when young becoming greenish-brown and rounded.

Leaves: Green, once-divided (15–20 cm long), with 3–5 pairs of oppositely held egg-shaped or oval leaflets (3–10 cm long and 2–3 cm wide) with broad and rounded bases, tapering towards the end with pointed tips; conspicuous gland at the base of each leaf stalk; alternately held on stems on reddish stalks (3–5 cm long).

Flowers: Bright yellow (20–30 mm across) in small clusters of 2–6 flowers in forks of uppermost leaves.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature, flattened, slightly curled (75–130 mm long and 8–10 mm wide), held upright.

ORIGIN

Argentina, Belize, Bolivia, Brazil, Cayman Islands, Costa Rica, Dominican Republic, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Nicaragua, Panama, Peru, Suriname and Venezuela.

REASON FOR INTRODUCTION

Coffee substitute, medicine and ornament.

INVADES

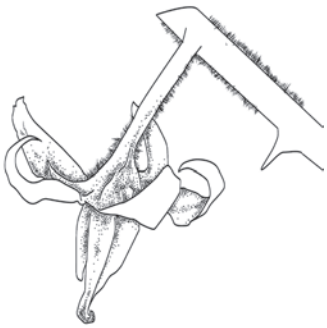
Roadsides, wasteland, disturbed land, fallow land, managed pastures, drainage ditches, woodland edges/gaps, savannah, riparian vegetation and gullies.

IMPACTS

Dense stands can displace native plant species, and reduce livestock carrying capacities in managed and natural pastures. Being allelopathic, it inhibits the germination and growth of other plants. Studies have shown that it has a negative impact on maize (Arora, 2013) and cotton yields (Higgins *et al*., 1986), and is an alternative host for crop diseases (Suteri *et al*., 1979). The seeds of *S. occidentalis* are highly toxic, containing compounds that damage the liver, the vascular system and the heart and lungs of domestic livestock, often leading to death in cattle (Barros *et al*., 1999), horses (Riet-Correa *et al*., 1998), goats (Suliman *et al*., 1982; Suliman and Shommein, 1986), pigs (Martins *et al*., 1986), poultry (Haraguchi *et al*., 1998), and rabbits (O'Hara and Pierce, 1974). Consumption of the seeds in western Uttar Pradesh, in India, resulted in the deaths of nine children within five days (Vashishtha *et al*., 2007).

Senna occidentalis (L.) Link

Solanum viarum



TOMATO FAMILY

Solanaceae

COMMON NAMES

English: tropical soda apple
Vietnam: cà trái vàng

DESCRIPTION

Evergreen, erect herb [50–150 (–200) cm tall], with densely hairy stems and branches with recurved (2–5 mm long) and straight spines (up to 20 mm long) on the leaf stalks and the leaf veins.

Leaves: Dark green, glossy above, duller below, hairy, simple, broadly egg-shaped [6–20 cm long and 6–15 cm wide], bluntly lobed, with spines on the veins and hairs on both sides, leaf stalks are 3–7 cm long with prickles.

Flowers: White (1.5 cm across), in clusters of 1–5.

Fruits: Berries (fleshy fruits that don't open at maturity), mottled light and dark green becoming pale yellow as they mature, smooth (2–3 cm across), containing 400 brown seeds (2–3 mm in diameter).

ORIGIN

Argentina, southern Brazil, Paraguay and Uruguay.

REASON FOR INTRODUCTION

Medicine and accidentally as a contaminant.

INVADES

Grassland, forest edges/gaps and riparian vegetation.

IMPACTS

Dense stands displace other plant species by crowding or shading them out. The prickles on the plants reduce wildlife forage and prevent movement of animals through invaded areas (USDA-FS, 2005). The foliage and stems are unpalatable to cattle, considerably reducing livestock-carrying capacities (Medal *et al*., 2012). Control costs of *S. viarum* to ranchers in Florida were estimated at US$ 6.5–16 million per year (Thomas, 2007). It has also caused poisoning of goats in Florida (Porter *et al*., 2003). It is an alternative host for many plant diseases including the cucumber mosaic virus, gemini virus, potato leafroll virus, potato virus Y, tobacco etch virus, tomato mosaic virus, tomato mottle virus and the fungal pathogen, *Alternaria solani* (Cooke, 1997). It is also a host for a number of insect pests (Sudbrink *et al*., 2000; Medal *et al*., 2012).

Solanum viarum Dunal

Stachytarpheta jamaicensis

VERBENA FAMILY

Verbenaceae

COMMON NAMES

English: blue porter weed, blue snake weed, Brazilian tea, Jamaica snakeweed, porterweed, snake weed
Indonesia: gewongan, jarong
Malaysia: ramput tahi babi, selaseh dandi
Philippines: albaka, bilu-bilu, bolomaros, kandi-kandilaan, limbagat, sentemiento, verbena de las antilles
Vietnam: cây đuôi chuột, hải tiên

DESCRIPTION

Evergreen shrubby herb (60–120 cm high), young stems green or purplish, mostly hairless and square in cross-section becoming rounded, light brown and woody as they mature; woody rootstock.

Leaves: Green with a bluish or greyish tinge, leathery, hairless or with a few hairs on veins on undersides, simple, leaves egg-shaped, oval or somewhat elongated with almost parallel sides (2–12 cm long and 1–5 cm wide) with rounded tips, margins sharp but finely toothed; leaves held opposite each other on stems on stalks 5–35 mm long.

Flowers: Light blue, blue or mauve, tubular (7–11 mm long and 8 mm across) on long, curved and thick spikes (15–50 cm long and 3–7 mm thick) at the end of branches.

Fruits: Capsules (dry fruits that open at maturity), green turning dark brown, dark purple or black as they mature, small, somewhat elongated with almost parallel sides (3–7 mm long and 1.5–2 mm across).

ORIGIN

Belize, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Suriname, south-eastern USA, Venezuela, and the Caribbean.

REASON FOR INTRODUCTION

Medicine and ornament.

INVADES

Roadsides, disturbed sites, wastelands, fallow land, plantations, managed pasture, gardens, drainage ditches, savannah, forest edges/gaps, woodland edges/gaps, lowlands, floodplains and coastal environs.

IMPACTS

Forms dense stands outcompeting native plants for water and nutrients. Probable host of cucumber mosaic cucumovirus in India (Mathew and Balakrishnan, 1991).

Stachytarpheta jamaicensis (L.) Vahl

Tithonia diversifolia

DAISY FAMILY

Asteraceae

COMMON NAMES

English: Mexican sunflower, shrub sunflower, tree marigold
Cambodia: chhouk roth japon
Indonesia: keladi-keladian
Vietnam: dã quỳ

DESCRIPTION

Annual or evergreen herbaceous shrub, woody at the base [2–3 (–5) m high]; stems slightly ridged and hairy when young.

Leaves: Greyish-green, finely hairy on underside giving a grey appearance, simple (6–33 cm long and 5–22 cm wide) with 3–5 (–7) pointed lobes, margins with a series of curved projections or teeth; held opposite or alternately on stem.

Flowers: Bright yellow, daisy or sunflower-like (up to 10 cm across), held on long and swollen stalks (7–30 cm long) which are velvety below the flowerhead.

Fruits: Achenes (small, dry, one-seeded fruits that don't open at maturity), brown (4–8 mm long), in a spiky mass.

ORIGIN

Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama.

REASON FOR INTRODUCTION

Fodder, medicine, mulch, soil improvement, hedge/barrier and ornament.

INVADES

Roadsides, disturbed sites, wastelands, urban open space, fallow land, savannah, lowlands and riparian vegetation.

IMPACTS

Forms dense stands displacing native plant species and the animals associated with them. *T. diversifolia* is displacing native species in the wetlands of the Apete River, Eleyele Lake and Oba Dam in Ibadan, Nigeria, including the invasive and aggressive shrub *Chromolaena odorata* (Oluode *et al*., 2011), and is now considered to be one of the most invasive species in Nigeria (Borokini, 2011). Mexican sunflower has the ability to compete with agricultural crops (Ilori *et al*., 2007) and is contributing to the extinction of local species, including important medicinal plants (Oludare and Muoghalu, 2014). According to reports, it is leading to the abandonment of farms in the Copperbelt region of Zambia.

Tithonia diversifolia (Hemsl.) Gray

This page intentionally left blank

PAGE 130

PAGE 132

SUCCULENTS

Jatropha gossypiifolia

SPURGE FAMILY

Euphorbiaceae

COMMON NAMES

English: American purging nut, bellyache bush, red fig-nut flower, red physic nut, wild cassava.

DESCRIPTION

Evergreen, erect shrub [1–3 (4) m tall]; older stems are thick and succulent-like; young branches are purplish and hairy; young shoots exude a brownish latex when damaged.

Leaves: Reddish-brown to dark bronze or purplish turning bright green with age, hairless, simple (4.5–10 cm long and 5–13 cm wide), usually with 3 or 5 deep lobes, 3–5 veins from the base, margins glandular and minutely toothed; leaf stalks are 6–9 cm long and covered in sticky hairs.

Flowers: Five dark red or deep purple petals with yellow centre, borne in branched clusters (8–15 cm long) at the tips of branches.

Fruits: Capsules (dry fruits that open at maturity), glossy green turning brown as they mature, three-lobed, slightly hairy, somewhat elongated with almost parallel sides to almost round (about 12 mm long and 10 mm wide), containing three large light brown seeds.

ORIGIN

Antigua and Barbuda, Bolivia, Brazil, Colombia, Costa Rica, Dominica, Ecuador, Guadeloupe, Honduras, Mexico, Nicaragua, Paraguay, Peru, Puerto Rico, St. Kitts and Nevis, St. Lucia and Venezuela.

REASON FOR INTRODUCTION

Medicine, natural oils, hedge/barrier and ornament.

INVADES

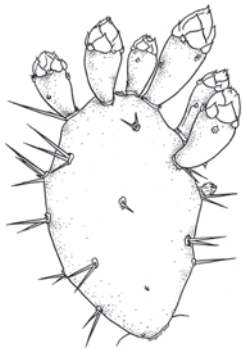
Roadsides, disturbed areas, urban open space, drainage ditches, savannah, lowlands, gullies and dry riverbeds.

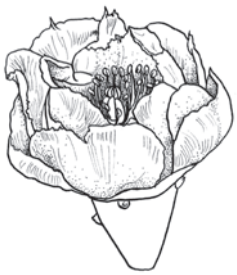
IMPACTS

This weed forms dense thickets, especially in riparian areas where it readily displaces native plant species and prevents their regeneration. It also significantly reduces livestock carrying capacities outcompeting valuable forage species. Although the plant is not consumed by livestock, accidental ingestion does occur. In 1995, in northern Queensland, Australia, 312 head of livestock died (290 cattle, 7 horses and 15 goats) after accidentally consuming the plant during a drought (Csurhes, 1999).

Jatropha gossypiifolia L.

Opuntia stricta





CACTUS FAMILY

Cactaceae

COMMON NAMES

English: Australian pest pear, common pest pear, erect prickly pear, sour prickly pear.

DESCRIPTION

Succulent erect, spreading shrub [0.5–1.3 (–2) m high]; thicket-forming; modified stems called cladodes are blue-green, longer than broad (10–20 cm long and 7.5–14 cm wide); 3–5 areoles (raised structures or bumps on the stems of cacti, out of which grow clusters of spines) per diagonal row on each cladode; 1–2 straight and flattened yellow spines (1.5–4 cm long) usually restricted to marginal areoles as opposed to *O. stricta* (Ahw.) Haw. var. *dillenii* (Ker Gawl.) Benson where there are 4–7 (–11) banded spines (1.5–4 cm long) on most areoles.

Leaves: Cylindrical, minute and shed early.

Flowers: Yellow and large (5–6 cm long and 5–6 cm wide).

Fruits: Berries (fleshy fruits that don't open at maturity), green turning red-purple as they mature, egg-shaped (4–6 cm long and 2.5–3 cm wide), outer surface smooth with clusters of glochids (barbed hairs or bristles), narrowed at the base, purple sour pulp, white seeds.

ORIGIN

Ecuador, Mexico, Southern USA, Venezuela, and the Caribbean.

REASON FOR INTRODUCTION

Hedge/barrier and ornament.

INVADES

Roadsides, wastelands, disturbed areas, rocky outcrops, savannah, grassland and riverbanks in arid to semi-arid regions.

IMPACTS

Can form dense stands, preventing access to homes, water resources and pasture. On Madagascar, *O. stricta* has invaded land used for crop and pasture production, and has encroached on villages and roads, impeding human mobility (Larsson, 2004). Here, the cactus has had a negative impact on native grasses and herbs, and it is even affecting trees by inhibiting their growth and regeneration (Larsson, 2004). The small spines (known as glochids) on the fruit, when consumed by livestock, lodge in their gums, on their tongues, or in their gastrointestinal tracts, causing bacterial infections, while the hard seeds may cause rumen impaction, which can be fatal, and which often leads to excessive, enforced culling of affected animals (Ueckert *et al*., 1990). People who consume the fruits develop diarrhoea and may suffer from serious infections caused by the spines (Larsson, 2004). In Kenya, *O. stricta* infestations have resulted in the abandonment of farmlands.

Opuntia stricta (Haw.) Haw.


PAGE 136


PAGE 138


PAGE 140


PAGE 142

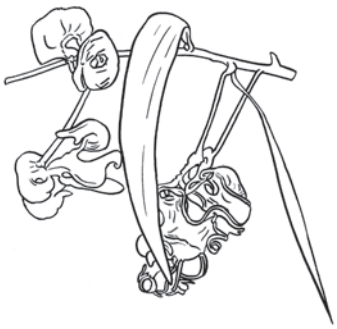

PAGE 144


PAGE 146


PAGE 148


PAGE 150

Acacia auriculiformis



PEA FAMILY

Fabaceae; Subfamily: Mimosaceae

COMMON NAMES

English: earleaf acacia, Japanese acacia, northern black wattle, tan wattle
Cambodia: acacia sleuk toch, smach tehs
Indonesia: akasia kuning, pohon akasia
Malaysia: akasia kuning, bunga siam, kasia
Philippines: auri
Thailand: kratin-narong
Vietnam: keo lá tram, tràm bông vàng

DESCRIPTION

Evergreen tree with no thorns/spines [8–20 (–35) m tall], trunk 60 cm in diameter, often multi-stemmed with compact spread.

Bark: Grey or brown, sometimes black at the base, smooth in young trees, becoming rough and longitudinally fissured with age.

Leaves: Greyish-green, 'leaves' are flattened leaf stalks called phyllodes, slightly curved (8–20 cm long and 1.0–4.5 cm wide), hairless and thinly textured; 3–7 longitudinal veins running together towards the lower margin or in the middle near the base, with many fine, crowded secondary veins, and a distinct gland at the base of the phyllodes.

Flowers: Light golden-orange, minute, in spikes (8.5 cm long), fragrant.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature, initially straight or curved becoming twisted and coiled (6.5 cm long and 1.5 cm wide) containing shiny black seeds (0.4–0.6 cm long and 0.3–0.4 cm wide) encircled by a long red, yellow or orange structure.

ORIGIN

Australia and Papua New Guinea.

REASON FOR INTRODUCTION

Fuelwood, building materials, timber, pulp, erosion control, land reclamation, shade and ornament.

INVADES

Roadsides, disturbed areas, wastelands, urban open space, forest edges/gaps and riparian vegetation.

IMPACTS

Displaces native vegetation and shades out indigenous plant species. In Florida, USA, it threatens rare plant species such as the listed scrub pinweed, *Lechea cernua* Sm. (Cistaceae), in remnant scrub areas (K. C. Burks, Florida Department of Environmental Protection, *pers. obs*., in FLEPPC, 2015). In Singapore, it is very persistent in disturbed and secondary forests (Tan, 2011). It is also considered to be allelopathic, inhibiting the germination and growth of agricultural crops tested (Hoque *et al*., 2003).

Acacia auriculiformis A. Cunn. ex Benth.

Acacia decurrens

PEA FAMILY

Fabaceae; Subfamily: Mimosaceae

COMMON NAMES

English: acacia bark, early black wattle, green wattle, Sydney wattle, tan wattle
Indonesia: wartel

DESCRIPTION

Evergreen tree with no thorns/spines [5–10 (–15) m tall]; no visible hairs; branches prominently angled with wings or ridges that emanate from the leaf bases.

Bark: Olive-green turning grey, smooth to deeply fissured.

Leaves: Bright green, twice-divided, feathery; leaflets slender (6–15 mm long), a single raised gland occurs at the junction of each pair of leaf branchlets.

Flowers: Bright yellow, rounded clusters arranged into larger, showy, elongated compound clusters.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning dark brown as they mature, elongated, hairless, slightly flattened (2–10 cm long), containing about 11 black seeds.

ORIGIN

Southeast Australia

REASON FOR INTRODUCTION

Fuelwood, building materials, timber, tannins, pulp, soil conservation, windbreaks, shelter, shade and ornament.

INVADES

Roadsides, disturbed land, wasteland, urban open space, grasslands, savannah, forest edges/gaps and riparian vegetation.

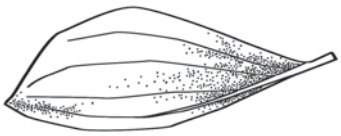
IMPACTS

The accumulation of dead/rotting foliage forms a thick ground cover which, over time, eliminates the growth and establishment of other vegetation (Ruskin, 1983). When it forms dense thickets along waterways it reduces water flow and can contribute to flooding (Hill *et al*., 2000) and streambank erosion. It has a significant impact on water runoff, and because it fixes nitrogen, it alters soil nutrient cycling. Its pollen is reported to be allergenic.

Acacia decurrens Willd

All images © Sunardi Mansyur

Acacia mangium



PEA FAMILY

Fabaceae; Subfamily: Mimosaceae

COMMON NAMES

English: brown salwood, hickory wattle, mangium
Cambodia: acacia sleuk thom
Indonesia: mangge hutan, nak, sabah salwood, tongke hutan
Philippines: maber
Thailand: krathinthepha
Vietnam: keo tai tượng

DESCRIPTION

Evergreen tree with no thorns/spines (30–35 m tall) and often with a straight trunk [25–50 (–90) cm in diameter].

Bark: Greenish and smooth in young trees; rough, greyish brown to dark brown, hard, fissured near the base of older trees.

Leaves: Dark green, 'leaves' are expanded leaf stalks called phyllodes, straight on one side and slightly curved on the other (25 cm long and 3.5–10 cm wide), 4–5 main longitudinal veins, gland conspicuous at the base of the phyllodes.

Flowers: Numerous tiny white or cream flowers in loose spikes (5–12 cm long).

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature (8–10 cm long and 0.3–0.5 cm wide), initially straight and broad but irregularly coiled when ripe; seeds are black and shiny (3–5 mm long and 2–3 mm wide), attached to the pods by an orange-to-red folded appendage.

ORIGIN

Australia, Indonesia and Papua New Guinea.

REASON FOR INTRODUCTION

Fuelwood, building materials, timber, fibre, tannins, shade, shelter and ornament.

INVADES

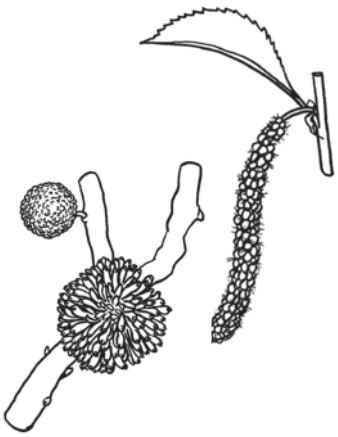
Roadsides, disturbed areas, wastelands, urban open space, plantations, croplands, forest edges/gaps, woodland edges/gaps and coastal areas.

IMPACTS

In forests in Brunei *A. mangium* has displaced many native plants and, in particular, heath forest species (Osunkoya *et al*., 2005). The tree has also invaded fruit and coffee farms and has a negative impact on the germination and growth of two local rice varieties (Ismail and Metali, 2014). It also uses significant amounts of water, more that the natural vegetation that it replaces. By fixing nitrogen it also impacts on soil nutrient cycling.

Acacia mangium Willd

Broussonetia papyrifera



MULBERRY FAMILY

Moraceae

COMMON NAMES

English: paper mulberry, tapa cloth tree
Cambodia: krung tehs, mon barang
Indonesia: daluang, saeh
Myanmar: malaing
Thailand: por-gra-saa, por-saa, ton-saa
Vietnam: cây dướng

DESCRIPTION

Small tree or shrub with milky sap (20 m or higher) and a trunk diameter of 0.6 m; round or spreading crown, branches smooth and mottled grey, marked with orange-tan stipular scars, shallow rooted; sheds most of its leaves at the end of the growing season.

Bark: Tan or light grey with pale orange to light tan stripes, becoming yellowish with age, smooth to slightly fissured.

Leaves: Greyish, rough surface above and fuzzy-downy below, simple, shape variable – either egg-shaped with a broad and round base tapering towards the end, heart-shaped or deeply lobed (7–20 cm long), margins with forward-pointing fine projections or teeth; held alternately or almost opposite each other on stems; leaf stalks are 3–10 cm long.

Flowers: Male flowers yellowish-white in clusters (3.5–7.5 cm); female flowers in rounded clusters, round heads (about 1.3 cm wide), hairy.

Fruits: Syncarp (a fleshy compound fruit), berry-like, initially green turning red, purple to orange as it matures, fleshy, round (1–2 cm wide) with many embedded or protruding tiny red seeds.

ORIGIN

China, India, Japan, Korea, Malaysia, Pakistan and Thailand.

REASON FOR INTRODUCTION

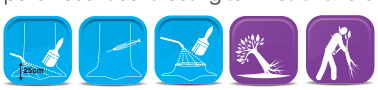
Fuelwood, fodder, paper, pulp, shade and ornament.

INVADES

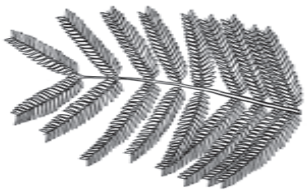
Roadsides, disturbed areas, wastelands, urban open space, plantations, forest edges/gaps and riparian vegetation.

IMPACTS

Forms dense stands that displace native species, prevent forest regeneration and reduce water availability. In Pakistan, *B. papyrifera* limits the growth of *Dalbergia sissoo* Roxb. (Fabaceae), *Morus alba* L. (Moraceae) and *Ziziphus* sp. In the Philippines, native species such as *Trema orientalis* (L.) Blume (Cannabaceae), *Macaranga tanarius* (L.) Müll. Arg. (Euphorbiaceae), *Melanolepis multiglandulosus* (Reinw. ex Blume) Rchb.f. & Zoll. (Euphorbiaceae), *Mallotus philippinensis* (Lam.) Muell. Arg. (Euphorbiaceae), *Ficus nota* (Blanco) Merr. (Moraceae), *Ficus septica* Burm., *Ficus ulmifolia* Lam., *Polyscias nodosa* (Blume) Seem (Araliaceae), and other species were displaced by paper mulberry (Baguinon *et al*., 2003). Paper mulberry produces considerable amounts of allergenic pollen which has been shown to exacerbate asthma in sufferers. In Islamabad, Pakistan, paper mulberry can account for75% of the total pollen count contributing to ill health and even death in the old and infirm.



Broussonetia papyrifera (L.) Vent



PEA FAMILY

Fabaceae

COMMON NAMES

English: calliandra, red calliandra
Indonesia: kaliandra, kaliandra merah
Malaysia: kaliandra
Vietnam: muồng hoa pháo

DESCRIPTION

Evergreen, thornless, often multi-stemmed leguminous shrub or small tree [5–6 (–12 m) tall] with a trunk diameter of 20 (–30) cm.

Bark: White to red-brown and hairless, sometimes finely hairy.

Leaves: Dark green, twice-divided (10–19 cm long) with 6–20 pairs of leaflet branchlets, each with 19–60 pairs of linear, somewhat elongated and pointed leaflets (5–8 mm long and 1 mm wide).

Flowers: Red in terminal clusters up to 30 cm long with numerous long shiny red stamens, showy.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature, straight, flattened (8–13 cm long and 1–1.6 cm wide) with thickened and raised margins splitting open, with each half curling back, held erect on stem.

ORIGIN

Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama.

REASON FOR INTRODUCTION

Fuelwood, building materials, fodder, ornament, soil conservation, nitrogen fixation and green manure.

INVADES

Roadsides, disturbed land, urban open space, plantation edges/gaps, forest edges/gaps, riparian vegetation and lowlands.

IMPACTS

It has the ability to form dense thickets, displacing native species, especially in riparian areas. It is an aggressive colonizer of disturbed habitats, is highly adaptable, and able to grow under a wide variety of soil and environmental conditions (Macqueen, 1992; Palmer *et al*., 1994). It has the potential to suppress other plants very quickly when competing for water and nutrients (CONABIO, 2014). In Kabale, Uganda, some farmers claimed that it competed with food crops, impacted negatively on soil nutrients and harboured pest birds. Calliandra also fixes nitrogen and as a result impacts on soil nutrient cycling.

Calliandra houstoniana **(Mill.) Standl. var. *calothyrsus* (Meisn.) Barneby**

Leucaena leucocephala

PEA FAMILY

Fabaceae; Sub-family: Mimosaceae

COMMON NAMES

English: jumbie bean, lead tree, leucaena, wild tamarind; Cambodia: khtum tehs, krathum thet; Indonesia: petai cina; Lao PDR: kathin; kh'oonz, koong khaaw; Malaysia: lamtoro, petai belalang; Philippines: bayani, komkompitis, loyloy, palomaria; Thailand: kra thin, to-bao; Vietnam: cây keo dậu

DESCRIPTION

Evergreen thornless shrub or small tree [2–10 (15) m high]; young stems green and densely covered in greyish-coloured hairs.

Bark: Smooth, greyish-brown with numerous small raised spots.

Leaves: Dark green, twice-divided [0.7–15 (–35) cm long] with small raised structure (gland) usually on leaf stalk, 3–10 pairs of leaf branchlets, each 2–10 cm long and each bearing 5–22 pairs of leaflets that are somewhat elongated, almost parallel sided or sword-shaped (7–21 mm long and 1.5–5 mm wide).

Flowers: White or pale yellow in globular clusters (12–30 mm across), borne singly or in groups of 2–3 located at the juncture of the leaf and stem.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown or reddish brown as they mature, elongated, almost straight (8–18 cm long and 2 cm wide), flattened but raised over the seeds, pointed tips; containing 10–25 hard seeds.

ORIGIN

Belize, Guatemala and Mexico.

REASON FOR INTRODUCTION

Fuelwood, fodder, tannins, nitrogen fixation, soil conservation, shade and ornament.

INVADES

Roadsides, disturbed land, urban open space, drainage ditches, forest edges/gaps, woodland edges/gaps, riparian vegetation, lowlands and coastal shrub.

IMPACTS

Forms large monocultures displacing native plant and animal species. In Hawaii, it is outcompeting open forest species (Cronk and Fuller, 1995), while on the Brazilian island of Fernando de Noronha, it impacts endemic flora. The invasion of leucaena has had a severe effect on the native plant community in the Ogasawara (Bonin) Islands, Japan, and may alter secondary succession, promoting the invasion and establishment of more aggressive alien plant species (Yoshida and Oka, 2004). In Guam, leucaena is preventing the establishment of indigenous species (B. Lawrence, *pers. comm.*, in Walton, 2003). In Vanuatu, it can form dense monospecific thickets, threatening native plant species and is 'very difficult to eradicate once established, rendering extensive areas unusable and inaccessible' (Bakeo and Qarani, 2005). In the Erap Valley of Papua New Guinea, it forms monospecific stands in river valleys, replacing native riparian vegetation (G. Werren, *pers. comm.*, in Walton, 2003).

Leucaena leucocephala (Lam.) de Wit

Miconia calvescens

TIBOUCHINA FAMILY

Melastomataceae

COMMON NAMES

English: bush currant, miconia, purple plague, velvet tree
Vietnam: cây micona

DESCRIPTION

Evergreen shrub or small tree [4–8 (–16) m tall]; young stems are green, four-angled and covered in tiny star-shaped hairs; stems become brown and rounded with age.

Leaves: Dark green above and bright purple below, hairless, simple, oval with pointed tips [17–40 (–100) cm long and 7–25 cm wide], margins entire or finely toothed, three-veined from base to tip of leaf; leaf stalks are 2–6 cm long.

Flowers: White or pinkish, small, held in large clusters (20–50 cm long) at end of branches.

Fruits: Berries (fleshy fruits that don't open at maturity), green turning bluish black or dark purple as they mature (about 6 mm across), containing 140–230 seeds.

ORIGIN

Bolivia, Brazil, Colombia, Ecuador, Guatemala, Mexico, Panama, Paraguay and Peru.

REASON FOR INTRODUCTION

Ornament and in contaminated soil.

INVADES

Roadsides, disturbed land, plantations, forest edges/gaps, woodland edges/gaps, plantations, riverbanks and coastal areas.

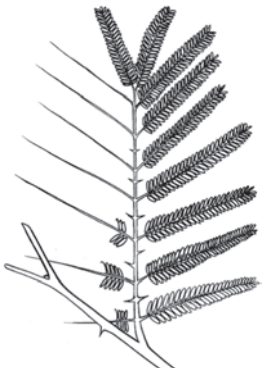
IMPACTS

Areas invaded become totally transformed due to the creation of deep shade which few native species can tolerate (Meyer, 1994). This weed now covers over two-thirds of the island of Tahiti, forming dense monotypic stands, that have overwhelmed the native forests, where between 40 and 50 of the 107 species endemic to Tahiti are thought to be on the verge of extinction (Meyer and Florence, 1996). Between 70 and 100 native plant species, including 40–50 species endemic to French Polynesia, are estimated to be directly threatened by *M. calvescens* with significant knock-on impacts on endemic birds and other organisms (Meyer and Florence, 1996). The lack of ground cover under infestations also contributes to higher rates of soil erosion. Impacts have let to infestations being termed the 'green cancer' of Tahiti and the 'purple plague' of Hawaii.

Miconia calvescens DC.

All images ©Jean-Yves Meyer

Mimosa pigra



PEA FAMILY

Fabaceae; Sub-family: Mimosaceae

COMMON NAMES

English: bashful bush, black mimosa, giant mimosa, giant sensitive plant
Cambodia: banla uyyas, banla yuon, deoum klab yeik; Indonesia: ki kerbau, putri malu; Malaysia: kembang gajah, semalu gajah; Thailand: maiyaraap ton, mai yah raap yak; Vietnam: trinh nữ thân gỗ, trinh nữ đầm lầy

DESCRIPTION

Evergreen shrub or small tree (3–6 m high), forming dense thickets, young stems green, rounded, armed with scattered prickles (5–12 mm long), taproot is 1–2 m deep.

Bark: Older stems grey and woody.

Leaves: Yellowish-green, with short fine hairs below, twice-divided (20–31 cm long), straight thorn at the junction of each of the 6–16 pairs of leaflet branchlets, each branchlet with 20–45 pairs of small elongated leaflets (3–12 mm long and 0.5–2 mm wide), leaves fold together at night or when touched.

Flowers: Pink or mauve, in fluffy round heads (1–2 cm wide), borne singly or in groups of two or three, on stalks (2–7 cm long), arising from each upper leaf fork.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning brown as they mature, flat and elongated (3–12 cm long and 7–14 mm wide), covered in bristly hairs, borne in clusters (1–30), break transversely into 14–26 segments; seeds greenish-brown to light brown (4–6 mm long and 2–2.5 mm wide).

ORIGIN

Argentina, Belize, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname and Venezuela.

REASON FOR INTRODUCTION

Green manure, nitrogen fixation, medicine, hedge/barrier and ornament.

INVADES

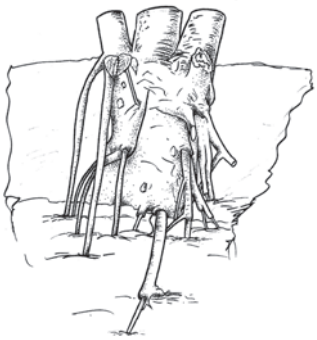
Roadsides, disturbed land, wastelands, urban open space, drainage ditches, irrigation channels, dams, riversides, floodplains, swamps, wetlands, lake edges and gullies.

IMPACTS

Dense infestations of *M. pigra* contribute to a decline in abundance and diversity of species of plants and animals. In Tram Chim National Park, Vietnam, it has reduced the density of native plant species threatening the vulnerable sarus crane (*Grus antigone* L.) (Triet and Dung, 2001). *M. pigra* thickets in Australia had fewer plants, birds and lizards, than native vegetation (Braithwaite *et al*., 1989). In Lochinvar National Park, Zambia, infestations reduced bird diversity by almost 50% and abundance by more than 95% (Shanungu, 2009). In Cambodia, farmers ranked mimosa as the most significant problem affecting rice farming, 'ahead of pests, rodents, and drought problems' (Chamroeun *et al*., 2002). *M. pigra* also hampers fishing activities and prevents access to water bodies.

Mimosa pigra L.

Piper aduncum



PEPPER FAMILY

Piperaceae

COMMON NAMES

English: bamboo piper, false matico, jointwood, piper

DESCRIPTION

Evergreen shrub or small tree (6–8 m tall), with short stilt roots, often in thickets, branches are erect, but with drooping twigs and swollen, purplish nodes, foliage and twigs aromatic.

Bark: Yellow-green, finely hairy stems and enlarged, ringed nodes.

Leaves: Green, softly hairy beneath, broadly sword- to oval-shaped (13–25 cm long and 3.5–8 cm wide), tapering into long tips with the base asymmetric, short leaf stalks.

Flowers: Yellowish, tiny, in long curving spikes opposite the leaves.

Fruits: Berries (fleshy fruits that don't open at maturity), green, small, egg-shaped, compressed into greyish, worm-like spikes.

ORIGIN

Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Venezuela, and the Caribbean.

REASON FOR INTRODUCTION

Medicine, spice and ornament.

INVADES

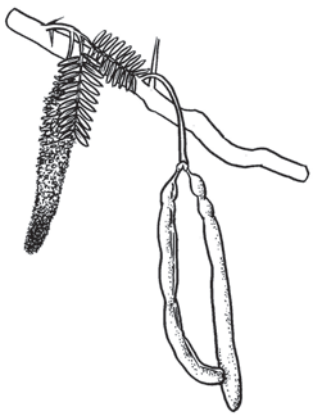
Roadsides, disturbed land, fallow land, plantations, forest edges/gaps, lowlands and riparian zones.

IMPACTS

P. aduncum establishes dense stands which shade out native species and prevent forest regeneration. In field surveys in Papua New Guinea, it was found to be present in all garden plots, 92% of riverine plots, 80% of young secondary and 65% of old secondary forest plots, and 75% of the gaps (Leps *et al*., 2002). In regenerating areas, *P. aduncum* sometimes attained a canopy cover of 75% and suppressed the native species which local communities utilized extensively in the past (Leps *et al*., 2002). In the Pacific, it is accidentally harvested with kava (*Piper methysticum* G. Forst), an important crop, lowering its quality. It also competes with kava and other crops and may act as a host for kava pests and pathogens (Plant Protection Service, 2001). It consumes large quantities of water, drying out the soil, and absorbs significant amounts of nutrients to the detriment of crops.

Piper aduncum L.

Prosopis juliflora



PEA FAMILY

Fabaceae; subfamily: Mimosaceae

COMMON NAMES

English: algorroba, ironwood, mesquite
Philippines: aroma

DESCRIPTION

Evergreen shrub or tree with thorns/spines, multi-stemmed but occasionally single stemmed [3–5 (15) m high], twigs distinctively zigzag.

Bark: Thick, rough grey-green, scaly with age and armed with sharp thorns/spines (up to 5 cm long).

Leaves: Dark green, hairless or hairy, twice-divided, 1–3 (–4) pairs of leaf branchlets (3–11 cm long) each with 11–15 pairs of leaflets, narrow, somewhat elongated with parallel sides (6–23 mm long and 1.6–5.5 mm wide), with smooth margins, no terminal leaflet, leaves grow alternately on stem.

Flowers: Yellow, small, in cylindrical spikes (5–10 cm long and 1.5 cm side), solitary or in clusters near the leaf axils, fragrant.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning yellow as they mature, flat, slightly curved (8–29 cm long and 9–17 mm wide), containing 10–20 oval seeds (2–8 mm long).

ORIGIN

Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama and Venezuela.

REASON FOR INTRODUCTION

Fuelwood, timber, fodder, tannin, landscape restoration, windbreaks, shade, hedge/barrier and ornament.

INVADES

Roadsides, disturbed land, wastelands, fallow land, drainage ditches, woodland edges/gaps, savannah, riparian vegetation, floodplains, gullies and sandy stream beds.

IMPACTS

Displaces native plant species and reduces the abundance and diversity of bird and other animal species. In Ethiopia, *P. juliflora* has reduced understorey basal cover for perennial grasses and reduced the number of grass species from seven to two (Kebede and Coppock, 2015). By transforming habitats and eliminating pasture species, it threatens the survival of Grévy's zebra (*Equus grevyi*) in invaded areas (Kebede and Coppock, 2015). Other negative impacts include encroachment onto paths, villages, homes, water sources, crop- and pasturelands; and injuries inflicted by the thorns (Maundu *et al*., 2009). Infestations have contributed to the abandonment of agricultural land, homes and small villages. The pollen has been identified as a major allergen (Killian and McMichael, 2004). In semi-arid parts of Africa, *P. juliflora* has depleted the natural resources on which thousands of people depend, spawning conflict between communities over the diminishing resources.

Prosopis juliflora (Sw.) DC.

Spathodea campanulata

JACARANDA FAMILY

Bignoniaceae

COMMON NAMES

English: fireball, flame tree, fountain tree, Nandi flame, Nile flame, tulip tree
Cambodia: angkie dei chmool
Indonesia: pohon hujan
Vietnam: cây hoa tuylip châu phi

DESCRIPTION

Large, upright tree [10–15 (–35) m tall] with trunk up to 170 cm in diameter with a dense wide crown; younger branches are almost hairless or have a sparse covering of short hairs, older branches thick with small white-coloured corky spots; shoots, buds and branchlets covered in yellow-brown hairs, slightly buttressed; sheds leaves at the end of the growing season.

Bark: Pale, grey-brown, smooth, rough with age.

Leaves: Green, yellow-brown soft hairs on underside, large, once-divided (50 cm long) with (7–) 11–15 (–17) broadly oval or egg-shaped leaflets (15 cm long and 7.5 cm wide) with base rounded and gradually tapering towards the end, margins entire, 2–3 glands at base of each leaflet, leaves oppositely arranged on stalks that are up to 6 cm long.

Flowers: Orange, showy, tulip-shaped, in dense clusters (8–10 cm long) on long stalks (10 cm long) at the end of branches, individual flower stalks short and covered in brownish hairs; there is a yellow-flowering variety.

Fruits: Pod-like (several-seeded dry fruit that splits open at maturity), green changing to brown as they mature, elongated (17–30 cm long and 3.5–5 cm wide).

ORIGIN

Angola, Benin, Burundi, Cameroon, Democratic Republic of Congo, Equatorial Guinea, Ghana, Gabon, Guinea, Ivory Coast, Liberia, Nigeria, Rwanda, Sierra Leone and Togo.

REASON FOR INTRODUCTION

Fuelwood, carving, medicine, bee forage, erosion control, mulch, windbreak, shade and ornament.

INVADES

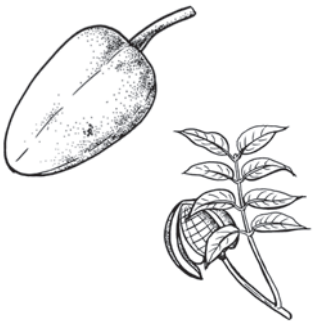
Roadsides, disturbed land, forest edges/gaps and riparian areas.

IMPACTS

Native plants are displaced by the shading effect of the large leaves, resulting in reduced biodiversity under tree canopies (Weber, 2003). In surveys in Fiji, respondents claimed that the African tulip tree competes with crops, reduces the amount of land available for grazing livestock, and leads to the loss of more desirable trees that are used for medicinal purposes and/or firewood (Brown and Daigneault, 2014). It is a weed of coffee plantations in Cuba, reducing yields (Herrera-Isla *et al*., 2002).

Spathodea campanulata P. Beauv.

Swietenia macrophylla



MAHOGANY FAMILY

Meliaceae

COMMON NAMES

English: big-leaved mahogany, broad-leaved mahogany, Honduras mahogany
Cambodia: kroab baek
Indonesia: mahoni
Malaysia: cheria mahogany
Thailand: mahokkani-bailek
Vietnam: cây nhạc ngựa

DESCRIPTION

Evergreen tropical tree species (up to 40–60 m high), trunk is straight, cylindrical, 3–4 m in circumference, buttresses up to 5 m high, crown of young trees is narrow, but old trees have a broad, dense and highly branched crown.

Bark: Brownish-grey to reddish-brown, deeply furrowed, scaly, inner bark red-brown or pinkish red, flaking off in small patches.

Leaves: Green, once-divided [12–45 (–60) cm long], 3–6 pairs of sword- or egg-shaped leaflets (5–12 cm long and 2–5 cm wide), margins entire, gradually tapering to a sharp point.

Flowers: Small (0.5–1 cm long and 8 mm across), in clusters (10–20 cm long).

Fruits: Capsules (dry fruits that open at maturity), light grey to brown, egg-shaped (12–39 cm long and 7–12 cm wide) containing 20–70 winged seeds (7–12 cm long and 2–2.5 cm wide).

ORIGIN

Belize, Brazil, Bolivia, Colombia, Costa Rica, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru and Venezuela.

REASON FOR INTRODUCTION

Fuelwood, building materials, timber, shade and ornament.

INVADES

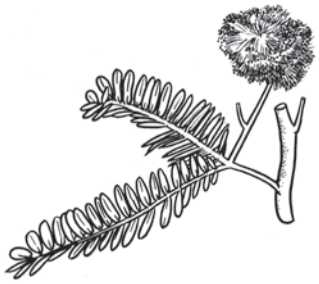
Disturbed land, forest edges/gaps and riparian vegetation.

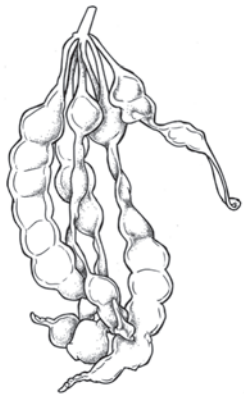
IMPACTS

Mahogany readily invades secondary forests and forest edges and gaps preventing native species regeneration. In the lowlands of Mount Makiling, Philippines, mahogany has penetrated 250 m into secondary forests in 70 years (Baguinon, 2011). Dominance is facilitated by the fact that mahogany may also be allelopathic (Thinley, 2002). Extracts from the leaves of mahogany were shown to retard the growth of narra (*Pterocarpus indicus* Willd.) seedlings in the Philippines (Baguinon *et al*., 2003). Diversity of native plants in general was also considerably reduced under or near *S. macrophylla* stands. Invasive mahogany species, together with other introduced plants, are preventing the regeneration of dipterocarp and non-dipterocarp forests in parts of Asia.

Swietenia macrophylla King

Vachellia nilotica





PEA FAMILY

Fabaceae; Subfamily Mimosaceae

COMMON NAMES

English: gum arabic, Nile thorn, prickly acacia, scented thorn
Indonesia: akasia
Vietnam: keo å rập

DESCRIPTION

Evergreen thorny tree or shrub [4–6 (–25) m]; usually single-stemmed, crown scattered when young, later umbrella-shaped; thorns greyish (up to 10 cm long); deep and well-developed root system.

Bark: In young trees tinge of orange and/or green; in older trees brown-black, rough and deeply grooved.

Leaves: Dark green, hairless, twice-divided with 3–10 pairs of leaf branchlets (4 cm long), each with 10–25 pairs of leaflets, which are narrow and somewhat elongated with almost parallel sides (2–6 mm long and 0.5–1.5 mm wide); pair of spines (1–5 cm long) at base of each group of leaves in young stems.

Flowers: Pale to golden yellow globular flowerheads (1–1.5 cm across) on 2 cm long stalks, fragrant.

Fruits: Pods (several-seeded dry fruits that split open at maturity), green turning black as they mature, straight or slightly curved (10–20 cm long and 5–17 mm wide), constrictions between each seed in the pod resemble a string of pearls.

ORIGIN

India, Myanmar, Oman, Pakistan and Yemen.

REASON FOR INTRODUCTION

Fuelwood, building materials, timber, tools, medicine, chicory-substitute in coffee, fodder, nitrogen fixation, soil conservation, windbreak, firebreak, shade and ornament.

INVADES

Roadsides, disturbed land, urban open space, drainage ditches, irrigation channels, woodland edges/gaps, savannah and natural pasture.

IMPACTS

In Queensland, Australia, tree cover of just 25–30% has reduced the amount of pasture by 50% (Carter, 1994). Dense thickets also make it difficult to herd livestock, and animals have reduced access to water. In Indonesia, *A. nilotica* in Baluran National Park has reduced the amount of grazing available for herbivores, threatening the continued existence of the endangered banteng (*Bos javanicus* d'Alton; Bovidae). Infestations also contribute to increase soil erosion. Because the tree fixes nitrogen it also impacts on soil nutrient cycling.

Vachellia nilotica subsp. *indica* (Benth.) Kyal. & Boatwr.

This page intentionally left blank

Useful Websites

ASEAN Centre for Biodiversity (ACB) (**www.aseanbiodiversity.org**)

Asia-Pacific Forest Invasive Species Network (APFISN) (**www.apfisn.net**)

CABI Invasive Species Compendium (ISC) (**www.cabi.org/isc**)

Convention on Biological Diversity (CBD) (**www.cbd.int**)

Convention on Wetlands of International Importance (RAMSAR) (**www.ramsar.org**)

Environmental Weeds of Australia (**http://keyserver.lucidcentral.org/weeds/data/media/Html/index.htm#A**)

Global Invasive Species Database (GISD) (**www.iucngisd.org/gisd**)

International Plant Protection Convention (IPPC) (**www.ippc.int**)

New South Wales Department of Primary Industries (**www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds**)

Pacific Island Ecosystems at Risk (PIER) (**www.hear.org/pier**)

Scientific Committee on Problems of the Environment (SCOPE) (**www.icsu-scope.org**)

South African Working for Water Programme (WfW) (**http://dwaf.gov.za/wfw/**)

United States Department of Agriculture (USDA) National Invasive Species Information Center (**http://invasivespeciesinfo.gov/**)

This page intentionally left blank

References

Abhilash PC, Nandita S, Sylas VP, Kumar BA, Mathew JC, Satheesh R, Thomas AP (2008). Eco-distribution mapping of invasive weed *Limnocharis flava* (L.) Buchenau using Geographical Information System: implications for containment and integrated weed management for ecosystem conservation. *Taiwania* 53(1): 30-41.

Akobundu, IO (1987). *Weed Science in the Tropics. Principles and Practices*. John Wiley & Sons, New York, USA, 522 pp.

Alabi BS, Ayeni AO, Agboola AA, Majek BA (2001) Giant sensitive plant interference in cassava. *Weed Science* 49(2):171-176.

Anderson CR, Gardner ED (1999). An evaluation of the wilt-causing bacterium *Ralstonia solanacearum* as a potential biological control agent for the alien Kahili ginger (*Hedychium gardnerianum*) in Hawaiian forests. *Biocontrol* 15(2): 89-96.

Anderson LWJ (1993). Aquatic weed problems and management in the western United States and Canada. *In*: Pieterse AH, Murphy KJ (eds.). *Aquatic Weeds*, (2nd edn.). Oxford Scientific Press, Oxford, UK, pp. 371-391.

Anonymous (1987). Indonesia girds to battle *Salvinia molesta*. *Weedwatcher* 2: 1-2.

Arce OE, Robinet HA, Mansilla de Andrada N, Dfaz y BE, Guillén S (1995). Determination of losses in soybean (*Glycine max*) by competition from arrowhead (*Bidens subalternans*) in the northwestern province of Tucumán-Argentina. (Determinación de pérdidas de cultivo de soja [*Glycine max*] por competencia de saetilla [*Bidens subalternans*] en el noroeste de la provincia de Tucumán-Argentina). *Resúmenes XII Congreso Latinoamericano de Malezas*, pp. 216-220.

Arora K (2013). Allelopathic influence of *Cassia occidentalis* L. on growth of Zea mays. *Indian Journal of Scientific Research and Technology* 1(1): 15-17.

Arraudeau M (1986). Final Report on International Upland Rice Genetic Survey (IURGS). International Rice Research Institute, Los Baños, Laguna, Philippines.

Arthington AH, Milton DA, McKay RJ (1983). Effects of urban development and habitat alterations on the distribution and abundance of native and exotic freshwater fish in the Brisbane region, Queensland. *Australian Journal of Ecology* 8: 87-101.

Auld BA (1969). The distribution of *Eupatorium adenophorum* Spreng. on the far north coast of New South Wales. *Journal and Proceedings of the Royal Society of New South Wales* 102: 159-161.

Auld BA (1970). Eupatorium weed species in Australia. *Pest Articles and News Summaries* 16: 82-86.

Auld BA, Menz K.M, Medd RW (1978). Bioeconomic model of weeds in pastures. *Agro-Ecosystems* 5(1): 69-84.

Baguinon NT (2011). Plant bioinvasions in the northeastern slopes of Mt. Makiling, Luzon, Philippines (1998-2009). *Asia Life Sciences Supplement* 6: 13-30.

Baguinon NT, Quimado MO, Francisco JG (2003). Country report on forest invasive species in the Philippines, In: McKenzie P, Brown C, Jianghua S, Jian W (eds.). *The Unwelcome Guests: Proceedings of the Asia-Pacific Forest Invasive Species Conference*. Food and Agricultural Organization of the United Nations, Regional Office for Asia and Pacific, Bangkok, pp. 109-160.

Bakeo R, Qarani F (2005). Country report on the forestry invasive species situation in Vanuatu. *In*: McKenzie P, Brown, C, Jianghua S, Jian W (eds.). *The Unwelcome Guests: Proceedings of the Asia-Pacific Forest Invasive Species Conference*.Food and Agricultural Organization of the United Nations, Regional Office for Asia and Pacific, Bangkok, pp. 130-136.

Barros CSL, Ilha MRS, Bezerra Junior PS, Langohr IM, Kommers GD (1999). Poisoning with *Senna occidentalis* in grazing cattle. *Pesquisa Veterinária Brasileira* 19(2): 68-70.

Bizimana N (1994). Traditional Veterinary Practice in Africa. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Federal Republic of Germany, 916 pp.

Borokini TI (2011). Invasive alien plant species in Nigeria and their effects on biodiversity conservation. *Tropical Conservation Science* 4(1): 103-110.

Braithwaite RW, Lonsdale WA, Estbergs J A (1989). Alien vegetation and native biota in tropical Australia: The spread and impact of *Mimosa pigra*. *Biological Conservation* 48: 189-210.

Brighenti AM, Voll E, Gazziero DLP (2003). Biology and management of *Cardiospermum halicacabum*. *Planta Daninda* 21: 229-237.

Brown P, Daigneault A (2014). Cost–benefit analysis of managing the invasive African tulip tree (*Spathodea campanulata*) in the Pacific. *Environmental Science and Policy* 39: 65-76.

Brunt AA, Crabtree K, Dallwitz MJ, Gibbs AJ, Watson L, Zurcher E. (eds.). (1996). *Viruses of Plants*. Descriptions and lists from the VIDE database. CAB International, Wallingford, UK, 1484 pp.

Bunn SE, Davies PM, Kellaway DM, Prosser IP (1998). Influence of invasive macrophytes on channel morphology and hydrology in an open tropical lowland stream, and potential control by riparian shading. *Freshwater Biology* 39: 171-178.

Burnett K, Kaiser B, Roumasset J (2007). Economic lessons from control efforts for an invasive species: *Miconia calvescens* in Hawaii. *Journal of Forest Economics* 13: 2-3.

Burton GJ (1960). Studies on the bionomics of mosquito vectors which transmit filariasis in India. II. The role of water hyacinth (*Eichhornia speciosa* Kunth) as an important host plant in the life cycle of *Mansonia uniformis* (Theobald) with notes on the differentiation of the late embryonic and newly hatched stages of *Mansonia annulifera* (Theobold). *Indian Journal of Malariology* 14: 81-106.

CABI (2016), Invasive Species Compendium. CAB International, Wallingford, UK. (www.cabi.org/isc).

Carter JO (1994). *Acacia nilotica* – a tree legume out of control. In: Gutteridge RC, Shelton HM (eds.). *Forage Tree Legumes in Tropical Agriculture*. CAB International, Wallingford, UK, pp. 338-351.

Chamroeun K, Peng Seang T, Sophal H, Sun Hout S, Vuthy H (2002). An investigation of the impacts of *Mimosa pigra* on rice and fishery productivity in Kandal Province, Cambodia. *In*: McKenney (ed.). *Economy and Environment: Case studies in Cambodia*. Economy and Environment Program for Southeast Asia (EEPSEA), Singapore, pp. 24-31.

Chippendale J, Panetta FD (1994). The cost of parthenium weed to the Queensland cattle industry. *Plant Protection Quarterly* 9: 73-76.

Chow CY, Thevasagayam ES, Wambek EG (1955). Control of Salvinia; A host plant of *Mansonia* mosquitoes. *Bulletin of the World Health Organization* 12(3): 365-369.

Coates D (1982). Salvinia – Possible biological effects on fish in Papua New Guinea? *Aquatics* 4(3):2.

Colvin BM, Harrison LR, Sangster LT, Gosser HS (1986). *Cassia occidentalis* toxicosis in growing pigs. *Journal of the American Veterinary Medical Association* 189(4): 423-426.

CONABIO – Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (National Commission for the Knowledge and Use of Biodiversity (2014). *Calliandra calothyrsus*, species information. (http://www.conabio.gob.mx/conocimiento/info_especies/arboles/doctos/40-legum11m.pdf).

Cooke L (1997). Nothing but a wasteful weed. *Agricultural Research* (Washington) 45(4): 14-15.

CRC for Weed Management (2003). *Weed Management Guide: Siam weed or chromolaena (Chromolaena odorata)*, CRC for Australian Weed Management, Commonwealth Department of Environment and Heritage. (https://www.environment.gov.au/biodiversity/invasive/weeds/publications/guidelines/alert/pubs/c-odorata.pdf).

Cronk QCB, Fuller JL (1995). *Plant Invaders: The Threat to Natural Ecosystems*. Chapman & Hall, London, UK, 241 pp.

Csurhes SM (1999). *Bellyache bush (Jatropha gossypiifolia) in Queensland*. Pest Status Review Series – Land Protection, Queensland Department of Natural Resources and Mines, Brisbane, Queensland, Australia, 38 pp.

Day MD, Kawi A, Kurika K, Dewhurst CF, Waisale S, Saul-Maora J, Fidelis J, Bokosou J, Moxon J, Orapa W, and Senaratne KAD (2012). *Mikania micrantha* Kunth (Asteraceae) (mile-a-minute): Its distribution and physical and socio-economic impacts in Papua New Guinea. *Pacific Science* 66(2): 213-223.

De Groote H, Ajuonu O, Attignon S, Djessou R, Neuenschwander P (2003). Economic impact of biological control of water hyacinth in Southern Benin. *Ecological Economics* 45: 105-117.

De Lange WJ, van Wilgen BW (2010). An economic assessment of the contribution of weed biological control to the management of invasive alien plants and to the protection of ecosystem services in South Africa. *Biological Invasions* 12: 4113-4124.

Dean WRJ, Anderson MD, Milton SJ, Anderson TA (2002). Avian assemblages in native Acacia and alien Prosopis drainage line woodland in the Kalahari, South Africa. *Journal of Arid Environments* 51: 1-19.

Dempsey MA (2011). Anatomical and morphological responses of *Cardiospermum halicacabum* L. (balloon vine), to four levels of water availability. MSc Dissertation, University of North Texas, USA. (http://digital.library.unt.edu/ark:/67531/metadc67974/).

Department of Primary Industries (DPI) (2008). Cobblers Pegs (*Bidens pilosa* L.): *Impact Assessment* – Cobblers Pegs (*Bidens pilosa* L.) in Victoria. Victorian Resources Online Statewide (http://hear.org/starr/publications/2006_lanai_islets_botanical_survey.pdf).

De Wit M, Crookes D, van Wilgen BW (2001). Conflicts of interest in environmental management: Estimating the costs and benefits of a tree invasion. *Biological Invasions* 3: 167–178.

Dogra KS, Kohli RK , Sood SK, Praveen KD (2009). Impact of *Ageratum conyzoides* L. on the diversity and composition of vegetation in the Shivalik hills of Himachal Pradesh (Northwestern Himalaya), India. *International Journal of Biodiversity and Conservation* 1(4): 135-145.

Dray FA, Center TD (2002). Water lettuce. *In*: Van Driesche R, Blossey B, Hoddle M, Lyon S, Reardon R (eds.). *Biological Control of Invasive Plants in the Eastern United States*. USDA Forest Service Publication FHTET-2002-04, USDA Forest Service, Morgantown, West Virginia, pp. 311-321. (http://wiki.bugwood.org/Archive:BCIPEUS).

Dray FA, Center TD, Wheeler GS (2001). Lessons from unsuccessful attempts to establish *Spodoptera pectinicornis* (Lepidoptera: Noctuidae), a biological control agent of water lettuce. *Biocontrol Science and Technology* 11: 301-316.

Ellis JM, Shaw DR, Barrentine WL (1998). Soybean (*Glycine max*) seed quality and harvesting efficiency as affected by low weed densities. *Weed Technology* 12(1): 166-173.

Ernst JJ, Ketner P (2007). Study on the ecology and possible control methods of the invasive plant species *Antigonon leptopus* (Corallita or Mexican Creeper). Final report, Corallita Pilot Project, St.Eustatius, Netherlands Antilles, 38 pp. (http://www.abcadvies.org/rapporten/Coralitta%20Pilot%20Project%20St.Eustatius.pdf).

Evans HC (1997). *Parthenium hysterophorus* L.: A review of its weed status and possibilities for biological control. *Biocontrol News and Information* 18(3): 89-98.

Everaarts AP (1993). Effects of competition with weeds on the growth, development and yield of sorghum. *Journal of Agricultural Science* 120(2): 187-196.

Everist SL (1974). *Poisonous Plants of Australia*. Angus & Robertson, London/Sydney, Australia, 996 pp.

Fisk P (1991). Ponded pastures as a potential weed problem. *In: Probing Ponded Pastures Workshop*, University of Central Queensland, Rockhampton, Queensland, Australia.

FLEPPC – Florida Exotic Pest Plant Council (2015) Florida Exotic Pest Plant Council's 2015 List of Invasive Plant Species. (http://www.fleppc.org/list/2015FLEPPCLIST-LARGEFORMAT-FINAL.pdf).

Flint E, Rehkemper C (2002). Control and eradication of the introduced grass, *Cenchrus echinatus*, at Laysan Island, Central Pacific Ocean. *In*: Veitch CR, Clout MN (eds.). *Turning the Tide: The Eradication of Island Invasives*, IUCN SSC Invasive Species Specialist Group IUCN, Gland, Switzerland, and Cambridge, UK, pp 110-115.

Fowler SV (2000). Trivial and political reasons for the failure of classical biological control of weeds: A personal view. *In*: Spencer NR (ed.). *Proceedings of the X International Symposium on Biological Control of Weeds*. Advanced Litho Printing, Great Falls, Montana, USA, pp. 169-172.

Fowler SV, Syrett P, Hill RL (2000). Success and safety in the biological control of environmental weeds in New Zealand. *Austral Ecology* 25: 553–562.

Francis JK (ed.) (2004). *Wildland Shrubs of the United States and its Territories: Thamnic Descriptions*: Volume 1. General Technical Report IITF-GTR-26, United States Department of Agriculture, Forest Service, International Institute of Tropical Forestry, San Juan, United States, and United States Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, 830 pp.

Garrison JSE, Rauzon MJ, Duin KN, Wilcox BA (2002). Marine Corps Base Hawaii: Invasive Species Management Study. Sustainable Resources Group International, Inc., Honolulu, Hawaii, USA.

Gewertz DB (1983). *Salvinia molesta*: The destruction of an ecosystem. *In*: Gewertz DB (ed.). *Sepik River Societies: a Historical Ethnography of the Chambri and their Neighbors*. Yale University Press, New Haven, Connecticut, USA, pp. 196-217.

Goodall JG, Morley TA (1995). Ntambanana vegetation survey and veld improvement plan. Report submitted to the Mpendle Ntambanana Agricultural Company (Pty.) Ltd., unpublished.

Gopal B (1987). Water Hyacinth. Aquatic Plant Studies I. Elsevier, Amsterdam, Netherlands, 471 pp.

Greathead DJ (1995). Benefits and risks of classical biological control. *In*: Hokkanen HMT, Lynch JM (eds.). *Biological Control: Benefits and Risks*. Cambridge University Press, Cambridge, UK, pp. 53-63.

Hammerton JL (1981). Weed problems and weed control in the Commonwealth Caribbean. *Tropical Pest Management* 27(3): 379-387.

Haraguchi M, Górniak SL, Calore EE, Cavaliere, MJ, Raspantini, PC, Calore, NMP, Dagli MLZ (1998). Muscle degeneration in chicks caused by *Senna occidentalis* seeds. *Avian Pathology* 27(4): 346-351.

Hazarika B, Sannigrahi AK (2001). Allelopathic research in vegetable production: A review. *Environment and Ecology* 19: 799-806.

Henty EE, Pritchard GH (1975). Weeds of New Guinea and their Control. Papua New Guinea: Department of Forests, Division of Botany. *Botany Bulletin* 7.

Herrera Isla L, Brice L, Grillo Ravelo H (2002). Methodology for the artificial inoculation with *Ceratocystis* sp. for the control of *Spathodea campanulata* Beauv. (Metodología para la inoculación artificial de Ceratocystis sp. para el control de Spathodea campanulata Beauv.) *Centro Agrícola* 29(3): 56-58.

Higgins JM, Walker RH, Whitwell T (1986). Coffee senna (*Cassia occidentalis*) competition with cotton. *Weed Science* 34(1): 52-56.

Higgins SI, Turpie JK, Costanza R, Cowling RM, Le Maitre DC, Marais C, Midgley GF (1997). An ecological economic simulation model of mountain fynbos ecosystems: Dynamics, valuation and management. *Ecological Economics* 22: 155-169.

Hill MP (1998). Life history and laboratory host range of *Stenopelmus rufinasus*, a natural enemy for *Azolla filiculoides* in South Africa. *BioControl* 43: 215-224.

Hocking PJ, Liddle MJ (1986). The biology of Australian weeds: 15. *Xanthium occidentale* Bertol. complex and *Xanthium spinosum* L. Journal of the *Australian Institute of Agricultural Science* 52(4): 191-221.

Holm LG, Doll J, Holm E, Pancho J, Herberger J (1997). *World Weeds: Natural Histories and Distribution*. John Wiley & Sons, New York, USA, 1129 pp.

Holm LG, Pancho JV, Herbenger JP, Plucknett DL (1991). *A Geographical Atlas of World Weeds*. John Wiley & Sons, New York, USA, 391 pp.

Holm LG, Plucknett DL, Pancho JV, Herberger JP (1977). *The World's Worst Weeds. Distribution and Biology*. University Press of Hawaii, Honolulu, USA, 609 pp.

Hoque A, Ahmed R, Uddin M, Hossain M (2003). Allelopathic effect of different concentration of water extracts of *Acacia auriculiformis* leaf on some initial growth parameters of five common agricultural crops. *Pakistan Journal of Agronomy* 2(2): 92-100.

Humphries SE, Groves RH, Mitchell DS (1994). Plant Invasions: Homogenising Australian Ecosystems. *In*: Moritz C, Kikkawa J (eds.). *Conservation Biology in Australia and Oceania*, Surrey Beatty and Sons Limited, Norton, pp. 149–170.

Hurst SJ (1980). Balloonvine (*Cardiospermum halicacabum* L.) A noxious weed. *Newsletter of the Association of Official Seed Analysts* 54(3): 69-71.

Ilori OJ, Otusanya OO, Adelusi AA (2007). Phytotoxic effects of *Tithonia diversifolia* on germination and growth of *Oryza sativa*. *Research Journal of Botany* 2(1): 23-32.

Irigoyen LF, Graca DL, Barros CSL (1991). Experimental poisoning by *Cassia occidentalis* (Leg. Caes) in horses (Intoxicação experimental por *Cassia occidentalis* [Leg. Caes.] em eqüinos). *Pesquisa Veterinaria* Brasileira 11: 35-44.

Ismail NAN, Metali F (2014). Allelopathic effects of invasive *Acacia mangium* on germination and growth of local paddy varieties. *Journal of Agronomy* 13: 158-168.

Jayachandra M (1971). Parthenium weed in Mysore State and its control. *Current Science* 40: 568-569.

Joseph K, Bridgit TK (1993). Effect of chemical and integrated weed management in upland rice. *Journal of Tropical Agriculture* 31: 77-80.

Julien MH, Griffiths MW (1998). *Biological Control of Weeds: A World Catalogue of Agents and their Target Weeds* (4th edn.). CAB International, Wallingford, UK, 223 pp.

Karikari SK, Bagai C, Segwagwe, A (2000). Allelopathic activity of five Botswana weed species on Bambara groundnut [*Vigna subterranea* (L.) Verdc] and sorghum [*Sorghum bicolor* (L.) Moench]. *Crop Research (Hisar)* 20(3): 397-406.

Kebede AT, Coppock LD (2015). Livestock-mediated dispersal of *Prosopis juliflora* imperils grasslands and the endangered Grevy's Zebra in Northeastern Ethiopia. *Rangeland Ecology and Management* 68(5): 402-407.

Kohli RK, Batish DR, Singh HP (2006). Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantana camara* L.) in India. *Biological Invasions* 8(7): 1501-1510.

Khosla SN, Sobti, SN (1979). Parthenium: A national hazard, its control and utility: A review. *Pesticides* 13:25-27.

Killian S, McMichael J (2004). The human allergens of mesquite (*Prosopis juliflora*). *Clinical and Molecular Allergy*, *2*(8). DOI: 10.1186/1476-7961-2-8

Kostermans AJGH, Wirjahardja S, Dekker RJ (1987). The weeds: description, ecology and control. *In*: Soerjani M, Kostermans AJGH, Tjitrosoepomo G (eds.). *Weeds of Rice in Indonesia*. Balai Pustaka, Jakarta, Indonesia, pp. 24-565.

Kotalawala J (1976). Noxious water vegetation in Sri Lanka: the extent and impact of existing infestations. *In*: Varshney CK, Rzóska J (eds.). *Aquatic weeds in South.East Asia – Proceedings of a Regional Seminar on Noxious Aquatic Vegetation.* W. Junk, The Hague, Netherlands, pp. 51-58.

Krauss U (2012). 161 Invasive Alien Species present in Saint Lucia and their current status. *Caribbean Alien Invasive Species Network* (CIASNET), 12 pp. (http://www.ciasnet.org/wp-content/uploads/2010/08/IAS-present-in-SLU-May-2012-revision.pdf)

Kuniata LS (1994). Importation and establishment of *Heteropsylla spinulosa* (Homoptera: Psyllidae) for the biological control of *Mimosa invisa* in Papua New Guinea. *International Journal of Pest Management* 40(1): 64-65.

Langeland KA, Cherry HM, McCormick CM, Craddock Burks KA (2008). *Identification and Biology of Non-native Plants in Florida's Natural Areas* (2nd edn.) University of Florida/IFAS Extension, Gainesville, USA 210 pp.

Larsson P (2004). Introduced *Opuntia* spp. in Madagascar. Problems and Opportunities. Minor Field Studies No. 285, Swedish University of Agricultural Sciences, SLU/Repro, Uppsala, 25 pp.

Le Maitre DC, Versfeld DB, Chapman RA (2000). The impact of invading alien plants on surface water resources in South Africa: A preliminary assessment. *Water* SA 26: 397-408.

Lee SO (1976). Weed studies in pineapple growing areas. University of, Kuala Lumpur, Malaysia, 148 pp.

Leps J, Novotny V, Cizek L, Molem K, Isua B, William B, Kutil R, Auga J, Kasbal M, Manumbor M, Hiuk S (2002). Successful invasion of the neotropical species *Piper aduncum* in rain forests in Papua New Guinea. *Applied Vegetation Science* 5: 255-262.

Leslie AJ, Spotila JR (2001). Alien plant threatens Nile crocodile (*Crocodylus niloticus*) breeding in Lake St. Lucia, South Africa. *Biological Conservation* 98: 347-355.

Lounibos, LP, Larson V, Morris CD (1990). Parity, fecundity, and body size of *Mansonia dyari* in Florida. *Journal of the American Mosquito Control Association* 6: 121-126.

Lovell SJ, Stone SF, Fernandez L (2006) The economic impacts of aquatic invasive species: A review of the literature. *Agricultural and Resource Economics Review* 35: 195-208.

Macanawai AR (2013). Impact of *Sphaegneticola trilobata* on plant diversity in soils in south-east Viti Levu, Fiji. *Journal of Life Sciences* 7(6): 635-642.

Macqueen DJ (1992). *Calliandra calothyrsus*: implications of plant taxonomy, ecology and biology for seed collection. *Commonwealth Forestry Review* 71(1): 20-34.

Markin GP, Lai PY, Funasaki GY (1992). Status of biological control of weeds in Hawai'i and implications for managing native ecosystems. *In*: Stone CP, Smith CW, Tunison JT (eds.). *Alien Plant Invasions in Native Ecosystems of Hawai'i: Management and Research*. University of Hawaii Cooperative National Park Resources Studies Unit, Honolulu, Hawaii, USA, pp. 466-482.

Martin BW, Terry MK, Bridges CH, Bailey EM Jr (1981). Toxicity of *Cassia occidentalis* in the horse. *Veterinary and Human Toxicology* 23(6): 416-417.

Martins E, Martins VMV, Riet Correa F, Soncini RA, Paraboni SV (1986). *Cassia occidentalis* poisoning in swine. (Intoxicação por *Cassia occidentalis* (Leguminoseae) em suinos). *Pesquisa Veterinaria Brasileira* 6(2): 35-38.

Mathew AV, Balakrishnan S (1991). Mosaic disease of *Stachytarpheta indica* Vahl., a source of virus infection to crop plants. *Madras Agricultural Journal*, 78(1-4): 27-31.

Maundu P, Kibet S, Morimoto Y, Imbumi M, Adekar, R (2009). Impact of *Prosopis juliflora* on Kenya's semi-arid and arid ecosystems and local livelihoods. *Biodiversity* 10(2-3): 33-50.

McFadyen RE (1995). Parthenium weed and human health in Queensland. *Australian Family Physician* 24: 1455-1459.

McFadyen RE (2000). Successes in biological control of weeds. *In*: Spencer, N.R. (ed.). *Proceedings of the X International Symposium on Biological Control of Weeds*. Advanced Litho Printing, Great Falls, Montana, USA, pp. 3-14.

McFadyen, RE (2004). Chromolaena in East Timor: History, extent and control. *In*: Day MD, McFadyen RC. (eds.). *Proceedings of the VI International Workshop on Biological Control and Management of* Chromolaena. ACIAR Technical Reports 55, ACIAR, Canberra, Australia, pp. 8-10.

Medal J, Overholt W, Charudattan W, Mullahey J, Gaskalla R, Diaz R, Cuda J (2012). Tropical Soda Apple Management Plan. University of Florida-IFAS, Gainesville, Florida, USA, 87 pp. (http://plants.ifas.ufl.edu/images/solvia/TSA_Management_Plan.pdf)

Medeiros AC, Loope LL, Chimera C. (1993). *Kanaio Natural Area Reserve Biological Inventory and Management Recommendations*. *Report to Hawaii Natural Area Reserve Commission*. *Haleakala National Park*. (http://dlnr.hawaii.gov/ecosystems/files/2013/07/Kanaio-Biological-Inventory-and-Management-Recommendations.pdf)

Meyer J-Y (1994). History of introduction and invasion by *Miconia calvescens* in Tahiti. (Histoire de l'introduction et de l'invasion de *Miconia calvescens* à Tahiti). *Bulletin de la Société des Etudes Océaniennes*, 263-264: 106-119.

Meyer JY, Florence J (1996). Tahiti's native flora endangered by the invasion of *Miconia calvescens* DC. (Melastomataceae). *Journal of Biogeography Special issue*. *Trees and Shrubs in Time and Space* 23(6): 775-781.

Mohamed AZ, Lee BS, Lum KY (1992). Developing a biological control initiative in Malaysia. *In*: Ooi PAC, Lim GS, Teng PS (eds.). *Proceedings of the 3rd International Conference on Plant Protection in the Tropics – Biological Control: Issues in the Tropics*, pp. 59-62.

Morgan EC, Overholt WA, Langeland KA (2004). Wildland Weeds: Arrowhead Vine, *Syngonium podophyllum*. Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, USA.

Motooka P, Castro L, Nelson D, Nagai G, Ching L (eds.) (2003). *Cenchrus echinatus*. *In*: *Weeds of Hawai'i's Pastures and Natural Areas: An Identification and Management Guide*. College of Tropical Agriculture and Human Resources, University of Hawai'i at Mänoa. (http://www.ctahr.hawaii.edu/invweed/WeedsHI/W_Cenchrus_echinatus.pdf)

Muniappan R, Reddy GVP, Raman A (2009). *Coccinia grandis* (L.) Voigt (Cucurbitaceae). *In*: Muniappan, R., Reddy, G.V.P. & Raman, A (eds.). *Biological Control of Tropical Weeds Using Arthropods*. Cambridge University Press, Cambridge, UK, pp. 175-182.

Mvere B (2004). *Bidens pilosa* L. *In*: Grubben GJH, Denton OA (eds.). PROTA 2: Vegetables/Legumes. [CD-Rom]. PROTA, Wageningen, Netherlands.

Mwangi E, Swallow B (2005). Invasion of *Prosopis juliflora* and local livelihoods: Case study from the Lake Baringo area of Kenya. ICRAF Working Paper, No. 3. World Agroforestry Centre, Nairobi, Kenya, 68 pp.

Narasimhan TR, Ananth M, Swamy MN, Babu MR, Mangala A, Rao PVS (1977). Toxicity of *Parthenium hysterophorus* L. *Current Science* 46: 15-16.

Nazif M (1993). The effectiveness of a mixture of several kinds of herbicides to control weeds in an *Acacia mangium* landscape (Efektivitas campuran beberapa jenis herbisida untuk mengendalikan gulma di pertamanan *Acacia mangium*). *Buletin Penelitian Hutan* 556: 1-21.

Nghiem LTP, Soliman T, Yeo DCJ, Tan HTW, Evans TA, Mumford DJ, Reuben PK, Baker AHR, Corlett TR, Carrasco RL (2013). Economic and environmental impacts of harmful non-indigenous species in Southeast Asia. *PLoS ONE* 8(8): e71255. doi:10.1371/journal.pone.0071255

O'Hara PJ, Pierce KR (1974). A toxic cardiomyopathy caused by *Cassia occidentalis*. I. Morphologic studies in poisoned rabbits. II. Biochemical studies in poisoned rabbits. *Veterinary Pathology* 11(2): 97-109; 110-124.

Olubode OS, Awodoyin RO, Ogunyemi S (2011). Floral diversity in the wetlands of Apete River, Eleyele Lake and Oba Dam in Ibadan, Nigeria: Its implication for biodiversity erosion. *West African Journal of Applied Ecology* 18: 109-119.

Oludare A, Muoghalu JI (2014). Impact of *Tithonia diversifolia* (Hemsly) A. Gray on the soil, species diversity and composition of vegetation in Ile-Ife (Southwestern Nigeria), Nigeria. *International Journal of Biodiversity and Conservation* 6(7): 555-562.

Osunkoya OO, Othman FE, Kahar RS (2005). Growth and competition between seedlings of an invasive plantation tree, *Acacia mangium*, and those of a native Borneo heath-forest species, *Melastoma beccarianum*. *Ecological Research* 20: 205-214.

Page AR, Lacey, KL (2006). *Economic Impact Assessment of Australian Weed Biological Control*. CRC for Australian Weed Management. Technical Series 10, 165 pp.

Palmer B, Macqueen DJ, Gutteridge RC (1994). *Calliandra calothyrsus* – a multipurpose tree legume for humid locations. *In*: Gutteridge RC, Shelton HM (eds.). *Forage Tree Legumes in Tropical Agriculture*. CAB International, Wallingford, UK, pp. 65-74.

Pancho, JV, Soerjani M (1978). *Aquatic Weeds of Southeast Asia*. National Publication Cooperative, Quezon City, Philippines.

Parsons WT, Cuthbertson EG (1992). *Noxious Weeds of Australia*. Inkata Press, Melbourne, Australia, 692 pp.

Peng SY, Sze WB (1974). Competititon effect of *Panicum repens* Linn. on sugarcane and its eradication by herbicides. *Taiwan Sugar* 5: 155-166.

PIER – Pacific Islands Ecosystems at Risk (2005). *Coccinea grandis*. HEAR, University of Hawaii, Honolulu, USA. (http://www.hear.org/pier/species/coccinia_grandis.htm).

Pimentel D, McNair S, Janecka J, Wightman J, Simmonds C, O'Connell C, Wong E, Russel L, Zern, J, Aquino T, Tsomondo T (2001). Economic and environmental threats of alien plant, animal and microbe invasions. *Agriculture, Ecosystems and Environment* 84: 1-20.

Plant Protection Service (2001). *Pest Alert: False kava*. Secretariat of the Pacific Community. (http://www.spc.org.nc/pps/PestAlerts/PestAlertNo19-False_Kava.pdf).

Pocs T (1989). A preliminary study of the undergrowth of primary and secondary submontane rainforests in the East Usambara Mountains, with notes on epiphytes. *In*: Hamilton AC, Bensted-Smith R (eds.). *Forest Conservation in the East Usambara Mountains, Tanzania*. IUCN, Gland, Switzerland, pp. 301-306.

Porter MB, MacKay RJ, Uhl E, Platt SR, Lahunta Ade (2003). Neurologic disease putatively associated with ingestion of *Solanum viarum* in goats. *Journal of the American Veterinary Medical Association* 223(4): 501-504.

Possley J (2004). Exotic species threaten rare ferns in Miami-Dade County. *Wildland Weeds* 7: 12-15.

Qi SS, Dai ZC, Miao SL, Zhai DL, Si CC, Huang P, Wang PR, Du DL (2014). Light limitation and litter of an invasive clonal plant, *Wedelia trilobata*, inhibit its seedling recruitment. *Annals of Botany* 114 (2): 425-433.

Queensland Department of Primary Industries and Fisheries (2007). Thunbergia species Fact Sheet. Special Edition of Environmental Weeds of Australia for Biosecurity Queensland, The University of Queensland and Department of Primary Industries and Fisheries, Australia. (http://www.daff.qld.gov.au/documents/Biosecurity_EnvironmentalPests/IPA-Thunbergia-PP23.pdf).

Ramachandran CP (1960). The culture of *Mansonia*, using an aquatic plant – Salvinia. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 54: 6-7.

Ramos LRM, Pitelli RA (1994). Nutrient extraction of weeds in competition with the corn crop (*Zea mays* L.). *Arquivos de Biologia e Tecnologia* 37(1): 123-138.

Richardson M (2007). Species Assessment and Listing Priority Assignment Form – *Platydesma cornuta var. decurrens*. US Fish and Wildlife Service and Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii, USA.

Riet-Correa F, Soares MP, Mendez MRT (1998). Poisoning of horses in Brazil (Intoxicações em eqüinos no Brasil). *Ciência Rural, Santa Maria* 28(4): 715-722.

Roder W, Phengchanh S, Keoboualapha B, Maniphone S (1995). *Chromolaena odorata* in slash-and-burn rice systems of northern Laos. *Agroforestry Systems* 31(1): 79-92.

Rogers RJ, Gibson J, Reichmann KG (1979). The toxicity of *Cassia occidentalis* for cattle. *Australian Veterinary Journal* 55(9): 408-412.

Royal SS, Brecke BJ, Shokes FM, Colvin DL (1997). Influence of broadleaf weeds on chlorothalonil deposition, foliar disease incidence, and peanut (*Arachis hypogaea*) yield. *Weed Technology* 11(1): 51-58.

Rushing GS, Oliver LR (1998). Influence of planting date on common cocklebur (*Xanthium strumarium*) interference in early-maturing soybean (*Glycine max*). *Weed Science* 46(1): 99-104.

Ruskin FR (1983). Firewood Crops. Shrub and Tree Species for Energy Production. Volume 2. BOSTID Report No. 40. National Academy of Sciences, Washington DC, USA, 92 pp.

Sajise PE, Palis RK, Norcio NV, Lales JS (1974). The biology of *Chromolaena odorata* (L.) R.M. King and H. Robinson. 1. Flowering behaviour, pattern of growth and nitrate metabolism. *Philippine Weed Science Bulletin* 1(1): 17-24.

Scanlan S, Eagles D, Vacher N, Irvine M, Ryan C, Mckenzie RA (2006). *Duranta erecta* poisoning in nine dogs and a cat. *Australian Veterinary Journal* 84(10): 367-370.

Schmitz DG, Denton JH (1977). Senna bean toxicity in cattle. *Southwestern Veterinarian* 30(2): 165-170.

Sculthorpe CD (1985). The Biology of Aquatic Vascular Plants. Koeltz Scientific Books, Konigstein, West Germany, 610 pp.

Seeruttun S, Barbe C, Gaungoo A (2005). Vine weeds in sugarcane: fluroxypyr provides cost-effective post-emergence control in Mauritius. XXVth Congress of the International Society of Sugar Cane Technologists. *Sugarcane International* 23(3): 3-5.

Shanungu GK (2009). Management of the invasive *Mimosa pigra* L. in Lochinvar National Park, Zambia. *Biodiversity* 10 (2 & 3): 56-60.

Sharma B D, Malhotra S, Bhatia V, Rathee M (1999). Epidemic dropsy in India. *Postgraduate Medical Journal* 75(889): 657-661.

Singh AB, Kumar P (2004). Aerial pollen diversity in India and their clinical significance in allergic diseases. *Indian Journal of Clinical Biochemistry* 19: 190-201.

Singh SP (1996). Biological Control. *In*: Paroda RS, Chadha KL (eds.). *50 Years of Crop Science Research in India*. Indian Council of Agricultural Research, New Delhi, pp. 88-116.

Smith CW (1985). Impact of Alien Plants on Hawai'i's Native Biota. *In*: Stone CP, Scott JM (eds.). *Hawai'i's Terrestrial Ecosystems: Preservation and Management*. University of Hawai'i Cooperative National Park Resources Studies Unit, Honolulu, Hawaii, USA, pp. 180-250.

Snipes CE, Buchanan GA, Street JE, McGuire JA (1982). Competition of common cocklebur (*Xanthium pensylvanicum*) with cotton (*Gossypium hirsutum*). *Weed Science* 30(5): 553-556.

Soares DJ, Barreto RW (2008). Fungal pathogens of the invasive riparian weed *Hedychium coronarium* from Brazil and their potential for biological control. *Fungal Diversity* 28: 85-96.

Soerohaldoko S (1975). The after effect of filtered sunlight through green leaves on the seed germination of *Chromolaena odorata* (L.) R.M. King and H. Robinson compared with that of sunlight and darkness. *In*: Indonesian Weed Science Conference (eds.). *Proceedings of the Third Indonesian Weed Science Conference*, pp. 12-17.

Space JC, Flynn T (2000). *Observations on Invasive Plant Species in American Samoa*. USDA Forest Service, Honolulu, Hawaii, USA, 51 pp.

Spira WM, Huq A, Ahmed QS, Saeed TA (1981). Uptake of Vibrio cholera biotype eltor from contaminated water by water hyacinth (*Eichhornia crassipes*). *Applied Environmental Microbiology* 42: 550-553.

Starr F, Martz K (2000). New plant records for Midway Atoll for 1999. *Bishop Museum Occasional Papers* 64: 10-12.

Starr F, Starr K, Loope L (2003a). *Coccinea grandis* in Hawaii. Report from the U.S. Geological Survey, Biological Resources Division, Haleakala Field Station Hawaii, USA, 7 pp. (http://www.hear.org/starr/hiplants/reports/pdf/coccinia_grandis.pdf).

Starr F, Starr K, Loope L (2003b). *Thunbergia grandiflora* in Hawaii. Report from the U.S. Geological Survey, Biological Resources Division, Haleakala Field Station Hawaii, USA, 5 pp. (http://www.hear.org/starr/hiplants/reports/pdf/thunbergia_grandiflora.pdf).

Stoller EW, Harrison SK, Wax LM, Regnier EE, Nafziger ED (1987). Weed interference in soybeans (*Glycine max*). *Reviews of Weed Science* 3: 155-181.

Sudbrink Jr DL, Snodgrass GL, Bryson CT, Medal JC, Cuda JP, Gandolfo D (2000). Arthropods associated with tropical soda apple, Solanum viarum in the Southeastern USA. In: Spencer NR (ed.). *Xth International Symposium on the Biological Control of Weeds*. Advanced Litho Printing, Great Falls, Montana, USA, pp. 154.

Suliman HB, Ibrahim AW, Adam SEI (1982). The toxicity of *Cassia occidentalis* to goats. *Veterinary and Human Toxicology* 24(5): 326-30.

Suliman HB, Shommein AM (1986). Toxic effect of the roasted and unroasted beans of *Cassia occidentalis* in goats. *Veterinary and Human Toxicology* 28(1): 6-11.

Suteri BD, Joshi CC, Bala S (1979). Some ornamentals and weeds as reservoirs of potato virus Y and cucumber mosaic virus in Kumaon. *Indian Phytopathology* 32(4): 640.

Sutherland, AK (1953). *Duranta repens* poisoning of a dairy cow at Oxley. Queensland Department of Primary Industries Natural Toxin Database files, unpublished report.

Swarbrick JT, Hart R (2000). Environmental weeds of Christmas Island (Indian Ocean) and their management. *Plant Protection Quarterly* 16: 54-57.

Tan B (2011). Alien invasive species in Singapore: An introduction, with suggestions for next steps. *In*: Ming LT, Chew HH (eds.). *Proceedings of Nature Society, Singapore's Conference on 'Nature Conservation for a Sustainable Singapore,'* pp. 93–97.

Teoh CH, Chung GF, Liau SS, Ibrahim G, Tan AM, Lee SA, Mohammed M (1985). Prospects for biological control of *Mikania micrantha* HBK in Malaysia. *Planter Kuala Lumpur* 61: 515-530.

Thinley P (2002). Negative interaction between large leaf mahogany (**Swietenia macrophylla* King) and some indigenous tree secies in lowland forest of Mt. Makiling – allelopathy, a possible cause? BS Forestry Thesis, University of the Philippines Los Banos-College of Forestry and Natural Resources (UPLB-CFNR), Manila, Philippines.

Thomas JI (2007). Mapping and modelling of *Mimosa pigra* expansion in Lochinvar National Park, Zambia. MSc Thesis, International Institute for Geo-information Science and Earth Observation, Enschede, Netherlands.

Torres WLN, Nakano M, Nobre D, Momose N (1971). Poisoning of fowls by *Cassia occidentalis*. *Biologico* 37(8): 204-208.

Triet T, Dung NV (2001). Finding the best solution for management of giant sensitive plant *Mimosa pigra* in Tram Chim National Park, pp. 21-28.

Tripathi SM, and Singh DK (2000). Molluscicidal activity of *Punica granatum* bark and *Canna indica* root. *Brazilian Journal of Medical and Biological Research* 33(11): 1351-1355.

Tungtrakanpoung N, Rhienpanish K (1992). The toxicity of *Mimosa invisa* Mart. var. *inermis* Adelbert to buffaloes. *Buffalo Bulletin* 11(2): 30-31.

Turner PJ, Downey PO (2010). Ensuring invasive alien plant management delivers biodiversity conservation: Insights from an assessment of *Lantana camara* in Australia. *Plant Protection Quarterly* 25: 102-110.

Tzul LG (undated). *Syngonium podophyllum* Control in Citrus. Citrus Research and Education Institute. Citrus Growers Association (www.belizecitrus.org).

Ueckert DN, Livingston CW Jr, Huston JE, Menzies CS, Dusek RK, Petersen JL, Lawrence BK (1990). Range and sheep management for reducing pearmouth and other pricklypear-related health problems in sheep flocks. Sheep and Goat, Wool and Mohair, Research Report, Texas Agricultural Experiment Station, San Angelo, Texas.

USFWS – United States Fish and Wildlife Service (USFWS) (1999). Endangered and threatened wildlife and plants; final endangered status for 10 plant taxa from Maui Nui, Hawaii. 64 FR 171:48307-48324.

USDA-FS – United States Department of Agriculture – Forest Service (2005). Weed of the Week (March 8 2005) Tropical Soda Apple, *Solanum viarum* Dunal. Forest Health Staff, Newtown Square, PA. (http://www.na.fs.fed.us/fhp/invasive_plants/weeds/tropical-soda-apple.pdf).

USDA-NRCS – United States Department of Agriculture – Natural Resources Conservation Service (2011). Coral vine (*Antigonon leptopus*). Invasive Species Fact Sheet, Pacific Islands Area. (ftp://ftp-fc.sc.egov.usda.gov/HI/pub/technotes/Range_%26_Pasture/RP_TechNote_3/3_TechNote3_FactSheet-03_Antigonon_leptopus.pdf).

Van der Hoeven CA, Prins HHT (2007). Invasive plant species threatens gorilla in equatorial Africa. *In*: The Missing Link: Bridging the Gap between Science and Conservation. PhD Thesis, Department of Environmental Sciences, Resource Ecology Group, Wageningen University, the Netherlands.

Van Dyck S (1979). Destruction of wild tobacco trees (*Solanum mauritianum* Scopoli) by mountain possums (Trichosurus caninus Ogilby). *Memoirs of the Queensland Museum* 19: 367-371.

Van Oosterhout E (2004). Lantana control manual, current management and control options for lantana (*Lantana camara*) in Australia. Queensland Department of Natural Resources, Mines and Energy, Queensland, Australia.

Van Wilgen B W, de Wit MP, Anderson HJ, Le Maitre DC, Kotze IM, Ndala S, Brown B, Rapholo MB (2004). Costs and benefits of biological control of invasive alien plants: Case studies from South Africa. *South African Journal of Science* 100: 113-122.

Van Wilgen BW, Reyers B, Le Maitre DC, Richardson DM, Schonegevel L (2008). A biome-sale assessment of the impact of invasive alien plants on ecosystem services in South Africa. *Journal of Environmental Management* 89: 336-349.

Vashishtha VM, Nayak NC, Jacob JT, Kumar A (2007). Recurrent annual outbreaks of a hepato-myo-encephalopathy syndrome in children in western Uttar Pradesh, India. *The Indian Journal of Medical Research* 125(4): 523-533.

Versfeld DB, Le Maitre DC, Chapman RA (1998). Alien invading plants and water resources in South Africa: a preliminary assessment. WRC Report No. TT 99/98 and CSIR No. ENV/S-C 97154.

Viswam K, Srinivasan R, Panicker KN (1989). Laboratory studies on the host plant preference of *Mansonia annulifera*, the vector of brugian filariasis. *Entomon* 14: 183-186.

Walton C (2003). Leucaena (*Leucaena leucocephala*) in Queensland. Pest Status Review Series. Department of Natural Resources and Mines, Queensland. (http://www.dpi.qld.gov.au/documents/Biosecurity_EnvironmentalPests/IPA-Leucaena-PSA.pdf).

Wapshere AJ (1974). An ecological study of an attempt at biological control of Noogoora burr (*Xanthium strumarium*). *Australian Journal of Agricultural Research* 25(2): 275-292.

Waterhouse B (2003). Know your enemy: Recent records of potentially serious weeds in northern Australia, Papua New Guinea and Papua (Indonesia). *Telopea* 10: 477-485.

Waterhouse B and Mitchell AA (1998). Northern Australian Quarantine Strategy: Weeds Target List (2nd edn.) Australian Quarantine and Inspection Service, Miscellaneous Publication No. 6/98. 110 pp.

Waterhouse DF (1993). *The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia*. ACIAR Monograph No. 21. Australian Centre for International Agricultural Research, Canberra, Australia, 141 pp.

Waterhouse DF, Norris KR (1987). *Biological Control: Pacific Prospects*. Inkata Press, Melbourne Australia, 454 pp.

Weaver SE, Lechowicz MJ (1983). The biology of Canadian weeds. 56. *Xanthium strumarium* L. *Canadian Journal of Plant Science* 63(1): 211-225.

Weber E (2003). *Invasive Plant Species of the World. A Reference Guide to Environmental Weeds*. CAB International, Wallingford, UK, 302 pp.

Webster TM, Coble HD (1997). Changes in the weed species composition of the southern United States: 1974 to 1995. *Weed Technology* 11(2): 308-317.

Wells MJ, Stirton CH (1988). *Lantana camara* a poisonous declared weed. *Farming in South Africa Weeds* A.27: 1-4.

Wheeler, JA (1895). A fatal case of poisoning, presumably by berries of *Duranta plumieri*. *Australia's Medical Gazette* 16: 338-339.

Winston RL, Schwarzländer M, Hinz HL, Day MD, Cock MJW, Julien MH (eds.). (2012) *Biological Control of Weeds: A World Catalogue of Agents and their Target Weeds* (5th edn.) USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia, USA. FHTET-2014-04, 838pp.

Yoshida K, Oka S (2004). Invasion of *Leucaena leucocephala* and its effects on the native plant community in the Ogasawara (Bonin) Islands 1. *Weed Technology* 18(1): 1371-1375.

Zhang YH, Liu MF, Ling TJ, Wei Xiao Y (2004). Allelopathic sesquiterpene lactones from *Wedelia trilobata*. *Journal of Tropical and Subtropical Botany* 12(6): 533-537.

Zimmerman HG, Moran VC, Hoffman HJ (2004). Biological control in the management of invasive alien plants in South Africa, and the role of the Working for Water Programme. *South African Journal of Science* 100(1): 34-40.

This page intentionally left blank

Appendix A

Summary table of plant species included in this Guide that are considered to be naturalized or invasive in Southeast Asia.

Species	Family	Growth form	Cultivated use	Origin
Ruellia tuberosa L.	Acanthaceae	Herb	Medicinal, ornament	America – tropical
Thunbergia grandiflora Roxb.	Acanthaceae	Climber	Ornament	Asia – tropical
Pistia stratiotes L.	Araceae	Aquatic	Ornament	America – tropical
Syngonium podophyllum Schott	Araceae	Climber	Ornament	America – tropical
Ageratina adenophora (Spreng.) R.M. King & H. Rob.	Asteraceae	Herb/sub-shrub	Ornament	America – tropical
Ageratum conyzoides L.	Asteraceae	Herb	Ornament	America – tropical
Ageratum houstonianum Mill.	Asteraceae	Herb	Ornament	America – tropical
Bidens pilosa L.	Asteraceae	Herb	None	America – tropical
Chromolaena odorata (L.) R.M. King & H. Rob.	Asteraceae	Woody tree/ shrub	?Ornament	America – tropical
Austroeupatorium inulifolium (Kunth) R.M. King & H. Rob	Asteraceae	Woody tree/ shrub	Ornament	America – tropical
Mikania micrantha Kunth	Asteraceae	Climber	Ornament	America – tropical
Parthenium hysterophorus L.	Asteraceae	Herb	None	America – tropical
Sphagneticola trilobata (L.) Pruski	Asteraceae	Herb	Cover/binder, ornament	America – tropical
Tithonia diversifolia (Hemsl.) A. Gray	Asteraceae	Woody tree/ shrub	Agricultural crop (green manure); barrier, ornament	America – tropical
Xanthium strumarium L.	Asteraceae	Herb	Medicinal	America – tropical
Spathodea campanulata P. Beauv.	Bignoniaceae	Woody tree/ shrub	Agricultural crop (bee forage), domestic, medicinal, ornament	Africa – tropical
Opuntia stricta (Haw.) Haw.	Cactaceae	Succulent tree/ shrub	Barrier, ornament	America – tropical
Canna indica L.	Cannaceae	Herb	Ornament	America – tropical
Merremia peltata (L.) Merr.	Convolvulaceae	Cimber	Medicinal, ornament	Indian Ocean and Pacific Islands, southeast Asia – tropical
Coccinea grandis (L.) Voigt	Cucurbitaceae	Climber	Agricultural crop (food); ornament	Africa – tropical
Jatropha gossypiifolia L.	Euphorbiaceae	Woody tree/ shrub	Agricultural crop (oil); barrier, medicinal, ornament	America – tropical
Acacia auriculiformis Benth.	Fabaceae	Woody tree/ shrub	Domestic, ornament	Australia – sth temperate
Acacia decurrens Willd.	Fabaceae	Woody tree/ shrub	Agricultural crop (tannins); domestic, ornament; silvicultural crop	Australia – sth temperate

Species	Family	Growth form	Cultivated use	Origin
Acacia mangium Willd.	Fabaceae	Woody tree/ shrub	Agricultural crop (fibre); domestic, ornament; silvicultural crop	Australia, Indonesia, Papua New Guinea – tropical
Calliandra houstoniana (Mill.) Standl. var. *calothyrsus* (Meisn.) Barneby	Fabaceae	Woody tree/ shrub	Agricultural crop (fodder), barrier, domestic, ornament	America – tropical
Leucaena leucocephala (Lam.) de Wit	Fabaceae	Woody tree/ shrub	Agricultural crop (fodder, nitrogen-fixation), barrier, cover/binder, domestic, ornament	America – tropical
Mimosa diplotricha Sauvalle	Fabaceae	Woody tree/ shrub	Barrier, cover/binder, ornament	America – tropical
Mimosa pigra L.	Fabaceae	Woody tree/ shrub	Agricultural crop (green manure, nitrogen-fixation), barrier, ornament	America – tropical
Mimosa pudica L.	Fabaceae	Herb	Cover/binder, ornament	America – tropical
Prosopis juliflora (Sw.) DC.	Fabaceae	Woody tree/ shrub	Agricultural crop (bee forage, food, fodder), barrier, cover/binder, domestic, ornament	America – tropical
Senna occidentalis (L.) Link	Fabaceae	Woody tree/ shrub	Domestic, medicinal, ornament	America – tropical
Vachellia nilotica ssp. *indica* (Benth.) Kyal. & Boetwr. (Syn.: *Acacia nilotica* ssp. indica (Benth.) Brenan)	Fabaceae	Woody tree/ shrub	Agricultural crop (chicory substitute, fodder), domestic, ornament	Asia – nth temperate
Myriophyllum aquaticum (Vell.) Verdc.	Haloragaceae	Aquatic	Ornament	America – tropical
Limnocharis flava (L.) Buch.	Limnocharitaceae	Aquatic	Ornament	Asia – tropical
Clidemia hirta (L.) D. Don	Melastomataceae	Woody tree/ shrub	Ornament	America – tropical
Miconia calvescens DC.	Melastomataceae	Woody tree/ shrub	Ornament	America – tropical
Swietenia macrophylla King	Meliaceae	Woody tree/ shrub	Domestic, ornament, silvicultural crop	America – tropical
Broussonetia papyrifera (L.) L'Her. ex Vent.	Moraceae	Woody tree/ shrub	Ornament, silvicultural crop	Asia – nth temperate
Argemone mexicana L.	Papaveraceae	Herb	None	America – tropical
Passiflora foetida L.	Passifloraceae	Climber	Ornament	America – tropical
Passiflora suberosa L.	Passifloraceae	Climber	Ornament	America – tropical
Piper aduncum L.	Piperaceae	Woody tree/ shrub	Agricultural crop (spice), medicinal, ornament	America – tropical
Brachiaria mutica (Forsk.) Stapf.	Poaceae	Grass	Agricultural crop (fodder)	Africa – tropical
Cenchrus echinatus L.	Poaceae	Grass	None	America – tropical
Panicum repens L.	Poaceae	Grass	Agricultural crop (fodder)	Africa and Mediterranean – tropical and nth temperate
Antigonon leptopus Hook. & Arn.	Polygonaceae	Climber	Ornament	America – tropical

Species	Family	Growth form	Cultivated use	Origin
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Aquatic	Ornament	America – tropical
Salvinia molesta D.S. Mitch.	Salviniaceae	Aquatic	Ornament	America – tropical
Cardiospermum halicacabum L.	Sapindaceae	Climber	Ornament	America and Africa – tropical and sth temperate
Cestrum aurantiacum Lindl.	Solanaceae	Woody tree/ shrub	Barrier, ornament	America – tropical
Solanum viarum Dunal	Solanaceae	Woody tree/ shrub	Medicinal, none	America – tropical
Duranta erecta L.	Verbenaceae	Woody tree/ shrub	Barrier, ornament	America – tropical
Lantana camara L.	Verbenaceae	Woody tree/ shrub	Barrier, medicinal, ornament	America – tropical
Stachytarpheta jamaicensis (L.) Vahl	Verbeaceae	Herb	Ornament	America – tropical
Hedychium coronarium J. Koenig	Zingiberaceae	Herb	Ornament	Asia – nth temperate
Hedychium gardnerianum Sheppard ex Ker Gawl.	Zingiberaceae	Herb	Ornament	Asia – nth temperate

This page intentionally left blank

Appendix B

Biological control agents that have established in Southeast Asia and/or elsewhere on some of the species of plants included in this Field Guide (from Winston *et al*., 2014 and R.L. Winston, *pers. comm*.)

Species	Plant family	Agent species	Agent family	Country/countries established
Pistia stratiotes L.	Araceae	*Neohydronomus affinis* Hustache	Curculionidae	Australia, Benin, Botswana, Cote d'Ivoire, Ghana, Kenya, Morocco, Mozambique, Nigeria, Papua New Guinea, Puerto Rico*, Republic of Congo, Republic of South Africa, République Togolaise, Senegal, United States of America, Vanuatu, Zambia, Zimbabwe
		Spodoptera pctinicornis (Hampson)	Noctuidae	Thailand
Ageratina adenophora (Spreng.) R.M. King & H. Rob.	Asteraceae	*Oidaematophorus benefices* Yano & Heppner	Pterophoridae	Hawaii USA
		Passalora ageratinae Crous & A.R. Wood	Capnodiales	Australia, Hawaii USA, India, Nepal, New Zealand, People's Republic of China, Republic of South Africa
		Procecidochares utilis Stone	Tephritidae	Australia, Hawaii USA, India, Nepal, New Zealand, People's Republic of China, Republic of South Africa, Thailand
Chromolaena odorata (L.) R.M. King & H. Rob.	Asteraceae	*Acalitus adoratus* Keifer	Eriophyidae	Bangladesh, Federated States of Micronesia, Guam, India, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Northern Mariana Islands, Palau, Papua New Guinea, People's Republic of China, Philippines, Singapore, Taiwan, Thailand, Timor Leste, Vietnam
		Actinote anteas (Doubleday)	Nymphalidae	Indonesia
		Actinote thalia pyrrha Fabricius		Indonesia
		Actinote thalia thalia Keifer		Indonesia
		Calycomyza eupatorivora Spencer	Agromyzidae	Republic of South Africa
		Cecidochares connexa Macquart	Tephritidae	Cote d'Ivoire, Federated States of Micronesia, Ghana, Guam, India, Indonesia, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Tanzania*, Thailand, Thailand, Timor Leste
		Dichrorampha odorata Brown & Zachariades	Tortricidae	Republic of South Africa
		Lixus aemulus Petri	Curculionidae	Republic of South Africa*
		Pareuchaetes insulata (Walker)	Erebidae	Republic of South Africa

Species	Plant family	Agent species	Agent family	Country/countries established
		Pareuchaetes pseudoinsulata Rego Barros	Erebidae	Benin, Brunei, Cote d'Ivoire, Federated States of Micronesia, Ghana, Guam, India, Indonesia, Malaysia, Nigeria, Northern Mariana Islands, Papua New Guinea, Philippines, Republic of South Africa, Sri Lanka
Mikania micrantha Kunth	Asteraceae	*Actinote anteas*	Nymphalidae	Indonesia
		Actinote thalia pyrrha Fabricius	Nymphalidae	Indonesia
		Puccinia spegazzinii De Toni	Pucciniales	Fiji, China, India*, Papua New Guinea, People's Republic of China, Taiwan, Vanuatu
Parthenium hysterophorus L.	Asteraceae	*Bucculatrix pathenica* Bradley	Bucculatricidae	Australia
		Carmenta sp. nr *ithacae* (Beutenmüller)	Sesiidae	Australia
		Conotrachelus albocinereus Fiedler	Curculionidae	Australia
		Epiblema strenuana (Walker)	Tortricidae	Australia
		Listronotus setosipennis (Hustache)	Curculionidae	Australia, Republic of South Africa*
		Platphalonidia mystica (Razowski & Becker)	Tortricidae	Australia
		Puccinia abrupta Dietel & Holw. var. *partheniicola* (H.S. Jacks.) Parmelee	Pucciniales	Australia, Ethiopia, India, Kenya, Mauritius, Nepal, People's Republic of China, Republic of South Africa, Tanzania
		Puccinia xanthii Schwein. var. *parthenii-hysterophorae* Seier, H. C. Evans & Á. Romero.	Pucciniales	Australia, Republic of South Africa
		Smicronyx lutulentus Dietz	Curculionidae	Australia
		Stobaera concinna (Stål)	Delphacidae	Australia
		Zygogramma bicolorata Pallister	Chrysomelidae	Australia, Ethiopia*, India, Nepal, Pakistan, Republic of South Africa*, Tanzania*, Vanuatu*
Xanthium strumarium L.	Asteraceae	*Epiblema strenuana* (Walker)	Tortricidae	Australia
		Euaresta aequalis Loew	Tephritidae	Australia
		Mecas cana ssp. *saturnina* (LeConte)	Cerambycidae	Australia*
		Nupserha vexator (Pascoe)	Cerambycidae	Australia
		Ophraella communa LeSage	Chrysomelidae	Japan

Species	Plant family	Agent species	Agent family	Country/countries established
		Puccinia xanthii Schweinitz	Pucciniales	Australia
Opuntia stricta (Haw.) Haw.	Cactaceae	*Cactoblastis cactorum* (Berg)	Pyralidae	Antigua, Australia, Bahamas, Cayman Islands, Cuba, Federation of St Kitts and Nevis, Guadeloupe, Jamaica, Montserrat, New Caledonia, Puerto Rico, Republic of South Africa, U.S. Virgin Islands
		Chelinidea tabulata (Burmeister)	Coreidae	Australia
		Chelinidea vittiger Uhler		Australia*
		Dactylopius confusus Cockerell	Dactylopiidae	Australia
		Dactolopius opuntiae (Cockerell)		Australia, Federation of St Kitts and Nevis, India, Kenya, Republic of South Africa, Sri Lanka
		Moneilema blapsides (Newman) ssp. *ulkei* Horn	Cerambycidae	Australia
		Moneilema variolare Thomson	Cerambycidae	Australia
		Olycella junctolineella (Hulst)	Pyralidae	Australia
Coccinea grandis (L.) Voigt	Cucurbitaceae	*Acythopeus burkhartorum* O'Brien & Pakaluk	Cuculionidae	Guam*
		Acythopeus cocciniae O'Brien & Pakaluk	Curculionidae	Guam, Hawaii, Northern Mariana Islands
		Melittia oedipus Oberthür	Sesiidae	Guam, Hawaii, Northern Mariana Islands
Jatropha gossypiifolia L.	Euphorbiaceae	*Agonosoma trilineatum* (Fabricius)	Scutelleridae	Australia
Acacia decurrens (Wendl.) Willd	Fabaceae	*Melanterius maculatus* Lea	Curculionidae	South Africa
Leucaena leucocephala (Lam.) de Wit	Fabaceae	*Acanthoscelides macrophthalmus* Schaeffer	Chrysomelidae	Australia, Benin, India, Japan, People's Republic of China, Republic of Cyprus, Republic of South Africa, République Togolaise, Senegal, Taiwan, Thailand, Vietnam
Mimosa diplotricha Sauvalle	Fabaceae	*Heteropsylla spinulosa* Muddiman, Hodkinson & Hollis	Psyllidae	American Samoa, Australia, Cook Islands, Federated States of Micronesia, Fiji, Guam, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor Leste, Tonga, Vanuatu
Mimosa pigra L.	Fabaceae	*Acanthoscelides puniceus* Johnson	Chrysomelidae	Australia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Papua New Guinea*, Singapore, Thailand, Vietnam

Species	Plant family	Agent species	Agent family	Country/countries established
		Acanthoscelideser quadridentatus (Schaeffer)		Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Papua New, Guinea*, Singapore, Thailand, Vietnam
		Carmenta mimosa Eichlin & Passoa	Sesiidae	Australia, Malaysia, Vietnam
		Chalcodermus serripes Fåhraeus	Curculionidae	Australia
		Chlamisus mimosa Karren	Chrysomelidae	Australia, Thailand*, Vietnam*
		Coelocephalapion pigrae Kissinger	Brentidae	Australia
		Diabole cubensis (Arthur & J. R. Johnst.) Arthur	Pucciniales	Australia
		Leuciris fimbriaria (Stoll)	Geometridae	Australia
		Macaria pallidata (Warren)		Australia
		Malacorhinus irregularis Jacoby	Chrysomelidae	Australia
		Nesaecrepida infuscata (Schaeffer)		Australia
		Neurostrota gunniella (Busck)	Gracillariidae	Australia
		Rhytiphora piperitia Hope	Cerambycidae	Australia
Prosopis juliflora (Sw.) DC.	Fabaceae	*Algarobius bottimeri* Kingsolver	Chrysomelidae	Australia
		Algarobius prosopis (Le Conte)	Chrysomelidae	Ascension Island, Australia, Botswana, Egypt, Namibia, Oman, Republic of South Africa, Saudi Arabia, United Arab Emirates, Yemen
		Evippe sp. # 1	Gelechiidae	Australia
		Heteropsylla reducta Caldwell & Martorell	Psyllidae	Ascension Island
		Neltumius arizonensis (Schaeffer)	Chrysomelidae	Ascension Island, Botswana, Namibia, Republic of South Africa
		Prosopidopsylla flava Burckhardt	Psyllidae	Australia
		Rhinocloa sp.	Miridae	Ascension Island
Vachellia nilotica ssp. *indica* (Benth.) Kyal. & Boatwr. (Syn.: *Acacia nilotica* ssp. *indica* [Benth.] Brenan)	Fabaceae	*Bruchidius sahlbergi* Schilsky	Bruchidae	Australia
		Chiasmia assimillis (Warren)	Chrysomelidae	Australia

Species	Plant family	Agent species	Agent family	Country/countries established
Myriophyllum aquaticum (Vell.) Verdc.	Haloragaceae	*Lysathia* sp.	Chrysomelidae	South Africa, Zimbabwe
Clidemia hirta (L.) D. Don	Melastomataceae	*Antiblemma acclinalis* Hübner	Erebidae	Hawaii USA
		Ategumia matutinalis (Guenée)	Crambidae	Hawaii USA
		Colletotrichum clidemiae B. Weir & P. R. Johnst.	Incertae sedis	Hawaii USA
		Liothrips urichi Karny	Phlaeothripidae	American Samoa, Fiji, Hawaii USA, Palau
		Lius poseidon Napp	Buprestidae	Hawaii USA
		Mompha trithalama Meyrick	Momphidae	Hawaii USA
Miconia calvescens DC	Melastomataceae	*Colletotrichum gloeosporioides* (Penz.) & Sacc. F. sp. *miconiae* Killgore & L. Sugiyama	Incertae sedis	French Polynesia, Hawaii USA
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	*Acremonium zonatum* (Sawada) W. Gams	Hypocreales	Mexico
		Alternaria eichhorniae Nag Raj & Ponnappa	Pleosporales	Egypt, Republic of South Africa
		Bellura densa (Walker)	Noctuidae	United States of America
		Cercospora piaropi Tharp	Capnodiales	Mexico, United States of America, Republic of South Africa
		Cornops aquaticum Bruner	Acrididae	South Africa*
		Eccritotarsus catarinensis (Carvalho)	Miridae	Ghana, Malawi, Republic of South Africa
		Megamelus scutellaris Berg	Delphacidae	Republic of South Africa, United States of America
		Neochetina bruchi Hustache	Erirhinidae	Argentina, Australia, Benin, Bolivia, Burkina Faso, Cote d'Ivoire, Cuba, Egypt, Ghana, Honduras, India, Indonesia, Kenya, Malawi, Malaysia, Mali, Mexico, Mozambique, Niger Republic*, Nigeria, Panama*, Papua New Guinea, People's Republic of China, Philippines*, Republic of Congo, Republic of South Africa, République Togolaise, Rwanda, South Sudan, Sri Lanka, Sudan, Tanzania, Thailand, Uganda, United States of America, Vanuatu, Vietnam, Zambia, Zimbabwe

Species	Plant family	Agent species	Agent family	Country/countries established
		Neochetina eichhorniae Warner	Erirhinidae	Australia, Benin, Bolivia, Burkina Faso, Cote d'Ivoire, Cuba, Egypt, Fiji, Ghana, Honduras, India, Indonesia, Kenya, Malawi, Malaysia, Mali, Mexico, Mozambique, Myanmar, Nauru*, Niger Republic, Nigeria, Papua New Guinea, People's Republic of China, Philippines*, Republic of Congo, Republic of South Africa, République Togolaise, Rwanda, Solomon Islands, South Sudan, Sri Lanka, Sudan, Tanzania, Thailand, Uganda, United States of America, Vanuatu, Vietnam*, Zambia, Zimbabwe
		Niphograpta albiguttalis (Warren)	Crambidae	Australia, Benin, Cuba, Ghana, Kenya, Malawi*, Malaysia, Mexico, Nigeria, Panama*, Puerto Rico, Republic of South Africa, South Sudan, Thailand, United States of America, Zimbabwe
		Orthogalumna terebrantis Wallwork	Galumnidae	Cuba, India, Jamaica, Malawi, Mozambique, Republic of South Africa, United States of America Zambia, Zimbabwe
		Xubida infusella (Walker)	Crambidae	Australia, Papua New Guinea*, Thailand
Salvinia molesta D.S. Mitch.	Salviniaceae	*Cyrtobagous salviniae* Calder & Sands	Erirhinidae	Australia, Botswana, Cote d'Ivoire, Fiji, Ghana, India, Indonesia, Kenya, Malaysia, Mali, Mauritania, Namibia, Papua New Guinea, Philippines, Republic of Congo, Republic of South Africa, République Togolaise, Senegal Sri Lanka, Zambia, Zimbabwe
		Cyrtobagous singularis Hustache		Botswana, Fiji, Zambia, Zimbabwe
		Paulinia acuminata (De Geer)	Pauliniidae	Fiji, Mozambique, Zambia, Zimbabwe
		Samea multiplicalis (Guenée)	Crambidae	Australia, Fiji
Lantana camara L.	Verbenaceae	*Aceria lantanae* (Cook)	Eriophyidae	Australia*, Republic of South Africa, United States of America
		Aconophora compressa Walker	Membracidae	Australia
		Calycomyza lantanae (Frick)	Agromyzidae	Australia, Benin, Cambodia, Ethiopia, Federated States of Micronesia, Fiji, Guam, Indonesia, Kenya, La Réunion, Madagascar, Malaysia, Palau, Papua New Guinea, Philippines, Republic of South Africa, Singapore, Solomon Islands, Sri Lanka, Swaziland, Taiwan, Tanzania, Thailand, Timor Leste, Uganda, Vanuatu, Vietnam, Zimbabwe
		Coelocephalapion camarae Kissinger	Brentidae	Republic of South Africa

Species	Plant family	Agent species	Agent family	Country/countries established
		Cremastobombycia lantanella Busck	Gracillariidae	Hawaii USA
		Crocidosema lantana Busck	Torticidae	Australia, Federated States of Micronesia, Guam, Hawaii USA, India, Marshall Islands, Northern Mariana Islands, Palau, Republic of South Africa, Sri Lanka, Vanuatu, Zimbabwe
		Diastema tigris Guenée	Noctuidae	Mauritius
		Eutreta xanthochaeta Aldrich	Tephritidae	Hawaii USA
		Falconia intermedia (Distant)	Miridae	Australia, Republic of South Africa
		Hypena laceratalis Walker	Erebidae	Australia, Cape Verde Islands, Federated States of Micronesia, Fiji, Guam, Hawaii USA, Mauritius, New Caledonia, Northern Mariana Islands, Papua New Guinea, Philippines, Republic of South Africa, Taiwan*, Vanuatu
		Lantanophaga pusillidactyla (Walker)	Pterophoridae	Australia, Federated States of Micronesia, Guam, Hawaii USA, Hong Kong, India, Israel, Italy, Morocco, Myanmar, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, People's Republic of China, Philippines, Portugal, Republic of South Africa, Spain, Sri Lanka, Taiwan, Thailand, Timor Leste, Zambia, Zimbabwe
		Leptobyrsa decora Drake	Tingidae	Australia, Cook Islands*, Hawaii USA, Tonga*
		Longitarus bethae Savini & Escalona	Chrysomelidae	Republic of South Africa
		Neogalea sunia (Guenée)	Noctuidae	Australia, Hawaii USA, New Caledonia
		Octotoma championi Baly	Chrysomelidae	Australia
		Octotoma scabripennis Guérin-Méneville		Australia, Ghana, Guam, Hawaii USA, India, New Caledonia, Republic of South Africa, Solomon Islands*, Swaziland
		Ophiomyia camarae Spencer	Agromyzidae	Argentina, Ethiopia, Kenya, Madagascar, Mozambique, Swaziland, Tanzania, Zimbabwe

Species	Plant family	Agent species	Agent family	Country/countries established
		Ophiomyia lantanae (Froggatt)		Argentina, Australia, Benin, Cook Islands* Ethiopia, Federated States of Micronesia, Fiji, French Polynesia, Ghana, Guam, Hawaii USA, Hong Kong, India, Indonesia, Kenya, La Réunion, Madagascar, Malaysia, Mozambique, Myanmar, New Caledonia, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Republic of South Africa, Samoa, Singapore, Sri Lanka, Swaziland, Taiwan, Tanzania, Thailand, Timor Leste, Tonga, Vanuatu, Vietnam, Zambia, Zimbabwe
		Orthezia insignis Browne	Ortheziidae	Ascension Island, Cape Verde Islands, Ethiopia, Hawaii USA, India, Kenya, La Réunion, Mauritius, Republic of South Africa, Sri Lanka, St Helena, Swaziland
		Passalora lantanae var. *lantanae* (Chupp) U. Braun	Capnodiales	Sri Lanka
		Phenacoccus parvus Morrison	Pseudococcidae	Australia
		Plagiohammus spinipennis (Thomson)	Cerambycidae	Australia
		Prospodium tuberculatum (Spegazzini) Arthur	Pucciniales	Australia
		Salbia haemorrhoidalis Guenée	Crambidae	Australia, Benin, Federated States of Micronesia, Fiji, Hawaii USA, Mauritius, Republic of South Africa, Uganda, Zambia
		Septoria sp.	Capnodiales	Hawaii USA
		Strymon bazochii (Godart)	Lycaenidae	Fiji, Hawaii USA*
		Teleonemia scrupulosa Stål	Tingidae	Ascension Island, Australia, Benin, Botswana, Federated States of Micronesia, Fiji, French Polynesia, Ghana, Guam, Hawaii USA, India, Indonesia, Kenya, La Réunion, Madagascar, Malaysia, Mauritius, Namibia, New Caledonia, Niue, Northern Mariana Islands, Palau Papua New Guinea, Philippines, Republic of South Africa, Samoa, Solomon Islands, Sri Lanka, St Helena, Swaziland, Tanzania, Thailand, Timor Leste, Tonga, Uganda, Vanuatu, Zambia, Zimbabwe
		Tmolus echion (L.)	Lycaenidae	Hawaii USA
		Uroplata fulvopustulata Baly	Chrysomelidae	Australia

Species	Plant family	Agent species	Agent family	Country/countries established
		Uroplata girardi Pic		Ascension Island, Australia, Cook Islands, Ethiopia, Federated States of Micronesia, Fiji, Ghana, Guam, Hawaii USA, India, Mauritius, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Republic of South Africa, Samoa, Solomon Islands, St Helena*, Tanzania, Tonga, Trinidad and Tobago*, Uganda, Vanuatu, Zambia

*Released but establishment not yet confirmed

This page intentionally left blank

Appendix C

Herbicides registered or permissible with minor or emergency use permits in Australia, by the Australian Pesticides and Veterinary Medicines Authority, against some of the plant species included in this Field Guide (Joseph Vitelli; Department of Agriculture and Fisheries; Queensland Government; Australia; *pers. comm*.).

(Abbreviations used: g/L = grams/litre; g/kg = grams per kilogram)

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
Ruellia tuberosa L.	Acanthaceae	Glyphosate	Glyphosate (360g/L)	9.76g/L water	Foliar
Thunbergia grandiflora Roxb.	Acanthaceae	Imazapyr	Imazapyr (250g/L)	0.25 g/L water	Cut stump ("V" shape cut 2mls/cut)
		Imazapyr	Imazapyr (250g/L)	1.875 g/L water	Foliar
		Imazapyr + Glyphosate	Imazapyr (150g/L) + Glyphosate (150g/L)	1.875 + 1.875 g/L water	Foliar
Limnocharis flava (L.) Buch.	Alismataceae	2,4-D	2,4-D Amine (625g/L)	0.45g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	0.54g/L water	Foliar
		Imazapyr	Imazapyr (250g/L)	0.16g/L water	Foliar
Pistia stratiotes L.	Araceae	Diquat	Diquat (200g/L)	0.67g/L water	Foliar
		Flumioxazin	Flumioxazin (500g/L)	0.7g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	4.68g/L water	Foliar
Syngonium podophyllum Schott	Araceae	2,4-D	2,4-D Amine (625g/L)	5.0g/L water + wetter	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	2.0g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	3.6g/L water + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water + wetter	Foliar
Ageratina adenophora (Spreng.) R.M. King & H. Rob	Asteraceae	2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	1.95g + 0.49g/L water + wetter	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.5g + 0.5g + 0.04g/L water	Splatter gun
		Aminopyralid + Metsulfuron	Aminopyralid (375g/kg) + Metsulfuron (300g/kg)	0.1125g + 0.09g/L water + wetter	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	1.0g/L water	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.05g + 0.35g + 0.028g/L water	Foliar
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	0.07g/L + 0.98g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	1.8g/L water + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.09g/L water + wetter	Foliar
		Triclopyr + Metsulfuron	Triclopyr (75g/L) + Metsulfuron (28g/L)	0.28g + 0.11g/L water + wetter	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
Ageratum conyzoides L.	Asteraceae	Fluroxypyr	Fluroxypyr (333g/L)	0.25g/L water	Foliar
		Glufosinate ammonium	Glufosinate ammonium (200g/L)	1g/L water	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water + wetter	Foliar
Austroeupatorium inulifolium (Kunth) R.M. King & H. Rob	Asteraceae	2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	1.95g + 0.49g/L water + wetter	Foliar
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	0.07g/L + 0.98g/L water + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.09g/L water + wetter	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.05g + 0.35g + 0.028g/L water	Foliar
Bidens pilosa L.	Asteraceae	2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	0.25g + 0.06g/L water	Foliar
		2,4-D	2,4-D Amine (625g/L)	0.52g/L water	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	1.0g/L water	Foliar
		Dicamba	Dicamba (500g/L)	3.0g/L water	Foliar
		Glufosinate ammonium	Glufosinate ammonium (200g/L)	1.0g/L water	Foliar
		Imazapyr + Glyphosate	Imazapyr (150g/L) + Glyphosate (150g/L)	0.625g + 0.625g/L water	Foliar
Chromolaena odorata (L.) R.M. King & H. Rob	Asteraceae	Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	0.05g + 0.7g/L water	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	0.7g/L water	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.0g + 0.35g + 0.028/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	15g + 5g + 0.4/L water	Splatter gun
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	1.42g +20.0g/L water	Splatter gun
Mikania micrantha Kunth	Asteraceae	Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.0g + 0.35g + 0.028/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
Parthenium hysterophorus L.	Asteraceae	2,4-D	2,4-D Amine (500g/L)	2.0g/L water	Foliar
		2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	0.6g + 0.15g/L water	Foliar
		Triclopyr + Metsulfuron	Triclopyr (75g/L) + Metsulfuron (28g/L)	0.15g + 0.06g/L water + wetter	Foliar
		Dicamba	Dicamba (500g/L)	2.75g/L water	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
		Hexazinone	Hexazinone (250g/L)	0.175g/L water per 2 square metres	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.03g/L water	Foliar
		Aminopyralid + Metsulfuron	Aminopyralid (375g/kg) + Metsulfuron (300g/kg)	0.375g + 0.09g/L water + wetter	Foliar
Sphagneticola trilobata (L.) Pruski	Asteraceae	Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.09g/L water + wetter	Foliar
Tithonia diversifolia (Hemsl.) Gray	Asteraceae	Aminopyralid + Metsulfuron	Aminopyralid (375g/kg) + Metsulfuron (300g/kg)	0.075g + 0.06g/L water + wetter	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.05g + 0.35g + 0.028g/L water	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water + wetter	Foliar
Xanthium strumarium L.	Asteraceae	Fluroxypyr	Fluroxypyr (333g/L)	0.15g/L water	Foliar
		MCPA	MCPA (500g/L)	1.33g/L water	Foliar
		2,4-D	2,4-D Amine (625g/L)	1.9 g/L water	Foliar
		Aminopyralid + Metsulfuron	Aminopyralid (375g/kg) + Metsulfuron (300g/kg)	0.0525g + 0.042g/L water + wetter	Foliar
		2,4-D + Picloram	2,4-D Amine (300g/L) + Picloram (75g/L)	200g + 50 g/L water	Foliar
		Dicamba	Dicamba (500g/L)	3.0 g/L water	Foliar
		Imazapyr	Imazapyr (250g/L)	0.625 g/L water	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.038g/L water + wetter	Foliar
		Triclopyr + Metsulfuron	Triclopyr (75g/L) + Metsulfuron (28g/L)	0.15g + 0.06g/L water + wetter	Foliar
Spathodea campanulata P. Beauv.	Bignoniaceae	Glyphosate	Glyphosate (360g/L)	180 g/L water	Stem injection
		Triclopyr + Picloram	Triclopyr (200 g/L)+ Picloram (100 g/L)	50g + 25 g/L water	Stem injection
		Glyphosate	Glyphosate (360g/L)	180 g/L water	Cut stump
		Triclopyr + Picloram	Triclopyr (200 g/L)+ Picloram (100 g/L)	10g + 5 g/L water	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Opuntia stricta (Haw.) Haw	Cactaceae	Amitrole + Ammonium Thiocyanate	Amitrole (250g/L) + Ammonium Thiocyanate (220g/L)	10g/L + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.12g/L water + wetter	Foliar
		MSMA	MSMA (800g/Kg)	18g/L water +wetter	Foliar
		Picloram + Fluroxypyr + Polysiloxane	Picloram (240g/L) + Fluroxypyr (333g/L) + 1020 (g/L) Polysiloxane	0.5g + 0.42g + 1.7g/L water	Foliar
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
		Triclopyr + Picloram + Aminopyralid	Triclopyr (200g/L) + Picloram (100g/L) + Aminopyralid (25g/L)	5g + 2.5g + 0.625/L water	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.5g + 0.5g + 0.04g/L water	Foliar
Canna indica L.	Cannaceae	Glyphosate	Glyphosate (360g/L)	3.6 g/L + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06 g/L + wetter	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
Merremia peltata (L.) Merr.	Convolvulaceae	MCPA	MCPA (500g/L)	0.7g/L water	Foliar
Coccinia grandiflora (L.) Voigt	Cucurbitaceae	Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Jatropha gossypiifolia L.	Euphorbiaceae	Fluroxypyr	Fluroxypyr (333g/L)	1.0 g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	3.6 g/L water	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.09 g/L water + wetter	Foliar
		Metsulfuron-methyl + Aminopyralid	Metsulfuron-methyl (300g/kg) + Aminopyralid (375g/L)	0.06g + 0.075g/L water + wetter	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.05g + 0.35g + 0.028g/L water + wetter	Foliar
Acacia auriculiformis A. Cunn. ex Benth.	Fabaceae	Fluroxypyr	Fluroxypyr (333g/L)	2.0g/L water	Foliar
		Clopyralid	Clopyralid (600g/L)	1.5g/L water	Foliar
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	0.07g +1.0g/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Acacia decurrens Willd.	Fabaceae	Triclopyr	Triclopyr (600g/L)	1.9g/L water	Foliar (seedlings)
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
		Triclopyr	Triclopyr (600g/L)	10g/L diesel	Basal bark/ Cut stump
Acacia mangium Willd.	Fabaceae	Fluroxypyr	Fluroxypyr (333g/L)	2.0g/L water	Foliar
		Clopyralid	Clopyralid (600g/L)	1.5g/L water	Foliar
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	0.07g +1.0g/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Calliandra houstoniana (Mill.) Standl. var. *calothyrsus* (Meisn.) Barneby	Fabaceae	Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
Leucaena leucocephala (Lam.) de Wit	Fabaceae	Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
Mimosa diplotricha Sauvalle	Fabaceae	Dicamba	Dicamba (500g/L)	2.0g/L water	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	1.0g/L water	Foliar
		Glufosinate ammonium	Glufosinate ammonium (200g/L)	1.0g/L water	Foliar
Mimosa pigra L.	Fabaceae	Fluroxypyr	Fluroxypyr (333g/L)	1.0g/L water	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.09g/L water + wetter	Foliar
		Aminopyralid + Metsulfuron	Aminopyralid (375g/kg) + Metsulfuron (300g/kg)	0.11g + 0.09g/L water + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	1.2g/L water + wetter	Cut stump
		Tebuthiuron	Tebuthiuron (200g/L)	0.2g per square metre of soil around plant	Spot ground application
Mimosa pudica L.	Fabaceae	Dicamba	Dicamba (500g/L)	2.0g/L water	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	1.0g/L water	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	0.6g + 0.2g + 0.016/L water	Foliar
Prosopis juliflora (Sw.) DC.	Fabaceae	Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.05g/L + 0.35g/L + 0.028g/L water + wetter	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g+2g/L diesel	Basal bark/ Cut stump
Senna occidentalis (L.) Link	Fabaceae	Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.05g/L + 0.35g/L + 0.028g/L water + wetter	Foliar
		2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	0.9g + 0.225g/L water + wetter	Foliar
Swietenia macrophylla King	Fabaceae	Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
Vachellia nilotica ssp. *indica* (Benth.) Kyal. & Boatwr. (Syn.: *Acacia nilotica* ssp. *indica* [Benth.] Brenan)	Fabaceae	Fluroxypyr	Fluroxypyr (333g/L)	1.5g/L water	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr	Triclopyr (600g/L)	5g/L diesel	Basal bark/ Cut stump
		Tebuthiuron	Tebuthiuron (200g/L)	0.3g per square metre of soil around plant	Spot ground application
		Diuron	Diuron (900g/kg)	26.62g per square metre of wet soil	Bore drains
		Hexazinone	Hexazinone (250g/L)	1g per square metre of soil around plant	Spot ground application
Myriophyllum aquaticum (Vell.) Verdc.	Haloragaceae	Flumioxazin	Flumioxazin (500g/L)	0.35g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	3.6g/L water + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water + wetter	Foliar
Clidemia hirta (L.) Don	Melastomataceae	Metsulfuron-methyl + Fluroxypyr	Metsulfuron-methyl (600g/kg) + Fluroxypyr (333g/L)	0.012g + 0.3g/L water + wetter	Foliar
		Triclopyr	Triclopyr (600g/L)	0.63g/L water + wetter	Foliar
Miconia calvescens DC.	Melastomataceae	Triclopyr	Triclopyr (600g/L)	2.1g/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr	Triclopyr (600g/L)	2.1g/L diesel	Basal bark/ Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	0.84g + 0.42g/L diesel	Basal bark/ Cut stump
Broussonetia papyrifera (L.) Vent	Moraceae	Glyphosate	Glyphosate (360g/L)	180g/L water	Cut stump
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr	Triclopyr (600g/L)	20g/L diesel	Basal bark
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g +2g/L diesel	Basal bark/ Cut stump
		Triclopyr + Picloram + Aminopyralid	Triclopyr (200g/L) + Picloram (100g/L) + Aminopyralid (25g/L)	50g + 25g + 6.25g/L water	Stem injection
Argemone mexicana L.	Papaveraceae	2,4-D	2,4-D (625g/L)	0.73g/L water	Foliar
		2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	0.25g + 0.06g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	0.45g/L water	Foliar
Argemone spp.	Papaveraceae	2,4-D	2,4-D (625g/L)	0.73g/L water	Foliar
		2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	0.25g + 0.06g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	0.45g/L water	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
Passiflora foetida L.	Passifloraceae	Fluroxypyr	Fluroxypyr (200g/L)	4.5g/L water	Foliar
		Triclopyr + Picloram	Triclopyr (200 g/L) + Picloram (100 g/L)	2g + 1g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	180g/L water	Cut stump
		Triclopyr + Picloram	Triclopyr (200 g/L) + Picloram (100 g/L)	10g + 5g/L water	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark
Passiflora suberosa L.	Passifloraceae	Glyphosate	Glyphosate (360g/L)	180g/L water	Cut stump
		Glyphosate	Glyphosate (360g/L)	7.2g/L water	Foliar
Piper aduncum L.	Piperaceae	Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Brachiaria mutica (Forsk.) Stapf	Poaceae	Glyphosate	Glyphosate (360g/L)	4.5g/L water	Foliar
		Haloxyfop	Haloxyfop (520 g/L)	0.35g/L water	Foliar
Cenchrus echinatus L.	Poaceae	Ametryn	Ametryn (800g/L)	2.0g/L water + wetter	Foliar
		Atrazine	Atrazine (900g/kg)	1.5g/L water + wetter	Foliar
		Fluazifop	Fluazifop (212g/L)	2.1g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	2.5g/L water + wetter	Foliar
		Haloxyfop	Haloxyfop (520g/L)	0.07g/L water + wetter	Foliar
Panicum repens L.	Poaceae	Fluazifop	Fluazifop (212g/L)	0.53g/L water	Foliar
		Glufosinate ammonium	Glufosinate ammonium (200g/L)	1.0g/L water	Foliar
		Imazapyr	Imazapyr (250g/L)	0.625g/L water	Foliar
Antigonon leptopus Hook. & Arn	Polygonaceae	Fluroxypyr	Fluroxypyr (333g/L)	1.2g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	3.6 g/L + wetter	Foliar
		MCPA + Dicamba	MCPA (340g/L) + Dicamba (80g/L)	1.6g/L + 0.38g/L water + wetter	Foliar
		Triclopyr + Picloram	Triclopyr (300g/L) + Picloram (100g/L)	1.5g/L + 0.5g/L water + wetter	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.5g/L + 0.5g/L + 0.04g/L water + wetter	Foliar
Eichhornia crassipes (Mart.) Solms	Pontederiaceae	Amitrole + Ammonium Thiocyanate	Amitrole (250g/L) + Ammonium Thiocyanate (220g/L)	0.7g + 0.62g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	4.68g/L + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water	Foliar
Salvinia molesta D.S. Mitch	Salviniaceae	Diquat	Diquat (200g/L)	1.67g/L water	Foliar
		Flumioxazin	Flumioxazin (500g/L)	0.35g/L water	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water + wetter	Foliar
Cardiospermum halicacabum L.	Sapindaceae	Glyphosate	Glyphosate (360g/L)	3.6 g/L + wetter	Foliar
		Metsulfuron-methyl + Glyphosate	Metsulfuron-methyl (600g/kg) + Glyphosate (360g/L)	0.09g/L + 0.72g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	240 g/L	Cut stump
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
Cestrum aurantiacum Lindl.	Solanaceae	Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.2g + 0.4g + 0.032/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
		Glyphosate	Glyphosate (360g/L)	360g/L water	Cut stump
		Glyphosate	Glyphosate (360g/L)	360g/L water	Stem scrape
Solanum viarum Dunal	Solanaceae	2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	1.95g + 0.49g/L water + wetter	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	1.0g/L water	Foliar
		Glyphosate	Glyphosate (360g/L)	7.2g/L water + wetter	Foliar
		Imazapyr	Imazapyr (250g/L)	2.5g/L water	Foliar
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	1.5g + 0.5g + 0.04g/L water	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Imazapyr	Imazapyr (250g/L)	50.0g/L water	Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Duranta erecta L.	Verbenaceae	2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	3.0g + 0.75g/L water + wetter	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	2g/L water	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.06g/L water + wetter	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	7.0g/L diesel	Basal bark
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g +2g/L diesel	Basal bark/ Cut stump
Lantana camara L.	Verbenaceae	2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	1.95g/L + 0.49g/L water + wetter	Foliar
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	.07g/L + 0.98g/L water + wetter	Foliar
		Fluroxypyr	Fluroxypyr (200g/L)	2.0g/L water + wetter	Foliar
		Glyphosate	Glyphosate (360g/L)	3.6g/L water + wetter	Foliar

Species	Family	Active constituent	Active constituent with concentration	A.I. (grams) per litre	Method of application
		Triclopyr + Picloram + Aminopyralid	Triclopyr (300g/L) + Picloram (100g/L) + Aminopyralid (8g/L)	2.25g + 0.75g + 0.06g/L water + wetter	Foliar
		2,4-D + Picloram	2,4-D (300g/L) + Picloram (75g/L)	1.95g/L + 0.49g/L water + wetter	Foliar
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Aminopyralid + Fluroxypyr	Aminopyralid (10g/L) + Fluroxypyr (140g/L)	1.0g/L + 14.0g/L water + wetter	Splatter gun
		Glyphosate	Glyphosate (360g/L)	36g/L water + wetter	Splatter gun
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	1.2g/L water + wetter	Splatter gun
		Triclopyr	Triclopyr (600g/L)	10g/L diesel	Basal bark/ Cut stump
		Triclopyr + Picloram	Triclopyr (240g/L) + Picloram (120g/L)	4g + 2g/L diesel	Basal bark/ Cut stump
Stachytarpheta jamaicensis (L.) Vahl	Verbenaceae	2,4-D	2,4-D Amine (500g/L)	1.0g/L water	Foliar
		Fluroxypyr	Fluroxypyr (333g/L)	1.5g/L water	Foliar
Hedychium coronarium J. Koenig	Zingiberaceae	Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.12g/L water + wetter	Foliar
		Imazapyr	Imazapyr (250g/L)	125g/L water + wetter	Cut stump
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.6g/L water + wetter	Cut stump (Spring and smmer application)
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	3.6g/L water + wetter	Cut stump (Winter application)
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr	Triclopyr (600g/L)	20g/L diesel	Basal bark
Hedychium gardnerianum Sheppard ex Ker Gawl.	Zingiberaceae	Imazapyr	Imazapyr (250g/L)	125g/L water + wetter	Cut stump
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.12g/L water + wetter	Foliar
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	0.6g/L water + wetter	Cut stump (Spring and Summer application)
		Metsulfuron-methyl	Metsulfuron-methyl (600g/kg)	3.6g/L water + wetter	Cut stump (Winter application)
		Picloram + Aminopyralid	Picloram (43g/Kg) + Aminopyralid (4.3g/Kg)	Neat - 3 to 5 mm layer	Cut stump
		Triclopyr	Triclopyr (600g/L)	20g/L diesel	Basal bark

This page intentionally left blank

Appendix D

Registered and minor-use* herbicides applied in South Africa for the control of some of the plant species included in this Field Guide with herbicide concentrations/volumes based on weed densities of closed stands (100% cover) [South Africa Department of Environment Affairs (DEA): Environmental Programmes (EP): Natural Resource Management (NRM) and XACT Information (2005)]. Please note that "lopping/pruning" and "cut and spray" applications use a similar methodology as that of "cut-stump," as explained elsewhere.

(Abbreviations used: cm = centimetre; EC = emulsifiable concentrate; g/kg = grams per kilogram; g/l = grams per litre; ha = hectare; kg = kilogram; L = litre; m = metre; m^2 = square metre; ME = micro-emulsion; ml = millilitre; mm = millimetre; SC = suspension concentrate; SL = solution; WG = water dispensable granule; WP = wettable powder)

Species	Active constituent with concentration	Age	Dosage (ml/g)	Wetter/ dye	A.I, (L/ kg)	Mix (L)	% mix	Estimated product (L/ha or kg/ha)	Vol. of mix	Method of application
Ageratum conyzoides L. (Asteraceae)	2.4D (as dimethylamine salt) 480 g/L SL	Young	150	0.10%	0.15	10	1.5	2.25	150	Foliar spray
	Glyphosate (as isopropylamine salt) 480 g/L SL		150		0.15	10	1.5	4.5	300	Foliar spray
Chromolaena odorata (L.) R.M. King & H. Rob. (Asteraceae)	Clopyralid 90 + Triclopyr (as amine salt) 270 g/L SL	Young	50	0.50%	0.05	10	0.5	1.5	300	Foliar spray
			Use 50 ml mineral oil /10 L water. Apply as a full cover spray to actively growing plants. Plants to high should be slashed and regrowth sprayed.							
	Fluroxypyr 80 + Picloram 80 g/L ME		75	0.50%	0.075	10	0.75	2.25	300	Foliar spray
			Use 75 ml/10 L water+ 50 ml mineral oil. Apply to actively growing plants.							
	Glyphosate (as ammonium salt) 680 g/kg WG		80	0.10%	0.08	10	0.8	2.4	300	Foliar spray
			Use 80g/10 L water. Slash established plants and apply as a full cover spray when regrowth is 0.5 – 1.2 m high.							
	Glyphosate (as isopropylamine salt) 360 g/L SL		100	0.10%	0.1	10	1	3	300	Foliar spray
			Use 100 ml/10 L water. Slash established plants and apply as full cover spray when regrowth is 0.5 – 1.2 m high							
	Glyphosate (as potassium salt) 450g/L SL		120	0.10%	0.12	10	1.2	3.6	300	Foliar spray
			Use 120 ml/10 L water. Slash established plants and spray regrowth at 0.5 – 1.2 m high.							
	Glyphosate (as isopropylamine salt) 480 g/L SL		110	0.10%	0.11	10	1.1	3.3	300	Foliar spray
			Use 110 ml/10 L water. Apply to regrowth of slashed plants.							
	Glyphosate (as potassium salt) 500 SL		70	0.10%	0.07	10	0.7	2.1	300	Foliar spray
			Use 70 ml/10 L water. Slash rank growth in winter and apply to regrowth in summer.							
	Glyphosate (as sodium salt) 500g/kg WG		75	0.50%	0.075	10	0.75	2.25	300	Foliar spray
			Use 75 g/10 L water. Slash plants and apply to regrowth as a full cover spray.							
	Metsulfuron methyl 600g/kg WP		25	0.10%	0.25	100	0.25	0.75	300	Foliar spray
			Use 2.5 g/10 L water and add a surfactant. Apply to actively growing plants between 50 cm and 75 cm high. Taller plants should be slashed and regrowth treated.							

Species	Active constituent with concentration	Age	Dosage (ml/g)	Wetter/ dye	A.I, (L/ kg)	Mix (L)	% mix	Estimated product (L/ha or kg/ha)	Vol. of mix	Method of application
	Triclopyr (as butoxy ethyl ester) 240 g/L EC	Young	75	0.10%	0.075	10	0.75	2.25	300	Foliar spray
			Use 75 ml + 50 ml mineral oil/10 L water. Apply as a full cover spray to actively growing plants. Taller plants must be slashed and regrowth treated.							
	Triclopyr (as butoxy ethyl ester) 480 g/L EC		37.5	0.50%	0.0375	10	0.375	1.125	300	Foliar spray
			Use 37.5 ml + 50 ml mineral oil/10 L water. Apply as a full cover spray to actively growing plants. Plants too high should be slashed and regrowth sprayed when 0.5 m high.							
	Triclopyr (as triethyl ammonium) 120 g/L + Aminopyralid 12 g/L		75	0.50%	0.075	10	0.75	2.25	300	Foliar spray
	Clopyralid 90 + Triclopyr (as amine salt) 270 g/L SL	Adult	200	0.50%	0.2	10	2	4	200	Cut and spray
			Use 200 ml + 50 ml mineral oil/10 L water. Apply to cut surface of low cut stems within 3 hours of felling.							
	Fluroxypyr 80 + Picloram 80 g/L ME		75	0.50%	0.075	10	0.75	1.5	200	Cut and spray
			Use 75 ml + 50 ml mineral oil/10 L water. Apply to cut surface of low cut stems.							
	Imazapyr 100 g/L SL		200		0.2	10	2	4	200	Cut and spray
			Use 200 ml/10 L water. Apply to freshly cut stumps. Use at least 10 ml per 10 cm of stump diameter.							
	Picloram (as potassium salt) 240g/L SL		100	0.50%	0.1	10	1	2	200	Cut and spray
			Use 100 ml + 50 ml mineral oil /10 L water. Apply to cut surface of low cut stems within 3 hours of felling							
	Triclopyr (as butoxy ethyl ester) 240 g/L EC		200	0.10%	0.2	10	2	4	200	Cut and spray
			Use 200 ml/10 L diesel. Apply to cut surface, all exposed bark and root crown of low cut stems							
	Triclopyr (as amine salt) 360 g/L SL		200	0.10%	0.2	10	2	4	200	Cut and spray
			Use 200 ml + 50 ml mineral oil /100 L water. Apply to the cut surface of low cut stumps.							
	Triclopyr (as butoxy ethyl ester) 480 g/L EC		100		0.1	10	1	2	200	Cut and spray + diesel
			Use 100 ml/10 L diesel. Apply to cut surface, all exposed bark and root crown of low cut stumps.							
Parthenium hysterophorus L. (Asteraceae)	Glyphosate (as potassium salt) 500 SL	Young	200	0.10%	0.2	10	2	6	300	Foliar spray
	Picloram (as potassium salt) 240g/L SL		50	0.50%	0.05	10	0.5	1.5	300	Foliar spray
	Glyphosate (as isopropylamine salt) 480 g/L SL		150		0.15	10	1.5	4.5	300	Foliar spray

Species	Active constituent with concentration	Age	Dosage (ml/g)	Wetter/ dye	A.I, (L/ kg)	Mix (L)	% mix	Estimated product (L/ha or kg/ha)	Vol. of mix	Method of application
Xanthium strumarium L. (Asteraceae)	2.4D (as dimethylamine salt) 480g/L SL	Young	150	0.10%	0.15	10	1.5	2.25	150	Foliar spray
	Chlorimuron ethyl (as sulfonyl urea) 500g/ kg WP		17.5	0.10%	0.0175	10	0.175	0.525	300	Foliar spray
Leucaena leucocephala (Lam.) de Wit (Fabaceae)	Triclopyr (as butoxy ethyl ester) 480 g/L EC*	Young	100		0.1	10	1	2	200	Basal stem + diesel
	Triclopyr (as butoxy ethyl ester) 480 g/L EC	Adult	100		0.1	10	1	2	200	Basal stem + diesel
Mimosa pigra L. (Fabaceae)	Glyphosate (as isopropylamine salt) 360 g/L SL	Young	300		0.3	10	3	9	300	Foliar spray
			Use 300 ml/10 L water with knapsack sprayer or 400 ml/10 l water with mistblower. Apply as a full cover spray in summer to autumn.							
	Glyphosate (as sodium salt) 500g/kg WG		220		0.22	10	2.2	6.6	300	Foliar spray
	Glyphosate (as sodium salt) 700g/kg WG		157		0.157	10	1.57	4.71	300	Foliar spray
Senna occidentalis (L.) Link (Fabaceae)	Imazapyr 100 g/L SL*	Adult	500		0.5	10	5	10	200	Cut and spray
Prosopis glandulosa Torr. (Fabaceae) (A congener, *P. juliflora* is present in SE Asia – the same chemicals may be effective)	Clopyralid 90 + Triclopyr (as amine salt) 270 g/L SL		150	0.50%	0.15	10	1.5	4.5	300	Foliar spray
			Use 100-150 ml + 50 ml mineral oil/10 L water. Apply as a full cover spray. Plants to high should be slashed and regrowth sprayed.							
	Glyphosate (as potassium salt) 500 SL		500	0.10%	0.5	10	5	15	300	Foliar spray
			Use 350-660 ml/10 L water. Apply to seedlings and regrowth.							
	Triclopyr (as triethyl ammonium) 120 g/L + Aminopyralid 12 g/L		300	0.50%	0.3	10	3	9	300	Foliar spray
	Clopyralid 90 + Triclopyr (as amine salt) 270 g/L SL		400	0.50%	0.4	10	4	8	200	Lopping/ pruning
	Triclopyr (as butoxy ethyl ester) 240 g/L EC		800	0.10%	0.8	10	8	16	200	Lopping/ pruning
	Triclopyr (as amine salt) 360 g/L SL		500	2.00%	0.5	10	5	10	200	Lopping/ pruning

Species	Active constituent with concentration	Age	Dosage (ml/g)	Wetter/ dye	A.I, (L/ kg)	Mix (L)	% mix	Estimated product (L/ha or kg/ha)	Vol. of mix	Method of application
	Clopyralid 90 + Triclopyr (as amine salt) 270 g/L SL		400	0.50%	0.4	10	4	8	200	Cut stump/ frill
			Use 400 ml + 50 ml mineral oil/10 L water. Apply to cut surface of low cut stumps within 3 hours of felling,							
	Triclopyr (as butoxy ethyl ester) 240 g/L EC		800	0.10%	0.8	10	8	16	200	Cut stump/ frill
			Use 800 ml/10 L diesel. Apply to the cut surface and all bark and root crown of low cut stumps.							
	Triclopyr (as amine salt) 360 g/L SL		500	2.00%	0.5	10	5	10	200	Cut stump/ frill
			Use 500 ml + 200 ml mineral oil/10 L water. Apply to the cut surface of low cut stumps within 3 hours of felling.							
	Picloram (as potassium salt) 54g/ kg + Triclopyr (as triethylamine) 36g/kg		Paint directly onto stumps 10g/10mm stump			200				Cut stump/ frill
	Triclopyr (as butoxy ethyl ester) 480 g/L EC		400	0.50%	0.4	10	4	8	200	Cut stump/ frill
	Glyphosate (as potassium salt) 500 SL		500	0.50%	0.5	10	5	20	400	Aerial application
Myriophyllum aquaticum (Vell.) Verdc. (Haloragaceae)	Diquat dibromide (as dibromide salt) 200g/L SL	All	7500	0.10%	7.5	10	75	37.5	50	Spray from boat/ shoreline
	Glyphosate (as isopropylamine salt) 480 g/L SL		300	0.10%	0.3	10	3	9	300	Spray from boat/ shoreline
	Glyphosate (as sodium salt) 500g/kg WG		300	0.10%	0.3	10	3	9	300	Spray from boat/ shoreline
	Glyphosate (as sodium salt) 700g/kg WG		200	0.10%	0.2	10	2	6	300	Spray from boat/ shoreline
Argemone mexicana L. (Papaveraceae)	Glyphosate (as isopropylamine salt) 180 g/l SL	Young	150		0.15	10	1.5	6	400	Foliar spray
	Glyphosate (as sodium salt) 500g/kg WG		220		0.22	10	2.2	8.8	400	Foliar spray
	Tebuthiuron 250g/L + Bromacil 250g/L SC	All	600		0.6	10	6	90	1500	Soil
	Glyphosate (as isopropylamine salt) 480 g/L SL*		300	0.10%	0.3	10	3	9	300	Foliar spray

Species	Active constituent with concentration	Age	Dosage (ml/g)	Wetter/ dye	A.I, (L/ kg)	Mix (L)	% mix	Estimated product (L/ha or kg/ha)	Vol. of mix	Method of application
Eichhornia crassipes (Mart.) Solms (Pontederiaceae)	Glyphosate (as sodium salt) 700g/kg WG	All	220	0.50%	0.22	10	2.2	6.6	300	Spray from boat/ shoreline
	Glyphosate (as isopropylamine salt) 480 g/L SL		220	0.10%	0.22	10	2.2	6.6	300	Spray from boat/ shoreline
			Use 220ml/10 L water with a pressurized or knapsack sprayer and 300 ml/10 L with a mistblower. Apply when maximum exposure of leaves is visible.							
	Glyphosate (as sodium salt) 500g/kg WG		220		0.22	10	2.2	6.6	300	Spray from boat/ shoreline
	Glyphosate (as potassium salt) 500 SL		450		0.45	10	4.5	13.5	300	Spray from boat/ shoreline
			Use 200-265 ml/10 L water. Apply in summer on actively growing plants.							
	Glyphosate (as phosponic acid) 480g/L SL		225		0.225	10	2.25	6.75	300	Spray from boat/ shoreline
	Diquat dibromide (as dibromide salt) 200g/L SL		500		0.5	10	5	2.5	50	Aerial
			Use 7.5-10 L + 1.5 L wetting agent – 40 L water/ha. Apply on actively growing plants.							
	Glyphosate (as potassium salt) 500 SL		450		0.45	10	4.5	4.5	100	Aerial
			Use 4-5.3 l/30 L water/ha. Apply in summer on actively growing plants.							
Salvinia molesta D.S. Mitch. (Salviniaceae)	Glyphosate (as sodium salt) 500g/kg WG	All	300	0.10%	0.3	10	3	9	300	Spray from boat/ shoreline
	Glyphosate (as sodium salt) 700g/kg WG		300	0.10%	0.3	10	3	9	300	Spray from boat/ shoreline
	Glyphosate (as isopropylamine salt) 480 g/L SL		200	0.10%	0.2	10	2	6	300	Spray from boat/ shoreline
	Diquat dibromide (as dibromide salt) 200g/L SL		500	0.10%	0.5	10	5	2.5	50	Aerial
			Use 7.5 – 10 l + 1.5 L Agral 90/ha. Apply in 35 – 40 L water/ha.							
Cestrum aurantiacum Lindl. (Solanaceae)	Imazapyr 100 g/L SL	Adult	150		0.15	10	1.5	3	200	Cut and spray
Datura stramonium L. (Solanaceae)	2.4D (as dimethylamine salt) 480g/L SL	Young	150	0.10%	0.15	10	1.5	2.25	150	Foliar spray
	Chlorimuron ethyl (as sulfonyl urea) 500g/ kg WP		17.5	0.10%	0.0175	10	0.175	0.35	200	Foliar spray
	Glyphosate (as sodium salt) 500g/kg WG		110		0.11	10	1.1	2.2	200	Foliar spray
	Glyphosate (as isopropylamine salt) 180 g/l SL		150		0.15	10	1.5	3	200	Foliar spray
	Tebuthiuron 250g/L + Bromacil 250g/L SC	All	150		0.15	10	1.5	3	200	Soil

Species	Active constituent with concentration	Age	Dosage (ml/g)	Wetter/ dye	A.I, (L/ kg)	Mix (L)	% mix	Estimated product (L/ha or kg/ha)	Vol. of mix	Method of application
Lantana camara L. (Verbenaceae)	Fluroxypyr 80 + Picloram 80 g/L ME	Young	150	0.50%	0.15	10	1.5	4.5	300	Foliar spray
			Use 150 ml + 50 ml mineral oil/10 L water. Apply as a full cover spray on actively growing plants.							
	Glyphosate (as ammonium salt) 680 g/kg WG		160	0.10%	0.16	10	1.6	4.8	300	Foliar spray
			Use 160 g/10 L water with knapsack sprayer or 200 g/10 L water with mistblower. Apply as a full cover spay.							
	Glyphosate (as isopropylamine salt) 360 g/L SL		300	0.10%	0.3	10	3	9	300	Foliar spray
			Use 300 ml/10 L water with knapsack sprayer or 400 ml/10 L water with mistblower. Apply as a full cover spray in summer to autumn.							
	Glyphosate (as potassium salt) 450g/L SL		240	0.10%	0.24	10	2.4	7.2	300	Foliar spray
	Glyphosate (as isopropylamine salt) 480 g/L SL		220	0.10%	0.22	10	2.2	6.6	300	Foliar spray
			Use 220 ml/10 L water with knapsack sprayer and 300 ml/10 L with a mistblower.							
	Glyphosate (as potassium salt) 500 SL		200	0.10%	0.2	10	2	6	300	Foliar spray
			Use 200 ml/10 L water. Slash large bushes in winter and apply to regrowth in summer.							
	Glyphosate (as sodium salt) 500g/kg WG		220	0.50%	0.22	10	2.2	6.6	300	Foliar spray
	Imazapyr 100 g/L SL		200		0.2	10	2	6	300	Foliar spray
			Use 200 ml/10 L water. Apply as a full cover spray when regrowth is 0.5 to 1 m high.							
	Picloram (as potassium salt) 240g/L SL		100	0.50%	0.1	10	1	3	300	Foliar spray
			Use 75–100 ml + 50 ml mineral oil/10 L water. For high volume application use 50 ml/10 L water and add a foaming agent. Apply as a full cover spray. Use higher rate for previously slashed plants with big stumps.							
	Fluroxypyr 80 + Picloram 80 g/L ME	Adult	150	0.50%	0.15	10	1.5	3	200	Cut and spray
			Use 150 ml + 50 ml mineral oil/10 L water. Apply to cut surface of low cut stumps within 3 hours of felling.							
	Imazapyr 100 g/L SL		200		0.2	10	2	4	200	Cut and spray
			Use 200 ml/10 IL water. Apply to the cut surface of freshly cut stumps. Use at least 10 ml per 10 cm of stump diameter.							
	Picloram (as potassium salt) 240g/L SL		100	0.50%	0.1	10	1	2	200	Cut and spray
			Use 100 ml + 50 ml mineral oil/10 L water. Apply to the cut surface of low cut stumps within 3 hours of felling.							
Hedychium coronarium J. Koenig (Zingiberaceae)	Imazapyr 100 g/L SL*	Adult	200		0.2	10	2	4	200	Cut and spray
Hedychium gardnerianum Sheppard ex Ker Gawl. (Zingiberaceae)	Imazapyr 100 g/L SL*	Adult	200		0.2	10	2	4	200	Cut and spray

Index (Bold page numbers indicate tables)

GUIDE TO THE NATURALIZED AND INVASIVE PLANTS OF

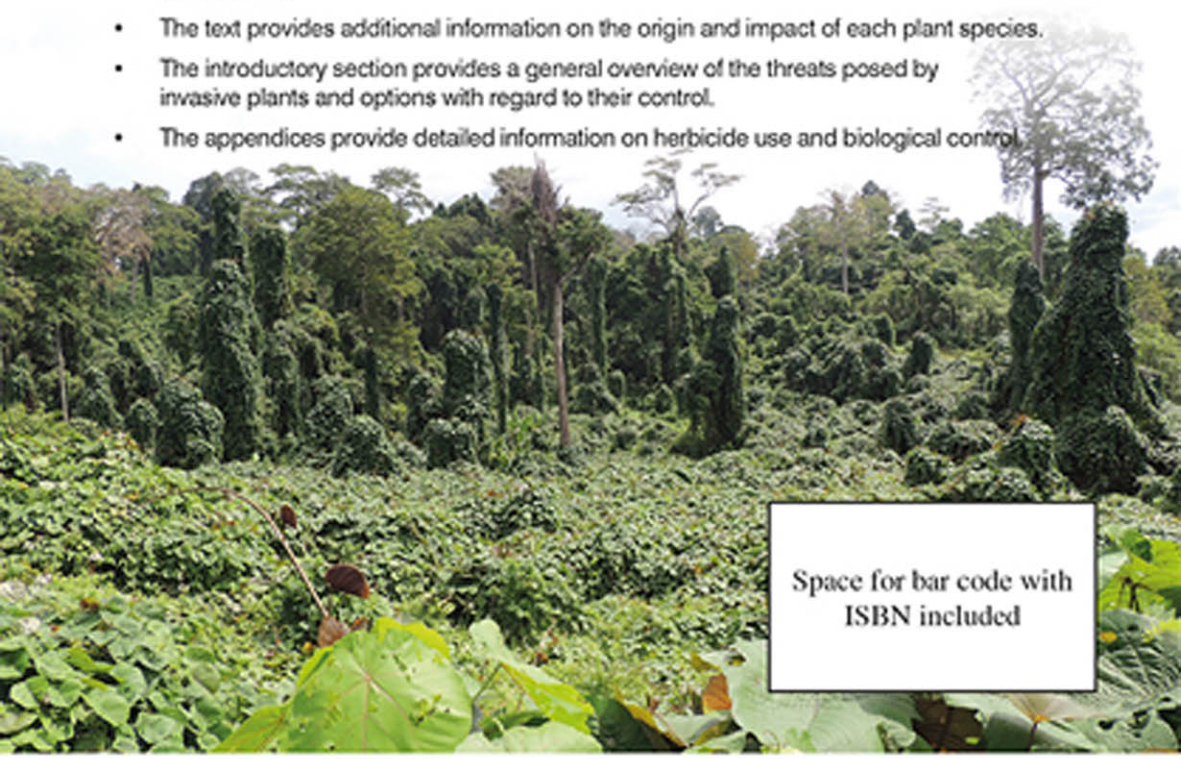
SOUTHEAST ASIA

Arne Witt, CABI

Southeast Asia occupies about 3% of the earth's surface area, yet hosts 20% of all known plant and animal species. Many of these species are endemic, occurring only in this region. Sadly, of the 64,800 known species in Southeast Asia, 1,312 are endangered, and may be lost if efforts are not made to deal with the many threats they face. Invasive Alien Species (IAS) are one of the most significant threats to this spectacularly diverse region.

The UN Environment-GEF Project "Removing Barriers to Invasive Species Management in Production and Protection Forests in SE Asia" was developed to deal specifically with this issue. One of the major barriers to effective management is the lack of information on the presence, impact, and management of invasive species. This Field Guide has been developed to help address this issue. Although this Guide only includes a few of the many problematic exotic species in the region, it provides insights into the various threats posed by these alien "intruders" and offers an "entry point" for those that want to learn more about invasive plants.

- The Guide includes information on 55 naturalized or invasive plant species, with descriptive text and more than 350 line drawings and colour images for easy identification.
- The text provides additional information on the origin and impact of each plant species.
- The introductory section provides a general overview of the threats posed by invasive plants and options with regard to their control.
- The appendices provide detailed information on herbicide use and biological control.



Space for bar code with ISBN included