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The Human Dimensions of Invasive Plants in Tropical Africa

Pierre Binggeli

Introduction

The human dimensions of invasive plants have received some attention (McNeely, 2001), but the focus of the research has been on developed countries. Although most instances of invasive plant species have been reported from and investigated in the temperate zones and a limited number of publications focusing on the tropics have been produced, tropical systems are far from immune from invasive organisms (Binggeli, 1996). This review focuses solely on plants in tropical Africa and surrounding islands (for a global review of invasive woody plants, see Binggeli, 2001a) and aims to highlight how populations with a low standard of living and restricted access to the modern world perceive introduced and invasive species. The impacts of invasives on human daily activities in relation to socio-economic factors, occasionally leading to conflicts of interest between different stakeholder groups, are reviewed. Scientific activities in relation to invasive species are also investigated. In view of the dearth of publications on the topic and the difficulty in tracing information, this paper can only hope to bring a preliminary account on the way in which introduced and invasive plants are viewed, used and managed in tropical Africa.

An historical perspective of plant introductions

Plants have undoubtedly been transported by humans for millennia and were an essential component of early agricultural societies. Indeed, many regions of the tropics, and oceanic islands in particular, would not have been colonized without the introduction of various food crops. Tropical Africa, when compared to the tropical Americas and Asia, has few important native food crops and 86 introduced crop species have been documented (Alpern, 2008).

The significance of introduced crop species to African agriculture and diet is not generally appreciated. For instance, a group of mostly graduate African and European students attending a Tropical Biology Association field course identified most commonly used staple foods as of African origin. While many non-native plant species have been highly beneficial, if not essential, to the survival and development of humanity, an increasing number of species have become detrimental to the well-being of humans and their daily activities.

The history of plant introductions is closely linked with that of transportation (improved sailing technology) and European exploration of the planet (16th–19th centuries) (Grove, 1995; Mack, 2004). Oceanic islands (e.g. Mauritius) and some coastal areas were the focus of attention until the colonization of the African interior in the late 19th century. During the early period most introductions were aimed at food production to provide sailors with subsistence or species providing essential raw materials. Each colonial power established botanical gardens and experimental stations on tropical islands (e.g. Mauritius), later on mainland coastal areas and finally in more inland locations. By the 20th century, the purpose of introductions shifted from food plants to timber and other species yielding non-agricultural products. Introductions of other species, deliberate, mostly ornamentals, or accidental (e.g. seed contaminants) increased dramatically during the latter part of the 20th century. In tropical Africa four main phases of plant introductions may be recognized (after Binggeli et al, 1998):

- Early exploration and slave trade when a few fruit tree species and vegetable varieties were planted around forts at a number of coastal locations. Some species associated with religious beliefs were brought from South America.
- During the early colonial period (late 19th century) a number of experimental gardens were established by missionaries and private individuals. These were followed by several major botanic gardens established by the respective colonial powers in the 1890s and after. These gardens specialized in testing the economic value exotic plants with commercial potential but ornamentals were also introduced.
- Colonial exploitation, when large-scale forestry plantations were established after World War II using a number of introduced timber tree species.
- Post-colonial development with an increase in the number of tree species and provenances as well as the number of planting locations.

Although accidental introductions (e.g. seed contaminants) have taken place throughout these four periods, many of the most noxious weedy species were introduced during the 20th century. Secondary introductions of plants within countries are poorly reported but must have been commonplace. Two East African examples and one from Malagasy illustrate this practice. *Prosopis* spp was introduced to Kenya on more than one occasion by private individuals (seed sources are reported to have been from Hawaii and Brazil). In one instance it was done in order to increase farm productivity. Then, secondary introductions were made by the Nightingale family of Njoro and Mr de

Haller (coastal Bamburi Cement quarry) to a number of locations along the Mombasa–Nairobi railway line, and to Mrs Roberts at Lake Baringo (Nightingale, 1981). Lake Baringo is now heavily infested with the tree and has received much media attention in recent years. The Kenyan Government and FAO have been blamed for the introduction in 1980, resulting in a court case (e.g. Mawathe, 2006), suggesting that the species was planted at least on two occasions near the lake. In the 1990s, farmers from Central Ethiopia heard about the usage of *L. camara* as an effective field boundary (common practice in parts of the tropics, (Howes, 1946)) and obtained the shrub and planted it to protect their crops from their grazing animals (Binggeli and Desalegn Desissa, 2002). An *Opuntia* taxon (probably *O. monacantha*) was introduced into southwest Madagascar to defend a French fort from attack by the natives. The local tribes rapidly realized the potential usage of this plant as a live-fence, and a source of food and water, subsequently spreading the cactus to much of southern Madagascar, and by 1900 this plant dominated much of the southern Malagasy countryside (Binggeli, 2003a).

The majority of plant species that are now spreading in tropical Africa and the surrounding islands have been introduced intentionally and purposefully from one biogeographical region to another. A few notable exceptions among the woody plants include *Clidemia hirta* in Madagascar (Cabanis et al, 1969) and many agricultural weeds such as *Parthenium hysterophorus* (CABI, 2005). The history of introductions of woody plants is better documented than that of other life-forms. The purpose of introducing those species that have become invasive is broadly similar to the rest of the world, in decreasing order of importance they are: amenity planting; forestry; agriculture; landscape management; and botanic collections (see Binggeli, 1996 and Binggeli et al, 1998 for details). In many instances secondary unintentional introductions by humans have spread woody species within new biotic regions. This section illustrates the diversity of purposes involved in plant introductions.

Agriculture

Especially during the exploration and conquest of the world by western European powers, essential vegetables were planted wherever they would grow and fruit trees were widely dispersed. Scores of introduced species were planted to provide impenetrable hedges to keep livestock in or out of fields or demarcate field boundaries (Howes, 1946). Many species were introduced for various agricultural purposes including as foodstuff for livestock, preferably with both foliage and fruit being edible, for example *Prosopis* spp to East Africa (Pasiecznik et al, 2001) and *Azadirachta indica* in West Africa (Judd, 2004). Some weeds 'followed' crops as they were dispersed across the planet (e.g. weeds with rice from Asia to Africa, (Alpern, 2008)). More recently, germplasm exchanges between agricultural institutions, at both the national and international level, have favoured the spread of these species (Dantsey-Barry, 2003).

Although we do have a satisfactory chronology of when crop species were introduced (Alpern, 2008), the pathways of introductions are rather sketchy.

Some unusual examples include the introduction of *Chromolaena odorata* to West Africa to control weedy grasses, but *Imperata* spp in particular (Chevalier, 1952). It is alleged that a European planter introduced the weedy *Rubus mollucanus*, called 'vigne marrone' (wild vine), from Réunion to Madagascar because he mistook it for a grape vine (Koechlin et al, 1974).

Traditional uses

The introduction of plants for traditional uses, such as medicinal and religious practices, has received scant attention in the literature. Morat (1972) reported that the seeds of *Albizia lebbeck*, introduced from Asia via Mauritius in 1814, were widely used in divination (Sikidy) in western Madagascar. The use of plants for spiritual and medicinal purposes is central to the practice of Candomblé, a religion of the Yoruba that originated in West Africa and brought to Brazil with the slave trade; leading to the translocation of plant species across the Atlantic. The return of first-generation slaves to Africa is thought to be responsible for the introduction of now widespread neotropical species, such as *Sida rhombifolia*, *Petiveria tetrandra* and *Solanum paniculatum* (Voeks, 1990).

Wood production and environmental management

Exotic species have always fascinated people and the term exotic has often conveyed a degree of superiority. Research funding was easier to obtain to work on exotics than on indigenous species and among foresters the word exotic can become a deciding factor in choosing species. Practical considerations have also been important, such as lack of knowledge of native species and ease of propagation and establishment of fast-growing trees in plantations (Zobel et al, 1987; Persson, 1995).

Numerous woody species were introduced throughout the 20th century in the large-scale planting of trees for timber production (Richardson, 1998) and experimental plots involving scores of species were established at many forestry stations (e.g. for Madagascar see Binggeli, 2003b). Species that tolerate low rainfall, heat and poor or saline soils have been widely used in the dry tropics to halt desertification. In more recent decades the emphasis has shifted from forest timber trees to agroforestry species. Woody legumes have been widely introduced to tropical Africa and the reasons for the introduction of these taxa have been to supply fuelwood, prevent desertification, restore degraded lands, and provide fodder to livestock. More recently, the provision of food for humans to complement existing agricultural production has been a further aim (Harwood et al, 1999). Forestry introductions have occasionally resulted in the translocation of non-forestry species. Seeds of *Chromolaena odorata* were inadvertently introduced into southeast Nigeria from Sri Lanka in 1936–1937 during the importation of *Gmelina arborea* seeds to establish timber plantations (Moder, 1996).

In the East Usambara Mountains (Tanzania), an IUCN conservation project included the demarcation of forest reserves to prevent forest encroachment.

In order to make the demarcation clear, use was made of noticeable exotics including species known to be invading the natural forest, and species such as *Cedrela odorata* were planted (Binggeli et al, 1998). In some regions seeds of various tree species, including the weedy *Acacia dealbata* in Madagascar, were broadcast over large expanses of the landscape from the air (Le Bourdiec, 1972).

'Botanic gardens' and amenity planting

Large numbers of ornamentals have been widely introduced to much of sub-Saharan Africa. These introductions were carried out by botanic gardens, missions and a large number of private individuals (see Binggeli et al, 1998 for further details). Botanic gardens, which were originally chiefly concerned with the introduction of economic plants, were established in a number of European colonies mainly in the 1890s. These included Limbe, formerly Victoria, (Cameroon), Fouta-Djalon (Guinea), Eala (Congo), Lagos and Calabar (Nigeria), Entebbe (Uganda), Amani (Tanzania) and Tsimbazaza (Madagascar). Pineapple on the oceanic island of Mauritius was established much earlier in 1729. In every instance some of the planted species began to spread into the surrounding vegetation and the case of Amani Botanic Gardens has been closely examined (Dawson et al, 2008). Many of these undertakings have been largely forgotten and have sometimes vanished and this West African example illustrates this point. In 1908, the Dalaba Garden (in former French Guinea) was established with the planting of around 950 species and six years later a tree nursery was planted with forest species originating from Indochina. At the onset of World War I both sites were abandoned and by 1947 the gardens had disappeared, whereas the tree nursery had grown into a small forest. The structure and species composition of this stand was similar to a southeast Asian forest and many of the species were reported to be regenerating in the undergrowth (Adam, 1957). A botanic garden near Toliara in southwest Madagascar is protected from cattle intrusions by a dense and slowly spreading live fence of *Opuntia ficus-indica*.

Countries dominated and populated by the British, such as Kenya, rapidly built up a large catalogue of extensively planted exotics (see Jex-Blake, 1934). However, urban ornamentals have been planted throughout Africa's urban areas. In rural areas, trees such as *Azadirachta indica* have been planted in villages for shade (Judd, 2004).

Scientific

Although scientists rarely write about their motives and the historical perspectives of their work, some facts can be gleaned from the literature. The French botanist Auguste Chevalier wrote a paper on human roles in the dispersal and spread of tropical plants (Chevalier, 1931), and regarded *Chromolaena odorata* as a weed (Chevalier, 1949), yet he recommended its introduction to West Africa in order to control weedy grasses (Chevalier, 1952). The exchange of contaminated crop germplasm between research institutions appears to have led to the spread of weedy species (Dantsey-Barry, 2003).

Impacts on humans

Rural communities

In rural Africa, some species have become dominant over large areas and have a number of significant impacts, often both deleterious and beneficial to local communities. Severe negative impacts on humans are usually widely reported but other effects tend not to be so widely known.

A major feature of the majority of the most invasive species is that they form impenetrable monotypic stands and often thrive thanks to human-induced disturbances. Furthermore a number of taxa may be spiny, as in many woody plants, or have deleterious health effects. Thus, a number of species do have some highly negative and widespread effects on rural populations. Dense mats of *Eichhornia crassipes* greatly hinder or even prevent boating by fishermen and may halt fishing altogether. Transport of goods on Lake Victoria was seriously hindered during a massive bloom in 1994–1995 (CABI, 2005). The dense stands of thorny and prickly *Opuntia* spp and many other thorny taxa prevent access to large areas of the countryside in semi-arid zones. Paths situated in stands of prickly shrubs, such as *Lantana camara* and *Rubus* spp, require regular maintenance to keep access open (Binggeli et al, 1998; CABI, 2005). Thorns of various species may readily cause punctures to bicycle tyres.

A number of species can be poisonous to livestock. Ingestion of *Lantana camara* fruits may result in the death of cattle and sheep. In Kenya, varying impacts have been reported following the ingestion of *P. juliflora* pods by livestock, including diarrhoea, toxic reactions and even death (Anttila et al, 1993; Anon., 1997). Both thorns and hairs *O. monacantha* induced intestinal inflammation in Malagasy cattle, often resulting in death (Binggeli, 2003a). Local people from Kenya's Baringo region claimed that *P. juliflora* seeds stick to goats' gums, eventually causing their teeth to fall out. They marched a toothless goat into court to demonstrate their case (Mawathe, 2006).

Some invasive species favour the spread of taxa that can be highly detrimental to humans. The tree locust (*Anacridium melanorhodon arabafrum*), a major pest in Africa, and hitherto not a problem in the Lake Turkana region of Kenya, was found to be feeding on *Prosopis juliflora* introduced in the early 1980s. The subsequent spread of the shrub has given this potentially devastating pest the opportunity to become established in the area (Anon., 1997). In Madagascar, *Opuntia* infestations became refuges for a number of mammal species, introduced rat species in particular (Binggeli, 2003a).

A number of widespread species that become dominant in the landscape produce masses of fruits which are highly sought after by humans. The shrubby tree *Psidium guajava* is often considered a pest, but its fruit is highly valued. In Mauritius *Psidium cattleianum* smothers the vegetation of the National Park, yet it is the focus of large-scale fruit-collecting by thousands of people and fruit vendors. The monetary value of fruit sold by about 1000 traders over a six-month period was estimated to be around US$3 million per season (Pappiah, 2001). In the drier region of Madagascar *Opuntia* fruits are often the only ones found in local markets and are viewed as a key food by

local human populations. Prior to the eradication of *Opuntia monacantha* in the 1920s, local tribes were also dependent on this cactus for water for much of the year (Binggeli, 2003a).

Some invasive species provide resources that are exploited by livestock and sometimes harvested for future use. Pods of *Prosopis juliflora* are collected and stored for feeding livestock by some Kenyan tribes where the shrub is prevalent (Anttila et al, 1993). Many invasive species are viewed as important to bee-keeping as they attract large numbers of bees (e.g. *Prosopis juliflora* in Kenya, (Gichora, 2003)). *Azadirachta indica* appears to have clear insecticidal properties beneficial to farmers (CABI, 2005).

In West Africa the grass *Imperata cylindrica* is a field weed and Chikoye et al (1999) found that over 80 per cent of farmers had to manually control the grass three to four times per season to sustain crops. The appearance of new species may result in a shift in farmers' behaviour, in most instances increasing the amount of weeding. With the appearance of *Chromolaena odorata* the traditional slash-and-burn practices could not be sustained and novel agricultural practices had to be initiated (Hauser and Mekoa, 2009). In other cases local people's reluctance to clear weeds may lead to land-use changes. As soon as *Lantana camara* became a noxious weed on the eastern coast of Madagascar, the local Betsimisaraka people preferred to abandon infested areas rather than clear land smothered by the shrub's spiny and intertwined stems (Binggeli, 2003c).

Forestry and erosion

A number of invasive tree species can provide timber products. However, the timber and wood value of invasive trees varies widely. In Malawi the timber of *Pinus patula* is worth only 5 per cent of the native *Widdringtonia cupressoides*, which it is displacing. Small tree species such as *Psidium cattleianum* in Mauritius, *P. guajava*, a neotropical species invading much of the tropics, and *Prosopis juliflora* supply valuable firewood, especially in regions that have suffered from acute deforestation (CABI, 2005). Some shrubby species have an impact on forestry operations, access to plantations and natural forests may be seriously hindered by shrub species such as *Lantana camara* and *Rubus* spp. Natural regeneration of native trees and young plantations can be suppressed by *Lantana camara* and *Chromolaena odorata*. *In* some mountainous regions of Tanzania and Mauritius the presence of *L. camara* and *Rubus* spp was once viewed as a good erosion-preventing ground cover (e.g. Strahm, 1993).

Public health

Some introduced species are a cause for concern and threaten public health. As many invasive species are thorny and form extensive impenetrable thickets, their sharp spines often puncture people's skin and increase the likelihood of infections. The wind-blown fruit hairs of *Opuntia monacantha* caused lung problems and conjunctivitis (Binggeli, 2003a). The fruits of a number of species are edible, but in some cases they can create health issues and/or even

be fatal. The unripe fruits of the ubiquitous *Lantana camara* eaten by children have resulted in some fatalities (CABI, 2005). Pods of *Prosopis juliflora* have been found by Kenya's Turkana people to be a tasty food that has, at times, caused stomach problems (Anon., 1997). The seeds appear to vary greatly in palatability or even toxicity and this resource can only be described as famine food. Pollen and debris (trichomes) of *Parthenium hysterophorus*, a species rapidly spreading in East Africa, has been reported as causing severe allergenic reactions. In India *Parthenium*-contaminated animal feed led to tainted milk that causes Indian childhood cirrhosis (CABI, 2005).

Indirect health effects are also well reported. In Tanzania *L. camara* thickets provide breeding grounds for tsetse flies infected with trypanosomes of domestic animals, so the species is considered a serious health threat (CABI, 2005). By promoting stagnant water, *Eichhornia crassipes* favours mosquitoes and other insects as well as snails, and these can propagate serious and widespread diseases such bilharzia, filariasis and malaria (CABI, 2005).

Since the 19th century introduced plants have been used by specialist and non-specialist African healers and include invasive species such as *Argemone mexicana*, *Datura stramonium*, *Lantana camara*, and *Solanum mauritianum* (Dold and Cocks, 2000). Introduced and invasive species can represent a substantial proportion of the plants used in traditional medicine (e.g. for Madagascar see Pernet, 1957, 1959; for West Africa, Burkill, 1985–97; Alpern, 2008). However, many of these species have been introduced only a few decades ago and it is generally unclear how these plants should be identified for the cure of particular ailments. In South Africa, Dold and Cocks (2000) reported recent new usage of introduced plants and concluded that African traditional healing is dynamic. In most cases information relating to the use of new species came from family members and for one specialist four species were identified by means of promoting dreams! Much remains to be understood about how a recently introduced plant species gains an important role in traditional health care and whether they actually provide any health benefit.

Perceptions of introduced and invasive plants

Although academic journals give the impression that invasive plants are chiefly, and sometimes only, a concern of scientists and conservationists, the grey literature and the media reveal that society has, at times, great interest in these issues. Cultural and political aspects of non-native species and their effect on people's perception, including that of scientists, are sometimes important and the following reported examples will illustrate this point.

Species names

Vernacular names assigned locally to new species give a good indication of people's perception of their status (Table 13.1). *Chromolaena odorata* has been given many names in tropical Africa and this reflects the species speed of spread and negative impacts on countryside, often using political leaders for inspiration.

Table 13.1 *Examples of common names of invasive plants referring to their weediness*

Scientific name	*Common name*	*Meaning*	*Region*	*Source*
Chromolaena odorata	Achearnpong	Military head of state	Ghana	Timbilla and Braimah (1996)
Chromolaena odorata	Adiawuo	Killer	Ghana	Timbilla and Braimah (1996)
Chromolaena odorata	Woafa me fuo	You have taken my farm	Ghana	Timbilla and Braimah (1996)
Chromolaena odorata	Wo amma me gye	I am taking over if you are not coming	Ghana	Timbilla and Braimah (1996)
Chromolaena odorata	Bokassa	Ruling president	Central African Republic	Loumeto (1998)
Chromolaena odorata	L'envahisseur	The invader	Cameroon	Baxter (1995)
Chromolaena odorata	Oiabantou	Toxic	Congo	Banil and Le Gall (1996)
Chromolaena odorata	Rawlings	Species' forceful growth recalls Rawlings' repeated seizures of power	West Africa	Loumeto (1998)
Lantana camara	Curse of India	Indicates a pest introduced from India	East Africa	Pratt and Gwynne (1977)
Solanum verbascifolium	Fiente de sauterelle or Kondogbo	Grasshopper's excrement	Sierra Leone	Portères (1959)

Rural populations

There appears to be a clear tendency for rural populations to favour the planting of introduced trees. They are seen as faster growing and requiring less maintenance. Many species are also viewed as unpalatable by livestock and thus more likely to survive. When Judd (2004) was trying to grow native species in Gambia some incredulous farmers remarked 'Why do you grow these? We already have them!' In much of rural Ethiopia there is no tradition of growing trees from seeds and farmers will then readily buy seedlings of easily grown exotics (Binggeli, pers. obs.). Farmers do not differentiate between native and introduced weeds, but rapidly identify and assess new weeds. In West Africa, *Imperata cylindrica* and *Chromolaena odorata* are widespread invasive plants of agricultural land and are ranked, respectively by 50 per cent and 39 per cent of farmers, as the two most important weeds (Chikoye et al, 1999). Around Lake Victoria surveys identified a number of important effects of *E. crassipes*

on lake-shore communities. The main social effects were difficulty in accessing water points, increase in vector-borne diseases, and migration of communities. Reduced fish catches, increase in transportation costs, and difficulties in water extraction were perceived as the main negative economic consequences of the weed (Mailu, 2001).

Campaigns to educate the public have been initiated for some time. After World War II a poster with the bold caption: 'Wanted for stealing the land! Kill Lantana on sight' was circulated in southern Africa. In 2009 posters entitled 'Warning! Dangerous weed invasion – Uproot and destroy it on spot!' could be seen here and there in Uganda. They also warned the population against the deleterious properties of *Parthenium hysterophorus*. These belated campaigns are initiated when the introduced species is beyond the point of eradication and probably have no impact on the course of the invasion.

City-dwellers

Little can be gleaned about city-dwellers' perception of invasives from the literature. One exception is the importance of *Psidium cattleianum* to people on Mauritius. The species is ubiquitous in the green parts of the island and, when it bears fruit, it provides Mauritians an opportunity to visit the countryside and gather ample delicious fruit. Not only does it provide a sought-after food, it also turns into a major family occasion that often results in massive traffic jams.

Media

A decade before biological invasions became a global issue the *Maesopsis eminii* invasion of the Est Usambaras made the front page of the Tanzanian *Daily News*. Two articles provided a good popular account of the issues relating to the tree invasion of an important biodiversity site (Mwalubandu, 1989a, b). When *Prosopis juliflora* became a widespread weed at the turn of the millennium it made headlines in newspapers and radio programmes in much of Africa and Europe. Some of these headlines are more sensational than factual (Table 13.2), though no different from an article entitled '*Chromolaena odorata*: The benevolent dictator?' written by and for biologists (Norgrove et al, 2008).

The scientific community

Interest in invasive species stems back to the mid 19th century (de Candolle, 1855), yet most scientists neglected this topic until the 1980s. In the 1950s, 'ecologists worked mainly in natural systems, often avoiding human-modified systems and alien organisms as if these were "noise"' (Richardson, 2000) and many phytosociologists have maintained this tradition much longer. Until quite recently invasive plants have received greater attention in Anglo-Saxon countries than elsewhere. This emphasis reflected differing scientific traditions relating to the perception of vegetation as well as scientific method. Scientists' perceptions of introduced species and of the impacts of invasives have varied

Table 13.2 *Selected media headlines depicting the spread of invasive plants in Africa*

Prosopis juliflora	
Kenya's imported dream tree becomes a nightmare.	*Mail and Guardian*, 16 April 2006
Devil of a problem: the tree that's eating Africa.	*The Independent*, London, 2006
Saviour shrub turns killer.	*Kenya Times Magazine*, 2006
Au Kenya, l'arbre miracle est devenu fléau.	*La Libre Belgique*, 19 April 2005
Killer weed hits Kenyan herders.	*BBC News*, 7 August 2006
Goats: heroes of drought-stricken Africa.	*The Times*, 18 February, 2006
Residents file fresh suit over 'toxic weed'.	*The East African Standard* (Nairobi), 24 August 2006
Namibia: alien trees pose invader problem.	*The Namibian*, 27 July 2006
Chromolaena odorata	
Acheampong weed is killing Ghana.	*Accra Mail*, 14 October 2002

widely and appear to be strongly affected by their area of biological specialization and background.

In conservation circles invasive species are widely viewed as deleterious additions to ecosystems. However, in countries such as Ethiopia, where biodiversity is highly threatened by wood harvesting and deforestation, the spread of invasive harvestable woody species could be viewed as an potential answer to prevent species extinction (Ensermu, pers. comm., 2001). In Madagascar invasive plants were only viewed as a problem if they were deemed to be harmful to human activities and especially if they were economically detrimental (Perrier de la Bâthie, 1928). Carrière et al (2008) found that 37 per cent of people involved in nature conservation in Madagascar had no opinion on the subject of bio-invasions or thought they were not a problem. On the other hand managers of conservation areas considered invasive species a major issue but were unable to take action as the official policy of National Parks is to allow nature to take its course. NGOs were considering what to do about the problem, but thought it not to be significant because they consider invasions to occur only in disturbed areas, hence outside protected areas.

The eradication of *Opuntia monacantha* from southern Madagascar in the early 20th century caused a major controversy and has been the focus of renewed interest in recent years. Three reviews of the subject have resulted in differing conclusions probably reflecting the researchers' respective backgrounds and training (see Middleton, 1999; Kaufmann, 2001; Binggeli, 2003a).

Much of nature conservation focuses on taxonomic groups that are attractive to the public, such as most bird and many mammal species. In order to enhance the prospects of rare species, habitats are managed in order to build up their populations. In some cases invasive species are recognized as

supplying resources deemed to be essential to threatened species. In Kenya lantana thickets provide shelter, now readily available in a human-dominated countryside, to a threatened bird species Hinde's Babbler (*Turdoides hinduei*) (Njoroge and Bennun, 2000). Presumably Kenyan bird conservationists would now view lantana most favourably. A Malagasy lemur species can spend up to 95 per cent of its time looking for fruits of the invasive *P. cattleianum* and the control of the tree could be detrimental to lemurs (Carrière et al, 2008). In southern Madagascar Long and Racey (2007) suggested that plantations of exotic species may viewed as a keystone resource for endemic fruit bats. It appears that researchers involved in single taxa conservation may overlook the issues of ecosystem conservation by focusing on the value of an invasive to their subject of interest.

Agroforesters have generally viewed the natural spread of woody plants into semi-natural vegetation and highly degraded habitats as a bonus (Richardson et al, 2004). Baumer (1990) stated in reference to Africa that, 'one would be only too happy in certain very degraded, not to say denuded, regions to find an invasive plant with as many qualities as *Prosopis*' and this view is largely supported by others (e.g. Coppen, 1995). These authors were also of the opinion that the spread of *P. juliflora* had to be checked in some areas to prevent any negative spread through good management (i.e. 'necessary precautions'). Similar statements have often been made in the agroforestry literature (e.g. BOSTID, 1980); however, workable guidelines have never been provided to indicate how 'good management' could be achieved and more importantly how 'necessary precautions' could be defined and successfully implemented. As highlighted by Mack (2008) agroforestry researchers knew that the species they were promoting were a hazard, but still favoured their introduction, and the current interest in biofuel crops appears to suffer from the same issues. Furthermore, most authors have largely ignored the environmental and human impacts of spreading agroforestry species. In the Sudan the spreading *P. juliflora* was viewed as having a great potential for rural people and became a key component of agro-ecosystems, and it was actively promoted. 'The natural spreading of this exotic tree species can be viewed as of great value in areas empty of natural vegetation and common in Sudan today' (El Fadl, 1997); and the author hoped 'that the results of this work will be of benefit to mankind'. Within a decade the emphasis had shifted to containing the weed's spread. The invasive potential of *Prosopis* species has long been known and this issue was ignored when the taxa was considered for large-scale planting in Africa. In Kenya *Prosopis* taxa were widely informally used and planted along the coast and inland throughout the 20th century. It became a major focus of an agroforestry project in the Bura region and it was rapidly realized that the shrub had strong weedy tendencies. Apart from a short note by concerned entomologists (Anon., 1997) the scientific community, and agroforesters in particular, did not confront the issue until this decade when forced by complaints from the general public that were widely reported in the media. In South Africa, a country faced with similar problems, Zimmermann et al (2006) concluded that, 'It is unfortunate that the agroforestry fraternity is not becoming more

involved in finding solutions to the problems that they have created and in preventing future invasions from new species.'

Traditionally, attributes such as ease of propagation and fast growth rates have been favoured in agroforestry species selection. However, any detailed species specific descriptions of desirable traits are unusual. A recent, well described example was *Acacia colei* identified as the most promising species among a number of Australian taxa introduced to Niger. Harwood et al (1999) identified the most significant traits of *A. colei* as:

- prolific seeding;
- early fruiting (from age of two years onwards);
- foliage that is unattractive to livestock.

They also noted that:

- The species grew well on disturbed sites.
- It was self-fertile.
- Genetic changes could lead to high-yielding individuals.
- To reduce costs direct seeding would be an advantage.

They were aware of the invasive issue and swiftly dealt with the risk of invasiveness by stating that:

- Many of the useful plants in the region 'were also exotic at one time.
- Australian acacias do not sucker, seldom regenerate naturally from seed under Sahelian conditions, and have shown no ability to spread as weeds in the 20 years following their introduction to the Niger.

The view that *A. colei* will not become troublesome because it has shown no sign of spread after 20 years since its introduction is misguided. Most introduced woody plant species that have become invasive exhibit a time lag between their introduction and subsequent spread, typically in the tropics of between 40 and 70 years (Binggeli, 2001b). The duration of these time lags is determined by:

- biotic factors (e.g. change in grazing regime or dominant herbivore species, introduction of pollinator);
- abiotic factors (e.g. unusual and large disturbance events such as hurricane, flood, logging).

Another important factor is the issue of secondary introductions. When a species is first introduced to a region in a habitat inappropriate for natural regeneration (e.g. botanic gardens, trial plots) and is subsequently moved intentionally or accidentally to a habitat favourable to the species spread, it may become invasive (Binggeli, 2001b). In fact, the positive traits identified by Harwood et al (1999) are indicative of a high invasive potential and are

widely reported in the literature. This suggests a lack of awareness of these basic ecological facts among agroforesters.

At the onset of the 21st century the extent and impacts of the *P. juliflora* invasion on the drier regions of Kenya were revealed to the world via the media (Table 13.2). Yet the spread of the species had been well-known by agroforesters for over a decade and had been widely commented upon in 1993 in a special issue of the *East African Agriculture and Forestry Journal*. In fact, the whole scientific community failed to take notice and consider what may happen in the future. In the African literature there appears to be only one clear report of an individual identifying a species that could become troublesome and that required immediate action. Perrier de la Bâthie (1928), a leading Malagasy naturalist denigrated by Middleton (1999) as the 'peripheral amateur', identified *Eichhornia crassipes* as a potential threat to the freshwater bodies of Madagascar two decades after its introduction as an ornamental. His advice to eradicate the species was not heeded and by the late 20th century *E. crassipes* became an obnoxious weed (Binggeli, 2003d). This call for action, in view of the threat of potential extensive spread by a species, is in stark contrast to the widespread current advice for species monitoring.

Conflicts of interest

Clearly many invasive plants have both beneficial and deleterious effects on humans and of course often have major negative impacts on biodiversity. In many instances the conservation of biodiversity can only be successful if the invasive species is controlled and preferably eradicated. This is readily conceivable as long as the invader does not have any clear benefits. From the above review it is clear that a substantial number of invasive plants in Africa have benefits for some human groups. Various stakeholder groups will value a particular species differently. Conflicts of interest arise between those groups that want to either control a nuisance or maintain a precious resource. Species that produce vast quantities of edible or valuable fruits (*Opuntia* spp, *Psidium* spp, many legumes) will have supporters (e.g. farmers, fruit traders, single-species conservationists) who will object to the control of the weed, whereas for others, such as *Parthenium hysterophorus*, few or no objections will be made. For widespread invasive plant eradication is impossible and sustained control can potentially be achieved only through the introduction of biological control agents. These agents often target fruit and/or seed production and such a course of action will prove impossible where plants are highly valued for their fruits. For woody plants primarily used as a source of fuelwood this will not be an issue but may not be effective (e.g. for a South African programme; see Zimmermann et al (2006)). Other control methods include the use of the species in novel ways. In Mauritius, a project was envisaged to use *Psidium cattleianum* wood from the National Park to generate electricity (Pappiah, 2001).

Species with both positive and negative impacts, such as *Chromolaena odorata*, which are perceived differently in different locations and by different stakeholder groups, are more difficult to deal with. Many compromises have

to be made to try to bridge the gap between conflicting opinions. The likely outcome will be more a change in people's habits and traditions than a serious and effective control programme. In the case of C. *odorata*, it was suggested that if the species' positive effects on soil fertility in fallows proved to be correct the promotion of this plant with small-scale farmers might even be considered (Baxter, 1995).

In many instances conflicts of interest are most likely to arise between conservation priorities and local priorities. *Senna spectabilis* is considered a threat to the Gombe National Park and attempts at controlling it have been made. A recent survey of villagers adjoining the park revealed that *Senna* spp were the fifth most frequently listed tree taxa; it is a valued firewood (Chepstow-Lusty et al, 2006), and it is most unlikely that villagers would condone the disappearance of the resource unless an alternative were provided. Kull et al (2007) and Carrière et al (2008) have extensively discussed the conflicts of interest associated with *Acacia* species and *P. cattleianum* in Madagascar.

Conclusions

Introduced and invasive plants in tropical Africa have many facets. This review shows that the history and causes of introductions and people's perceptions of invasive plants as well their impacts are highly variable. For most of the poor rural Africa, where focusing on day-to-day survival is often the sole concern for much of the population, the status and origin of species is of little importance. In fact rural people's only concerns are the beneficial and deleterious effects of plants, whether they are native or not. People rapidly accept new species if beneficial and when confronted with undesirable plants they quickly try to make use of them. In parts of rural India, when confronted with serious environmental problems, villagers rely on outside help and development assistance has, as is traditionally the case, focused on the introduction of alien plants, even when the indigenous population is aware of the limited merit provided by the new species (Binggeli, 2001a). All these aspects have been studied too little in Africa and warrant further attention.

Conflicts of interest between various sectors of society are inevitable. Sharp differences of opinion and perception exist as to the value of a particular plant within the agricultural sector. A species may be viewed as a weed in large commercial monocultures whereas it may be perceived to be beneficial in traditional small-scale agriculture (and vice versa). Among conservationists similar conflicting points of view also exist. More difficult to solve are going to be those conflicts of interest between conservationists, applied scientists, horticulturalists and more particularly rural populations. As African countries are likely to face drastic changes in their social fabric and economic structures these conflicts of interests are likely to change in line with changes in perception and usage of introduced species. These changes have already been observed in the developed world but how extensive this might be is unclear as only anecdotal evidence has so far emerged (Binggeli, 2001a). In Africa woodfuel harvesting is extensive but will this resource be used as extensively in

future? If harvesting of wood for fuel decreases, perception of invasive woody species used for that purpose may well change radically.

The introduction of many plant species has been essential to the development of modern societies and the survival of many rural communities, yet too many species with major deleterious effects have been intentionally introduced to tropical Africa. These introductions have been carried out with little concern for potential problems that they may cause. Wherever a species started spreading, no action was taken until the plant had become a major pest; by that stage any hope of eradicating the problem would have vanished. The introduction of ornamentals via the horticultural trade has hitherto been limited compared to developed countries. How to prevent the introduction and spread of ornamentals introduced as well as the unintentional spread of seeds of weedy species is a major challenge facing Africa. Aid projects have to demonstrate the need for and long-lasting beneficial effects on human societies of introducing and promoting new species in the African tropics. It is also obvious that risk assessments should be mandatory for new introductions to a country and the translocation of rare or uncommon introduced species known to have invasive tendencies within a country. Above all more emphasis should be placed on enhancing the potential value of native species and plant communities, and providing environmental management systems appropriate to local conditions. This would help combat future negative impacts of invasive exotics.

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