The human dimensions of invasive woody plants

Pierre Binggeli

Abstract

This review of the human dimensions of invasive woody plants investigates the history and purposes of introductions, people's perceptions of alien and invasive species and the impact of invasives on human activities. A perusal of the literature indicates that all aspects of the human dimensions of alien woody plants are highly varied and some are still poorly documented. Changes in the usage of species over time as well as conflicts of interest in relation to species introduction and biological control show that alien woody plants cause social and economic problems and conflicts related to human activities. These problems interact with a variety of human activities and these issues need to be addressed with care.

Introduced woody plants

Woody plants have undoubtedly been transported by humans for millennia and were an essential component of early agricultural societies. Indeed, many regions of the world, and oceanic islands in particular, would not have been colonised without the introduction of various crops, many of which were woody plants. In these early societies woody plants were a source of a wide array of basic materials as well as food. In more recent centuries the type of species translocated has shifted with an ever-increasing proportion being ornamental plants.

Over the past two centuries many species have started to spread in their introduced ranges. Until relatively recently the majority of introduced woody species have been highly beneficial, if not essential, to humanity's development, but now ever-increasing numbers of species are becoming detrimental to the maintenance of the earth's biodiversity and to the well-being of human societies. This chapter attempts to unravel the relationships between humans and woody plants by looking at the changes in the introduction of species, the way they are perceived by different human groups and the impact these invasive species have on human activities. Finally, key examples illustrate how socio-economic factors and species utilisation may vary through time and that conflicts of interest between different groups often are inevitable.

Historical perspective of plant introductions

The history of woody plant introduction is closely linked with that of transportation and the European exploration of the planet (16th–19th century) (Crosby, 1986). At various times in European history some individuals greatly enhanced the discovery and introduction of new species. For instance, in Britain Joseph Banks was instrumental in the setting up of Kew Gardens as a major centre for economic plants and in promoting plant prospecting (O'Brian,

1987). Each colonial power established major botanical gardens and experimental stations in various parts of the world, first in the home country and on tropical islands, later in 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. Finally, during the latter part of the 20th century the importance of ornamental species increased dramatically, especially to the more developed and wealthier regions.

The timing and nature of species introduced vary in various parts of the world, as illustrated by tropical Africa and the Pacific islands. In tropical Africa four main phases of woody plant introductions may be recognised (Binggeli *et al*., 1998):

- Early exploration and slave trade during which time a few fruit tree species were planted at a number of coastal locations.
- Early colonial period when at the end of the 19th century a number of experimental gardens were established by missions and private individuals. These were followed by several major botanic gardens established by the respective colonial powers in the 1890s. These gardens specialised in testing economic exotic plants 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 species and provenances as well as the number of planting locations.

In the Pacific, Polynesians introduced many economic woody plants prior to European colonisation (Bevacqua, 1994; Barrau, 1967). Throughout the European exploration of the Pacific, seeds of economically valuable species were introduced to visited islands and expeditions were even mounted to collect valuable food plants such as the breadfruit, *Artocarpus altilis* (O'Brian, 1987). Even captains of navy ships would introduce seeds of edible species and instruct indigenous people how to grow them (Porter, 1986). In the 19th century economic gardens were established at a few locations (e.g., New Caledonia, Gargominy *et al*., 1996) and in the 20th century botanic gardens with the purpose of establishing exotic ornamental plants were established (e.g., Tahiti, Meyer, 1994).

Purpose of introductions of woody plants

With the exception of a very few species, such as *Clidemia hirta* in Madagascar (Cabanis *et al*., 1970), primary introductions of woody plants have been intentional. That is, the transport of a species from one biogeographical region to another was carried out with a particular purpose and these are reviewed below. Once introduced to a new region, many of these species have been spread un-intentionally by humans within the new biotic regions. These secondary introductions are chiefly of species with small seeds (e.g., *Miconia calvescens*) accidentally transported by vehicles or soil, or clonal species (e.g., *Fallopia japonica*) moved with soil material. These instances will not be discussed here.

The purpose of introduction of species which have become invasive is in decreasing order of importance: amenity (about half of the reported cases); forestry; agriculture; landscape; and botanic gardens (see Binggeli, 1996 and Binggeli *et al*., 1998 for details). This section aims to illustrate the diversity of purposes involved in species introductions.

Agriculture

Especially during the discovery and conquest of the world by western European powers, fruit trees were widely dispersed around the globe. Many species were introduced as foodstuff for

livestock, for example *Prosopis* spp. to Kenya (Anon., 1997a) with both foliage and fruit being edible. In the USA *Lonicera japonica* provides emergency winter grazing for cattle (Blaisdell, 1967). The introduction of *Chromolaena odorata* to West Africa was recommended to control weedy grasses, particularly *Imperata* spp. (Chevalier, 1952). It is alleged that a planter introduced the weedy *Rubus mollucanus*, called 'vigne marrone' (wild vine), from Réunion to Madagascar because he mistook it for the grape vine (Koechlin *et al*., 1974).

Forestry

Throughout the 20th century the large-scale planting of trees for timber production has been one of the main reasons for the introductions of a large number of species, especially conifers (e.g. *Pinus* and *Picea* species) and eucalypts, throughout the temperate and tropical regions (for details see Richardson, 1998). Introductions of woody species for fuelwood production, such as *Prosopis* spp., has been common in developing countries (e.g. Kenya, Anon., 1997a; India, Gold, 1999).

Environmental

Erosion control has been a common reason for the introduction of plant species in many parts of the world. This practice was very widespread in the USA and species like *Cytisus scoparius* (Blaisdell, 1967) and *Pueraria lobata* (Koopowitz and Kaye, 1990) were widely planted by government departments such as the Civilian Conservation Corps. Species providing a rapid and thorough cover such as *Lonicera japonica* and *Pueraria lobata* have been favoured but these have become major pests (Williams, 1994). In Hawaii *Rhizophora mangle* was introduced to stabilise coastal mudflats (Allen, 1998). *Elaeagnus angustifolia* was commonly planted as a windbreak and *Lonicera japonica* was planted by game managers for wild deer (Blaisdell, 1967). In countries such as Britain shrub species such as *Symphoricarpos albus*, were introduced to provide ground cover for game birds (Gilbert, 1995).

Amenity and botanic gardens

Ornamentals have been widely introduced in every part of the world. In the past, botanic gardens and individuals were responsible for these introductions. In 1833 the English botanist R.T. Lowe introduced *Solanum mauritianum* to Madeira and this species is now widely naturalised (Press and Short, 1994). *Lantana camara* was introduced to Sri Lanka at the request of the wife of the British consul who had been positively impressed by the plant when she visited Brazil (Guenther, 1931). Botanic gardens in all parts of the world have been responsible for the introduction of a large number of species and in every case species have started to spread into the surrounding vegetation (e.g. *Acacia dealbata* in southern France, Gams, 1967; *Lantana camara* in New Caledonia, Gargominy *et al*., 1996). Directors of some of these botanic gardens, which were originally chiefly concerned with the introduction of economic plants, were keen collectors of exotic ornamentals (Binggeli *et al*., 1998; Gargominy *et al*., 1996).

Scientific

Scientists themselves may sometimes be responsible for species invasions. For example, a field scientific experiment set up to investigate salt excretion of various plants at Mission Bay (California) in the late 1960s resulted in a thriving population of the small tree *Avicennia marina* a decade later (Moran, 1980).

Although the French botanist Auguste Chevalier regarded *Chromolaena odorata* as a weed (Chevalier, 1949) and had written a paper on man's role in the dispersal of tropical plants (Chevalier, 1931), he nevertheless recommended its introduction to West Africa to control weedy grasses (Chevalier, 1952).

Some scientists consider that the introduction of threatened plants from one oceanic island to another is a tool of conservation worth considering only with the greatest caution (Waldren *et al*., 1995).

Warfare

Woody plants were introduced and planted to camouflage military installations in many parts of the Pacific during World War II. The Japanese planted *Leucaena leucocephala* to hide fortresses on the Ogasawara (Bonin) Islands (Pacific) and the American military used *Ulex europaeus* on the Puget Sound to protect gun placements from attacks. Both species have since spread (Paterson, 2000). In earlier times, navies of various maritime nations introduced many plants and animals to remote islands as future food sources. During the war between the USA and Britain, for example, Captain David Porter (1986) of the US Frigate Essex reported that in 1813 he was planting seeds of a variety of plants, including citrus fruits, in native villages of the Madison's Island (Pacific).

The Dalaba Garden in the former French Guinea was initiated in 1908 with around 950 species being planted and a nursery was also established in 1914 with forest tree species originating from Indochina. When the two Europeans in charge were mobilised at the onset of First World War both the gardens and the tree nursery were abandoned and by 1947 the former had disappeared whereas the latter consisted in a small forest. The structure and species composition of this stand was similar to a south-east Asian forest and many of the species were reported to be regenerating in the undergrowth (Chevalier, 1947).

Traditional uses

Little is known about the introduction of woody plants for traditional uses, such as medicinal and religious practices. Under-reporting is likely to be a cause for the dearth of information. *Protasparagus* sp. is said to have come to Norfolk Island in the 1930s in a bridal bouquet (Macrae, n.d.). Shaw (1994) has reported that *Abrus precatorius*, a non-invasive leguminous climber from India, was introduced to Britain by the Asian community. Although its seeds may cause death when eaten, they are traditionally used as a potent contraceptive. *Sorbus aucuparia* is valued, particularly in Ireland and the highlands and islands of Scotland, for its protective powers (Vickery, 1995) and it is likely that this small tree was introduced to New Zealand and North America, where it is spreading, for its magical powers rather than its ornamental value. The seeds of *Albizia lebbeck*, introduced from Asia via Mauritius in 1814, are widely used in divination (Sikidy) in western Madagascar (Morat, 1972).

People's perception of exotic and invasive woody plant species

From a perusal of the scientific literature it would appear that issues relating to invasive woody plants are chiefly, and sometimes only, the concern of scientists and conservationists. In this section a number of examples are given to illustrate the importance of invasive woody plants to indigenous people and also to document how these populations view the problem. Cultural and political aspects of non-native species and their effect on people's perception of invasive species, including that of scientists, are also addressed.

Plant names

Local names of introduced woody plants are varied and are often imported with the plant. However, in many instances the plants are named after the person who first introduced them. For instance, *Cordia sebestena* is commonly called the Geiger-tree after John Geiger, an early

19th century ship pilot, who first planted this tree at Key West in Florida (Little, 1979). Other names reflect a fact relating to the introduction, such as the chicken tree (*Sapium sebiferum*) which used to be commonly planted around chicken coops in Louisiana, USA (Jubinsky and Anderson, 1996).

Woody species which have become serious weeds have been given names which clearly reflect their pest status and also often point at the name of the person responsible for the introduction of the plant (Table 1).

Table 1 Examples of common names of woody plants referring to their weediness.

Common name	Scientific name	Region	Source
Burbank's folly	*Rubus discolor*	Pacific Northwest	M. Edain (pers. comm. 2000)
Koster's curse	*Clidemia hirta*	Fiji	Paine (1934)
Ellington's curse	*Acacia farnesiana*	Fiji	Howes (1946)
McConnel's curse	*Gleditsia triacanthos*	Australia	Anon. (1997b)
Curse of India	*Lantana camara*	East Africa	Pratt and Gwynne (1977)
L'envahisseur	*Chromolaena odorata*	Cameroon	Baxter (1995)
Devil's fig	*Solanum torvum*	Papua New Guinea	Chadhokar (1976)
Fiente de sauterelle or Kondogbo	*Solanum verbascifolium*	Sierra Leone	Portères (1959)

Rajasthan

In Rajasthan *Prosopis juliflora* is called 'vilayati bambul' and often simply referred to as 'vilayati', 'foreign' while the native *Acacia nilotica* is known as 'desi bambul'. It is said that to unpractised eyes they look very much alike, but the latter species often fails to regenerate while the former has become a weed. Gold (1999) has investigated the cultural history of a rural village community faced with environmental change in an arid part of the Indian sub-continent. The region has suffered from massive deforestation and *P. juliflora* has become the only source of fuelwood for the local population. The older generations remember clearly what their environment used to be like, while young people are not fully aware of the changes that have taken place.

Local people's perception of *P. juliflora* is that the species has averted a serious fuel shortage but has been accompanied by several negative effects:

- it colonises agricultural land and is hard to remove;
- its thorns cause dangerous infections;
- the thorns play havoc with bicycle tires;
- the leaves are unappealing to goats;
- in its shade no grass or crops will grow.

Children as well as adults can evaluate the merits of *P. juliflora* compared to that of native trees and the changes that have occurred. Much of the area used to be covered with native trees which local people believe used to increase rain, whereas now *P. juliflora* is dominant. Much of the hills used to be covered by *Anogeissus pendula*, an excellent firewood, and this species was thornless. Village people often contrast *A. nilotica* with its multiple uses to *P. juliflora* which is only good 'for burning'. They know that goats eat the seed pods and new trees sprout from their dung, thus the species needs no human assistance, whereas most species of native trees must be protected from livestock and watered for several years. Locals believe that trees have souls but people need to cut trees to survive; however it is not a sin to cut *P. juliflora*. A young girl was

reported as saying that it is not a sin to kill a poisonous animal (e.g. snakes) and that the same applies to the foreign tree.

At first *P. juliflora* was found around a nearby town and later started to spread out, and then it was extensively planted by the Forest Department. At the time of its introduction the tree was welcomed as a field boundary. However, people rapidly became aware that the species had fewer positive assets when compared to native species and they have associated the "foreign" tree with a reduced quality of life. Yet in 1993 a Japanese-funded aid programme to improve India's environment was established in the village to propagate and plant over 20,000 *P. juliflora* on the hilly wastelands. Gold reported that no one opposed the project and that the school ran the tree nursery and the planting work was cheerfully carried out by local women.

Polynesia

Over the past two centuries the people of the small and remote island of Pitcairn (South Pacific) have struggled to scratch out a living despite isolation and environmental unpredictability. In order to improve their chances of survival, all new plant species which would either enhance their agriculture or provide ornamental flowers lacking on their island, have traditionally been welcomed to the island. In the process they have introduced many plants, pests and diseases. Many individuals have been fully aware of the problem and the Pitcairn situation has been vividly depicted in 1962 by Roy Clark, one of the island's long-term residents. Incidentally, Clark's perception of the invasive problem was far more accurate than that of the scientists who visited in the early 1990s (Binggeli, in press). Despite this awareness that introductions, without screening and proper quarantine, will lead to the spread of undesirable aliens, the local people have failed to curb their traditional inordinate fondness for introducing new plant species to the island.

Their perception of the status of introduced species is different from that of conservationists. In recent years Pitcairners have not considered *Lantana camara* as a major weed, as conservationists have done, but believed the shrub to be a soil improver. On the other hand the tree *Syzygium jambos* is viewed as a major pest, not because of its impact on the native flora and fauna, but rather because of its heavy shading and its spreading, shallow and dense rooting system which renders cultivation of gardens an arduous task. The weed status of a species relates to the way it interferes with day to day activities and will change through time as society develops (Binggeli, in press).

Probably due to the lack of 'photogenic' flowering plants two series of Pitcairn stamps produced by the Island's administration, based in New Zealand, have prominently featured the island's key invasive plants.

The recent *Miconia calvescens* invasion of the Pacific island of Tahiti (French Polynesia) has been rapid and dramatic and has received considerable attention from scientists, conservationists and the media. The public has been given much information relating to this major weed which affects mainly the ecological integrity of the island rather than people's day to day activities. Statements in Table 2 show that the population's understanding and views of the problem are highly varied. Tahitians using the countryside are clearly aware of the impact of the tree whereas others are poorly informed despite widespread publicity campaigns carried out by local authorities. These media efforts have included newspaper articles, TV programmes and a poster campaign entitled "Miconia, le Cancer Vert" (Miconia, green cancer).

Table 2 Views about and perception of *Miconia* by Tahitians (J.-Y. Meyer, pers. comm., 2000).

Informant	*Comment*
Teenager	"I thought it was a native plant, I have always seen it everywhere"
Horticulturist	"what a nice plant"
Old person	"all the fe'i [*Musa troglodytarum*] have disappeared in this valley since the arrival of *Miconia* in the 1970s"
Pig-hunter	"what a pest"
Middle-aged woman	Thought the small tree was a vine until she saw it on TV
Middle-aged man	Refused to carry a potted *Miconia* because he didn't want to catch some bad disease after noticing the poster entitled "Miconia, le Cancer Vert"

On the distant and rarely visited Island of Rapa the introduced *Rubus rosifolius* was first collected in 1926 (Meyer, 1998). In 1947 it was reported that "The Rapans think they are a prickly nuisance" (Johnson and Johnson, 1956).

Media

In recent years invasive woody plants have gained much coverage in the media. Many articles have been published in newspapers and magazines. In view of the problem caused by biological invasions, this is welcomed, although sometimes the way the subject is reported may be cause for some concern. Newspaper and magazine publishing is becoming increasingly competitive and the trend is to promote stories with a high profile and especially those that are highly controversial. Stories about aliens obviously fit the requirements of modern media (see Table 3 for examples) but there is a danger that the message sent out to the public misrepresents the problem at hand.

Table 3 Striking article titles in newspapers and popular magazines.

Newspapers
I think that I shall never see a thing as deadly as a tree (Villano, 1988)
Popular magazines
The on-going battle against aliens (Anon., 1983)
South Africa's other bush war (de Selincourt, 1992)
Creeping invasion of the "green cancers" (Wicht, 1971)

In Britain the public view of *Rhododendron ponticum* invasion and control is influenced by how the media portrays and interprets the situation. Despite being provided with briefings and literature by the Snowdonia National Park, newspapers often publish articles that misinform the public (Gritten, 1987) and the debate is commonly muddled up by the transfer of anthropomorphic concepts to plants (Binggeli, 1994a).

Foresters and horticulturists

Foresters only view an introduced woody plant as a weed when it starts interfering with silvicultural operations, especially when access by machinery and personnel becomes more difficult or when young plantations are suppressed. In Britain some foresters view *Rhododendron ponticum* as weeds while others do not. The species is not considered to be a major problem in plantation forestry although afforestation will not be carried out on areas infested by *R. ponticum* (Gritten, 1987) whereas it is viewed as a serious problem in the management of native woodlands (Tabbush and Williamson, 1987). In Northern Ireland the shrub *Rubus spectabilis* is now spreading into some conifer plantations and is considered to be a problem by the local foresters. Yet other foresters in Northern Ireland are not aware of the potential problem and when told about it they tend to dismiss it as a localised issue.

Different countries have very different approaches and views on exotic woody plants. The contrast among foresters and horticulturists between Britain and Germany is striking. In Germany the great majority of foresters are aware of the invasive problem whereas only 40% of managers of urban green areas are aware of this issue (Kowarik and Schepker, 1998). Indeed German foresters will not use exotic species and are very particular in their choice of provenances (Binggeli and Rushton, 1999) whereas landscapers will favour non-native species and provenances. Some academics have even suggested that the bias in favour of native species and against aliens is a continuation of Nazi policies (Groening and Wolschuke-Bulmahn, 1992). In Britain the converse is true, especially among foresters, who basically seem to have no interest in native species.

Conservationists

It is well known that conservationists dislike or even hate introduced woody plants. There are, however, a few instances where an invasive woody plant, if it can be kept well under control, becomes a positive asset. In Ireland the shrub *Hippophae rhamnoides* forms monotypic stands on coastal dune systems. A belt of this impenetrable thicket is kept and regularly contained between a nature reserve and a caravan park. This prevents various types of unwelcome holiday-makers (e.g. yobs, lager louts, and frolicking couples) from entering and damaging the reserve (D. Riley, pers. comm.).

Scientists

Although the interest in invasive species stems back to the mid-19th century (de Candolle, 1855), scientists generally neglected the issue until the 1980s. Differences in scientific traditions relating to the perception of vegetation as well as scientific methods have meant that greater emphasis has been placed on invasive woody plants in Anglo-Saxon countries than elsewhere. 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. Indeed in Brazil, despite a large number of invasive plants, scientists have no interest in plant invasions (S. Ziller, pers. comm., 2000). In Madagascar, throughout most of the 20th century, invasive species were only viewed as a problem if they were deemed to be harmful to human activities but especially if they were economically detrimental (Perrier de la Bathie, 1928).

Even when plant scientists have investigated invasives they have often failed to perceive the problem properly. In relation to the time-lag between the introduction, the spread and the pest status of an introduced woody plant, the reasons behind the failures and successes in detecting and understanding these time-lags have recently been identified (Binggeli, in press) as follows:

Failures:

- poor natural history skills and inability to understand species autecology in relation to ecosystem dynamics;
- lack of historical research and of the 'grey' literature in particular;
- poor use of local knowledge. Either this knowledge is not used or scientists misunderstand what locals are saying.

Successes:

- good knowledge of the ecosystem and of the flora in particular;
- regular monitoring;
- good historical records;
- learning from experiences in other regions;
- chance.

Western societies

More materially developed societies have had many more opportunities to introduce alien woody plants and more time to ponder about them. This is in sharp contrast with developing countries where day-to-day survival often is the sole concern of a large proportion of the population. The populations of developed countries are highly fragmented into a large array of traditions, opinions, beliefs and political views so that this section can only provide a glimpse of the broad spectrum of perceptions and views relating to invasive woody plants found in the 'Western world'.

In western Europe alien species which were introduced several centuries ago and which have become widespread have amassed a substantial amount of plant-lore. In Britain and Ireland *Acer pseudoplatanus* has been linked with many customs including the traditional May Day festival and in Scotland it became the favoured tree for hangings (Binggeli, 1993).

Much of the western world has become totally ignorant of natural history and the lack of public awareness of plant invasion has been documented (Colton and Alpert, 1998). One of the consequences of this ignorance is reflected in the inability to differentiate between native and alien species. For example, in Poland the 2 Grosze coin depicts the foliage of the American *Quercus rubra* instead of native oak.

Nowhere else than Britain is the mix between politics, ethics and culture so striking and this results in an array of contrasting and often highly controversial views (e.g. Moore, 1992 and Evans, 1996). Any word, action or view regarding introduced species becomes rapidly heavily loaded (Binggeli, 1994a) and renders rational discussions about biological invasions nearly impossible and more importantly prevents action to control invasives.

Adventurers and travellers

When reliable and based on good field observations, accounts by adventurers and travellers bring to light some interesting snippets of information. The Johnsons sailed around the world several times and occasionally made short, but precise, comments about invasives in their publications. For instance in 1947 they reported "the change in the island growth since a blight had killed orange and lemon trees and guavas had spread like wildfire" on the Galapagos Island of Floreana (Johnson and Johnson, 1956).

Sometimes major omissions occur. In 1987 during a Pacific trip the natural historian Andrew Mitchell spent some time on the island of Moorea and extensively reported the problems associated with the invasive African snail (Mitchell, 1989). Yet he failed to notice the invasive and highly conspicuous tree *Miconia calvescens* which by the early 1990s was recorded as covering substantial areas of the island (Meyer, 1994).

Impact of invasive woody plants on human activities

This section reviews the impact of introduced and invasive woody plants on human activities. This review is not exhaustive but is intended to demonstrate the broad spectrum of human activities that may become affected positively or negatively by non-indigenous species. In general, the majority of introduced species which have become invasive have been reported to have both positive and negative impacts on human activities, but from the reported impacts on human activities it would appear that the majority of invasive species exhibit more deleterious than positive impacts. Unless otherwise stated, all information is based on species accounts found in Binggeli *et al*. (1998).

Agriculture

In many parts of the world, but especially the tropics, grasslands are invaded by introduced woody plants and reduce the livestock carrying capacity of these pastures and sometimes make livestock farming uneconomic in places (e.g. *Acacia nilotica* and *Mimosa pigra* in northern Australia, *Psidium guajava* in Fiji and *Ulex europaeus* in many temperate and tropical regions). Some, like *Lantana camara*, are also poisonous, resulting in the death of cattle and sheep. Horses lose their hair when feeding on *Leucaena leucocephala* as both foliage and edible seeds contain the amino acid mimosine which is toxic in large quantities. Toxicity and even death in livestock has been reported in Kenya from pods of *Prosopis* spp. (Anon., 1997a).

Tree locust (*Anacridium melanorhodon arabafrum*), a major pest in Africa, and hitherto not a problem in the region of Lake Turkana (Kenya), was found to be feeding on *Prosopis* spp. These trees were introduced in the early 1980s and within a decade have covered large parts of the region and thus have given a chance to this potentially devastating pest to become established in the area (Anon., 1997a).

A number of widespread species are weeds in agricultural lands (e.g. *Chromolaena odorata*, *L. camara* and in Fiji *Clidemia hirta*). In the Marquesas Islands farmers consider *Leucaena leucocephala* as an agricultural weed which is nearly impossible to uproot completely. Similarly on Pitcairn Island the dense and extensive root mat produced by mature *Syzygium jambos* trees is detrimental to shifting agriculture or in agroforestry systems. Species such as *Clidemia hirta* may also hamper the development of plantations (cocoa, rubber).

In northern Australia *Mimosa pigra* has a detrimental effect on fishing as it restricts access to waterways to fishermen.

Many invasive species have some economic value as a food source. In India, thickets of *Prosopis juliflora* harbour many bee hives and nearby villagers extract the honey (Sharma, 1981). Species such as *Melaleuca quinquenervia* in Florida and *Syzygium jambos* appear to be important sources of nectar and pollen to the beekeeping industry. In the case of *M. quinquenervia*, its nectar and pollen are important for maintenance and the build-up of colonies, however its flavour is unpleasant and if present in a proportion higher than 5% in *Citrus* honey it makes the latter unsalable (Morton, 1964; Robinson, 1981). Species infested with aphids produce large quantities of honeydew which is readily gathered by bees often resulting in honeys with unpleasant flavours (Morton, 1964). *Acer pseudoplatanus* flowers when there is a dearth of ripe flowers in the British countryside and has therefore been ranked among the 13 most important pollen sources for bees (Howes, 1945). Many other invasive species are also visited by bees and they are claimed to be of value to bee-keepers but their importance has yet to be demonstrated. Some species are clearly unsafe sources of nectar or pollen as they may kill the bees or the resulting honey may be more or less toxic to humans as in the case of *Nerium oleander* (Morton, 1964). The fruit of *Passiflora mollissima* is widely grown and sold in New Zealand, but it has no economic value in the tropics. The fruit of *Psidium guajava* is highly valued yet in many regions the shrub is considered a pest.

Forestry

Numerous shrubs and woody vines interfere with forestry operations, especially with plantations. In New Zealand the vine *Passiflora mollissima* is a major problem, particularly following logging, and the shrub *Buddleja davidii* may outcompete newly-planted conifers. In the tropics both *Lantana camara* and *Chromolaena odorata* may be a problem and the former may even over-run young plantations. Tree health surveys in Northern Irish woodlands where the undergrowth is dominated by dense stands of invasive shrubs may take three times as long to carry out than on uninfested sites. The undergrowth hinders access to tree trunks as well as obstructs the view of their canopies, both of which need to be visually examined for fungal attacks (P. Blackstock, pers. comm., 2000).

Access to older plantations and natural forests may be seriously hindered in both the temperate (e.g. *Rhododendron ponticum* in Britain and Ireland) and tropical zones (*Lantana camara*). In Indian sandalwood forests *Lantana camara* not only competes with the tree crop but also favours the spread of the sandal spike disease.

The timber and wood value of invasive trees varies tremendously. In Malawi the timber of *Pinus patula* is worth only 5% of the native *Widdringtonia cupressoides*, which it is displacing. In Jamaica, the Australian *Pittosporum undulatum* is preferred by locals for firewood and may have potential as a source of timber. In many regions *Psidium guajava*, a neotropical species invading most of the tropics, supplies valuable firewood. In parts of the Indian Thar Desert the central American *Prosopis juliflora* may supply up to 90% of the villagers' fuelwood requirements as well as much of their needs in construction wood (Sharma, 1981).

Natural regeneration of desirable IAS is often viewed as positive by foresters. Alternatively natural regeneration of an exotic tree may be used to produce timber whenever control attempts have failed. In the northern French forest of Compiègne *Prunus serotina*, a North American tree introduced as game cover, has been steadily spreading in logged areas. Having failed to suppress the species, local foresters have decided not to combat it anymore. Now, they try to produce a harvestable crop as sawmillers do not differentiate between the timbers *P. serotina* and the native *P. avium* (Décant, pers. comm., 2000).

Leisure activities

In many parts of the world invasive woody plants tend to form monotypic stands which typically make the countryside less accessible to the public. Some species simply form dense stands which are difficult to walk through (e.g. *Casuarina equisetifolia*) but many are covered with sharp spines and render access impossible (e.g. thorny varieties of *Lantana camara*, *Rubus* spp.). *Ulex europaeus* even produces a persistent spiny litter. In northern Australia *Mimosa pigra* restricts access to waterways. A few tree species (*Syzygium jambos*) have the opposite effect as they suppress both the ground vegetation and shrub layer, thus favour access by humans.

Species forming monotypic stands will also seriously alter the physiognomy of the landscape. However the impact will vary depending on the values and judgements held by the observer as well as his/her perception of nature. A shift from grassland to woody vegetation, for example, readily diminishes the view. Similarly the spread of a shrub in forested landscapes (e.g., monotypic shrub layer of *Rubus spectabilis* in Irish broadleaf forests) dramatically alters the view experienced by visitors. The spread of *Acacia nilotica*, native to the Indian peninsula and much of Africa, may have an impact on the number of tourists frequenting the Baluran National Park (Java, Indonesia) as most visit the park to view large herds of herbivores in open grasslands. On the Cape sand plain of South Africa the alien acacias, unlike the low native fynbos vegetation, obscure the punters' view of racecourses (McDowell *et al*., 1991).

More subtle effects are produced by differences in foliage shape and size as well as colour and this is clearly illustrated by *Miconia calvescens* in the Pacific. At the time of flowering,

Rhododendron ponticum is perceived as a key landscape feature of Wales by a large proportion of the British public.

Urban areas

Introduced trees may cause a greater physical hazard to the public and property than native species. In Florida *Casuarina equisetifolia* is considered as a public safety hazard. During hurricanes the fall of this tall tree (up to 30m) can damage property or block evacuation roads. In northern areas frost-killed trees become a nuisance due to the fall of branches and crowns. In Hawaii the shrub *Clidemia hirta* grows densely along roadsides, thus increasing maintenance costs of verges.

Unwanted regeneration and vegetative spread is a serious problem in many urban and suburban areas throughout the world. Some trees become established on buildings making them unsound. Other species become established along roadways and pavements or spread vegetatively, damaging road surfaces (e.g. *Ailanthus altissima,* Newton, 1986). Elsewhere seedlings of introduced species become established in public areas and private gardens (e.g. *Acer pseudoplatanus* in Britain and *Schinus terebinthifolius* in Florida) which is unwelcome and increases maintenance costs. When establishment occurs along property boundaries in sub-urban areas this sometimes results in serious disputes. An extreme example from Britain illustrates the potential problem. The non-native, but non-invasive, Leylandii (x *Cupressocyparis leylandii*) is widely planted as a hedge along property boundaries. When uncut the plants rapidly grow into tall trees resulting in boundary disputes, house subsidence and in many instances court cases. These disputes have resulted in much unhappiness, bankruptcies and even murder, and legislation is to be passed to allow local authorities to forcibly cut down the offending trees (Brown, 2000).

Much of the British public object to the tree *Acer pseudoplatanus* in urban areas because it produces much sticky honeydew which coats cars and park benches alike (Binggeli, 1994b).

Health, well-being and traditional medicine

A number of invasive species may be considered as a health hazard. In both temperate and tropical regions large quantities of air-borne pollen of *Ligustrum* spp. (Mowatt and Smith, 1983) and *Casuarina equisetifolia* cause respiratory irritations. In the close vicinity of habitations, both *Schinus terebinthifolius* and *Melaleuca quinquenervia* appear to cause respiratory difficulties in many people (Morton, 1969). Skin contact with leaves and the milky sap of *S. terebinthifolius* results in red, itching rashes.

Children are known to have died after eating unripe berries of the ubiquitous tropical shrub *Lantana camara*. Pods of two *Prosopis* spp. introduced to Kenya were found to be a tasty food by local Turkana people soon after the species started to spread. However, “the pods recently appear to have turned poisonous” and serious stomach problems have been reported (Anon., 1997a).

In Tanzania *L. camara* can be considered as a serious health threat, as its thickets provide breeding grounds for Tsetse flies infected with trypanosomes of domestic animals. *Psidium guajava* provides an excellent breeding ground for insect pests, whilst *Melaleuca quinquenervia* seems to repel mosquitoes.

In many parts of the tropics invasive species are rapidly taken up by traditional doctors and administered as medicinal plants (e.g. in Tanzania, Ruffo *et al*., 1989; West Africa, Burkill, 1985-97). However, the efficacy of these remedies is unknown.

Natural resources and processes

The spread of invasive species, especially those forming monotypic stands, may have important impact on resources essential to local communities (e.g. water, soil erosion) and natural processes which may endanger life and property (e.g. fire, flood).

Ulex europaeus invades watersheds which supply a substantial amount of drinking water. In South Africa it has been estimated that the water used by invasive trees resulted in a 7% reduction in the mean annual runoff, but locally this figure may be as high as 75% and the water-use of invading plants is more than twice that of commercial forestry (Versveld *et al*., 1998).

Some species increase fire risk. In New Caledonia the climbing stems of *Lantana camara* dry out following reproduction and the dead material falls to the ground, increasing fire susceptibility. The shrub *Ulex europaeus* represents a fire hazard to private property in some tropical areas. On the other hand *Ligustrum* spp. appear to have a low flammability (Mowatt and Smith, 1983).

In some mountainous areas (Tanzania, India, Mauritius) the presence of *L. camara* and *Rubus* spp. was once considered as a good erosion-preventing ground cover (e.g. Strahm, 1993).

It has been estimated that in southern Africa the production of fuelwood and charcoal using invasive stands of *Acacia cyclops* and *A. saligna* was worth several million US$ and provided a source of income to probably hundreds of thousands of rural families (Azorin, 1992).

Employment and welfare

In many parts of the world people have gained employment to investigate, manage and control invasive species. In the latter part of the 1990s over 20,000 South Africans have been employed by the Working for Water Programme which has not only given work to poor and disabled people but has also enhanced workers' skills and provided health advice to rural populations (Anon., 2000).

Temporal changes in socio-economic factors and species utilisation

The North American tree *Robinia pseudoacacia* has been widely introduced throughout Europe as a source of high quality timber and for erosion control. Some now regard it as a permanent member of the flora (Gams, 1967). The main uses of *R. pseudoacacia* have been somewhat variable in different parts of Europe and have changed over time. In parts of France and Switzerland the young coppice wood was extensively used in vineyards to support the vines (Monnier, 1992) but in recent decades it has been replaced by metal posts and wire, and now the species is hardly used. Although the tree produces a highly durable timber, it is disliked by German foresters because the wrong strain, a shrubby variety, was introduced to that country. In Hungary the tree has remained a key timber and is the main source of honey (Keresztesi, 1977). Even new uses for the groves of this species have recently been found. The Hungarian Formula 1 Grand Prix brings over 100,000 spectators once a year but also attracts hundreds of prostitutes whose trade, over the past few years, has disturbed the tranquillity of local villages. This has now been restored as the local *R. pseudoacacia* groves have been put to new uses (Thorpe, 2000).

On Pitcairn Island the fuelwood tree *Syzygium jambos* is now widely considered a problem. The main reasons for the spread of this species have been marked changes in the island's population and economy since World War II. The population has steadily declined (drop from around 150 to less than 50 inhabitants) and the source of heat for cooking has shifted from wood

to electricity. As a result much less wood is now harvested and the species has been able to spread.

Numerous species of exotic woody plants have been and still are introduced as ornamentals. The criteria for selection are often very narrow and may include just the ease of propagation and the speed of growth. Potential negative impacts are not considered before the plant is promoted. For instance in Florida *Bischofia javanica* was promoted in the 1910s but soon after its introduction it was discovered to be unsuitable as an ornamental because it grew too big, had large surface roots, its foliage was prone to diseases and it regenerated freely (Morton, 1984). It was also pointed out that it was difficult to kill, yet the tree was widely sold for decades before being rejected. Morton noted that *B. javanica*, with its lack of quality and suitability, was just a typical example of many mistaken introductions to Florida by the nursery and landscaping trade which were detrimental to property owners, the community and the environment.

Conflicts of interest

The value of an alien species may be different to different interest groups and conflicts of interest may arise and sometimes may affect human activities. These conflicts are particularly acute when the introduction of a species is proposed or when a biological control of an invader is considered.

For example, *Chromolaena odorata* is considered a pest in many countries by both conservationists and owners of plantation crops. A biological control programme of the weed has been initiated in Asia and in Australia a massive effort is being made to eradicate the plant from a few infested areas. Agriculturalists recently have suggested that *C. odorata*, although not a nitrogen fixer, may have positive effects on soil fertility in fallows. If this proves to be correct the promotion of this plant with small-scale farmers may well be considered (Baxter, 1995).

Management and prevention vs perceived benefits

In South Africa, where over the past couple of decades much effort has been put into controlling invasive plants, a number of heated exchanges have appeared in the literature. Arguments as to the benefits and costs of various invasive species to South Africa have pitted various types of conservationists against commercial interest groups such as foresters (Löckhoff, 1977) and the ornamental trade (Matthaei, 1999; van Sittert, 1999).

Biological control of IAS is sometimes opposed. For example, *Rubus fruticosus* agg. is an important environmental weed of south-eastern Australia and biological control has been instigated. Apiarists and berry canners opposed the release of a biocontrol agent (a rust) because they considered it a threat to their respective trade. At the same time managers of grazing lands threatened to illegally import the rust if the release programme was halted. An economic analysis found that the costs associated the blackberry were 40 times greater than the benefits. Before the conflicts were resolved the rust was recorded in Victoria (Field and Bruzzese, 1985). Many other examples of potential conflicts between the biological control of weeds, such as *Lantana camara*, and the beekeeping industry may be found in the literature.

Conclusions

The human dimensions of invasive woody plants reviewed above show that the history of introductions, the causes of introductions, and people's perceptions of invasive woody plants as well their impact are highly varied. Many aspects have been well reported but no exhaustive overview of woody plant introductions or of their impacts exists. The role of people's perceptions of invasive woody plants has been understudied and the few examples given above

clearly show that the topic is highly fragmented and deserves further study. Areas of investigation that deserve particular attention are the interactions between the media, the public and the scientists/conservationists, the views of indigenous people in developing countries, and the traditional uses of invasive woody plants. An area not addressed here is the importance of invasive woody plants in providing employment (e.g., woodfuel harvesting) and how this may affect local economies.

Some of the major implications of the variations documented in this review are:

- People's perceptions of an alien woody plant are based on their interest in and knowledge of their local environment. Communication and education are essential and great care must be taken to prevent the media from misrepresenting the issues.
- Conflicts of interest between various sectors of society are inevitable. In fact, even within interest groups (e.g. agriculture) sharp differences exist as to the value of a particular plant. An introduced plant may be viewed as a weed in large commercial monocultures whereas it may be considered to be beneficial in traditional small-scale agriculture (and vice versa).
- With the observed temporal changes in production and consumption, the value of an alien species to a particular interest group will change. Introduction of new species must take into account future changes in usage and demonstrate that detrimental impacts will be limited.
- When confronted with serious environmental problems local populations rely on outside help and development assistance traditionally focuses on the introduction of alien plants, even when the indigenous population (e.g. Rajasthan) is aware of the limited merit provided by the new species. Aid to developing countries clearly needs to thoroughly investigate the potential of native species and provide environmental management systems appropriate to local conditions.

The introduction of alien woody plants has been essential to the development of modern societies, but not enough care has been shown in identifying key positive impacts to justify many introductions. Furthermore, negative impacts have been largely ignored and these need to be addressed in order to avoid the disastrous impacts often observed, if future introductions are to have long-lasting beneficial effects on human societies. Instead of introducing alien species, whose long-term effects on humans are largely unknown, emphasis should be placed on enhancing the potential value of native species and plant communities.