COUSIN AND COUSINE ISLANDS

Status and Management of Alien Invasive Species

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COUSIN AND COUSINE ISLANDS– Status of Alien Invasive Species

1.0 Introduction

The introduction of non-indigenous species to new regions is an increasing problem worldwide (Holt and Boose, 2000). Long-standing natural geographic barriers to species dispersal have been overcome through intentional and unintentional human intervention, enabling species to arrive in environments never before possible (McNeely *et al*., 2001; Wittenberg and Cock, 2001; Clout and Veitch, 2002). Although only one in one thousand of these exotic species is predicted to successfully establish *and* become invasive in their new environment (the 'tens rule' - Williamson, 1996; Reaser and Howard, 2003), the impacts that these few impose are often severe. The adverse effects associated with invaders in agriculture and horticulture has long been recognized due to the considerable economic threat they pose to these industries (Dunbar and Facelli 1999). More recently however, the intrusion of exotics into natural environments has become an important environmental issue, with alien invasive species now recognized internationally as one of the most significant drivers of environmental change (Center *et al.,* 1995; Dunbar and Facelli, 1999; McNeely *et al*., 2001; Wittenberg and Cock, 2001). Invasions of introduced species are capable of altering the structure, function, species composition, abundance and consequently the long-term ecological integrity of native communities (Humphries *et al.,* 1991; Franklin *et al.,* 1999; Cronk and Fuller, 2001). They now rank as second to habitat destruction and conversion as a cause of species endangerment, extinction and consequently the global homogenization of biological diversity (Wilcove *et al.,* 1998; Cronk and Fuller, 2001; Reaser and Howard, 2003).

As numerous examples internationally can demonstrate, the impact of invasive alien species can be significant if left undetected or unmanaged. Every country has suffered at the hand of invasive exotic species and even the most well protected natural areas are not immune to their effects (Reaser and Howard, 2003). Well known destruction of the environment as a result of invasive alien species include: The large scale erosion resulting from overgrazing by the European rabbit (*Oryctolagus cuniculus*) throughout Australia, the dominant nitrogen fixing shrub *Myrica faya*, in Hawaii (ISSG, 2005), the alteration of native forests and animal communities from browsing and predation by brush tail possums (*Trichosurus vulpecula*) in New Zealand (Brown and Sherley, 2002) and the widespread impacts of the aggressive generalist foraging red fire ants (*Solenopsis invicta*) in the USA (ISSG, 2005).

The deleterious effects that can occur through the presence of invasive species are nowhere more evident than on the uniquely evolved and fragile ecosystems of oceanic islands (Whittaker, 1998). Approximately 80% of all known animal extinctions are island species and presently one in three of all known threatened plant species are island endemics (Whittaker, 1998). Islands are reported to be particularly susceptible to the impacts of invasion, typically representing a higher proportion of alien taxa than continental ecosystems. A number of reasons have been suggested for this, including: species poor vegetation (providing greater vacant niche space to be exploited by exotic species), the effects of isolation and the lack of exposure of native species to introduced species (e.g. leads to a loss of defensive behaviours and vulnerability to introduced predators), and the small size of island populations (making them prone to extinction). Small geographic size has also been implicated, as often there is a lack of physical features large enough to prevent exploitation, disturbance and introduction on an island wide basis. Other factors such as the ecological release of invaders from their natural enemies

and patterns of human exploitation have also been cited as increasing the impact of invasive species on islands (Whittaker, 1998; Cronk and Fuller, 2001; Kairo *et al*., 2005). Whatever the cause, direct and indirect competition of exotics with native species for resources and critical habitat can lead to rapid, severe and unconfined ecosystem alteration on island environments.

The Seychelles consists of a scattered group of 115 granitic and coralline islands situated in the Western Indian Ocean approximately 1600 km from East Africa and 1700 km from India (Stoddart, 1984). Like most island nations, the Seychelles is a biological hotspot, displaying a high degree of endemnicity (Hill *et al*., 2002a). Despite their isolation, the Seychelles have not escaped the impacts of invasive alien species. Acting in synergy with habitat destruction and human persecution (Millett *et al*., 2004), their consequences are readily detected. For example, natural forest no longer exist except as relic vegetation at the very highest of altitudes, 21% of Seychelles flora is now considered threatened (Kueffer and Vos, 2004), three endemic bird taxa are now extinct and eight of the remaining eleven are of global concern (Millett *et al.*, 2004). The accidental arrival of crazy ants (*Anoplolepsis gracilipes*), *Rattus sp*. and the intentional introduction and cultivation of species such as the domestic cat (*Felis catus*), the coconut (*Cocos nucifera*), cinnamon (*Cinnamomum verum),* and guava (*Psidium cattleianum*) on Mahe and other surrounding small islands can all be implicated in the range reductions, population declines and extinction of native species. They all provide clear examples of the potential impacts of invasive species in the Seychelles and provide important lessons for invasive species prevention and management (Fleischmann, 1997; Feare, 1999; Hill *et al*., 2002b; 2002d; 2003; Merton *et al*., 2002). Conservation of what now remains becomes paramount in protecting the biological diversity and individuality of the Seychelles environment.

Cousin and Cousine are two of the smaller islands comprising the granitic Seychelles, occupying an approximate area of 27 and 26 hectares respectively (Feare and Lloyd, 1972; Shah *et al*., 1999). Having once been extensive coconut plantations (Wright and Passmore 1999; Hill *et al*., 2002c), the islands have successfully regenerated with a diverse native vegetation that provides a sanctuary and important breeding ground for an array of sea and land birds to utilise (three are listed as critically endangered or vulnerable) (Shah *et al*., 1999; Schumacher and Wuthrich 2000; Hill *et al*., 2002c). Persistence of the rare and endangered populations can largely be attributed to the rat and cat free environment of both islands – a habitat attribute shared only by five other islands in the Seychelles. Cousin and Cousine islands are also home to the Aldabran Giant Tortoises (*Geochelone aldabrensis*), provide breeding grounds for species of marine turtles and are surrounded by extensive reefs that support a diversity of coral reef fish (Shah *et al*., 1999). Such attributes both singularly and in combination emphasize the unique and significant nature of the Cousin and Cousine environments. This was recognised officially in 1975 when Cousin Island and its surrounding waters was designated as a Special Reserve under the National Parks and Nature Conservancy Act, 1969 (Shah *et al*., 1999). In contrast, Cousine is a privately owned exclusive eco-resort, but with conservation as a principal element of management. In both cases, the importance of conservation activities is recognised not only in a scientific sense (i.e. management of biodiversity) but also for the economic benefits of possessing something that is unique. Revenues raised through eco-tourism greatly assist in the protection of the islands and consequently to this day, conservation and regeneration practices can and do remain highly active.

The presence and/or introduction of alien invasive species onto Cousin and Cousine poses one of the greatest threats to the state of environment, the other being the effects of climate change. Unfortunately, the threat of invasive species arriving on Cousin and Cousine is a very real one, due quite simply to the ease of dispersal of foreign organisms and propagules by vectors such

as human transportation, exchange of foreign goods and migrating/visiting birds (Wittenberg and Cock, 2001). In most situations, the arrival of new species is not something that can realistically be avoided. Even areas under vigilant supervision will occasionally have species slip through (Reaser and Howard, 2003). On Cousin and Cousine it is not realistic or possible to stop most pathways of entry, especially in the case of visitors where they provide an important source of revenue through eco-tourism to the islands (Shah *et al*., 1999). However, through basic awareness and education, monitoring regimes and some responsibility by those utilising the islands, the risk of introduction events can be significantly reduced (Macdonald and Wilgen, 2002). Whilst the small size and isolation of the islands appears detrimental in terms of ecosystem susceptibility to negative impacts, paradoxically it also provides managers with a great advantage when aiming to control and prevent alien species. Introductions can be more easily identified and monitored, the probabilities associated with re-infestation can remain low, and consequently eradication campaigns can prove successful in the long term (Mack and Lonsdale, 2002).

This report aims to outline the current status of alien invasive species on Cousin and Cousine Islands and examine the management and preventative practices currently used, highlight potential pathways for dispersal and introduction, and, where appropriate apply some broad recommendations to improve the current management of invasive alien species. Parts 2 and 3 will additionally highlight potential invaders to Cousin and Cousine that may arise from the invasive alien species present in the greater Seychelles, as well as other Indian Ocean island territories.

2.0 The Current Status of Invasive Species

2.1 Definition

An invasive species is one whose introduction, establishment and (often rapid) spread threaten ecosystems, habitats or species (CBD, 2002; Kairo *et al*., 2005). Many invasive species are alien (non-native, non-indigenous, foreign and exotic), having been deliberately or accidentally introduced to an area from their native range, or from another site of introduction.

2.2 The Status of Alien Species on Cousin and Cousine

The current status of invasive species on both Cousin and Cousine Islands is positive, with a low-level of species numbers and abundance. Few harmful species of flora or fauna are present, and species that have proven problematic in other regions of the Seychelles are not well, if at all, represented on either island.

The following section describes the invasive species of note existing on each island, their relative abundance and problems associated with their presence. Species have been broken into the following categories for ease of reference: invasive flora (weeds) and invasive avian, marine, invertebrate and mammalian fauna.

2. 2.1 Flora (Weeds)

Vegetation surveys previously conducted on Cousin and Cousine have documented a large number of exotic species; most likely remnant of deliberate introductions during the period the coconut plantation was active (Fosberg 1970; 1984; Bathe and Bathe, 1982; Hill *et al*., 2002c). 51.1% of Cousin's listed flora comprises introduced species (Hill *et al*., 2002c). No such official figure exists for Cousine, the number of exotic species represented is comparable (Schumacher and Wuthrich, 2000). However, this is misleading, as actual representation and abundance of these species is generally restricted, with native species the dominant vegetation cover on both

islands. For example, the coffee trees near Cousin's marsh, whilst appearing on the species list (as part of the 51.1%), actually comprise only two individual trees, and can not be considred weedy or invasive (they form part of the 'cultural' aspect of the Cousin tourist trail, to highlight the previous occupation and efforts to make the island procuctive).

Cousin and Cousine share a similar exotic flora, most of which has become a naturalised component of the vegetation and does not impact upon ecosystem function nor the restoration/conservation efforts conducted in recent years. Only a small number of species exist that have become or have the potential to become widespread and troublesome across the island (Schumacher and Wuthrich, 2000; Hill *et al.,* 2002c). Consequently it is these species that have become the focus of control by island staff.

Species identified as weeds on Cousin and Cousine Islands are listed in Table 1. Although the list appears extensive, few can be defined as truly 'invasive', whereby establishing expanding populations in undisturbed vegetation communities to the detriment of the native vegetation (e.g. the woodland and scrub habitats of Cousin and Cousine), or to the diversity of birds and invertebrates that utilise it. Such species include *Adenanthera pavonina, Casuarina equisetifolia, Cocos nucifera, Carica papaya, Asystasia gangetica*, and *Quisqualis indica* (Fleischmann, 1997; Schumacher and Wuthrich, 2000; Hill *et al.* 2002c; Schumacher and Kueffer, 2002). All have examples of being invasive elsewhere in the Seychelles and in some circumstances in other regions of the world (Fleischmann, 1997; HEAR, 2005; PIER, 2004). In addition to these plants, the wardens of Cousin and Cousine have identified a number of other encroaching species of concern. These include: *Canavalia canthartica, Stachytarpheta jamaicensis, Achyranthes aspera, Passiflora foetida, Alocasia macrorrhiza* and *Hymenocallis littorallis*. These are predominantly herbaceous species that have the tendency to form dense monospecific thickets, which can lead to the exclusion of native species (Schumacher and Kueffer, 2002; Kueffer and Vos, 2004).

Table 1
List of invasive species identified by the wardens of Cousin and Cousin Islands. (Adapted from *Hill et al*., 2002c)
Frequency: Abundant (>1000 individuals); Common (100-1000 individuals); Frequent (10-100 individuals); Occasional (3-10 individuals); Rare (1-2 individuals)

Species	Common Name	Presence on Cousin	Frequency	Habitat	Presence on Cousine	Frequency	Habitat
1 Achyranthes aspera	Chaff flower	Yes	Abundant	Plateau woodland	Yes	Abundant	Grassland, Beach Crest, Plateau Woodland
Adenanthera pavonina	Red sandlewood	Yes	Occasional	High woodland	Yes	-	-
Alocasia macrorrhiza	Pig yam	Yes	Frequent	Plateau woodland	Yes	Frequent	Plateau Woodland, High Woodland
Amaranthus dubius	Amaranth	Yes	Common	Plateau woodland	Yes	Common	Plateau Woodland, Beach Crest
Ananas comosus	Pineapple	Yes	Frequent	Cultivated/ settlement, Glacis	Yes	Frequent	Hill
Asystasia gangetica	Chinese violet	No	Abundant	Plateau grassland, Glacis	Yes	Abundant	Glacis, Grassland, Plateau Woodland
2 Bambusa vulgaris	Bamboo	Yes	Rare	Marsh	Yes	Common	Hill
Canavalia canthartica	Wild pea	Yes	Abundant	Plateau woodland	Yes	Frequent	Plateau Woodland
Carica papaya	Papaya/Paw Paw	Yes	Common	Plateau woodland	Yes	Occasional	Plateau Woodland
Casuarina equisetifolia	Australian Pine	Yes	Frequent	Beach crest	Yes	Rare	West Ridge
Cocus nucifera	Coconut	Yes	Frequent	Plateau woodland, High woodland	Yes	Frequent	Plateau Woodland
Datura metel	Thorn apple	Yes	Frequent	Plateau grassland	Yes	Rare	Beach Crest/Plateau
Gossypium hirsutum	Cotton	Yes +++	Frequent	Plateau woodland	Yes	Rare	Beach Crest/Plateau
Hymenocallis littoralis	Spider lily	Yes	Frequent	Plateau woodland	Yes		
Ipomoea macrantha		Yes	Frequent	Beach Crest	Yes	Occasional	Plateau Woodland/Beach Crest
Ipomoea pes-caprae	Beach morning glory	Yes – but not a pest			Yes **	Common	Grasslands
Kalanchoe pinnata	Leaf of life	Yes	Occasional	Plateau woodland	No	-	-
Lucaena leucocephala	False acacia	No	-	-	No +	-	-
Nephrolepis biserrata	Sword fern	Yes +++	Abundant	Plateau woodland	Yes +++	Abundant	High Woodland
Panicum maximum	Fatak grass	Yes +++	Frequent	Marsh, Glacis	Yes +++	Frequent	Hill
Passiflora foetida	Passionfruit	Yes	Frequent	High woodland	Yes	Rare	Plateau Woodland
Quisqualis indica	Rangoon creeper	Yes	Rare	Cultivated area	No	-	-
Riccinus communis	Castor oil	Yes	Frequent	Plateau woodland	Yes	Rare	Beach Crest, Plateau Woodland
Senna occidentalis	Stinking weed	Yes	Common	Marsh, High woodland	Yes	Occasional	Plateau Woodland
Sesbania cannabina	Sesbania pea	Yes	Occasional	Marsh	No	-	-
Stachytarpheta jamaicensis	Snakeweed	Yes	Common	Plateau woodland, Plateau grassland	Yes	Abundant	Beach Crest, Grassland
Striga asiatica	Asiatic witchweed	No	-	-	No +	-	-

** Regarded only as a pest in certain habitats that are being manipulated for bird conservation
+ Has been eradicated – listed for monitoring purposes only
+++ Not managed – encroachment should be monitored

Trees, woody shrubs and large lianas are generally thought to be a more significant invasion risk than herbaceous species (Cronk and Fuller, 2001; Hill *et al.,* 2002d), although Kueffer and Vos (2004) admit that there is a knowledge gap concerning herbaceous species and their potentially serious impacts on environmental values.

Table 2 briefly discusses the species mentioned above in addition to a few others in more detail. These species were selected due to their potential invasive status or currently being widespread and problematic on the islands.

Of the species listed in Table 1, these remain the primary focus of control on Cousin and Cousine. In this table they are further sub-divided as high and medium priorities. Criteria for prioritization were:

- invasiveness, (as demonstrated elsewhere);
- current and potential impacts on the environmental values; and
- potential to spread.

Available information concerning the invasive nature of these species was limited, and in most instances species described as invasive were not elaborated upon.

Table 2
List of major species of concern on Cousin and Cousine. Species have been prioritised as high or medium priority depending on their invasiveness, (as demonstrated elsewhere), current and potential impacts on the environmental values and their potential for spread.

COUSIN

Species	Status	Priority	Comments
Adenanthera pavonina	Potentially invasive	High	*A. pavonina* is an invasive tree species, circumtropically. It is tolerant of shade and limestone, it fixes nitrogen, produces ample bird dispersed seed and forms a soil seed bank (PIER, 2004). It has rapidly extended its distribution in the palm, lowland and intermediate altitude forests of Mahe and Silouhette and presently occurs on 14 of the 19 outer islands (Fleischmann, 1997; Kueffer and Vos, 2004). Until recently a small number existed in the plateau woodland of Cousin. **Control:** as a result of control, currently no mature trees exist. Whilst the main threat has been eliminated, regenerating seedlings and saplings still need to be removed.
Casuarina equisetifolia	Potentially invasive	Medium	Exhibiting high salt and drought tolerance, *Casuarina* trees can be very invasive of beach environments, colonising the beach crest and greatly altering the dynamics of this habitat. Stands are often monotypic with little growing beneath them (PIER, 2004). Several *Casuarina* trees line the beach crest of most of Cousin island. **Control:** although it is heavily utilised by some bird species, this species should not be allowed to regenerate and preferably at some time removed.
Cocos nucifera	Potentially invasive/ Widespread	High	Coconut palms are likely to be indigenous and have only become problematic since being deliberately introduced and cultivated in the inner regions of the island during the plantation era. As a result of control, mature individuals are now few, however saplings and seedlings remain abundant on the plateau. **Control**: the practice of removing coconuts and uprooting saplings should continue to ensure that they do not become a dominant part of the vegetation

			again.
Panicum maximum	Potentially invasive	Medium	Small populations are present in the glacis/high woodland environments. *P. maximum* is widely tolerant of many soils types and has become invasive across the Pacific/Hawaii region and Australia where it rapidly encroaches and out competes native species by creating a dense mat of rhizomes. This mat also creates a high fire risk (PIER, 2004). Potentially it could come to dominate areas of the glacis and marsh habitat to the exclusion of native species. **Control:** it should be removed while the population is still small and at a manageable level. At the very least, it should be actively contained and any encroachment monitored.
Passiflora foetida	Potentially invasive	High	*Passiflora* is a scrambling vine and is an invader of disturbed sites, where it forms a dense ground cover preventing or delaying the establishment of other species. A population is currently on the SW side of the island, a disturbed patch that was once predominantly *Asystasia.* **Control:** *Passiflora sp*. are highly invasive and therefore this vine should remain confined if not eradicated from this area.
Quisqualis indica	Potentially invasive	High	*Q.indica* is a semi-climbing shrub possessing heads of sweetly scented flowers. Introduced as an ornamental, it has shown invasive tendencies, climbing onto the crowns of *Ficus, Euphorbia* and *Pisonia* trees. Through vegetative propagation it has the potential to dominate large areas as it has in regions of Mahe and Praslin (Schumacher and Wuthrich, 2000). **Control:** currently it is confined to one location near the marsh where it is being managed with 'vigilant' herbicide (see section 4.1.2.1).
Achyranthes aspera	Widespread	Medium	*A. aspera* is the most ubiquitous species of Cousin, rapidly spreading through the plateau and occurring across almost the entire island. An erect herb~ 50cm in height, produces ample, hard barb-like seeds, that easily break from the infloresence and attach to clothing (Beaver, 1995). Typically excluded from closed canopy forests, it can form dense monotypic stands in disturbed areas or under partial shade and has the potential to close the understorey in these areas, out competing native seedlings and making the habitat unsuitable for certain native bird species of conservation concern (i.e. magpie robin). **Control:** needs to be addressed.
Canavalia canthartica	Widespread	High	The indigenous *C. carthartica* is a vigourous climbing species and is reported to be out of equilibrium with the Cousin environment since greatly expanding its range on the plateau after the severe storm of 2002 (Schumacher and Kueffer, 2002) (see later in this section). The climbing habit of *C. carthartica* smothers both the ground and the woodland trees that break under its weight. It also makes trees unsuitable for nesting birds and impedes seedling establishment of other native species (Schumacher and Wuthrich, 2000). **Control:** presently this is the main species of concern to Cousin staff due to its dominance on the plateau.
Carica papaya	Widespread	Medium	*C. papaya* has become well established on the plateau, particularly since the storm of 2002 (Schumacher and Kueffer, 2002). This is not considered a species of high concern, as it cannot shade out the native species (Hill *et al*., 2002c). It most likely competes with saplings however and is likely to support reduced numbers of invertebrate fauna that is beneficial for the native land birds. Fody's and sunbirds feed on fruit and nectar and are likely to aid in its dispersal. **Control:** due to its abundance and persistence in the woodland this species should be removed.

Stachytarpheta jamaicensis	Widespread	Medium	Although confined to more open regions, this species is abundant on paths throughout the island as well as the grassy areas of the houses and helipad. It is capable of rapidly forming monospecific thickets and creates a long-lived seed bank that making it a difficult species to control (PIER, 2004). **Control:** management of the species should remain active, particularly to keep areas of high traffic (the paths) clear of this species.
COUSINE			
Species	**Status**	**Priority**	**Comments**
Bambusa vulgaris	Potentially invasive	Medium	Propagating through vegetative means, bamboo is an invasive species that can rapidly out compete resident species and dominate large areas. This species has been controlled and the population reduced in size. **Control:** One patch is now confined to the lower region of the hill and should continue to be controlled.
Cocos nucifera	Potentially invasive/ Widespread	High	With the exception of the south of the island, few mature palms remain, however saplings are regenerating elsewhere. **Control:** removal of the seeds and saplings remains important and will be considerably easier whilst plants are small and their competitive effects much less.
Panicum maximum	Potentially invasive	Medium	This species currently occurs in two distinct populations on the side of the path to the residences. *P. maximum* is invasive elsewhere and could come to dominate larger areas. **Control:** These populations are apparently expanding and should be contained if not removed while still at a small and manageable level.
Achyranthes aspera	Widespread	High	*A. aspera* has been very dominant in the beach crest area where *Casuarina* trees have been removed and the grassland areas of the north and south points. **Control:** This species is currently being controlled and such management should continue.
Asystasia gangetica	Widespread	High	*Asystasia* is a rapidly growing perennial, shrubby herb that grows to 1m in height but can grow over shrubs up to 3 m tall. It occurs in almost monotypic stands and can smother all vegetation in the herbaceous layer (PIER, 2004). Commonly associated with disturbed areas, *Asystasia* is widespread on the island, occurring in gaps on the glacis habitat and in the grassy areas of the north point and south ridge. This species scrambles and is present in high densities where it excludes native species and makes the habitat unsuitable for birds. **Control:** Current management of this species should continue to prevent its large-scale spread.
Carica papaya	Widespread	Medium	*C. papaya* appears infrequently in the understorey of the woodland/scrub areas of the plateau. **Control:** Whilst it does not present a huge concern, an over abundance of growing saplings will compete heavily with native species and should therefore be removed.
Stachytarpheta jamaicensis	Widespread	Medium	Found predominantly on the beach crest near the villas and on the north point, where it is capable of forming extensive thickets that are difficult to control. **Control:** Manual removal of the species should continue to prevent uncontrollable thickets forming.

Of the remaining species listed in Table 1, many exist in small populations only, or are confined to areas of disturbance, light and nutrients (e.g. footpaths, marsh) where they are subject to

occasional removal. The bulk of these plants could be described as 'weedy', where they act as more of a reoccurring nuisance than a serious ecological problem for the islands. These species can be termed 'opportunistic' and possess traits that are associated with r-strategists or colonising species. Typically these are herbaceous perennial herbs or small shrubs exhibiting high rates of growth and maturation, a high reproductive effort, often wind-dispersed seed and the ability to reproduce by vegetative means (Cronk and Fuller, 2001). Such traits enable them to quickly invade and dominate an open or newly disturbed area. Shade and strong interspecific competition typically limit this form of invader (Cronk and Fuller, 2001).

The marsh habitat of Cousin is a good example of an area for these opportunistic weeds, as is evident with its dense infestation of numerous species. Similarly on Cousine the open areas of the grasslands managed for nesting bird species and the disturbed beach crest where *Casuarinas* have recently been removed are the concentrations of many of the reported weed species. Weed densities are likely to decline in this beach crest region as the altered habitat successionally advances towards its previous state. This is actively being assisted by Cousine staff who are planting indigenous species in the area. Numbers of introduced species are on the whole, thought to be declining (Hill *et al*., 2002c) with areas on Cousin documented to be once dominated by *A. aspera, A. gangetica* and *K. pinnata* are now native *Pisonia* woodland (Diamond, 2003).

Although centres for infestation are limited on both islands, a stochastic event can lead to an ecological release thereby producing ideal conditions for these opportunistic species to colonise. The severe storm that occurred in September 2002 provides a clear example of this. Extensive damage occurred to the *Pisonia* dominated plateau of Cousin resulting in large canopy gaps that provided ideal conditions for the establishment of creepers and herbaceous species (Schumacher and Kueffer, 2002). Typically such herbaceous species will be the first to establish in a disturbed area and can occur in such densities that the regeneration of native vegetation is seriously impeded. Therefore, because of their present limited distribution these species should not be ignored in weed control but instead be made a lower, less urgent priority. Managing them now while the population remains small will prove beneficial, rather than investing unnecessary time and effort after a population explosion that could have been avoided. Managing their habitat is also recommended. By creating conditions unsuitable for their persistence, the weeds will be suppressed and re-infestation minimised.

Other exotic species do occur on the islands that have proven invasive elsewhere (eg: *Eucalyptus sp*, *Coffea* sp, *Citrus* sp., *Averrhoa bilimbi)*. Currently these species are naturalised but their populations do not appear to be regenerating nor expanding. Therefore at present they do not present a concern for the managers of the islands. Despite their non-invasive status, these populations should be monitored and in the event of expansion, appropriate measures be taken to confine or remove the population.

According to Procter (1984), the vegetation of the low granitic islands (e.g. Fregate, Aride, Cousin, Cousine, Recif) has a greater similarity to the vegetation of the outer coralline islands than to the high granitic islands (Schumacher and Wuthrich, 2000). Presumably then the weed flora will also be considerably different. As most weed lists created for the Seychelles are derived from the high granitic islands, Hill *et al.* (2002d) assessed the status of invasive introduced species on eleven small islands throughout the inner Seychelles. This involved determining the relative importance of weed species across the eleven islands by assessing the density and distribution within each island and calculating the frequency of occurrence between them. Table 3 lists the main species identified from the survey and it was concluded that only a small number of predominantly woody invasive species exist in undisturbed habitats. Cousin

and Cousine possess very few of the species identified and consequently Cousin was recognised as possessing the lowest score (according to density and distribution measures) for invasive species across all of the islands investigated. Although Cousine was not part of the survey, it is evident from Table 3 that a similar conclusion would have been made.

Results such as these described in Hill *et al*., (2002d) should be encouraging to the managers of Cousin and Cousine. Efforts made towards weed control are obviously not wasted and should present a form of motivation to further manage and eradicate the species present. Table 3, in combination with species listed in chapter 2 of this report highlights the large proportion of other invasive species that occur outside of Cousin and Cousine and it is important that monitoring activities remain active and care be taken to prevent their introduction. As those species listed in Table 3 are invasives common of habitat/conditions of other small granitic islands, these are likely to represent the greatest potential threats to Cousin and Cousine. Familiarisation of these species with staff could be an important component of management to enable detection at a very early stage of invasion.

Table 3
Introduced invasive plant species present on the eleven islands of then inner Seychelles that were assessed. (Table adapted from Hill *et al*., 2002)

	Present on Cousin	**Present on Cousine**
Woody species invading woodland and scrub habitats		
Adenanthera pavonina	Yes	
Anacardium occidentale		
Carica papaya	Yes	Yes
Chrysobalanus icaco		
Cinnamomum verum		
Cocus nucifera	Yes	Yes
Lantana camara		
Passiflora suberosa		
Species potentially invasive of woodland and scrub habitats		
Clidemia hirta		
Psidium guajava		
Psidium cattleianum		
Paraserianthes falcataria		
Syzygium jambos		
Vanilla planifolia		
Species potentially invasive of glacis or open habitats		
Alstonia macrophylla		
Ananas comosus	Yes	Yes
Diucranopteris linearis		
Furcraea foetida		

Panicum maximum	Yes	Yes
Species potentially invasive of wetlands		
Ipomoea aquatica		

2.2.1.1 Summary

- Table 1 lists the invasive and troublesome plant species of Cousin and Cousine as detected by the wardens of both islands.
- Few are regarded as truly invasive; instead most represent species that require light and/or disturbance to thrive.
- Table 2 outlines the status and invasive characteristics of the dominant weed species on Cousin and Cousine. These are species that are potentially invasive but presently occur in low numbers and species that are presently widespread and impacting on native vegetation.
- Eradication of some species is very probable due to their low frequency.
- Table 3 lists the main invasive plant species of other small granitic islands of the Seychelles. Both Cousin and Cousine possess few of the species listed, and consequently the islands are regarded as having a high conservation value.
- Futhermore Table 3 provides an overview of immediate species that are likely to establish and adversely impact on the Cousin and Cousine environment.
- As both islands remain relatively free of serious invasive plant species, time should be dedicated towards preventing introductions and quickly detecting and eradicating any that do establish.

2.2.2 Fauna

Geographic isolation and a large degree of good fortune have left Cousine and Cousin almost free of exotic and invasive fauna. Most notably the islands have been spared of large-scale deleterious impacts associated with domestic species and most importantly *Rattus sp.* Additionally cats are not present on either island, although they were only recently eradicated from Cousine. The damage caused by species of rats and cats internationally has in many cases resulted in the extinction of endemic island species (Whittaker 1998; Parkes *et al.,* 2002) and needless to say their arrival on Cousin and Cousine would be devastating. The threat of their arrival on the two islands remains imminent requiring strict protocol to ensure they remain unaffected for as long as possible.

The second greatest threat to Cousin and Cousine perhaps comes in the form of invertebrate species that can arrive easily undetected, reproduce rapidly and have some profound impacts on ecosystems. Numerous pathogens and species of invertebrates have been recorded internationally to have severe environmental impacts, with their effects often cascading through ecosystems.

Table four outlines the exotic fauna recorded on Cousin and Cousine to date. Few species are present and exist populations not large enough to be of major concern. However, the simple fact that their presence has been noted at some point in time poses them as a risk, having the potential to further increase in number and in impact. The following paragraphs, very briefly describes the status and invasive attributes of the species represented on each island. For ease of reference, the fauna has been divided into the following categories: Avian, Marine, Invertebrate and Mammalian fauna.

Table 4
Invasive Fauna present on Cousin and Cousine Islands

Category	Species	Common Name	Present on Cousin	Control	Present on Cousine	Control
Avian	*Acridotheres tristis*	Common mynah	Rare, potentially eradicated	Shooting	Occasional breeding pairs sighted	Shooting
	Tyto alba	Barn owl	One resident bird	No control	Rare sightings – no resident individuals	No control
	Bubulcus ibis	Cattle egret	Resident population of approximately 50	Nest disturbance	Rare sightings – no resident individuals	No control
Mammalian	*Lepus nigrocollis*	Black-naped hare	Resident population of approximately 30	No control	No	-
Marine	A baseline survey of marine invasive species is yet to be conducted.					
Invertebrate	*Aleurodicus dispersus*	Spiraling white fly	Present in low numbers	No control	Present in low numbers	No control
	Unidentified	Scale 1	Common on *Euphorbia pyrifolia, Ficus lutea* and *Ficus reflexa*	No control	Present, but not causing damage	No control
	Unidentified	Scale 2	Not present	No control	Common on *Euphorbia pyrifolia*	No control
	Anoplolepsis gracilipes	Crazy ant	Rare	No control	No records to date	N/a

2.3.1 Avian

Common Mynah (*Acridotheres tristis*)

The common mynah is native to India, but despite its tropical origins can now be found all over the world. Being introduced to many countries as a control for agricultural insect populations, the omnivorous bird foraged elsewhere becoming an agent for the reduction of biodiversity. The birds are highly aggressive and compete for nesting spaces, destroy chicks and eggs of native species and evict small mammals (ISSG, 2005). It is listed by the ISSG (Invasive Species Specialist Group) as a member of the 100 worst aliens of the world.

In the Seychelles, mynahs have become numerous on most islands negatively impacting on some taxa, most notably the endangered magpie robins and white-eyes and has been implicated in spreading seed of invasive alien plants such as cinnamon and lantana (*Lantana camara*) – species that are yet to colonise Cousin and Cousine (Skerrett *et al.,* 2001; Hill *et al*., 2002c; Millett *et al.,* 2004). Sightings of *A. tristis* on Cousin have been rare, although conflicting reports exist as to when populations last inhabited the island and in what densities (Hill *et al.,* 2002c; Millett *et al.,* 2004). Despite this*, A. tristis* is regarded as eradicated from Cousin, and re-invasion of the bird tends to be low (Millett *et al.* 2004). Cousine however has had far more frequent sightings of the mynah, with small populations occasionally colonising along the North point of the island.

Barn Owl (*Tyto alba*)

A survey conducted on Cousin in 1999 suggested that a resident barn owl is present on the island. This individual is still believed to be a resident, however its presence is yet to be confirmed (Hill *et al*., 2002c). Prey items of the barn owl include rodents, lizards, insects and birds. Terns, in particular fairy terns (*Gygis alba*) are a preferable food source for the *T. alba* population on Aride, especially during the tern breeding season (Skerrett *et al.,* 2001). At other times of the year rodents make up the bulk of the diet (Skerrett *et al.,* 2001). Due to the absence of rodents on Cousin and Cousine, terns and other bird species are likely to remain the dominant prey item. Obviously the impact of the owl on Cousin is minimal at present if only one bird is resident. If Barn owl numbers were to ever increase, they then may pose a more serious threat to the well being of seabird and endangered species populations.

Barn owls have been sighted on occasion on Cousine but no resident birds are believed to be present.

Cattle Egret (*Bubulcus ibis)*
Populations of cattle egrets on Cousin and Cousine presents a similar problem to the barn owl. The *B. Ibis* diet predominantly consists of large insects, frogs, crayfish, earthworms and snakes, however they can also predate upon bird eggs and nestlings, particularly of the sooty tern (Skerrett *et al.,* 2001). Additionally they can become aggressive and are highly gregarious, competing for nest spaces and crowding out native species (Tulane, 2000; Skerrett *et al*., 2001). Cattle egrets have been reported in some areas to have no effect on native species (Tulane, 2000), but it is also commonly reported as a pest, particularly of island nations such as the Galapagos, Pacific and Hawaiian groups (PIER, 2004; HEAR 2005), as well as the greater Seychelles (Skerrett *et al.,* 2001). To have a large population residing on Cousin or Cousine may be deleterious due to the small size of the islands and a corresponding lack of prey items other than bird eggs and nestlings. Pressures exerted by the birds may be too great to enable a breeding colony of egrets as well as healthy populations of endemic and seabird species.

Currently a population of approximately fifty egrets is attempting to colonise the mangrove area of Cousin Island. On Cousine, cattle egrets are sighted but no known breeding population exists.

2.2.2.2 Marine

The terrestrial ecosystems of Cousin and Cousine are not the only environments threatened by invasive species. Marine environments and reef systems can and are also being seriously impacted by exotic species, their spread between international waters occurring predominantly through ballast waters of ships and the aquarium trade (Wittenberg and Cock, 2001). The consequences of marine invasives can be just as severe as terrestrial organisms, dramatically altering ecosystem structure and function and reducing biological diversity. A number of international examples exist, with organisms from multiple taxa being represented. *Asterias amurensis* (starfish), *Carijoa riisei* (coral), *Undaria pinnatifida* (alga) and *Crepidula fornicata* (mollusc) are just a few examples of marine species causing widespread ecological and economic harm in their introduced ranges (ISSG, 2005). Like terrestrial organisms, the impacts of species such as these are often associated with high rates of predation on native species, competition, species exclusion and extreme habitat alteration. Unfortunately, few management options are available to eradicate marine organisms, however control and prevention measures can be implemented in some circumstances to halt range expansion and minimise their impacts (ISSG, 2005).

Baseline surveys confirming the presence of invasive marine organisms in the reefs surrounding Cousin and Cousine are yet to be conducted. It is expected however that damaging exotic species are absent from both areas (Abdulla, pers comm). A survey detailing fish species and benthic organisms present in the marine environment surrounding both islands would be beneficial. Such a survey would provide documented evidence of the current state of the environment and what species are present and can be used for comparison with results obtained from surveys conducted at a later date. It will also provide a basis on which to develop a series of guidelines to prevent, control and confine and possibly eradicate potential invasive species.

2.2.2.3 Invertebrate

Yellow Crazy Ant (*Anoplolepis gracilipes*, synonym *Anoplolepis longipes)*
Yellow crazy ants or long-legged ants (*Anoplolepis gracilipes*) have been introduced across the tropics as a byproduct of human commerce (Haines and Haines, 1978). As scavenging predators, they invade urban, agricultural and native ecosystems where they can have significant impacts (ISSG, 2005). Crazy ants, their name derived from their frantic behaviour and frequent changes in direction when disturbed, can form multi-queened 'super-colonies' in which ants occur at very high densities (DEH, 2004; ABC, 2005). The edge of a super-colony can expand at around three metres per day or around one kilometre per year. (DEH, 2004). It is at their highest densities that they can have significant ecosystem altering effects preying upon a variety of litter and canopy fauna, from small isopods, myriapods, molluscs, arachnids, and insects to large land crabs, birds, mammals, and reptiles (ABC, 2005). In these frenzies of feeding, *A. gracilipes* can effectively remove 'keystone' species, the deletion of which can cause a rapid state of change in native communities (DEH, 2004; ABC 2005; ISSG, 2005).

The crazy ant invasion of Christmas Island perhaps provides the best known example of the cascading ecosystem effects that *A. gracilipes* can cause. In addition to the obvious direct impacts such as the death of the land crabs, birds and reptiles, crazy ants played an important indirect role in a rapid transformation of the rainforest ecosystem (O'Dowd *et al.*, 1999; Slip, 2002). The dominant red crab (*Gecardcoidea natualis*) is a keystone species and controls seedling recruitment and litter breakdown in the rainforest. Crazy ants eliminated the crab from infested areas and consequently the ecosystem was greatly altered in terms of habitat structure, species composition and ecosystem process (Slip, 2002; DEH, 2004). In addition to this, *A. gracilipes* forms a mutualistic relationship with species of the honeydew secreting Hemoptera (Hill *et al*., 2002b; 2003). The honeydew forms an important component of the ant's diet and the crazy ants can be seen to 'farm' the insects – protecting them from predators and relocating nymphs to new host plants (ABC, 2005). Heavy infestation of these generalist herbivores usually results, which can directly lead to plant deformity and death, or indirectly by promoting the growth of a sooty mould on the leaves of plants, formed from the excretion of the honeydew (DEH, 2004; DPI, 2004; ABC, 2005; ISSG, 2005). This mould interferes with photosynthesis of the plant and can result in canopy dieback (DPI, 2004; ABC, 2005).

Anoplolepis gracilipes is listed by the ISSG (Invasive Species Specialist Group) as a member of the 100 worst aliens of the world.

Yellow crazy ants were first recorded in the Seychelles in the 1960's on Mahe (Feare 1999). Despite efforts to contain its distribution, the species now occurs on at least nine of the inner islands (Hill *et al*., 2002d). The infestation on Bird Island has become most prominent, as being one of the few rat free islands it could be an ideal location for translocation of endemic bird species if it were not for the ants (Hill *et al*, 2003). *A. gracilipes* dominates the invertebrate assemblages of Bird Island, with a number of invertebrate families being notably absent from ant infested regions of the island (Hill *et al.,* 2002b). The ant has formed a mutualism with the introduced Hemopteran species *Pulvinaria urbicola*, encouraging its growth on the native *Pisonia grandis* trees (Hill *et al*., 2002b; 2003). Secretions from the bug have enabled sooty moulds to develop on the leaves of *Pisonia* and in areas of heavy infestation have resulted in their death (Feare, 1999; Hill *et al*., 2002). Ants are also believed to have direct effects on crabs, turtle hatchlings, skinks and seabirds (Feare 1999).

The flora and fauna of Bird Island is similar to the coastal plateau of Cousin and presumably Cousine (Hill *et al.,* 2002d). It is therefore feasible to assume that both islands could support crazy ant populations where they could impose similar consequences to the fauna and vegetation. Dieback of the *Pisonia* is severe enough, but higher order effects on species utilising the vegetation will also occur (Hill *et al.,* 2002d).

Pitfall trapping on Cousin detected two crazy ant individuals in 1999 (Hill *et al*., 2002c). Small nests have similarly been located and destroyed around the houses of the island. Populations should be monitored as the species can undergo rapid reproduction and suddenly appear in high population densities as seen on Christmas and Bird Islands (Feare 1999; O'Dowd *et al*., 1999; DEH, 2004). *A. gracilipes* is yet to be located on Cousine, however no specific search for their presence has been conducted.

Spiraling White Fly (*Aleurodicus dispersus*)

Spiraling White Fly (*Aleurodicus dispersus*) is a pest of predominantly horticultural crops, but also an extensive range of ornamentals and shade trees (DPI, 2004). Originating from the Caribbean region, White Fly is in fact not a fly at all, but a relative of aphids (Botha *et al*., 2000). Its name is derived from the characteristic silken spirals that the female produces when laying her eggs on the foliage (Botha *et al*., 2000). Damage is caused to the host plant mainly by the sap sucking immature and adult white flies that feed on the underside of foliage (DPI, 2004). Plants that are heavily infested also develop a sooty appearance as a result of the honeydew secretion of the insect, which can substantially reduce photosynthesis and consequently place undue stress on the plant (DPI, 2004; Mern, 2004/5). *A. dispersus* possesses very high reproductive rates and large populations can result in defoliation, loss of production and at times death of its host (DPI, 2004).

A. dispersus was first recorded in the Seychelles in March 2003, where it now infests a large range of host plants including vegetables, ornamentals, fruit and shade trees (Mern, 2004/5). Observations made in February 2005 identified populations of spiraling white fly occurring on both Cousin and Cousine. Although currently very limited, these populations are expected to increase in the coming months of the dry season as *A. dispersus* densities are negatively correlated with ambient humidity (Hazell, pers comm). Presently, *A. dispersus* does not appear to be a serious problem of native plants on either island, choosing predominantly introduced ornamentals and fruit trees as its host (eg banana) (Hazell, pers. comm). Therefore to date its impacts are quite limited. However, if densities increase and *A. dispersus* does adopt native plants as a primary host, it is predicted to have a strong negative effect on the ecology of Cousin and Cousine (Hazell pers. comm).

Scale Insects (Unidentified)

During February 2005, an unidentified scale insect was discovered to be damaging native *Euphorbia pyrifolia, Ficus lutea* and *Ficus reflexa* trees of Cousin (Hazell, pers comm). As the species is yet to be officially identified taxonomically, it is difficult to comment on its invasive status or its impacts. Only longer-term data will reveal whether the observed density and damage are part of a natural population cycle or is the beginning of something more serious. This scale is also located on Cousine but does not appear to be of concern presently (Hazell, pers comm). A second scale insect was however found on the island that is causing serious damage to *E. pyrifolia* (Hazell, pers comm). This scale insect is also yet to be formally identified and for the same reasons as mentioned above its status cannot be commented on.

The activity of both species should be closely monitored and steps taken for control if the situation begins to deteriorate. Scale and sap sucking insects are renowned worldwide

invasives, presenting serious problems for the agricultural sector as well as imposing severe effects on native vegetation (Hoy *et al*., 2003; Rashid *et al*., 2003). Thriving on almost all parts of the host plant, the insects pierce the plant and suck sap, resulting in a variety of plant deformities including stunted growth, dropping of leaves, deformed fruits and shoot development and at times of heavy infestation, host death (Hoy *et al*., 2003; DPI, 2004; Sowers and Kendall, 2003). Honeydew secretion is also an attribute of scale encouraging sooty mould growth and placing stress on the plants (DPI, 2004) as previously mentioned in the crazy ant section above. Examples of well-known scales and sap sucking insects include *Maconellicoccus hirsutus* (the pink hibiscus mealybug) (Hoy *et al*., 2003) *Planococcus ficus (*grapevine mealybug*)(*UC, 2004*), Aulacaspis yasumatsui (*cycad scale*)* (Weissling *et al*., 1999), and of course the coccid *Tachardina aurantiaca,* associated with the super colonies of crazy ant on Christmas Island (ABC, 2005).

Given the mutualistic relationship between crazy ants and scale insects, a sudden increase in scale densities on Cousin warrants urgent further investigation. An increase in scale could be two fold in impacts 1) – the dieback of the native forest that can occur as a direct result of the scale and sooty mould development, and, 2) Crazy ant populations may have increased and are deliberately assisting the scale infestation.

2.2.2.4 Mammals

Black-naped hare (*Lepus nigricollis*)

The Black-naped hare (*Lepus nigricollis*) or Indian hare is an endemic of southern India and Sri Lanka and was introduced to Mauritius and possibly Java in the late eighteenth century (Brouard, 1963). During the 1920's Mauritian coconut plantation workers introduced the hare to Cousin as a source of food to Cousin, where a population still remains today (Kirk and Racey, 1992). In Mauritius this species is predominantly an agricultural pest, but is also of environmental concern as it browses on native vegetation in important conservation areas (Mauremootoo, 2003). During the 1990's it actually became a target of a mammal eradication program on Gunners Quoin, an island off the north coast of Mauritius where it was successfully removed (Bell, 2002).

The population size of *L. nigricollis* on Cousin was estimated at between 120-170 individuals in the 1980's (Kirk and Racey, 1992), with a more recent survey suggesting that the population had decreased to approximately 32 individuals (Virah Sawmy, 2001). Given the size of the island, these populations are relatively large and therefore would expect the effects of grazing to be significant (Kirk and Racey, 1992). This is yet to be fully documented (Hill *et al.,* 2002c), although the two surveys conducted on the hares believe the mammal has little impact. It has been hypothesized that *L. nigricollis* is assisting in the spread of weedy species across the island, in particular *A. aspera*, and has repressed the growth of a number of other herbaceous species such as *Bohervia repens* and *A.gangetica.* – both once abundant on the island (Kirk and Racey, 1992; Virah Sawmy, 2001). The regeneration of *Casuarina* trees has also reportedly being slowed by hare foraging (Kirk and Racey, 1992). This apparent reduction of herbaceous species on the islands should be noted or further investigated, as this could have important implications in management if the species was to be removed. Often where herbivorous mammals have been eradicated from island environments the results have been mixed, with a flux of repressed weed species responding to the lack of foraging as well as native plants and animals (Zavaleta *et al.,* 2001; Kessler, 2002; Klinger *et al*., 2002). It was further suggested that the hares are competing with the giant tortoises for food resources and are consequently impacting on tortoise recruitment (Virah Sawmy, 2001). Although analysis of diet indicated an overlap of species, the results are far from conclusive.

2.2.2.5 Summary

- Cousin and Cousine remain relatively free of exotic and invasive terrestrial and marine fauna.
- *Acridotheres tristis* (common mynah), *Tyto alba* (Barn Owl) *Bubulcus ibis* (cattle egret), *Lepus nigricollis* (black-naped hare), *Aleurodicus dispersus* (Spiraling white fly) and *Anoplolepsis gracilipes* (yellow crazy ant), have all been detected on one or both islands. Population densities do not appear to be at a critical level that will result in large-scale negative impacts.
- The presence of invasive marine species is yet to be studied.
- Scale insects detected on Cousin and Cousine in early 2005 appear to be damaging *Euphorbia pyrifolia, Ficus lutea* and *Ficus reflexa*. The scales need to be officially identified before any concrete conclusions concerning their invasibility can be made.
- Of the species listed above, *A. tristis* on Cousine and *B. ibis* and *A. gracilipes* on Cousin probably present the greatest risk to the islands based on their known presence and potential impacts.

(a)

(b)

(c)

(d)

(e)

(f)

Figure 1 – Invasive flora of Cousine - **(a)(b)** *Achyranthes aspera* (Chaff Flower), **(c)(d)** *Panicum maximum* (Fatak Grass) and **(e)(f)** *Asystasia gangetica* (Chinese Violet)

(a)

(b)

(c)

(d)

(e)

(f)

Figure 2 – Invasive flora of Cousin **(a)(b)** *Andenanthera pavonina* (Red Sandlewood), **(c)(d)** *Canavalia canthartica* (Wild Pea), **(e)** *Quisqualis indica* (Rangoon creeper), and **(f)** *Kalanchoe pinnata* (Leaf of Life)

(a)

(b)

(c)

(d)

(e)

(f)

Figure 3 – Invasive Fauna of Cousin and Cousine. **(a)** *Aleurodicus dispersis* (Spiraling Whitefly) **(b)** *Bubulcus ibis* (Cattle Egret), **(c)** *Anoplolepsis gracilipes* (Yellow Crazy Ant) attending scale insects, **(d)** sooty moulds developing from honeydew secretions, (e) *Acridotheres tristis* (Common Mynah), and **(e)** *Lepus nigricollis nigricollis* (Black-naped Hare)

3.0 Pathways of entry (vectors) and invasion risk

3.1 Pathways

The possibilities for new introductions to Cousin and Cousine are many and varied. Approximately 54% of Seychelles vegetation is composed of exotic species (Procter, 1984), thus providing a large pool from which new invasives can be derived. Serious pests of Mahe and other surrounding islands such as cinnamon (*Cinnamomum verum),* guava (*Psidium cattleianum)*, false acacia (*Leucaena leucocephala*), the Takamaka wilt (*Verticillium calophylli*), *Rattus sp*. and domestic cats (*Felis cattus*) can all theoretically arrive on Cousin and Cousine and impart strong negative effects their ecology. Stopping such arrivals becomes of paramount importance, and prevention is the first and most cost effective line of defence against alien species (Wittenberg and Cock, 2001). Although targeting individual species can be an effective measure for prevention, a more comprehensive approach is to identify the pathways/vectors that lead to invasions and manage the risk associated with these (Wittenberg and Cock, 2001).

Six pathways have been identified enabling the introduction of new species to Cousin and Cousine and to act as vectors that further disperse propagules across the islands once populations are already established. These are as follows:

1. Tourists, staff and other visitors to the islands

Tourists most likely represent the primary pathway for the introduction of new species to Cousin and Cousine. The increased mobility and volume of tourists to remote and isolated regions is rapidly increasing in importance as a vector of globally invasive species (Wittenberg and Cock, 2001). Plant propagules and other organisms 'hitchhiking' on clothing, in soils, on footwear and in or on luggage can easily arrive undetected. Tourist movement throughout the island would additionally assist in furthering the range of those species already established on the islands, again by this hitchhiking notion.

Staff, researchers and other visitors present similar threats as tourists, as they too can unintentionally bring foreign species to the islands and transfer propagules across them. Staff actively involved in weed removal should heed special caution, ensuring they do not transfer plant parts from an infested area to one that is uninhabited (Coulston, 2002).

2. Translocation of foreign goods, foodstuffs and plant material

New species have often been recorded occurring near construction sites and housing areas where presumably propagules have arrived with materials used. The crazy ant provides a good example in this case, been transported to various islands in cargo, as does rat invasion. The bringing of certain species of fruit, vegetables and plants onto the island can also introduce new species. This in a practical sense is unavoidable and no problems will arise if the waste/seeds are disposed of in a responsible manner.

The introduction of plant material should be avoided at all costs. Not only are the plants themselves a risk, but the imported specimen can be contaminated with other organisms (Wittenberg and Cock, 2001).

3. Boats – unauthorised landings

Neither Cousin nor Cousine possess a jetty that may promote spontaneous arrivals to the islands, and landing of foreign boats and offshore moorings are prohibited. The probability of unauthorised landings is likely to be small, but is a possible entry point for exotic species.

4. *Birds*

Only a few species of birds that reside on or visit the islands feed predominantly on seeds and fruits. Two species of note are the Madagascar turtle dove (*Streptopelia picturata*) and the Seychelles blue pigeon (*Alectroenas pulcherrima*), the latter being known to feed on cinnamon and guava (Skerrett *et al*., 2001) – plants yet to colonise Cousin and Cousine. Schumacher and Wuthrich (2000) recorded the presence of the bright red seeds of *Adenanthera pavonina* occurring across Cousin in areas where adult trees do not exist and suggest that birds are the most likely agent of spread. The Seychelles fruit bat could also be a potential dispersal agent of seeds from other areas. Fruit bats fly from Praslin to the islands each evening.

5. *Wind*

Wind dispersal has been implicated in some parts of the world for new weed introductions to islands and re-invasion of species after eradication (e.g., Ile Aux Aigrettes and Round Island Mauritius and multiple offshore islands of New Zealand (see Timmins and Braithwaite, 2002; Newfield *et al*., 2003)). This form of dispersal is highly dependent on wind speed and direction (Timmins and Braithwaite, 2002) and is species specific (i.e. does the plant possess morphological adaptations for wind dispersal and what is its projected seed shadow? (E.g. how far will seed disperse and it what number?).

6. Black-naped hare

Whilst not an introductory agent, Virah Sawmy, (2001) suggested that weeds of Cousin may be transferred across the island by *Lepus nigricollis*, in particular aiding the spread of the ubiquitous *A. aspera*. *A. aspera* is a primary constituent of *L. nigricollis* diet (Kirk and Racey, 1992; Virah Sawmy, 2001), and whilst grazing on the herb, the barb like seed of *A. aspera* could easily be caught in the hare's fur and subsequently translocated.

Given the nature of these pathways for invasion, in addition to the protection that geographic isolation affords islands, the probability of new species introductions to Cousin and Cousine remains low. Procedures involving the entry of goods and people generally occur on a small scale and are overseen and managed by only small numbers of staff. Assuming that staff is informed of and are aware of the risks involved with the introduction of new species, simple preventative measures such as inspection in combination with any written protocol should result in the detection of conspicuous introductions. Practicing caution will greatly assist in avoiding unwanted invasion events.

3.2 How invasible are Cousin and Cousine?

No predictive theory regarding habitat invasibility or invasive species traits exists that can explain patterns across all systems. Generalisations are emerging, however they are unlikely to always be true (Mack, 1996; Rejmanek *et al*., 2001). Available evidence indicates that only very few alien species invade successionally advanced plant communities and that generally, disturbance, nutrient enrichment, slow recovery rate of resident vegetation and fragmentation of successionally advanced communities promote plant invasions (Rejmanek, 1989; Rejmanek *et al*., 2001). Invasions will occur only if/when these conditions coincide with the availability of suitable propagules (Davis *et al.,* 2000). Risk of invasion is also thought to increase with a greater propagule pressure (i.e. essentially a greater number of introduction events) (Williamson, 1996; D'Antonio *et al*., 2001; Rejmanek *et al*., 2001).

Oceanic islands are often reported to be more susceptible to invasion than continental ecosystems (Cronk and Fuller, 2001). Exotic species have undeniably had profound impacts on island systems and establishment rates of introduced organisms is statistically higher than that predicted by the 'tens rule' – a statistical rule of thumb that predicts how frequently invasive species establish and become pests (Williamson 1996; Whittaker, 1998). Again no concrete

conclusions have been made as to why this is the case, with a number of theories existing as discussed in the introduction of this paper. However, despite the inherent idea that island habitats are naturally more easily invaded than continental habitats, even within islands, evidence supporting the notion of less disturbed habitats providing greater resistance to invasion still exists (Corlett, 1992; Williamson 1996; Whittaker 1998).

Approximately 86% of the habitats of Cousin are defined as 'near natural'. 'Near natural' habitats are those dominated by native species, in vegetation types which would persist on islands prior to human interference (in the case of the small islands usually woodland or scrub) (Hill *et al*., 2002d). This is an encouraging figure, as presumably the *Pisonia* dominated communities are close to being at their successional peak (Fosberg 1970) and therefore offer a strong resistance to the establishment of introduced species. This figure can be further bolstered by also considering the glacis habitat of the granite hill, which was not included in the survey. This is also an area of low disturbance and of the variety of Seychelles habitats, glacis environments are the most resistant to plant invasion (Kueffer and Vos, 2004) - most likely a result of the extreme environmental conditions they are subjected to (Fleischmann *et al.,* 1996).

Whilst no such official figure exists for Cousine island, (it was not part of the Hill *et al*., (2002) study), the degree of 'naturalness' should be comparable.

Whether or not Cousin and Cousine as islands are more susceptible to invasion than undisturbed mainland ecosystems, the probability of invasion remains low. The pathways for invasion are manageable, propagule pressure is relatively low and the state of 'naturalness' is very good. Presumably in combination, these attributes significantly reduce the invasibility of Cousin and Cousine. Disturbed areas (e.g. footpaths, marsh, houses and villas etc with light and low competition) and regions composed of a more fertile soil type than the phosphatic sandstone (limestone) of much of the coastal plateaus (Shah *et al*. 1999), are likely to be the focus of most establishing species.

3.3 Summary

- Six pathways for entry and dispersal of exotic species onto and around Cousin and Cousine were identified as (in order of importance):
    1. tourists, staff and other visitors to the islands,
    2. translocation of foreign goods, foodstuffs and plant material,
    3. unauthorised landing of boats,
    4. birds,
    5. wind, and
    6. *Lepus nigricollis* - the Black-naped hare.
- Tourists and the translocation of foreign materials represent the greatest probability of introducing new species to the islands. The likelihood of this occurring should be mitigated through awareness of those utilising the islands and by adhering to any preventative protocols in place.
- The degree of 'near natural' habitats comprising Cousin and Cousine islands provides a degree of biotic resistance for the colonisation of exotic flora.
- Disturbed areas and regions of fertile soil are the environments most susceptible to invasion.

4.0 Invasive Species Management

As seen in Reaser and Howard (2003) and Wittenberg and Cock (2001) the management objectives for addressing problems posed by invasive alien species is as follows:

Prevention: Keeping an invasive alien species from being introduced into a new ecosystem. Prevention is the first and most cost-effective option and exclusion methods based on pathways provide the opportunity to intercept potential invaders.
Early Detection: Locating the invasive alien species before they have a chance to establish and spread. The possibility of early eradication or at least containing a new population makes investment in early detection worthwhile. This usually requires effective, site-based inventory and monitoring programs.
Eradication: When prevention fails, eradication is the next course of action. Killing the entire population of the invasive alien species can be a successful and cost effective solution. This is generally only possible if the organisms are detected early.
Control: The process of long-term management and reduction of density, abundance and distribution of the invasive alien species when eradication is no longer feasible. Successful control and eradication programs involve one or more of the following three forms. Integrated pest management (IPM) is their combined application and is the most recommended method of control.

> Mechanical – the physical removal of organisms – e.g. hand pulling of weeds, hand picking snails. This is a highly specific method but requires a long term investment of human resources.
> Chemical – Using chemicals to kill organisms – toxic baits for fauna and herbicides for plants. This is often an effective short term solution but the process can be quite costly, will usually require multiple applications and can have non-target effects.
> Biological – the introduction of a highly specific predator, parasite or pathogen that will attack the invasive species. The process is not likely to result in eradication but can reduce population sizes to a manageable level. The initial cost associated with research and development is high, but if done correctly, the long term costs once applied are low and relatively little maintenance is required.

Restoration: the process of re-establishing natural population and ecosystem functions. This is an important consideration in control as the removal of one invader often creates ideal conditions for the establishment of another. These will be measures that affect the whole ecosystem and are not just targeted at the invasives. It may involve minimizing disturbances, prescribed burning, re-planting etc. In theory, the resistance of the ecosystem to future invasions should be increased.

4.1 Invasive Species Management on Cousin and Cousine

4.1.1 Prevention

The geographic isolation and small size of Cousin and Cousine is itself a useful preventative tool for the introduction of new species. Almost all points of entry should be able to be monitored. In general, preventative measures on the islands appear few, with the exception of a written protocol for the exclusion of rats. Staff are however expected to dispose of vegetable/fruit material in a responsible manner to prevent dispersal across the island by skinks, crabs etc. Bringing plant material is also advised against. The introduction of Takamaka trees (*Calophyllum inophyllum*) is particularly prohibited on Cousine in an effort to keep the island free of the Takamaka wilt (*V. calophylli*).

Guidelines for the prevention of rodent invasions on the islands do exist, as does an emergency eradication plan in the event of an introduction (Appendix 1). The guidelines essentially outline procedures for the careful checking of packages on arrival. Packages should arrive sealed and anything suspicious in nature to be quarantined. On arrival to the islands all stores and bulk

items must be taken immediately to a rodent-proof room where rodents can be confined and destroyed if present in the cargo.

Rats can swim ashore from moored boats. This is mediated on Cousin and Cousine by not allowing landings of any boats other than their own and by preventing the unauthorised mooring of boats offshore.

It is also recommended that a monitoring regime to check for the presence of rats be conducted every three months. Gnaw sticks are to be placed throughout the islands and be examined for indications of rat activity.

Cousine Island actively follows this protocol, particularly with cargo that is regularly delivered by helicopter from Mahe. However, this does not occur systematically on Cousin.

The demand for prevention measures may not be overwhelming on either Cousin or Cousine, however it is important that basic guidelines be developed and adhered to so any chance of introduction is minimised. Complacency will inevitably lead to the establishment of an undesirable species.

4.1.2 Control

4.1.2.1 Weeds

Mechanical methods are currently used on Cousin and Cousine to control weed populations. Most species are removed through hand pulling. Much care has to be taken with some species to ensure that all parts of the plant are removed. These are able to regenerate asexually from any plant pieces left behind (e.g. *Alocasia macrorrhiza and Kalanchoe pinnata*). In one instance, a herbicide 'Vigilant' is used to aid in control of the invasive rangoon creeper (*Quisqualis indica*) on Cousin. Vigilant is a low toxicity herbicide gel containing 5% picloram as the active ingredient. It is used on woody weed species where the gel is applied directly to the freshly cut plant stem. This treatment has been in use on Cousin since late November 2004, and to date the results appear promising.

Control of weeds on both islands occurs on an ad hoc basis, but is estimated to fulfill up to 75% of the Cousin wardens working hours outside of obligations to tourists. On Cousine, the removal of weed populations is slightly more haphazard, making it difficult to allot an estimate of time spent on weeding activities.

Mechanical control is a labour intensive and depending on the species and extent of the infestation, a very time expensive activity. Lack of manpower provides the biggest constraint on weed control on Cousine Island, and to a lesser extent on Cousin. Maintaining control of populations once they have been cleared is difficult with the current level of labour and consequently many species are able to reproduce again before they are re-attended to. If long-term control of smaller populations or species eradication is the desirable outcome, this form of control is inadequate. Any benefit achieved through the previous removal is effectively undone. Focussed, systematic management needs to be adopted.

Use of broad targeting herbicides has not been considered on Cousin or Cousine due to a number of reasons. These include: their general lack of specificity and residue build up, the expenses associated with the importation of the chemicals, as well as the potential side effects that their use may have on the resident bird species, in particular the endangered magpie robin.

4.1.2.2 Fauna

The common mynah and the cattle egret are the only fauna controlled on Cousin and Cousine. Birds from established mynah populations are shot by trained staff with an air rifle. This is a reasonably effective method, with the mynah now believed to be eradicated from Cousin. A population was removed in 2002 and to date no re-invasion has occurred (Millett *et al.,* 2004). On Cousine shooting was conducted in combination with nest trapping (Nevill, 1995). Although the population was reduced in number the eradication attempt was ineffective with at least three breeding pairs remaining in 2001 (Millett *et al.,* 2004). Controlling mynahs at a site becomes difficult as time progresses as they are highly intelligent and adaptable birds that learn to avoid dangerous situations by observing the behaviour of others and by communicating through a highly sophisticated system (Millett *et al.,* 2004; Tidemann, 2005).

The cattle egret population on Cousin is currently being managed by physically destroying their nests to prevent the colony from breeding and increasing. These birds are protected under Seychelles legislation (The Wild Birds Protection (Amendment) Regulations, S/I 19 of 1999) and therefore culling is not a viable method of control without seeking the appropriate permissions.

4.1.3 Control methods used outside of Cousin and Cousine

The following outlines methods for control utilized in other areas where these species are pests. Only those are listed where information was readily available.

4.1.3.1 Alternative Methods of Weed Control

***Adenanthera pavonina* –** Chemical – stem injection with Roundup or basal bark treatment with Garlon

***Casuarina equisetifolia* –** Chemical – 2% Garlon mixed with diesel and applied using the basal bark or hack and squirt method.
Physical – seedlings, saplings and young trees should be hand removed.

***Stachytarpheta jamaicensis* -** Chemical – herbicides of 2,4-D or wick-wiping with glyphosate at standard rates
Physical - controlled by chipping or cultivation. Suppressed by slashing and competition from vigorous pasture species.
Biological - possible biocontrol agents are discussed by Waterhouse and Norris (1987). Could not gain access to this resource.

***Asystasia gangetica* -** Chemical - probably sensitive to hormone-type herbicides.

***Panicum maximum* -** Chemical - susceptible to glyphosate and readily controlled by drizzle applications. Young plants are susceptible to selective grass-killers.

***Passiflora foetida* -** Physical and Chemical – control of other *Passiflora* species has proven difficult, particularly with chemical use, as it will grow over non-target species. If the support plant is not a target species, then cutting the stand at ground level and treating the stems with herbicide is recommended.
Biological - See Waterhouse (1994) for natural enemies. Could not gain access to this resource.

For a general description of options available for control of plant invaders see Cronk and Fuller, (2001). Numerous examples of weed control can also be found in the publications of the Global Invasive Species Program (GISP) of Wittenberg and Cock, (2001) and Veitch and Clout, (2002).

4.1.3.2 Alternative Methods of Fauna Control

***Acridotheres tristis* (Mynah)**
Several researchers, particularly in Canberra and Singapore have investigated mynah control (e.g. Kang *et al.,* 1990; Yap *et al*, 2002). Habitat modification and resource removal have been examined as potential means of control, however due to the extreme adaptability of the bird, limiting anything from food to roost sites is extremely hard to implement and therefore quite ineffective (Politi, 1998; Yap *et al*., 2002; Tidemann, 2005). Poisoning problem bird species is a popular method of control however is not a favoured option due to the non-specific nature of baits that can affect non-target species (Tidemann, 2005). Trapping has also proved reasonably ineffective as after the initial flux of caught birds, capture rates significantly decrease as others learn to avoid the trap particularly when those caught within it emit distress calls (Tidemann, 2005). Shooting has proved effective in reducing but not eradicating mynah populations of the Seychelles as once again the birds adapt to the threat and become very gun shy (Millett *et al.,* 2004).

A range of control methods to control mynah populations on Fregate were implemented during the 1990's. These included: trapping with mist nets, with Larsen traps, with Chardonneret traps and snares, and the associated use of decoys, both alive and dead. Baits were also trialled with stupefacient alphachloralose (Feare and Allan, 1992; Millett *et al.,* 2004). All were found to be relatively ineffective. A more recent study concluded that a combination of poison (Starlicide), shooting and trapping provided the best control on small to medium sized islands of the Seychelles. Poison is not recommended for use where magpie robins and the Seychelles fody are present (Millett *et al*., 2004).

In an attempt to overcome the difficulties of trapping, a study is currently underway at the Australian National University in Canberra, on the effectiveness of a newly designed trap that would be selective for mynas and minimise their avoidance behaviour by maximising the comfort and welfare of trapped birds. The trap consists of two sections. The first is the catching section where birds enter through valves (through which mynas can pass freely, but not other species) and the second is the roost section where undercover perches, food and water are provided, in order to mimic natural roost conditions. The roost section is accessible from the capture section through another valve, where the birds remain trapped. This entire section is then removed and taken off site where birds are euthanased with carbon dioxide, whilst the base section remains on site to enable free-feeding to continue. Although still in the trial phase, the initial results seem promising, with the trap being highly selective and the birds indicating low avoidance behaviour (Tidemann, 2005). Full details can be found at the common mynah web site (http://sres.anu.edu.au/associated/myna/index.html).

***Bubulcus ibis* (Cattle egret)**
In the greater Seychelles, cattle egret populations are culled. Poison is laid at the rubbish dumps on both islands, which are popular feeding sites for the birds.

No other information on control was located.

***Anoplolepsis gracilipes (*Yellow Crazy Ant)**
The crazy ant invasion of Christmas Island, presents probably the most well documented case of the cascading impacts that crazy ant can have on an entire ecosystem. Control and management of yellow crazy ants in Australia has primarily involved the broadcast of toxic chemical baits (Slip, 2002). Protein bait pellets made of fishmeal are laced with Fipronil, an insecticide, and are spread in the vicinity of nests. The concentration of the Fipronil in the bait is

low so that forager ants will live to take back the bait to the colony where it is shared amongst the other workers, larvae and most importantly the queens (ISSG, 2005). Queens are the only reproductive ants in a colony and therefore her death ensures that the colony is destroyed. Initial baiting trials on Christmas Island have found that when the bait is distributed at 0.5g of active ingredient per hectare, ant densities and nests were reduced, and impacts to non-target species minimal (ISSG, 2005). Eradication of the ant is not expected on Christmas Island, however it is believed that ant densities can be reduced to a level where the ants can co-exist with the other species (Slip, 2002). In other areas of Australia where outbreaks have recently been detected, eradication remains the primary objective while populations remain limited (ISSG, 2005).

Given the strong mutualism that exists between the crazy ant and honeydew secreting scale insects, long-term control of the ant may come from controlling the scale population (ISSG, 2005). Scale numbers notably decreased after the large-scale control program of crazy ant colonies on Christmas Island (Abbott, 10.05.05). Presumably, the opposite is true, with ant numbers remaining few in the absence of large scale populations. However, since the crazy ants protect the scale from predators, using biological agents for scale control will be difficult. Further research into understanding the dynamics of the scale-ant mutual relationship is being conducted and may provide important answers for long-term control of the crazy ant (Abbott, 10.05.05).

***Aleurodicus dispersus* (Spiraling Whitefly)**

In Australia, the whitefly is an emerging agricultural pest, particularly in the tropical areas of north Queensland and the Torres Strait. *Encarsia haitiensis* a small, almost microscopic orange-coloured wasp that is host specific to the whitefly (parasitoid) is being used successfully as a biological control agent in the Cape York Peninsula and in the Torres Strait. Due to its success of controlling populations, the parasitoid is also now being used to control mainland populations of *A. dispersus*. Insecticidal control is generally not recommended as evidence suggests that spraying with insecticides results in little long-term control and may potentially exacerbate the the whitefly problem by killing the parasitoids (DPI, 2004).

In Hawaii, *A. dispersus* is an economic pest and five natural enemies were introduced from the Caribbean to control populations. These included three coccinellid beetles (*Nephaspis oculatus*, *Delphastus pusillus, Nephaspis bicolor)* and two parasitic wasps (*Encarsia haitiensis* (Dozier) and *Encarsia* sp). *N. oculatus* proved effective against high population densities of whitefly, feeding on all stages of the *A. dispersus* lifecycle, however the wasps were found to be the most effective, especially against low population densities of whitefly (Kessing and Mau, 10.05.05).

***Lepus nigricollis* (Black-naped hare)**

In 1995, *L. nigricollis* was eradicated from Gunners Quoin, a small island off the north coast of Mauritius, during a baiting program designed to eradicate introduced mammals. Although the program did not initially target the hares, *L. nigricollis* consumed the baits laid for *Rattus norvegicus* and *Oryctolagus* sp. (domestic rabbit) and consequently were successfully eradicated from the island. Pestoff 20R baits were hand-laid directly onto the ground at 15kg/ha and additionally at areas wherever signs of hare activity were present (Bell, 2002).

4.1.4 Restoration

Restoration is being undertaken on Cousine island, particularly on the beach crest area where the Casuarina trees were removed. A variety of indigenous species are being planted in an effort to create a more diverse and protected environment in the area.

Cousin has what is basically a 'no interference' policy and believes that regeneration should occur naturally. However, future management planning includes restoration and habitat management options.

5.0 Recommendations for Invasive Species Management on Cousin and Cousine

Overall, the status of invasive species and their relative impacts on Cousin and Cousine is quite good. The closed canopy of *Pisonia* dominated woodlands provide resistance to weed establishment, levels of disturbance are low, invasive fauna is minimal and pathways for introduction of new species are few and manageable. However, to maintain this current status, dedicated management is required. Eradication of some species, particularly those with limited distribution is probable, at worst populations will decline to a much more manageable level. For this form of success to occur on the islands, some form of structure needs to be applied to the management program, particularly that of control of weed species, so that inputs (e.g. cost, time, effort) are maximised and sound results are achieved.

Much literature exists globally outlining legislation, policymaking and proposed infrastructure for the management and control of invasive alien species; little of it however explains how this will be achieved. Whilst such information is necessary and relevant to many situations, particularly nationwide approaches to management, it appears to have a lack of applicability to the pest situation present on Cousin and Cousine. No serious species exist on either island and the scale on which problem species do occur is not large enough to warrant investing time in developing complex frameworks for management. The invasive species of the islands have already been identified and their impacts and vectors for dispersal noted. Time now should be invested into on the ground management and developing a system that will be flexible, effective and most of all achievable.

The following points are a series of broad recommendations that aim to assist in developing a more strategic method, in which pest management on the islands can be conducted. Ideas are based on documented cases of pest species control on islands around the world, in particular Ile aux Aigrettes in Mauritius, where long term dedication to their invasive species problem is finally tipping the balance in their favour (Newfield *et al.,* 2003).

5.1 Weed Control

- Develop a more strategic approach to weed control, as opposed to haphazard clearing of species
  - Islands could be divided into sections that can be used as an easy reference tool to monitor the composition, abundance and spread of weed populations, points of introduction, the occurrence of weeding activities and consequently prioritise focus for control. The 50 x 50 m grid squares previously denoted on both islands provides a sound basis on which to start. Smaller unit areas would be preferable and more manageable, but in view of the reasonably low densities of weed species present, the existing grid may be adequate. If not, the use of half-squares could easily be carried out.
  - Blocks of grid squares can be prioritised depending on the urgency of management. Factors that many influence this decision will be species present, relative abundance, risk of further invasion etc. For example the plateau/*Pisonia* forest followed by the marsh area of Cousin maybe prioritised over the mangrove and glacis regions due to species present. Similarly on Cousine, the beach crest where Casuarina trees have

been removed and the open grassland areas of the north and south ridge may be areas considered essential for management.
    - Once areas have been prioritised, each grid square should be moved through systematically, methodically clearing each area of exotic species. All species removed and their relative abundance should be documented. Working teams should remain small (4-6 people/approximately 20m^2) and decide on a formation (e.g. line sweep) that will be time efficient and effective – only few standing plants can undo any benefit achieved.
- The schedule for grid maintenance will depend on their allocated priority level as well as on the biology of the species each square possesses. Squares ideally should be re-weeded before the next reproductive event.
- It is preferable that all squares can be targeted. However, if a lack of manpower, or inadequate time management prevents this, focus should be maintained on the prioritised species of *A. pavonina, Q. indica, A. gangetica, C. nucifera, A. aspera, C. papaya, P. foetida,* and *S. jamaicensis* whose effects are most severe and numbers most abundant. Eradication of a number of these species occurring in a restricted range is possible. Areas that have been by previous weeding activities should also remain a priority.
- It is essential to remember that weed control is a very labour intensive and timely task. Seed banks need to be depleted and re-invasions can occur. Results will not occur quickly and achievements can be quickly undone. Persistence and vigilance are the only measures that will prevail in overcoming the weed problem.
- Mechanical methods of removal should be maintained as the dominant form of control. Special care should be taken with species such as *Kalanchoe pinnata* and *Alocasia macrorrhiza* that can easily regenerate from discarded plant parts. Weed disposal should therefore be a consideration.
- Herbicide control may become an option if time restraints become too great. Use of herbicides has been shown to greatly reduce hours of labour, producing comparable results (e.g. 10 man hrs was reduced to 50 man minutes). The benefits would need to be measured against the costs incurred of buying and transporting suitable chemicals, applicators and training. The potential impacts on the resident birds would also need to be very carefully investigated – a herbicide as general as glyphosate (roundup) is not recommended for use around endangered species.
- Herbicide use may be necessary to kill the constantly regenerating *A. pavonina* trees. Although mature trees have been removed, stumps re-sprout and therefore continually require management.
- As a lack of manpower was identified as the largest constraint on weed control, organising some form of annual or biannual 'labour pulse' maybe necessary to assist in removal. Teams assigned to deal specifically with weed control over a significant time period on the islands could attend to all priority areas (e.g. 1-3 months). The use of volunteers (e.g. members of wildlife clubs etc) in weekend 'working bees' could also prove beneficial. Workers could be dispersed throughout the island or concentrated in areas of priority. Each group would have to be overseen and the records relevant to each grid square still made.
- Create a nursery of native plants. Replacing areas that have been disturbed through weeding activities or by a large scale disturbance such as another storm, will assist in speeding up regeneration, preventing consequent invasions of the area and help maintain a high level of biological diversity.

5.2 Fauna Management

- Current management of exotic fauna should be maintained. To date it appears relatively effective and should therefore be continued.

- The presence of the crazy ant on Cousin should be further investigated. Pitfall trapping may further quantify the ant population and highlight areas of higher density. Steps should be taken to remove them if found. Similarly, pitfall trapping could take place on Cousine to ensure *A. gracilipes* is not present.
- Consideration should be given to eradicating the black-naped hare on Cousin. The hares are an exotic herbivore that are potentially altering the composition and distribution of native herbaceous species as well as aiding in the dispersal of weed species. However, it may be necessary to first assess the weed recruitment that may occur in their absence. Simple exclusion plots placed around areas of foraging activity should give some indication as to the impact they exert on the vegetation of Cousin.
- The scale insects located on Cousin and Cousine should be formally identified and closely monitored to ensure that the damage associated with their presence does not continue to deteriorate.

5.3 Vector Management

- Prevention of invasive species if often targeted at individual species, however it is a far more comprehensive approach to manage the risks associated with the major pathways that can lead to harmful invasions.
- Footpaths and areas of high traffic should be made a priority to remain clear of weed species. If tourists/staff are acting as dispersal vectors, this provides an effective and simple method to mitigate spread.
- Possibly introduce some form of footbath on Cousin, and encourage tourists to leave as many bags etc as possible on boats. This will act as a simple method of quarantine against accidental introductions
- Relocate the compost heap on Cousine. All food scraps are thrown into this area, which unfortunately is an area of run-off. Fruit/vegetable species have been sighted growing in the depression where the run off collects.
- It is essential that staff be aware of their own potential for acting as a dispersal vector. Protocols in place should always be adhered to. Staff involved in weeding activities should be particularly aware of not spreading seeds adhered to clothing etc from the area they were working.
- As mentioned above – consider the eradication of the black-naped hare.

5.4 Monitoring

- By documenting the species and abundance of weed and invasives present in each grid square during the removal process, an important reference for monitoring weed populations has been created. Such an inventory will alert staff to new species introductions and re-invasion. Searching for the presence of species that are considered ‘eradicated’ should still occur on an occasional basis.
- It is important that **any** observations made or any common practices used to assist in invasive species management on the islands be documented. This will assist greatly when new staff becomes involved in management.
- The efficacy of weed surveillance can be improved by having a search image. Lists compiling species to be managed and potential invaders, accompanied with species information, photos or illustrations could be created. Such a tool would be extremely beneficial when volunteers are used on the islands and for staff who discover a new species during routine working procedures.
- The rodent contingency plans that have been drafted to keep islands free of *Rattus sp*. should be enforced and adhered to. Rat invasion presents one of the greatest threats to the conservation value of both islands.

- Monitoring for the appearance of invasive species should begin on the reefs. In view of the lack of success in controlling aquatic invasive once established, early detection is less of a priority. Prevention provides the best strategy in this case. However, examples of eradication of marine invasives do exist and eradication may become feasible if the invader can be detected at an early enough stage.

5.5 Public awareness and education

- Public awareness of the problems associated with bio invasions and public education about how to behave is considered an essential element of prevention programs. Education before travelers depart offers the best way to prevent introductions and therefore involving the tour operators will be beneficial. It is in their interest as well as the islands, not to allow the habitats to which they take tourists to be spoilt by invasive species.
- Incorporating a small section about the invasive species of the island and the impacts of new introductions into the Cousin display or talk is recommended to help increase awareness.

Section 2
Principal Alien Invasive Species of the Greater Seychelles

1.0 Introduction

As determined in the previous section, prevention and early detection remain as the two principal elements in managing the invasive species problem (Wittenberg and Cock, 2001; Reaser and Howard, 2003). Early detection is a tool of adequate and efficient monitoring activities. For monitoring to be effective in detecting new introductions, some form of early warning system needs to be developed, implemented and understood by those who utilise it. As at best it is very difficult to predict the invasiveness of a species invasion potential across all environments it may encounter, one relatively simple option is to be aware of the species behaviour in neighbouring environments/locations and in other areas of the world. Often it is useful to identify species within similar habitat types (e.g. climate, islands, soil types, community structure etc) as a starting point. As an example, the Global Invasive Species Program (GISP) and its Invasive Species Specialist Group (ISSG) (a component of GISP) is currently compiling an international database of invasive species, which can be used to develop an early warning system based on other countries experiences with each species (www.issg.org/database). Many countries, and regions within countries will also possess their own prioritised list of suspicious species that call for exclusion from an area, close monitoring or immediate action in their presence.

Cousin and Cousine Islands are only two of the many islands that comprise the Seychelles archipelago (Skerrett *et al.,* 2001). Being a member of the inner group of islands, Cousin and Cousine are situated in close proximity to other islands, in particular the larger and more heavily populated Mahe and Praslin. Examining the invasive species problem of such neighbouring areas presents the logical first step in identifying organisms that may become problematic in the future on either island if they were to be introduced. Most of the invasion pathways to Cousin and Cousine as outlined in the previous section will originate from these other Seychelles islands (i.e. higher propagule pressure) and therefore it is most likely that new unintentional introductions will be derived from this species pool.

The following section aims to very briefly outline the invasive organisms of principal concern in the Seychelles. Care should be taken when interpreting these lists as the higher altitude granitic islands of Mahe, Silouhette and Praslin possess obvious differences in geography and land uses and therefore conditions in which some of the highlighted species thrive in are likely

to share few similarities with Cousin and Cousine. Despite these differences, extreme caution should still be applied if any of these species were to arrive on either island.

2.0 Invasive Species of the Greater Seychelles

Kueffer and Vos (2004) conducted a detailed survey of the woody invasive plant species of the nations of the Western Indian Ocean. Part 5 of their report details the woody plant species of the Seychelles and the following sections (2.1 flora and 3.0 legislation) is a summary of their findings. For more details regarding information included in these sections please refer to their report ''Case Studies on the Status of Invasive Woody Plant Species in the Western Indian Ocean 5. Seychelles.''

2.1 Flora

Due to its unique composition and high level of endemism, the vegetation of the Seychelles is extremely valuable from a conservation perspective (35% of species are endemic). Unfortunately many of these unique and indigenous species are mostly left to survive in small, largely inaccessible areas where native forests still exist. Habitat destruction and the impacts of invasive species are largely responsible for the decline of the indigenous flora witnessed over the years. It is only in very recent times however that the presence and impacts of invasive species are finally being recognised as a major threat to the biological diversity values of the Seychelles.

Of the 370 woody plant species reported to occur on the granitic islands of the Seychelles, 72% are exotic. Whilst most have remained here with little impact, certain species in combination with deliberate habitat destruction, have left the forests of the Seychelles very highly degraded.

- Natural forests no longer exist, except as relic vegetation at the highest altitudes and on glacis
- 63% of the forest are secondary, and most of these have been invaded
- Invaded bush vegetation covers 17% of the total forested land, mainly on the Granitic islands

Tables 5-8 outline the woody plant species of concern in the Seychelles. Kueffer *et al.,* (2004) categorise a species as ''invasive'' if it is problematic in both anthropogenic and natural systems. A species is ''potentially invasive'' if it is naturalised and is known to be invasive elsewhere in the world, and/or is showing strong tendencies to invade secondary or primary vegetation.

The identified exotic woody plant species are further divided into four categories:

1. **Main invasive species**
   These are the species widely accepted as problematic. They are widespread, are continuing to spread and have a negative impact or invade sensitive areas. Within this category are species that are 'naturalized, regenerating but slowly spreading' and 'expanding woody plant species.'

2. **Non-consensus species**
   These are those species where no consensus on invasive status has been reached yet. Either a species is invasive only in restricted areas or evidence of invasion is too scarce for consensus to be reached.

3. Apparently non-invasive species

These are naturalized species introduced at least three decades ago that are not often reported to be regenerating or spreading. However, they are species that are invasive in other parts of the tropics, or within the Indian Ocean or have been widely planted in the Seychelles.

4. Potentially new invasive species

Species that have recently been introduced or become naturalized and are problematic in other islands, internationally and/or within the region.

A fifth category is also included below that summarises the main invasive non-woody plant species identified in the study (Table 9). Although non-woody species were not a focus of the report the authors concede that they are a major concern in the Seychelles and their spread is and will continue to be a serious problem if they are not appropriately controlled.

Table 5a, b, c
The (a) main invasive woody invasive species, (b) naturalised, regenerating, but slowly spreading woody plant species and (c) expanding woody plants species of the Seychelles as identified by Kueffer and Vos (2004). For more information regarding categories of invasiveness etc, see their report. Species in bold are considered the most problematic.

(a)

Species	Life Form	Mode of dispersal	Invaded Islands	Invaded habitats
Cinnamomum verum	**Tree**	**Birds**	**Granitics**	**All habitats**
Paraserianthes falcataria	**Tree**	**Wind**	**Silhouette, Mahe**	**Intermediate Altitude Forest**
Psidium cattleianum	**Tree**	**Birds**	**Granitics**	**Intermediate Altitude, Palm, Mountain Forests**
Syzygium jambos	**Tree**	**Frugivores**	**Granitics**	**Intermediate Altitude and Mountain Forests**
Casuarina equisetifolia	**Tree**	**Wind, water**	**Granitics, coralline**	**Coastal Forest**
Alstonia macrophylla	**Tree**	**Wind**	**Granitics**	**Coastal Forest, Glacis**
Chrysobalanus icaco	Shrub	Gravity, rats, frugivores	Granitics	Coastal and Intermediate Altitude Forest
Leucaena leucocephala	Shrub	Gravity	Granitics, coralline	Coastal Forest
Cocos nucifera	Palm	Gravity, water	Granitics, coralline	Coastal Forest
Adenanthera pavonina	Tree	Gravity, birds	Granitics	Intermediate Altitude and Palm Forest
Tabebuia pallida	Tree	Wind	Granitics, coralline	Coastal, Intermediate Altitude and Palm Forest
Lantana camara	Shrub	Birds	Granitics, coralline	Coastal and Intermediate Altitude Forest
Carica papaya	Tree	Frugivores	Granitics, coralline	Coastal Forest

(b)

NATURALIZED, REGENERATING, BUT SLOWLY SPREADING WOODY PLANT SPECIES	
Species	**Life Form**
Pentadesma butyracea	Tree
Sandoricum koetjape	Tree
Hevea brasiliensis	Tree

(c)

EXPANDING WOODY PLANT SPECIES	
Species	**Life Form**
Ardisia crenata	Shrub
Clidemia hirta	Shrub
Dillenia suffruticosa	Shrub
Memecylon caeruleum	Shrub

Table 6
Non-consensus woody plant species

Species	Life Form
Anacardium occidentale	Tree
Annona squamosa	Tree
Ardisia elliptica	Shrub
Artocarpus heterophyllus	Tree
Coffea canephora	Shrub
Ochna ciliate	Shrub or tree
Ochna kirkii	
Psidium guajava	Shrub or tree
Moringa oleifera	Tree

Table 7
Apparently non-invasive woody plant species

Species	Life Form
Eucalyptus sp	Tree
Pinus sp	Tree
Pterocarpus indicus	Tree
Swietenia macrophylla	Tree
Swietenia mahogany	Tree
Citrus sp	Tree
Mangifera indica	Tree
Aleurites moluccana	Tree
Flacourtia jangomas	Tree

Ricinus communis	Shrub

Syzygium aromaticum	Tree
Ravenala madagascariensis	Tree
Pandanus utilis	Tree
Camellia sinensis	Tree
Rubus rosaefolius	Tree

Table 8
Potentially new invasive woody plant species

Species	**Life Form**
Albizia lebbeck	Tree
Cananga odorata	Tree
Elaeis guineensis	Palm
Raphia farinifera	Palm
Spathodea campanulata	Tree
Melia azedarach	Tree
Allamanda carthartica	Shrub
Cola nitida	Tree
Litsea glutinosa	Tree
Acacia mangium	Tree
Citrus reticulata	Tree
Desmanthus virgatus	Shrub
Eugenia uniflora	Shrub
Gliricidea sepium	Tree
Jatropha curcas	Shrub
Mimusops coriacea	Tree
Murraya paniculata	Shrub
Schinus terebinthifolius	
Tamarindus indica	Tree
Tecoma stans	Shrub
Flacourtia indica	Tree
Trema orientalis	Shrub

Table 9
Main non-woody plant species

Species	**Life Form**
Merremia peltata	Tree
Philodendron sp	Shrub or tree
Epipremnum sp	Shrub
Thunbergia grandiflora	Creeper
Quisqualis indica	Creeper
Syngonium podophyllum	Creeper
Pueraria phaseoloides	Creeper
Passiflora edulis	Creeper
Dicranopteris linearis	Creeper
Eichhornia crassipes	Creeper
Pistia stratiotes	Creeper
Panicum maximum	Creeper
Agave sisalana	Creeper
Alocasia macrorrhiza	Creeper
Ananas comosus	Fern
Caladium sp	Aquatic
Clerodendrum sp	Aquatic
Desmodium canum	Grass
Dieffenbachia seguine	Other herbaceous
Elettaria cardamomum	Other herbaceous
Furcraea foetida	Other herbaceous
Stachytarpheta jamaicensis	Other herbaceous
Stachytarpheta urticaefolia	Other herbaceous

In recognising the habitat differences between the high granitic islands and the large number of the smaller outlying limestone and coralline islands, the species listed in Table 10 were identified as the most problematic invasive woody plant species for conservation managers for the smaller islands. This data was concluded from a study conducted by Hill *et al.* (2002) that investigated the flora and vegetation of 19 small and medium sized islands of the granitic Seychelles.

Table 10
Woody plant species that have proved invasive on small islands of the Seychelles

Species	Type	Habitats				Notes
		Forest	Scrub	Glacis	Grassland	
Cinnamomum verum	Tree	X	X			Prominent on larger islands and those close to Mahé and Praslin
Chrysobalanus icaco	Shrub	X	X	X	X	Predominantly in open areas but can survive shade, becomes dominant through seed and vegetative reproduction
Tabebuia pallida	Tree	X	X			High fecundity from seed, widely planted
Alstonia macrophylla	Tree		X	X	X	Recent on small islands, drought tolerant, germinates in light, threat to open habitats
Adenanthera pavonina	Tree	X	X			Widespread, heavy seed production, may become threat
Paraserianthes falcataria	Tree	X	X			Huge seed production, not widely planted but may become local threat
Leucaena leucocephala	Shrub		X		X	Can dominate open areas, especially coral island, plateau
Lantana camara	Shrub		X	X	X	Threat to open areas and scrub on plateau and hills, especially favoured by grazing, cannot survive heavy shade
Psidium guajava	Shrub	X	X	X	X	Mainly in open area, locally prominent where cultivated in past
Carica papaya	Shrub/ tree	X	X		X	Thrives on coralline islands and plateau, in clearings and open areas
Citrus spp.	Tree/ shrub	X	X		X	Locally prominent where heavily planted in past

2.2 Fauna

Like invasive plant species, introduced alien species of fauna can also have serious impacts on the indigenous vegetation of the Seychelles, as well as on its indigenous fauna. Exotics species appear efficient at adapting to and exploiting new niches in their new environment, preying upon native species that are poorly adapted to cope with the presence of the new invader. The state of the indigenous bird species of the Seychelles (i.e. high proportion of endangered species) provides a clear example of the potential impacts that exotic fauna can exert. Although acting in synergy with habitat destruction, predation by exotic fauna, most notably cats and rats have played a large hand in the population declines of Seychelles native fauna.

Table 11 presents the main exotic fauna (both terrestrial and marine) of concern to Seychelles biodiversity.

Table 11
Introduced species of fauna (including invertebrate species) of concern to biodiversity values in the Seychelles. (Sections of this table are adapted from the Seychelles Ministry of Environment website (http://www.pps.gov.sc/enviro/html/alien_invasive_species__plants.html:; http://www.pps.gov.sc/enviro/html/alien_invasive_species__animal.html.)

Species	Common Name	Distribution and Impacts
Acridotheres tristis	Common mynah	Mynah birds are a highly aggressive omnivorous species that compete for nesting spaces, destroy chicks and eggs of native species and evict small mammals. In the Seychelles is occurs on most islands and negatively impacts on some native species, most notably the endangered magpie robin. It is also a disperser of some alien plants including cinnamon and lantana (Skerrett *et al*. 2001; ISSG, 2005).
Bubulcus ibis	Cattle egret	Cattle egrets are a highly gregarious species and can become a pest of inhabitated and cultivated areas. Though predominantly a human nuisance, they can impact on native bird species, in particular the sooty tern, by preying on eggs and chicks (Skerrett *et al*., 2001).
Corvus splendens	Indian House Crow	This species has spread quickly across the globe becoming established and uncontrollable. It is an omnivorous species, feeding on seeds, fruits, buds, nectar, insects, lizards, rodents, crabs, small birds, eggs, nestlings, fish and household scraps and waste. A small population exists on Mahe, with scattered observations been made. Continuous efforts to eliminate the birds have prevented a population explosion, however eradication is yet to prove successful. Vigilance in its management needs to be maintained (Skerrett *et al*. 2001).
Passer domesticus	House Sparrow	Populations are currently established predominantly on the islands of the Amirantes group, however they have also been recently sighted in the vicinity of the power station on Mahe. Traditionally house sparrows are a pest of agriculture, carry disease and can compete with native bird species for critical food and habitat resources. Concern is mostly for competition with the Seychelles fody if large populations were let establish. Madagascar fodies are notably absent in some areas where sparrows have high densities. Eradication of the population at the port is reportedly underway.
Psittacula krameri	Ring-necked parakeet	Predominantly a pest of agriculture where it feeds on fruits, seeds and maize. Also a carrier of avian disease that may pose a threat to the Seychelles black parrot. It is thought that it may also compete with these birds for food and nest sites. Steps are being taken by the conservation section to eradicate this species from Mahe.
Tyto alba	Barn Owl	The Barn owl is known to occur on most granitic islands of

		the Seychelles. It was first introduced to the Seychelles as a biological control agent for rats in coconut plantations. In addition to rats, *T. alba* also predates on lizards, insects and birds. Terns have been noted to comprise a large portion of its diet (especially the fairy tern), as well as other native bird species such as the Seychelles sunbird. A 30 rupee bounty is paid by the Ministry of Environment to those who kill barn owls.
Capra hircus	Goats	Goats are located in the World Heritage site of Aldabra where they graze extensively on grasses and other herbaceous species. Grazing goats are reported to be out competing the giant tortoises for food resources and have also been implicated in the rarity of some endemic plant species.
Felis cattus	Domestic cat	Cats were originally introduced to the islands of the Seychelles as a control method for rats. In addition to rats, cats consumed many other terrestrial species and have been responsible for countless island extinctions worldwide. Cats have been successfully eradicated from a number of islands including Cousine, D'arros and Fregate.
Rattus rattus *Rattus norvegicus*	Black rat Norway rat	Rats are extremely efficient predators of native species. Eggs, invertebrates, reptiles, tortoises, birds and plant species can all be consumed by rats and as a consequence of their high densities, rats can and have severely impacted upon populations of native species. Additionally they can be an agricultural pest and are carriers of the potentially fatal disease *Leptospirosis*. Rat eradications have been conducted on a number of the smaller islands and have proven advantageous for several species of threatened birds.
Aleurodicus dispersus	Spiraling white fly	*A. dispersus* is only a relatively recent invader of the islands of Seychelles. Whilst its impacts at present are relatively limited to horticultural crops and introduced species, spiraling whitefly does have the capacity to infest native species. Whiteflies are sap sucking, honey dew secreting insects that can place serious stress on host plants resulting in defoliation, loss of production, plant deformities and at times host death (DPI, 2004:Mern, 2004/2005).
Anoplolepsis gracilipes	Yellow crazy ant	Crazy ants are aggressive predators of predominantly invertebrate but also a range of many other species. Their impacts on native impacts can be far reaching, affecting not only the organisms they feed on but indirectly by altering ecosystem dynamics and increasing the presence of honey dew excreting insects. The ants use these insects as an additional food resource that often results in a population explosion of the insects. The excess honeydew causes the host plants to develop a sooty mould, which can lead to difficulties in photosynthesis and in extreme cases death and forest dieback (ABC 2005; ISSG, 2005). Crazy ants are found on most major granitic

		islands of the Seychelles.
Leptographium calophylli	Takamaka wilt	*L. calophylli* is a fungal pathogen responsible for extensive wilting and dieback of Takamaka trees. Infestation can lead to the complete defoliation of the tree and death within only months of infestation. Pathogen spores are transferred by the endemic bark beetle *Cryphalus trypanus.* Since it was first recorded on Mahe in 1994, the wilt disease has reached 10 islands where on some it has caused significant mortality of Takamaka (Hill *et al*., 2003b).
??	Sandragon wilt disease	During 2000 a new wilt disease was discovered on the introduced sangdragon (*Pterocarpus indicus*). It is thought to be caused by an apparently introduced fungal pathogen and causes damage similar to that of the Takamaka wilt. This pathogen is of particular concern on Fregate, where Sangdragon is an important host for the restricted island endemic *Polposipus herculeanus* (the giant tenebrionid beetle) (Hill *et al.* 2003b).
Caulerpa taxifolia	Killer alga	*C. taxifolia* was recently found in the waters of some southern coralline islands of the Seychelles (Bijoux, 2004). This is an extremely invasive species, which can form dense monocultures, smothering all other algal, seas greases and sessile invertebrate communities. It outcompetes other species for food and light in combination with producing a toxic caulerpenyne compound (ISSG, 2005).
Calotes versicolor	Crested tree lizard	First sighted on Mahe in 1984, an established population of the lizard now resides on Silhouette. This species is omnivorous feeding predominantly on invertebrate species, but is opportunistic in its feeding and can prey on small vertebrates and plants also. Concern is related to this species spread to seabird islands where it is predicted to have the most significant ecological impact on island restricted endemics. *C. versicolor* is also a host of pathogens. Whether these are host specific or not is still unknown and therefore there is additional concern that such pathogens may infect native species of lizards and geckos (Matyot, 2004).
Trachemy scripta elegans	Red eared slider	Red eared sliders are freshwater turtles with distinctive red flashes on the side of the head. As they are popular pets they have spread rapidly across the world where they compete with native species of turtle. They are omnivorous and eat insects, crayfish, shrimp, worms, snails, amphibians, small fish and aquatic plants. They can also predate on young birds and destroy bird nests by basking on them and sliding them into the water (ISSG, 2005).
Euglandia rosea	Rosy Wolf Snail	*E. rosea* was first introduced to the Seychelles during 1960 as a biological control for the Giant African Snail *Achatina falica*. Also known as the 'cannibal snail' *E. rosea* failed to control this species and is now globally recognized as a

		major scourge of vulnerable native snail populations to the point of extinction. It is not entirely ground dwelling as reported – it is often also found in trees and will go under water in search of its prey (ISSG , 2005)

This list is not exhaustive. A detailed GEF funded project is currently being conducted by the Seychelles Ministry of Environment within which the status of invasive species in the Seychelles is being determined. This will provide a more detailed list of species of concern.

3.0 Legislation Framework of Invasive Alien Species in the Seychelles

Kueffer and Vos (2004) reported public awareness and concern for invasive plant species to be low and that legal frameworks in place to prevent and manage invasive species are seriously lacking.

No law exists in the Seychelles that deals solely with the prevention, control and/or management of invasive plant species. This applies at entry points to the country as well as a lack of regulation of movement between the islands of the nation. Two acts do exist that relate indirectly to the invasive plant issue (The Breadfruit and Other Trees (Protection) Act and the Plant Protection Act), however they fail to comprehensively address the issue and are extremely outdated. For example the Breadfruit and Other Trees Act actually protects ten widely acknowledged invasive tree species. These include: *Cocos nucifera, Paraserianthes falcataria, Alstonia macrophylla, Tabebuia pallida, Casuarina equisitifolia, Sandoricum koetjape, Adenanthera pavonina, Eucalyptus* spp, *Artocarpus altilis and Artocarpus heterophyllus*. Similarly the Plant Protection Act is directed at preventing the importation and spread of plant pests and diseases, yet the list of species provided in the act that are to be banned from entry fails to include any invasive woody plant species.

A Biodiversity Protection Act is being drafted that will repeal most of the current legislation aside from the Plant Protection Act. An extensive list of woody invasive plant species considered invasive and to not be protected is apparently outlined, as is the protection of certain habitats from invasion. There is no official timeframe for the implementation of the new Act.

The introduction of exotic fauna is covered by The Animals (Diseases and Imports) Act which explicitly states that no importation of any animal, carcass, egg or semen is allowed without holding a licence administered by the Chief Veterinary Officer of Seychelles. 'Animal' covers any mammal, four footed beast not a mammal, any bird or bird egg, reptiles and other cold blooded creatures, excluding fish, arthropods, insects, arachnids and myriopods, excluding crustaceans. No parrots are allowed to enter except as an approved pet, however no other invasive species are flagged in the act itself.

Given the legislation, it would appear that in the past, the introduction of alien fauna was a result of a lack of knowledge and research on behalf of those that issue the importation licences. The potential impacts of alien species associated with conservation and biodiversity values were largely neglected with the focus of the act being on potential impacts to agriculture through disease. However, more recently conservation issues are beginning to be addressed.

In the case of both flora and fauna, resources, knowledge and enforcement of the legislation at entry points to and inter island movement between the islands of the Seychelles was found to be very weak. Consequently, border control is ineffective in its mission. It can clearly be seen

that an updated and more comprehensive national approach is needed to address the invasive species situation urgently. Management of an ever-growing problem will never be possible if people remain complacent as to the urgency and importance of the presence of alien invasive species and if laws designed to protect the environment fail to do so.

3.1 Summary

- The species pool for potential introductions of fauna and flora to Cousin and Cousine from the Seychelles is quite extensive
- Not all species identified as invasive in other parts of the Seychelles will exhibit the same behaviour on Cousin and Cousine, however caution should still be applied if any new species arrive on either island
- In view of the extent of the species list in the Seychelles, the importance of preventative and early detection measures is emphasised in order to keep Cousin and Cousine free of alien introductions.

Section 3
Invasive Species of Other Western Indian Ocean Island Nations

1.0 Introduction

At an even greater level of scale, potential invasive species threats will come from locations outside of the Seychelles. Seychelles in situated in the Western Indian Ocean and is one of a number of island nations contained within it. Mauritius and Rodrigues, Reunion and the Comoros archipelago are all neighbouring nations that like Seychelles possess a unique evolution and consequently a unique environment. Although all islands differ in terms of geography and age they also share many common characteristics. These include: they are a priority area for international conservation, they are all countries identified as biological hotspots and they as island nations, are all prone to the invasion of introduced species. All countries have suffered high rates of extinction of their endemic and indigenous species at the hands of habitat destruction and the widespread establishment of invasive species. Invasive species are now regarded as the main threat to native biodiversity across these islands, except in the Comoros where large-scale deforestation still occurs.

Although separate entities, examination of the invasive species of these nations yields a comparatively similar list of invaders. It therefore becomes another logical step to examine these nations outside of the Seychelles as another potential source of introductions. Although this is an issue that should be predominantly dealt with at the national level (i.e. quarantine), it is still important to be aware of the problematic species of neighbouring regions to assist in further developing comprehensive early warning systems.

Considering the impacts felt by the presence of invasive species and the limited resources (funding and capacity) of small oceanic islands in general, organisation to fight invasive species has been a difficult challenge. Conscious of this weakness, the islands of the region have recently gathered to form a political group known as the Indian Ocean Commission. It is hoped that under this group, nations can assist each other and co-ordinate a successful program to mitigate the impacts and future introductions of alien invasive species.

The following section very briefly provides a general overview of the predominant flora and fauna species of concern in Mauritius, Rodrigues, Reunion and the Comoros archipelago. This introduction and the following presented data is a summary of the FAO reports investigating the status of invasive woody plant species in the Western Indian Ocean, except where otherwise

denoted. Please see this series of reports for further details (Kueffer *et al.*, 2004; Vos, 2004; Kueffer and Mauremootoo, 2004; Kueffer and Lavergne, 2004; Kueffer and Vos, 2004).

2.0 Mauritius and Rodrigues

2.1 Introduction

Mauritius lies 840 km from Madagascar, with a landmass of 1 865 km^2. With a population of 1.2 million, it has one of the highest population densities in the Afrotropics. Rodrigues lies approximately 1400 km from Madagascar, with a total land area of 109 km^2. Together they form a political unit that became independent in 1968.

Both islands have historically displayed high levels of endemnicity, in both flora and fauna, however since colonization, the number of these species has severely declined. The island of Mauritius was once almost entirely forested, however today only 5% of the native vegetation remains, with most of this being impacted upon by exotic and invasive species. 46% of the native vertebrate species have been lost. 39 plant species and 17 vertebrates species have become globally extinct, while 40% of native flora and 54% of the surviving vertebrate species have been reduced to globally threatened status. The history of Rodrigues native species is no better. Its native forest has now being destroyed entirely, eight endemic plant species are now extinct and all those remaining are threatened. All native land vertebrates with the exception of three bird species, two reptile species and a single endemic fruit bat species have been exterminated.

2.2 Flora

Tables 12-15 present the most important invasive alien plants of concern in Mauritius and Rodrigues. 'Invasive' and all the categories listed apply as described in Section 2 (Greater Seychelles) of this report. For further information regarding species listed see Kueffer and Mauremootoo (2004) FAO report 'Case Studies on the Status of Invasive Woody Plant Species in the Western Indian Ocean 3. Mauritius".

Table 12
List of the 18 main invasive woody plant species of biodiversity importance in Mauritius and Rodrigues (Adapted from Mauremootoo et al., 2003 and Kueffer and Mauretmootoo, 2004). Species in bold are considered the most problematic.

Species	Common Name	Habitat	Comments
Acacia nilotica	Piquant loulou	Lowland forest	Very invasive on both islands
Ardisia crenata	**Arbre de noel**	**Upland forest**	**Very invasive in Mauritius, not found in Rodrigues**
Clidemia hirta		Upland forest	Invasive in Mauritius
Flacourtia indica	Prune malgache	Lowland forest	Very invasive in Mauritius, less invasive in Rodrigues
Hiptage benghalensis	**Liane cerf**	**Lowland forest**	**Very invasive in Mauritius, not found in Rodrigues**
Homalanthus populifolius		Upland forest	Very invasive in Mauritius, not found in Rodrigues
Lantana camara	Vielle fille	Lowland forest	Invasive in Mauritius, very invasive in Rodrigues
Leucaena leucocephala	L'acacie	Lowland forest	Very invasive on both islands
Ligustrum robustum	Privet	Upland forest	Very invasive in Mauritius, not found in Rodrigues
Litsea glutinosa	Bois dóiseau	Upland forest	Very invasive on both islands
Livistona chinensis		Lowland forest	Invasive in Mauritius
Psidium cattleianum	Chinese guava	Upland forest	Very invasive in Mauritius and invasive in Rodrigues
Ravenala madagascariensis	Ravenal	Upland forest	Very invasive in Mauritius, invasive in Rodrigues
Rubus alceifolius	Vigne marron	Upland forest	Very invasive in Mauritius, not found in Rodrigues
Schinus terebinthifolius	Poivre marron	Lowland forest	Invasive in low and mid latitudes in Mauritius
Syzigium jambos	Jamrosa	Lowland forest	Very invasive on both islands
Tabebuia pallida	Tecoma	Lowland forest	Invasive in Mauritius and Rodrigues, not introduced to La Reunion

Table 13
Non-consensus woody plant species

Species
Acacia concinna
Acacia farnesiana
Albizia lebbeck
Ardisia elliptica
Camellia sinensis
Cinnamomum verum
Cordia dichotoma
Cyathea cooperi
Eugenia uniflora
Eupatorium pallescens

Table 14
Potentially invasive woody plant species

Species
Averhoa carambola
Casuarina equisetifolia
Eucalyptus spp
Melaleuca quinquenervia
Pinus spp
Prosopis juliflora
Raphia farinifera
Schefflera actinophylla
Sesbania punicea
Spathodea campanulata

Haematoxylum campechianum
Litsea glutinosa
Michelia champaca
Mimusops coriacea
Murraya paniculata
Pithecellobium dulce
Pongamia pinnata
Rhammus nepalensis
Santalum album
Tamarindus indica
Terminalia arjuna
Tibouchina viminea
Ziziphus mauritiana

Ulex europaeus

Table 15
Main invasive non-woody plant species

Group	Species	Group	Species
Grasses	*Arthraxon quartinianus*	Other Herbaceous Plants	*Ageratina riparia*
	Bothriochloa pertusa		*Argemone mexicana*
	Cenchrus echinatus		*Chromolaena odorata*
	Cynbodon dactylon		*Clerodendrum serratum*
	Cyperus rotundus		*Cordia curassavica*
	Cyperus stoloniferus		*Desmanthus virgatus*
	Heteropogon contortus		*Erigeron karwinskianus*
	Panicum maximum		*Furcraea foetida*
	Paspalum conjugatum		*Hedychium spp*
	Pennisetum purpureum		*Hippobroma longiflora*
	Phalaris arundinacea		*Impatiens flaccida*
	Sporobolus virginicus		*Justica gendarussa*
	Stenotaphrum dimidiatum		*Kalanchoe pinnata*
	Themeda quadrivalvis		*Opuntia vulgaris*
Creepers	*Argyreia nervosa*		*Ossaea marginata*
	Cissus spp.		*Rubus rosaefolius*
	Cyanchum callialata		*Stachytarpheta jamaicensis*
	Lonicera confusa		*Strobilanthes hamiltonianus*
	Mikania micrantha		*Turnera angustifolia*
	Neuracanthus rechardianus		*Wikstroemia indica*
	Paederia foetida		
	Thunbergia grandiflora		
Aquatic Plants	*Eichhornia crassipes*		

2.3 Fauna

Tables 16-18 outline the predominant invasive fauna identified in Mauritius and Rodrigues.

Table 16
List of freshwater species known to be introduced into Mauritian waters (Taken from Mauremootoo *et al*., 2003)

Group	Species	Common name
Crustacea	*Macrobrachium rosenbergii*	Rosenbergii
Fish	*Carassius auratus var auratus*	Goldfish
Fish	*Carassius auratus var gibelio*	Prussian carp
Fish	*Catla catla*	Hamilton
Fish	*Cirrhinus mrigala*	Mrigal
Fish	*Ctenopharyngodon idella*	Valenciennes
Fish	*Cyprinus carpio*	Carp
Fish	*Etroplus suratensis*	Tropical cichlid
Fish	*Hyphophthalmichthys molitrix*	Silver carp
Fish	*Labeo rohita*	Rohu
Fish	*Lepomis cyanellus*	Green sunfish
Fish	*Lepomis macrochirus*	Bluegill sunfish
Fish	*Lepomis microlophus*	Redear sunfish
Fish	*Lepomis micropterus*	Large mouth bass
Fish	*Oreochromis macrochir*	Tilapia
Fish	*Oreochromis niloticus*	Tilapia
Fish	*Osphronemus gouramy*	Gourami
Fish	*Salmo gairdneri*	Rainbow trout
Fish	*Tilapia rendalli*	Tilapia
Fish	*Tilapia zillii*	Tilapia
Fish	*Triple cross hybird (Oreochromis niloticus x O. mossambicus x O. aureus*	
Eel	*Channa stiata*	Snake head murrel
Reptile	*Trionyx steindachneri*	Soft shelled Chinese terrapin, tortue de riviere Baptiste

Table 17
List of marine species known to be introduced into Mauritian waters

Group	Species	Common Name
Oyster	*Crassostrea commercialis*	
Oyster	*Crassostrea gigas*	Japanese oyster
Oyster	*Crassostrea virginica*	American oyster
Oyster	*Ostrea edulis*	European oyster
Shrimp	*Metapenaeus monoceros*	
Shrimp	*Penaeus latisulcatus* *	
Shrimp	*Penaeus monodon* *	
Plankton	*Chlorella spp*	Green plankton
Plankton	*Treselmis spp.*	Green plankton
Rotifer	*Brachionus plicatilis*	
Fish	*Rhabdosargus sarba*	Gueule pavé
Fish	*Signaus sutar*	

* Many *Penaeus* species are found from the Western Indian Ocean to the Pacific, so these species may not be introductions.

Table 18
Introduced vertebrates and invertebrates thought to have a significant impact on native biodiversity in Mauritius and Rodrigues.

Invasive Alien Species in Mauritius		**Invasive in Rodrigues**	**Interaction with native and alien biota**
Species	**Common Name**		
Cervus timorensis	Deer	No	Consumes native plants
Rattus rattus and Rattus norvegicus	Rats	Yes	Consume eggs and young of native birds and reptiles and native plant seed predator
Sus scrofa	Pig	No	Consumes native plants and animals, disturbs soils and disperses fruit
Felis catus	Cat	No	Consumes native birds
Herpestes javanicus	Mongoose	No	Consumes native birds and reptiles
Mus musculus	Mouse	Yes	Native seed predator, feeds on native invertebrates and eggs of reptiles
Lepus nigricollis	Hare	No	Consumes native vegetation
Tenrec ecaudatus	Tenrec	No	Consumes native invertebrates, disperses alien plants
Bufo gutturalis	Toad	No	Consumes native invertebrates
Macaca fascicularis	Monkey	No	Consumes eggs and young of native birds, native plants and disperses alien plants
Suncus murinus	Indian house shrew	Yes	Consumes native invertebrates, reptile eggs and young
Achatina fulica and A. pantherea	Giant African land snails	Yes	Compete with native snails an consume native vegetation
Lycodon aulicus	Indian wolf snake	No	Competes with native reptiles and consumes native reptiles
Calotes versicolor	Indian agamid	Yes	Competes with native geckos and consumes native invertebrates
House geckos (5 species)		Yes, (4 species)	Compete with native geckos and consume native invertebrates
Alien birds (19 species)		Yes, (7 species)	Compete with native birds and disperse alien plants

3.0 Reunion

3.1 Introduction

Lying approximately 600 km west of Madagascar, Reunion, together with Mauritius and Rodrigues, forms the volcanic archipelago of the Mascarenes. With its topography being dominated by the emergence of two volcanoes, Reunion possesses the highest diversity of habitats in the Mascarenes. Unlike its island neighbours, Reunion remains an overseas department of France and now possesses a population of approximately 750 000. Since its inhabitation, much of its lowland and coastal vegetation has been destroyed. However, 20-30% of the vegetation, especially in the uplands, remains conserved in its primary or natural state.

At least six plant and 21 vertebrate endemic species have become globally extinct, while 18% of the native flora and 35% of the surviving vertebrate species have been reduced to threatened or near-threatened status. Today, exotic plants and animals are the main threats to the native flora and fauna.

3.2 Flora

Tables 19-22 present the most important invasive alien plants of concern in Reunion. 'Invasive' and all the categories listed apply as described in Section 2 (Greater Seychelles) of this report. For further information regarding species listed see Kueffer and Lavergne (2004) FAO report 'Case Studies on the Status of Invasive Woody Plant Species in the Western Indian Ocean 4. Reunion".

Table 19
Main invasive woody plant species in Reunion. Species in bold are considered the most problematic.

Species	Habitats
Ardisia crenata	Lowland Humid and Upland Forest
Casuarina equisetifolia	**Coastal Habitat, Volcanic Lava Flows**
Clidemia hirta	**Production Land, Lowland Humid and Upland Forests**
Fuchsia x exoniensis	Upland Forest
Fuchsia magellanica	Upland Forest
Hiptage benghalensis	**Production Land, Lowland Dry Forest**
Lantana camara	**Production Land, Lowland Dry Forest**
Leucaena leucocephala	Production Land, Lowland Dry Forest, Volcanic Lava Flows
Ligustrum robustrum	**Lowland Dry Forest, Upland Forest**
Litsea glutinosa	Coastal Habitat, Production Land, Lowland Dry and Lowland Humid Forests, Volcanic Lava Flows
Prosopis juliflora	Coastal habitat, Lowland Dry and Lowland Humid Forests
Psidium cattleianum	**Production Land, Lowland Humid Forest, Upland Forest, Volcanic Lava Flows**
Rubus alceifolius	**Production Land, Riverine, Lowland Humid and Upland Forests, Volcanic Lava Flows**
Schinus terebinthifolius	Coastal habitat, Production Land, Lowland Dry and Lowland Humid Forests
Solanum mauritianum	**Production Land and Upland Forests**
Syzygium jambos	**Production Land, Riverine and Lowland Humid Forests**
Tibouchina viminea	Undisturbed Upland Forest
Ulex europaeus	**Production Land, High Altitude Heathland**

Table 20
Non-consensus woody plant species of Reunion

Species	Habitat
Acacia mearnsii	Production Land, Riverine and Upland Forests
Boehmeria macrophylla	Riverine and Upland Forests, Volcanic Lava Flows
Boehmeria penduliflora	Volcanic Lava Flows, Upland Forest
Caesalpinia decapetala	Riverine Forest
Casuarina glauca	Upland Forest
Dichrostachys cinerea	Production Land, Lowland Dry Forest
Eucalyptus robusta	Upland Forest
Eriobotrya japonica	Upland Forest
Flacourtia indica	Coastal Habitat, Riverine, Lowland Dry and Lowland Humid Forests
Fuchsia boliviana	Upland Forest
Litsea monopetala	Upland Forest
Pinus pinaster	Upland Forest
Tecoma stans	Riverine and Lowland Dry Forests
Trema orientalis	Lowland Humid and Upland Forests
Ravenala madagascariensis	Riverine and Upland Forests

Table 21
Potentially invasive woody species in Reunion

Species	Species
Acacia auriculiformis	*Ligustrum ovalifolium*
Acacia dealbata	*Melaleuca quinquenervia*
Acacia melanoxylon	*Melia azedarach*
Aleurites moluccana	*Parkinsonia aculeata*
Azadirachta indica	*Pinus caribaea subsp. Hondurensis*
Chrysobalanus icaco	*Psidium friedrichsthalianum*
Cinnamomum camphora	*Samanea saman*
Cyathea cooperi	*Schefflera actinophylla*
Fraxinus floribunda	*Spathodea campanulata*
Gmelina arborea	*Swietenia mahogani*
Grevillea banksii	*Tabebuia pallida*

Table 22
Main invasive non-woody species in Reunion

Life Form	Species	Life Form	Species
Grass	*Anthoxanthum odoratum*	Erect Herbaceous Species	*Ageratina reparia*
	Carex balfourii		*Colocasia esculenta*
	Cortaderia selloana		*Cuphea ignea*
	Ehrharta stipoides		*Furcraea foetida*
	Holcus lanatus		*Hedychium coccineum*
	Melinis minutiflora		*Hedychium flavescens*
	Panicum maximum		*Hedychium gardnerianum*
	Scirpus fluitans		*Polygonum senegalense*
	Stenotaphrum dimidiatum		*Strobilanthes hamiltonianus*
Creepers	*Lonicera japonica*		*Verbascum thapsus*
	Merremia tuberosa		*Zantedeschia aethiopica*
	Antigonon leptopus	Ferns	*Nephrolepis biserrata*
	Cocculus orbiculatus		*Pteridium aquilinum*
Prostrate Herbaceous Species	*Duchesnea indica*	Aquatic Plants	*Eichhornia crassipes*
	Erigeron karwinskianus		*Pistia stratiotes*
	Hypoichaeris radicata		*Ludwigia octovalvis*
	Polygonum capitatum		

3.3 Fauna

Table 23 outlines the exotic fauna of Reunion. This list is unlikely to be complete. Due to time restraints and a lack of readily available information, those listed were the only species located using the ISSG database.

Table 23
The invasive fauna of Reunion. This list is likely to be incomplete.

Group	Species	Common Name
Insect	*Anoplolepsis gracilipes*	Yellow Crazy Ant
	Bemisia tabaci	Sweet Potato Whitefly
	Ceratitis capitata	Ceratitis Fruit Fly
Micro-organism	*Xanthomonas axonopodis pv. citri*	Citrus Canker
Fish	*Carassius auratus*	Goldfish
	Cyprinus carpio	Carp
	Gambusia holbrooki	Mosquito Fish
	Oncorhynchus mykiss	Rainbow Trout
Mollusc	*Euglandina rosea*	Rosy Wolf Snail
Mammal	*Suncus murinus*	Asian Musk Shrew
	Capra hircus	Goats
	Rattus rattus *Rattus norvegicus*	Rats

4.0 The Comoros Archipelago (Union of the Comoros and Mayotte)

4.1 Introduction

The Comoros archipelago is located in the northern region of the Mozambique Channel and is composed of four main islands: Grand Comore, Anjouan, Mayotte and Moheli. In 1975, Grande Comore, Anjouan and Moheli were united into the Independent Islamic Republic of Comoros and later the Union of the Comoros. Mayotte is a French Territorial Collectivity.

The islands exhibit a very diverse landscape, with Grande Comore being dominated by an active volcano. Due to such topography a great array of habitats also exist being governed by very mild to very extreme conditions.

The Comoros flora has not been studied in detail and as a result it is unclear as to how many indigenous vascular plant species truly exist in the area. Based on previous estimates, approximately 1/3 of the flora would be composed of exotic species, however more recent surveys are identifying a number of new vascular species in the area and therefore the validity of this figure is in doubt. The coastal and low-altitude vegetation has been almost totally disappeared as a result of human destruction. The high-altitude forests are the best preserved however it would seem that only very small and largely inaccessible tracts of it remain.

A detailed knowledge of the indigenous and introduced fauna is also incomplete. However, 15 species of fauna that represent all fauna groups are reported to be vulnerable or even highly endangered.

Very high rates of deforestation still occur on the islands in order to clear areas for human settlement to cope with the current extreme growth rate. Deforestation is the greatest threat to the Comoros flora and fauna, followed by the presence of invasive species.

4.2 Flora

Tables 24-27 present the most important invasive alien plants of concern in the Comoros. 'Invasive' and all the categories listed apply as described in Section 2 (Greater Seychelles) of this report. For further information regarding species listed see Vos (2004) FAO report 'Case Studies on the Status of Invasive Woody Plant Species in the Western Indian Ocean 2. The Comoros Archipelago".

Table 24
The main invasive woody plant species in the Comoros archipelago

Species	Invaded Islands	Invaded Habitats
Acacia auriculiformis	Mayotte, Moheli, Anjouan	Intermediate Altitude Humid Forest
Acacia mangium	Mayotte, Moheli, Anjouan	Padzas, Coastal and Intermediate-altitude Dry Forests
Albizia lebbeck	Mayotte, Moheli	Coastal and Intermediate-altitude Dry Forests
Cinnamomum verum	Mayotte, Moheli	Intermediate Altitude Humid Forest
Clidemia hirta	All	Intermediate Altitude Humid and High Altitude Forests
Gliricidia sepium	Moheli, Anjouan, Grande Comore	Intermediate-altitude Dry Forest
Jatropha curcas	All	Coastal and Intermediate-altitude Dry Forests
Lantana camara	All	Coastal and Intermediate-altitude Dry

		Forests
Leucaena leucocephala	All	Coastal and Intermediate-altitude Dry Forests
Litsea glutinosa	All	Intermediate Altitude Humid Forest
Psidium cattleianum	Anjouan, Grand Comore	Intermediate Altitude Humid, Mountain Cloud and High Altitude Forests
Psidium guajava	All	Coastal and Intermediate-altitude Dry Forests
Senna sp.	All	Intermediate-altitude Dry Forest
Spathodea campanulata	All	Intermediate Altitude Humid Forest
Syzgium aromaticum	Anjouan, Moheli	Intermediate Altitude Humid Forest
Syzygium jambos	All	Intermediate Altitude Humid and High Altitude Forests

Table 25
Potentially invasive woody plant species in the Comoros

Species	Invaded Habitats
Adenanthera pavonina	Intermediate Altitude Humid Forest
Albizia chinensis	Intermediate Altitude Humid Forest
Sleurites moluccana	Intermediate Altitude Humid Forest
Anacardium occidentale	Coastal and Intermediate Altitude Dry Forests
Annona squamosa	Intermediate Altitude Dry Forest
Casuarina equisitifolia	Coastal Forest
Citrus reticulata	Intermediate Altitude Humid Forest
Duranta erecta	Along roads
Kleinhovia hospita	?
Rubus alceifolius	Intermediate Altitude Humid Forest
Sapindus saponaria	?
Solanum sp.	Intermediate Altitude Humid Forest
Tectona grandis	Coastal and Intermediate Altitude Dry Forests
Terminalia catappa	Coastal Forest

Table 26
Non-consensus woody plant species in the Comoros

Species
Artocarpus altilis
Artocarupus herterophyllus
Cananga odorata
Eugenia dombeyi
Eugenia uniflora
Eucalyptus sp.
Ricinus communis
Rubus sp.
Samanea saman
Swietenia sp.
Syzygium cumini
Tribulus cistoides
Barleria cf *flavia*
Litsea tersa
Lantana montevidensis
Tecoma stans

Table 27
Main invasive non-woody plant species

Group	Species	Group	Species
Creepers	**Ancylobothrys petersiana**	Other herbaceous plants	*Achyranthes aspera*
	Antigonon leptopus		*Agave sisalana*
	Cissus quadrangularis		*Ananas comosus*
	Entada gigas		*Bidens sp.*
	Entada rheedii		*Desmodium incanum*
	Ipomoea quamoclit		*Elephantopus scaber*
	Ipomoea pes-caprae		*Furcraea foetida*
	Merremia peltata		*Dedychium gardnerianum*
	Piper betle		*Hedychium flavescens*
	Pueraria lobata		*Hibiscus surattensis*
	Quisqualis indica		*Mimosa pudica*
	Saba comorensis		*Ocimum sp.*
	Solanum mauritianum		*Pentas lanceolata*
	Solanum torvum		*Plectranthus sp*
Ferns	*Dicranopteris linearis*		*Sida sp*
	Nephrolepis sp.		*Solanum macranthum*
Grasses	*Bambusa glaucescens*		*Stachytarpheta sp.*
	Imperata cylindrica		*Teramnus labialis*
	Pennisetum sp.		*Turnera angustifolia*
Aquatic Plants	*Eichhnornia crassipes*		*Urena lobata*
	Pistia stratiotes		

4.3 Fauna

Table 28 outlines the exotic fauna of the Comoros Archipelago. This list is obviously incomplete. Due to time restraints and a lack of readily available information, those listed were the only species located using the ISSG database.

Table 28
The invasive fauna of the Comoros archipelago

Group	Species	Common Name
Mammal	*Herpestes javanicus*	Mongoose
	Suncus murinus	Asian Musk Shrew

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APPENDIX 1

SEYCHELLES RODENT INVASION CONTINGENCY POLICY
(DRAFT)

Compiled by Nirmal Jivan Shah, Steve Parr and Peter Hitchens, 1999.

Objective
The objective of this draft policy paper is to facilitate measures to minimise the risk of invasion by any rodent species, including rats and mice, on islands that are presently rodent-free. It is based on similar plans used in New Zealand, Mauritius and on Aride Island. Preventing the arrival of a rodent species is a better approach than the difficult task of eradicating them post-invasion. The risk of invasion can never be eliminated but some simple operating procedures can greatly reduce the risk of rodent invasion.

1. First Steps to be Implemented
Certain measures need to be taken at a national scale for the purpose of minimising the risk of invasion to rodent-free islands.

- A National Rodent Contingency Plan (NRCP) and team should be established along similar lines to the fire-fighting and oil spill contingency plans.
- Rodent-free islands not presently covered by protected area status should be protected by adequate legislation.
- A contingency plan, in case of rodent invasion, should be prepared for each rodent-free island (including those with only mice or Norway rats) and linked to the NRCP.
- Islands with harbours and jetties must take special measures including the construction of a rat-proof fence to an agreed standard of design.
- All boat transport visiting rat-proof islands must take rat control measures.
- Each island should have a room that has been rodent-proofed by sealing any gaps that a rodent could use to escape the room. It should be used for unpacking all stores. This room should have a minimum of furniture or stores to allow ease of searching.
- All packages should be packed and sealed prior to shipping from Mahé or the home port. Any broken seals will indicate that rodents are present.
- All food refuse should be held in specific sites –ideally only one and used for composting. Keep the area around the compost bins clear of vegetation, with ideally sand. Watch for signs of rodents.
- All island staff should be trained in all aspects of the NRCP.
- An adequate store of rodent poison bait, traps and other materials to be kept and maintained on all rodent-free islands.
- Each island should have radio or mobile phone communications and 50 kill traps available for emergency use.

2. Financial Measures
The activities described above have a cost burden. There thus should be financial assistance to:

- Build or modify a rat-proof room on each island
- Construct rat-proof fence around harbour
- Train personnel in above activities
- Establish a National Rodent Contingency Plan and team

- Fumigate bulk cargoes
- Build or purchase a stock of kill traps, live traps and poison baits for each island

3. Recommended measures to prevent invasion

There are certain measures that each island can take to prevent invasion and these are:

3.1 Cargo from commercial vessels

- Cargo should not be left exposed on docks or at customs.
- Holds of schooners and any bulk goods stored on deck should be fumigated (deck stores can be covered with a tarpaulin and fumigated) before arrival on the island if they cannot be adequately inspected.
- A thorough inspection of all goods transferred to island boats should be made, especially hollow goods (boxes, tubes) and soft goods (thatching reed, material)
- Any goods that cannot be checked on the boat should be examined in a rodent proof room (or if not possible, in a large open space i.e. on the beach by the waterline).
- All goods being unloaded should be done under supervision of the Manager or otherwise selected staff
- If being unloaded directly to shore, then examine as above.

3.2 Cargo from island boats or aircraft

- If being stored overnight off the island, cargo should be sealed in a box or plastic bag.
- On arrival, cargo should be examined for rodent damage or signs of disturbance.
- Any unsealed goods held overnight off the island should be unpacked in the rodent-proof room on arrival

3.3 Island boats moored elsewhere overnight

- Search cavities, tarpaulins, etc. whilst underway.
- Keep decks maintained so that rodents cannot gain access to below deck space.

3.4 Boats moored offshore overnight

- Owners of all boats that moor offshore should be contacted and agreement reached to carry poison bait stations, which are offered by island management. This is of benefit to owners as it reduces rat damage to boat, gear and catch.
- Around non-reserve islands, agreement to moor further offshore (at least 100m, preferably more) should be investigated. This may be impractical for boat owners and generate ill will unless voluntarily agreed to.
- For Reserves such as Cousin (boundary up to 400m) and Aride (up to 200m) this is enforceable.

3.5 Landings by poachers

- Anti-poaching patrols by island staff on boat and on foot as appropriate
- Establish good community relations
- Establish good contacts with local police, District Administrator and Ministry of Environment

3.6 Shipwreck

- Prevention techniques are limited to making navigation dangers around the islands widely known.
- If shipwreck occurs, immediately set in place NRCP to try and eliminate any rodents, suspected or otherwise and follow emergency measures (see p.3)

3.7 Deliberate release

- Rat-free status publicity should be carefully targeted to minimise this risk.
- Keep good relations with staff, local fishermen, other parties and officials.
- Promotion of the value of rodent-free islands to the economy via tourism and employment.

3.8 Personal items

- Do not encourage arrival of packing cases, large boxes etc.
- Unpack everything on arrival in the rodent-proof room.

4. Recommended Emergency Measures to Combat Invasion

If any rodents do escape onto the island, or are strongly suspected of it, then the NRCP should be activated immediately. If the NRCP and/or island plans are in preparation or not available then the following emergency measures should be followed:

4.1 Record details

i. Who reported sighting.
ii. Which island(s) affected.
iii. Description of sightings that have been seen or their signs include: colour, number, size, activities of animals, droppings, feeding signs any other useful information.
iv. Description of shipwreck or invasion incident
v. Who the information is passed on to and what action is taken and when.

4.2 Island Manager/Experienced Person

i. Send patrol team with radio/mobile phone and 50 kill traps (25 rat and 25 mouse) plus baits and take immediate action.
ii. Start a listening watch on radio/mobile phone
iii. Notify any key personnel with access to further equipment
iv. Establish through media staff any desired media contacts

4.3 Action for ship-wrecks

i. Immediately establish 50 -100 kill traps (paired traps of 1 mouse and 1 rat) within 500m of wreck and on/around coast adjacent to wreck. Number and mark and map each station so that they can be relocated.
ii. Immediately despatch at least 4 personnel with mobile communications and 200 poison bait stations (using variety of stations, baits and poisons) and establish a 25-30m grid of bait stations. Load each station with 2 baits. Number, mark and map each station. Erect appropriate signs.
iii. Attempt to check the wreck for signs of rodent presence. Inquire with crew. Salvage vessels and any boats offering assistance should be checked if they put ashore.

4.4 Action for rodent sightings

i. Immediately establish 50 kill traps (fenn traps or paired traps of one rat and one mouse, whichever is appropriate) within the vicinity of the sighting and or sign (at least over 500m radius). Number, mark and map each trap such that they can be relocated.
ii. Immediately despatch at least 4 personnel with mobile communications and 200 poison bait stations (using variety of stations, baits and poisons) and establish a 25-30m grid of bait stations within 500m of sighting/sign. Load each station with 2 baits. Number, mark and map each station. Erect appropriate signs.

iii. If the date of invasion is unknown or several days have elapsed the sighting has been confirmed then poison and traps should applied over the whole island, subject to the eradication plan of the island.

Monitoring techniques for rodents

4.5 Gnaw sticks

Rodents are attracted to most animal and vegetable oils and will gnaw on wooden pegs soaked in either, leaving clear indications of presence. Pre-soaked pegs should be placed permanently in the ground as widespread as possible at and beyond any likely landing site for rodents. Ideal size is 50x25x500mm with a sharpened end. Sticks should be carefully hammered to avoid marks that might be confused with rodent signs. Sticks should be established at intervals of 30-50m and numbered, mapped and tagged clearly.

4.6 Vegetable or fruit baits

Fruit or vegetable baits function in the same manner as gnaw sticks but are practical as indicators only during presence of survey team.. Pick baits that are free of marks or blemishes. Siting baits for easy detection is also important.

4.7 Trapping

Trapping is appropriate only when occupied and allows identification of species so that eradication can be structured for species. Breeding seabird seasons should be avoided. Irrespective of season, traps should be covered.

5. Equipment for monitoring and eradication

5.1 Traps

i. Live capture traps. Elliot No 1 traps are compact and easily transported and do not kill native fauna.

ii. Kill traps. Fenn Mark IV or Victor traps are best suited for rodent capture if used with a variety of baits. They are a threat to native fauna and must be set under secure covers. Snap traps are not suitable. Care must be taken for first time capture. Traps should be lubricated with oil and the trip mechanism filed to minimise creep. Failure to do so will result in trap-shy rodents.

5.2 Other methods

i. Lures. Peanut butter, canned tuna, freshly cut apple, cheese, chocolate and fresh fish to be the most effective lures. Fresh fish and apple are least durable.

ii. Contamination. Traps must be handled in such a way that they do not become contaminated with human scent. Gloves should be worn whenever possible.

iii. Poisons. Brodifacoum, a second-generation anti-coagulent, is most effective and is formulated in pelleted form in wax- and non-wax coated baits.