Weed invasion of the tropical Mackay coast, Queensland, Australia

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Summary

A three to five kilometre wide section of the tropical central Queensland coast around Mackay was studied. Naturalized exotic plants comprise 28% of the total flora. The naturalized flora includes 311 species belonging to 64 families and 203 genera. Herbaceous lifeforms (66.8%) dominate weed flora of the tropical Mackay coast. The changes in species composition and vegetation structure are viewed in terms of succession. Analysis of weed species occurrence indicated that 78% of species are either infrequent or rare in their present distribution reflecting secondary successional influences in disturbed habitats. Weed cover >35% was found to reduce native species richness in coastal *Casuarina* woodlands. Under current land-use practises weeds are not only naturalizing in ever increasing numbers but also have the potential to expand their present vegetation cover to thresholds that will reduce native species diversity over the long term.

We identified 56 species (18% of the total flora) of environmental weeds that are considered seriously invasive within this study area. The most susceptible vegetation types to environmental weed invasions are; riparian forest (44 species), open forest (32 species) and beach scrub (30 species). Disturbed habitats support approximately 95% of the environmental weeds. Priority control measures are required for *Brachiaria mutica*, *Bryophyllum* spp., *Dalbergia sissoo*, *Panicum maximum*, *Psidium guajava*, *Sporobolus* spp., *Syzygium cumini* and *Themeda quadrivalvis*.

Local authorities are responsible for the condition of native vegetation and as a result are encouraged to allocate resources to maintain the natural environment. Education of Mackay coastal managers and residents is urgently required to discourage unnecessary disturbance including the dumping of garden refuse into native vegetation.

Introduction

Weeds are considered a national problem requiring urgent attention (NWS 1997). The most current national definition of a weed includes any plant which has, or has the potential to have, a detrimental effect on economic, social or conservation values of an area (NWS 1997). As a result, any native or introduced plant which degrades the environment or reduces productivity is regarded as a weed. The term 'environmental weeds' is applied to the most troublesome invasive plants threatening native vegetation (Cheal 1991, Groves 1991, Hobbs 1991, Humphries *et al.* 1991, Carr *et al.* 1992, Carr 1993). We define 'environmental weeds' as non-indigenous plant species which are capable of spreading widely into intact native vegetation with or without human assistance. These weeds, by successful colonization and rapid growth, build up high populations, and as a result affect natural processes by changing and replacing the natural composition of vegetation (Batianoff and Franks 1997a,b,c).

Lodge (1993) states that biological invasions are common-place in nature and in general should not be viewed as abnormal events. Agricultural expansion and urbanization along the Mackay coastline has resulted in a high number of exotic plants growing in close proximity to native seashore communities. Fragmented coastal vegetation is particularly vulnerable to invasion by weeds (Batianoff and Franks 1997b). Much of the current data on exotic plant invasions are published and/or reported from temperate and subtropical studies. We therefore consider the pattern of weed colonization along the Mackay coast as relatively important to the overall knowledge of weed distribution generally and for vegetation management of the Queensland tropical coast specifically.

Materials and methods

The study area encompasses a three to five kilometre wide coastal strip along a 70 km long section of the tropical central Queensland coast in the vicinity of Mackay. It extends from Shoal Point in the north (latitude 21°00'S, longitude 149°09'E) to Salonika Beach in the south (latitude 21°19'S, longitude 149°18'E), representing a total area of about 300 km^2. All naturalized exotics not native to the Mackay coast, are considered in this report as weeds. The floristic data were derived from vegetation field work (1992–1994) by the senior author (detailed in the report by Batianoff and Franks 1997c). Additional data, nomenclature and recognition of exotic species status were gained from unpublished 1998 Queensland Herbarium records. Additional information on current naturalization was obtained from field botanists visiting and/or working in the Mackay area. A species list of environmental weeds, compiled from voucher specimens deposited with Queensland Herbarium, was constructed using the above definition (Appendix I).

Fifteen transects perpendicular to the shoreline were sampled to determine the effects of weed cover on species richness within the coastal *Casuarina* woodlands. Contiguous quadrats (10 × 20 m) were used for evaluating relative ground cover and woody species abundance. The vegetation data collected included percentage cover for both native and introduced species.

The introduced flora was analysed in terms of floristics, occurrence, lifeform and distribution. The occurrence of species are defined as abundant (occurs in more than 30% of sites and/or dominates in many locations), frequent (occurs in 15–30% of sites but only occasionally forms dominant stands), infrequent (occurs in 1–15% of sites and forms small populations) or rare (occurs in less than 1% of sites and mostly found as individuals). The broad habitat/vegetation units (Figure 1) were derived from an amalgam of vegetation classifications based on structure and/or habitats forming recognizable landscape areas (Batianoff and Franks 1997c). Disturbed habitats (DS) are defined as modified areas with <50% of their native flora and vegetation cover remaining. Nomenclature used throughout this paper follows Henderson (1997).

Results and discussion

Patterns of invasion

In this study 28% (311 species) of the total flora are naturalized exotics not native to Australia. The proportion of Mackay's exotic species is higher than for Queensland (14%, Johnson 1995) and Australia (15%, SEAC 1996) but similar to those of Victoria (28% of the total flora, Carr *et al.* 1992). We identified 56 species of environmental weeds (18% of the total naturalized flora) that we consider seriously invasive along this coast (Appendix I). This is a much lower proportion than the 48% listed environmental weeds of the total Victorian exotic flora (Carr *et al.* 1992).

Expansion of sugar cane cultivation, grazing and urban development has resulted in only 35% of the original area of native vegetation remaining along the tropical Mackay coast (Batianoff and Franks 1997c). Many of these remnants are small and are subject to high levels of weed invasion due to edge effects. The total number of native and introduced species recorded in the eleven habitat

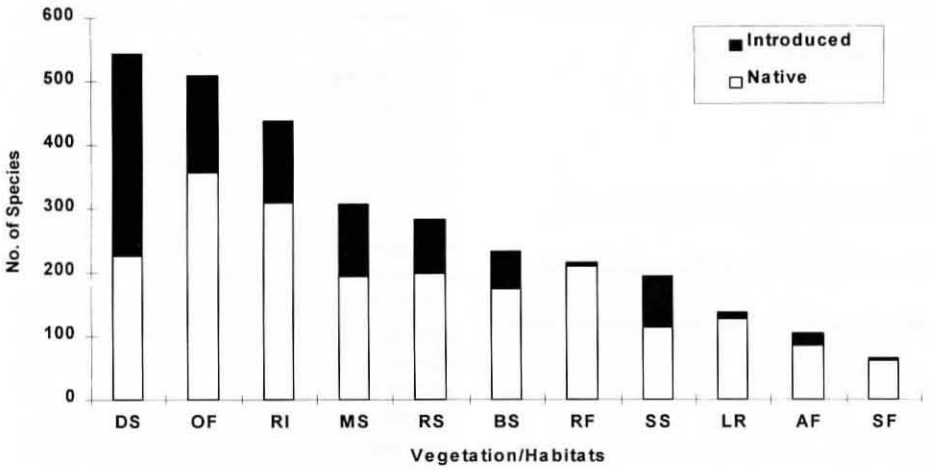


Figure 1. Mackay's vegetation/habitats species richness and composition of native and introduced plants. DS = disturbed, roadside, cleared, etc. vegetation, OF = eucalypt open forest; RI = riparian forest; MS = *Melaleuca* freshwater swamp; RS = rocky shore; BS = beach scrub; RF = hill and headland rainforest; SS = sandy seashore; LR = lowland littoral rainforest; AF = freshwater herbland; SF = saline flats.

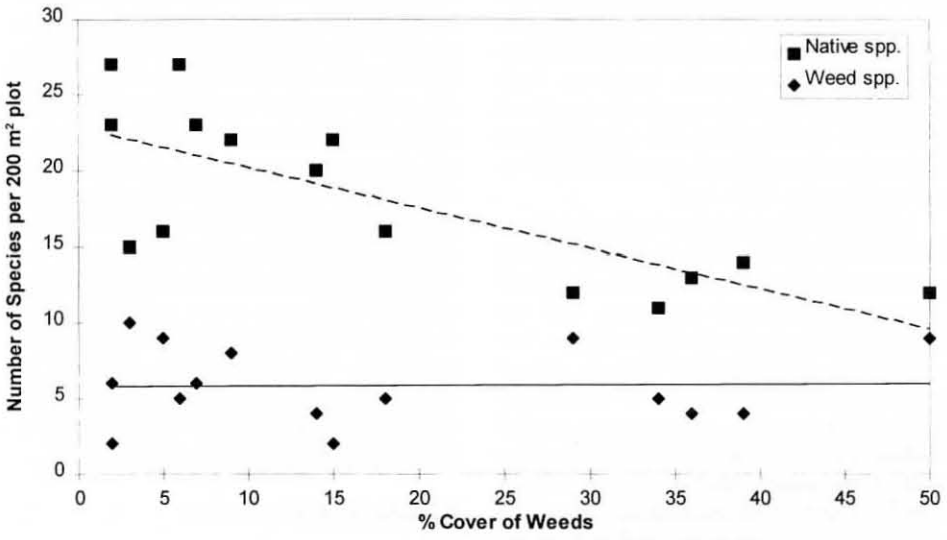


Figure 2. Relationship between native and weed species richness in relation to percent weed cover in the *Casuarina* woodland for Mackay beaches. Based on total number of species collected in a 200 m² area.

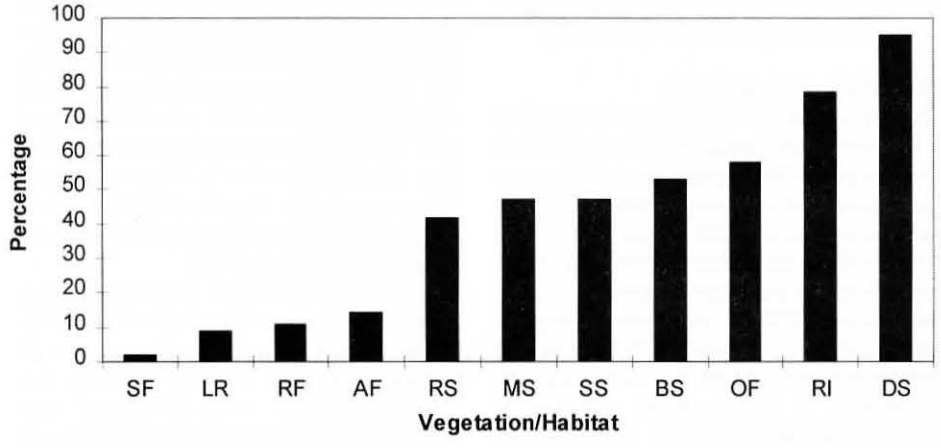


Figure 3. Percentage distribution of environmental weeds (Appendix I) along the tropical Mackay Coast showing susceptibility of vegetation/ habitat to weed invasion. See Figure 1 for caption codes.

units (Figure 1) indicates that uncleared habitats most susceptible to all weed invasions are; sandy seashore including coastal *Casuarina* woodlands (SS, 38.7%), *Melaleuca* forest (MS, 36.6%), rocky seashores (RS, 30%), eucalypt open forests (OF, 29.5%), and riparian habitats (RI, 28.4%). Conversely, mangrove areas (SF, 6.2%), disregarding some of the ecotonal zones, are remarkably free of weeds. The flora of freshwater treeless herbland (AF) habitat comprise 18.3% of weeds. Hill and headland rainforest (RF, 3.3%) and lowland littoral rainforest (LR, 5.0%) habitats also have low proportion of weeds. Amongst the rainforest vegetation, the beach scrub (BS, 23.7%) contain the highest percentage of weeds. However, the highest percentage of introduced species occurs in disturbed/roadside areas (DS, 56.1%).

Low levels of weed species are frequently associated with high levels of canopy cover e.g. rainforests and mangrove vegetation. According to Specht and Specht (1994), the interception of solar radiation by increased levels of overstorey canopy reduces the overall cover of the understorey and wealth of plants recorded in lower stratum. The high diversity of understorey weed species along sandy seashore (SS) and riparian (RI) habitats may be due to high levels of natural disturbance frequently reducing the amount of overstorey canopy. However other factors associated with the proximity of human habitation are also important, such as urban development, fire, clearing, agriculture, changes to soil moisture and fertility, and possibly long-term climate change.

The effects of weed species cover on species richness has been analysed within the *Casuarina* woodland zone (Figure 2). The dominant weed cover in this zone were primarily *Lantana camara*, *Panicum maximum* and *Melinis repens*. When these species are present within the *Casuarina* woodland they tend to form dense almost monospecific stands. A strong negative correlation exists between the total cover of these weeds and the number of native species present ($r^2 = -0.76$). It is evident that as the cover of these weeds exceeds 35%, the number of native species decreases (Figure 2). We postulate that this point represents a threshold weed cover above which the diversity of native species is reduced. Figure 2 indicates that the percentage cover threshold of weeds is different for native and other weed species, i.e. no correlation between the number weed species occurring within 2–50% cover of weeds ($r^2 = 0.02$). However, we have observed that in some instances over 60% of weed cover suppresses all plant species.

The accurate identification of potential weed problems within native vegetation

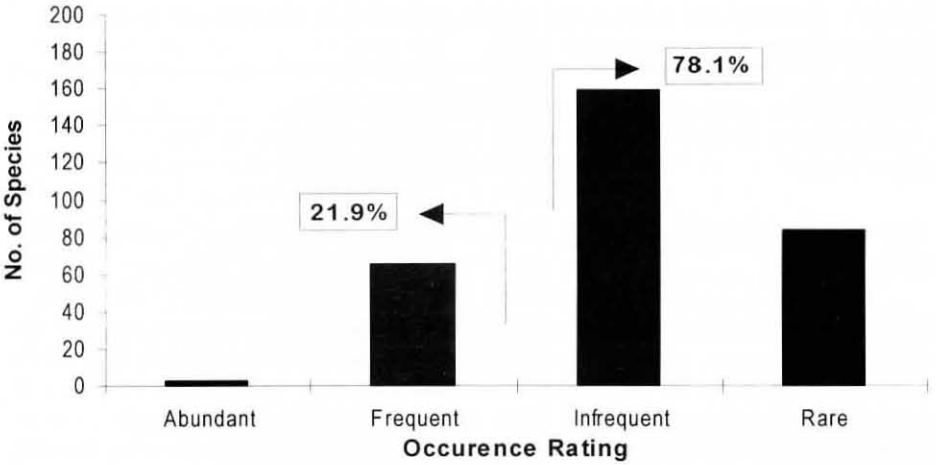
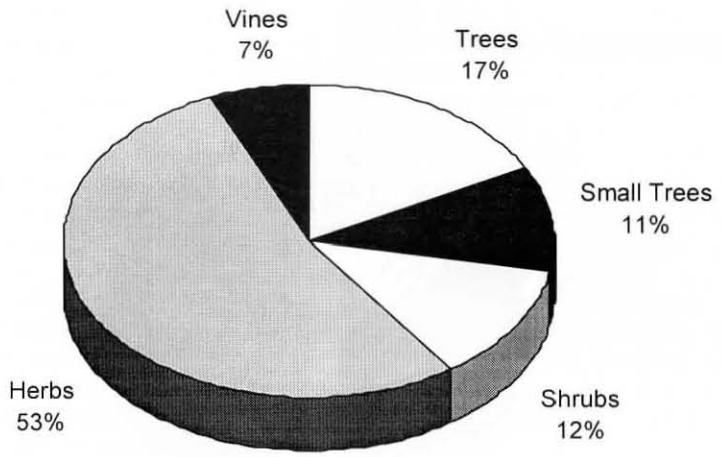
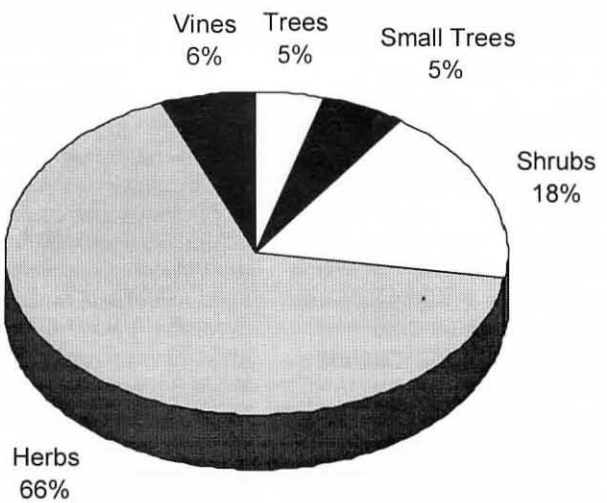


Figure 4. Composition of the introduced flora of the tropical Mackay coast indicating the number of abundant, frequent, infrequent and rare species occurrence. Approximation of flora occurrence: Abundant occurs in >30% of sites/areas, Frequent occurs in 15-30% of sites/areas, Infrequent occurs in 1-15% of sites/areas and Rare occurs in <1% of sites/areas.



Native



Introduced

Figure 5. Lifeform compositions of introduced and native floras along the Mackay coast expressed as percentages.

should also consider potential susceptibility of different vegetation/habitat to invasion by environmental weeds. In the Mackay area the most susceptible vegetation is riparian habitats (RI) containing 78% of the 56 listed environmental weeds, with disturbed sites being the highest (95%) (Figure 3). Other susceptible vegetation types include open forest (58%), beach scrubs (53%), *Melaleuca* forests (47%), sandy shore (47%) and rocky shore (42%). Having high numbers of exotic species, disturbed areas (DS) act as a major source of invasive pest species. For example 95% of the serious environmental weeds, originating from roadsides and other disturbed areas can colonize edges of native remnants. Vegetation data available from Victoria (Carr *et al.* 1992) indicates a similar trend to that in the Mackay area, i.e. the vegetation types most susceptible to weed invasion are woodlands, riparian and coastal/seashore vegetation. Less prone vegetation types include saline habitats, rainforest and freshwater wetlands.

Plant colonization/immigration and extinction rates influence the overall success of weed invasion. About 78% of the total introduced flora is recorded as being either infrequent or locally rare (Figure 4). These data indicate that the overall frequency of introduced species is slightly lower than data available for coastal vegetation from south-east Queensland (85%) (Batianoff and Franks in press). The coastal flora of south-east Queensland consists of 4% abundant weeds, as compared with the Mackay coast having only 1% of abundant weeds We postulate that after a relatively short period of active weed introduction (about 130 years since European settlement) and increasing levels of disturbances the low abundance but high number of many weed species is to be expected.

Potentially invasive weed species can exist in an area for a considerable time before becoming troublesome (Braithwaite *et al.* 1989; Batianoff and Franks 1997b). These plants are referred to as 'sleeper' weeds i.e. populations of exotic plants that appear benign for many years before spreading rapidly into natural vegetation following certain events (NWS 1997). In Mackay, *Syzygium cumini* may be one of many 'sleeper' weeds present in the area. This species has a high potential to spread into *Melaleuca* wetland and riparian habitats.

The lifeform composition of the flora is crucial in assessing the role of weed invasion into indigenous vegetation (Carr *et al.* 1992; Batianoff and Franks 1997c). The lifeform proportions of introduced flora of the Mackay coast are similar to those along the south-east Queensland coast (herbs 67%, trees and shrubs 27%, vines 6%; Batianoff and Franks in press) and

Victoria (herbs 71%, trees and shrubs 26%, vines 3%; Carr *et al.* 1992). The prevailing trends in lifeform invasiveness indicates that native woody species in the overstorey are being replaced by introduced herbaceous species in the understorey. In addition it appears that herbaceous understorey species richness is correlated with increased solar radiation (due to loss of overstorey) supporting similar relationships reported by Specht *et al.* (1990) and Specht and Specht (1994).

The major shift in lifeform proportions indicate a 15% increase of herbaceous lifeforms between the introduced and the native flora (Figure 5). Understorey shrubs display a similar increase. Conversely, the introduced flora dominated by understorey plants has a lower number of overstorey tree species when compared with the native flora. According to Crawley (1997), herbaceous plants are best adapted to early stages of naturalization after disturbance. Herbaceous species have a distinct advantage over late successional species in these situations due to their ease of establishment and rapid growth rate. The lifeform proportions of the introduced flora of the Mackay coast possibly reflect an early secondary successional trend of successful naturalization by understorey herbaceous species.

The secondary successional process is further complicated by the invasion of environmental weed species that deflect some successional stages by reconstructive facilitation thereby incorporating Connell and Slatyer's (1977) inhibition model of succession. For example in some instances herbaceous plants such as *Panicum maximum, Agave vivipara* and *Brachiaria mutica* maintain monospecific stands thereby inhibiting the recruitment of native and other species. It is important to view Connell and Slatyer's (1977) theory as logical explanation of enabling the perpetuation of dense populations of many environmental weeds for long periods of time, thereby changing natural successional processes and reducing biodiversity. Other mechanisms of weed succession and response to disturbance may also occur but in our view are beyond the scope of this paper.

Table 1 lists six plants that are recorded becoming initially naturalized in Queensland in the Mackay area (unpublished Queensland Herbarium Records, 1997). Both *Setaria barbata* and *Themeda quadrivalvis* are grasses that are relatively early introductions which were recorded as naturalized in the Mackay Port area. The other species listed are more recent arrivals with these being 'woody' garden escapees. From these early introductions only *Themeda quadrivalvis* is considered a major problem weed. It is too early to predict the likely outcome of the other five species listed in Table 1.

Table 1. Queensland introduced plants recorded as naturalized first in the Mackay region (current to July 1997).

Plant Names	Comments
Ardisia solanacea Roxb. (Myrsinaceae)	Small tree: Native of India and China. Queensland record: Slade Point, Mackay (21°04'S, 149°13'E), June 1992 (I.G. Champion).
Bunchosia glandulifera (Jacq.) Kunth (Malpighiaceae)	Small tree: Native of Caribbean, Central and South America. Queensland record: Andergrove, Mackay (21°06'S, 149°11'E), August 1994 (G.A. Lambert).
Carissa macrocarpa (Ecklon) DC. (Apocynaceae)	Shrub: Native of South Africa. Queensland record: Slade Point, Mackay (21°04'S, 149°13'E), March 1992 (I.G. Champion).
Saritaea magnifica (Sprague ex Steenis) Dugand (Bignoniaceae)	Vine: Native of Colombia and Ecuador. Queensland record: Hector Beach, Mackay (21°16'S, 149°17'E), August 1992 (G.N. Batianoff).
Setaria barbata (Lam.) Kunth (Poaceae)	Herb: Native of tropical Africa and Asia. Queensland record: Racecourse, Mackay (21°10'S, 149°09'E), July 1962 (C.L. Fillis).
Themeda quadrivalvis (L.) Kuntze (Poaceae)	Herb: Native of India. Queensland record: Habana, Mackay (21°02'S, 149°05'E), September 1935 (J.P. Kahler).

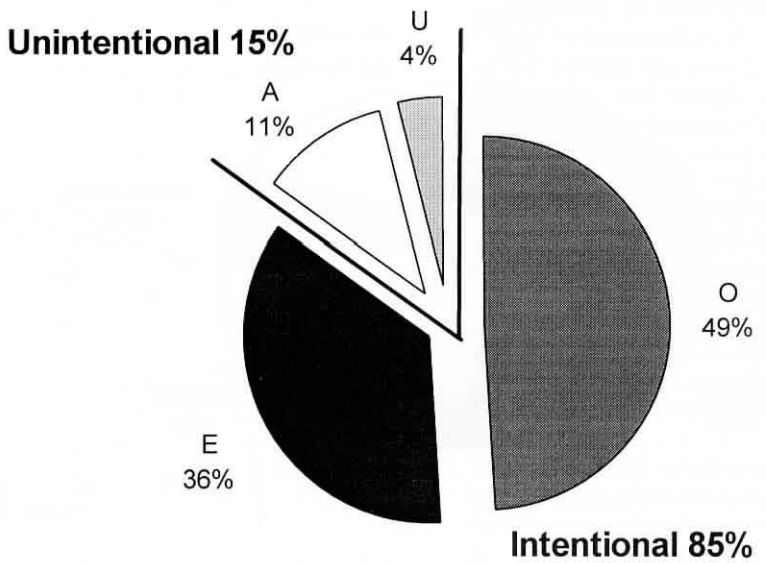


Figure 6. Modes of introduction of Mackay coast environmental weeds. O = ornamental, E = economic agronomic potential, A = accidental, U = unknown.

Appendix I identifies 56 plant species considered as environmental weeds of the Mackay coast. This list includes some of the well known coastal weeds of Queensland such as *Panicum maximum, Lantana camara, Brachiaria mutica, Themeda quadrivalvis* and *Wedelia trilobata*. Environmental weeds of particular significance to the Mackay coast are *Dalbergia sissoo, Syzygium cumini, Psidium guajava* and *Sporobolus* spp. According to Batianoff and Champion (1993) major infestations of *Dalbergia sissoo* occur along roadsides in eucalypt open forest and *Melaleuca* swamp vegetation particularly at Slade Point and Farleigh hillsides. They identified this species as an environmental weed and a weed of disturbance (road works and earthworks), spreading mainly through vegetative regrowth. *D. sissoo* was introduced as a tree for amenity planting in the Mackay area. According to Parsons and Cuthbertson (1992), *D. sissoo* is declared noxious in the Northern Territory because it is considered as a major threat to dunal areas of Darwin Harbour.

In the past and at present *Psidium guajava* was planted as a fruit tree in suburban Mackay. In more recent years native birds and flood waters are spreading *P. guajava* into dunal and forest vegetation. Large populations of this species now occur at Shoal Point and south of Mt. Hector. *Syzygium cumini* was a popular amenity tree used for plantings in city streets, railway screens and along the esplanades. As a result, areas around Mackay City support large populations of

this species. *S. cumini* is now spreading into riparian and *Melaleuca* swamp vegetation (Batianoff and Franks 1997c). Other riparian invasive plants include *Anredera cordifolia, B. mutica, L. camara, Leucaena leucocephala, Macfadyena unguiscati* (especially Reliance Creek National Park), *Panicum maximum, Pennisetum purpureum* Schumach. and *Sporobolus indicus* var. *major* (Buse) Baaijens.

We believe that since European settlement, the proportion of exotic naturalized plants and disturbance associated with development has steadily increased. We postulate that this trend will continue in light of present land use throughout the coastal zone. In our view, the number of environmental weeds and their abundance along this coast is still relatively low. At this stage many environmental weeds could be effectively managed using coordinated Coastcare/Landcare programs particularly in natural conservation areas.

Anthropogenic factors contributing to accelerated invasions

Weed control is now a major issue for local native vegetation managers. For example, *Panicum maximum* and *Lantana camara* are affecting natural processes along Mackay's sandy seashores especially in the *Casuarina equisetifolia* var. *incana* (Benth.) L.A.S.Johnson woodlands. As highlighted in Figure 2 the direct effect of increased weed cover is a reduction of native species diversity. However an indirect effect may be related to the fuel built up by *Panicum maximum* and *Lantana camara* and be equally damaging to native species composition. The increased fuel loads cause 'hot' fires which damage and reduce the populations of the fire sensitive species of *C. equisetifolia* var. *incana*. As a result natural establishment of tree seedlings is retarded in dunal areas degraded by dense covers of *P. maximum* and/or *L. camara*.

Disturbance (physical and/or chemical) plays a major role in facilitating weed invasion (Fox and Fox 1986, Hobbs 1991). Although coastal areas experience natural cycles of disturbance, it is our view that anthropogenic weed introductions and subsequent dispersal by humans are the most important factors responsible for the success of weed invasion into native vegetation (Batianoff and Franks in press). A strong relationship exists between the number of exotic species available for colonization of a given area and its proximity to settlement (Gullan 1988). Batianoff and Franks (in press) propose a minimum distance of at least 100 m between dwellings and native seashore vegetation to reduce to threat of weed infestation. Further, we suggest that unintentional and intentional plant introductions by humans is the single most important dispersal agent along the Mackay coast. In many instances uninformed choice of amenity plantings provide an unintentional source of propagules and assist the spread of environmental weeds, such as *Dalbergia sissoo* and *Syzygium cumini*.

Of the 56 significant environmental weeds of the Mackay coast (Appendix I), 85% were intentionally introduced (Figure 6). This is much higher than the 46% of the 233 exotic plants that have been proclaimed noxious in Australia which have been intentionally introduced (Panetta 1993). Lonsdale (1994) after examining the long history of pastoral plant introduction of northern Australia concluded that almost all of the successful introductions became weedy in some situations. In our study, ornamental (suburban garden) escapees are seen as the major and continuing source of the environmental weeds in this region (Figure 6).

Conclusions and recommendations

Weed invasion can be managed more effectively by early detection and intervention (Fox 1991, NWS 1997). The early identification of all exotic species, particularly those which are major inhibitors of natural succession processes (e.g. *Lantana camara, Dalbergia sissoo, Panicum maximum* and *Brachiaria mutica*), is highly recommended. Management objectives should include the avoidance of disturbance, in particular the reduction of overstorey canopy cover, thereby reducing secondary succession by exotic understorey species. Furthermore, we have identified a critical threshold value of >35% cover of weeds which at this point out-compete native species in *Casuarina* woodland. This threshold value should be used as a benchmark in assessing areas for restoration.

The findings of this study indicate that the disturbance along the Mackay coast initiated by human settlement has major similarities with the pattern of weed invasion along south-eastern Queensland coast. In our view, this similarity is based on ecological principles of succession. The early response to disturbance is the influx of herbaceous species followed by opportunistic and/or deflective species which may persist as environmental weeds for a long periods of time. Hence the coordinated framework of weed management, as advocated by the National Weed Strategy, should incorporate prevailing ecological principles as one of its important bases. The primary aim in weed management should be sustainable development with minimum disturbance.

The National Weed Strategy (NWS 1997) recommends the following points for weed control which are applicable to Mackay:

- Prevention and early intervention, particularly of 'sleeper' weeds, are seen as the most cost effective techniques against weed infestations.
- Successful weed management requires a coordinated framework at all levels of government, land holders, industry and communities including specialist bodies integrated into a multi-disciplinary approach.
- The primary responsibility for weed management rests with landholders/land managers.

In addition to the NWS (1997) general weed control recommendations, we suggest that for environmental weeds the following should be noted:

- Disturbances to natural vegetation be minimized. This includes use of buffer zones between human habitation and native vegetation. Avoiding the use of top soil and fertilizer applications near native vegetation.
- Environmental weed eradication and control measures be implemented with restoration of degraded areas.
- Education of the many values of native vegetation and flora be given to local coastal communities particularly those living within 500 m of native vegetation areas.
- An environmental levy/budget item be introduced at the local government level as an expenditure for conservation and education.
- Finally, we recommend uniform national priorities be given to weed management including the provision of training, followed by uniform legislation based on ecological principles of succession.

Acknowledgments

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Appendix I. Environmental weeds of the Mackay coast, July 1997.

Plant name	L/f	Occ	Habitat/Vegetation											Origin
			SS	SF	AF	MS	RI	LR	RF	OF	BS	RS	DS	
Acanthaceae														
Ruellia malacosperma Greenm.	S	I	–	–	–	–	RI	–	–	–	BS	–	DS	O
Thunbergia grandiflora Roxb.	V	I	–	–	–	–	–	–	–	–	BS	–	DS	O
Agavaceae														
Agave sisalana Perrine	S	I	SS	–	–	–	–	–	–	–	–	RS	DS	O
Agave vivipara L. var. *vivipara*	S	F	SS	–	–	–	–	–	–	–	BS	–	DS	O
Sansevieria trifasciata Prain	H	I	SS	–	–	–	RI	–	–	–	BS	RS	DS	O
Amaranthaceae														
Alternanthera dentata (Moench) Stuchlik ex R.E.Fr.	H	I	–	–	–	–	RI	–	–	OF	–	–	DS	O
Anacardiaceae														
Mangifera indica L.	T	I	–	–	–	MS	RI	–	–	–	BS	–	DS	E
Annonaceae														
Annona glabra L.	T	I	–	SF	–	–	RI	LR	RF	–	BS	–	DS	E
Apocynaceae														
Catharanthus roseus (L.) G.Don	H	F	SS	–	–	–	RI	–	–	OF	BS	RS	DS	O
Araceae														
Pistia stratiotes L.	H	I	–	–	AF	–	RI	–	–	–	–	–	–	O
Asteraceae														
Acanthospermum hispidum DC.	H	F	–	–	–	MS	RI	–	–	OF	–	–	DS	A
Ageratum conyzoides L.	H	F	–	–	–	MS	RI	–	–	OF	BS	RS	DS	O
Sigesbeckia orientalis L.	H	F	–	–	AF	MS	RI	–	–	OF	BS	DS	?	
Wedelia trilobata (L.) Hitchc.	H	I	SS	–	–	–	–	–	–	–	BS	RS	DS	O
Baseliaceae														
Anredera cordifolia (Ten.) Steenis	V	I	–	–	–	–	RI	–	–	–	BS	–	DS	O
Bignoniaceae														
Macfadyena unguis-cati (L.) A.H.Gentry	V	I	–	–	–	–	RI	LR	–	–	–	–	DS	O
Cactaceae														
Opuntia stricta (Haw.) Haw. var. *stricta*	H	F	SS	–	–	–	RI	–	–	OF	BS	RS	DS	E
Caesalpiniaceae														
Senna pendula var. *glabrata* (Vogel) Irwin & Barneby	ST	F	–	–	–	–	RI	–	–	OF	BS	–	DS	O
Commelinaceae														
Tradescantia spathacea Sw.	H	I	SS	–	–	–	–	–	RF	OF	BS	RS	DS	O
Convolvulaceae														
Ipomoea cairica (L.) Sweet	V	F	–	SF	–	–	RI	–	–	–	–	–	DS	O
Crassulaceae														
Bryophyllum daigremontianum (Raym.-Hamet & H.Perrier) A.Berger × *B.tubiflorum* Harv.	H	I	SS	–	–	–	RI	–	–	–	BS	RS	DS	O
Bryophyllum pinnatum (Lam.) Kurz	H	I	SS	–	–	–	–	–	–	–	BS	RS	DS	O
Bryophyllum tubiflorum Harv.	H	F	SS	–	–	–	RI	–	–	–	BS	RS	DS	O
Cyperaceae														
Cyperus involucratus Rottb.	H	I	–	–	AF	MS	RI	–	–	–	–	–	DS	O
Euphorbiaceae														
Euphorbia cyathophora Murr	S	I	SS	–	–	–	–	–	–	OF	BS	–	DS	O
Fabaceae														
Centrosema pubescens Benth.	H	F	SS	–	–	MS	RI	–	–	OF	–	–	DS	E
Dalbergia sissoo Roxb.	T	F	SS	–	–	MS	RI	–	–	OF	BS	RS	DS	O
Macroptilium atropurpureum (DC.) Urb.	H	F	SS	–	–	MS	RI	–	–	OF	–	RS	DS	E
Stylosanthes guianensis (Aubl.) Sw.	S	I	SS	–	–	MS	RI	–	–	OF	–	RS	DS	E
Stylosanthes scabra Vogel	S	I	–	–	–	MS	RI	–	–	OF	–	–	DS	E
Malvaceae														
Urena lobata L.	S	F	–	–	–	MS	RI	–	–	OF	BS	–	DS	U
Mimosaceae														
Leucaena leucocephala (Lam.) de Wit	ST	F	SS	–	–	–	RI	–	–	OF	BS	RS	DS	E
Mimosa pudica var. *setosa* Brenan	S	F	–	–	–	MS	RI	–	–	OF	–	RS	DS	E

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Appendix I. Environmental weeds of the Mackay coast, July 1997. **(.../continued from previous page)**

Plant name	L/f	Occ	Habitat/Vegetation											Origin
			SS	SF	AF	MS	RI	LR	RF	OF	BS	RS	DS	
Myrtaceae														
Psidium guajava L.	ST	F	SS	–	–	–	–	–	RF	OF	BS	RS	DS	E
Psidium guineense Sw.	ST	F	–	–	–	–	–	–	–	OF	BS	RS	DS	E
Syzygium cumini (L.) Skeels	T	I	–	–	–	MS	RI	–	–	–	–	–	DS	O
Ochnaceae														
Ochna serrulata (Hochst.) Walp.	S	I	–	–	–	–	RI	–	RF	OF	–	–	–	O
Passifloraceae														
Passiflora foetida L. var. *foetida*	V	F	SS	–	–	MS	RI	–	–	OF	BS	RS	DS	A
Passiflora suberosa L. var. *suberosa*	V	F	SS	–	–	MS	RI	–	–	OF	BS	RS	DS	A
Phytolaccaceae														
Rivina humilis L.	H	I	–	–	–	–	RI	LR	RF	–	BS	–	DS	O
Poaceae														
Axonopus compressus (Sw.) P.Beauv.	H	F	SS	–	–	MS	RI	LR	–	–	–	–	DS	O
Brachiaria mutica (Forssk.) Stapf	H	F	SS	–	AF	MS	RI	–	–	–	–	–	DS	E
Digitaria eriantha ssp. *pentzii* (Stent) Kok	H	F	SS	–	AF	MS	RI	–	–	OF	–	RS	DS	E
Echinochloa crus-galli (L.) P.Beauv.	H	F	–	–	AF	MS	RI	–	–	–	–	–	DS	E
Hymenachne amplexicaulis (Rudge) Nees cv. Olive	H	I	–	–	AF	–	–	–	–	–	–	–	DS	E
Hyparrhenia rufa (Nees) Stapf ssp. *rufa*	H	A	–	–	–	MS	RI	–	–	OF	–	–	DS	E
Melinis repens (Willd.) Zizka	H	A	SS	–	–	–	RI	–	–	OF	–	RS	DS	E
Panicum maximum Jacq. var. *maximum*	H	A	SS	–	–	MS	RI	–	–	OF	BS	RS	DS	E
Setaria sphacelata var. *sericea* (Stapf) Clayton	H	F	–	–	–	MS	RI	–	–	OF	BS	–	DS	E
Sporobolus indicus (L.) R.Br.	H	F	SS	–	–	MS	RI	–	–	OF	–	–	DS	A
Sporobolus jacquemontii Kunth	H	F	–	–	–	MS	RI	–	–	OF	–	–	DS	A
Sporobolus pyramidalis P.Beauv.	H	I	–	–	–	MS	–	–	–	OF	–	–	DS	A
Themeda quadrivalvis (L.) Kuntze	H	F	–	–	–	–	–	–	–	OF	–	–	DS	A
Pontederiaceae														
Eichhornia crassipes (Mart.) Solms	H	I	–	–	AF	–	RI	–	–	–	–	–	–	O
Verbenaceae														
Lantana camara L. var. *camara*	S	F	SS	–	–	MS	RI	LR	RF	OF	BS	RS	DS	O
Stachytarpheta jamaicensis (L.) Vahl	H	F	SS	–	–	MS	RI	–	–	OF	–	–	DS	O

Lifeform: T = tree >5 m; ST = short tree 2–5 m; S = shrub <2 m; H = herb; V = vine.
Occurrence: A = abundant; F = frequent; I = infrequent.
Habitat/Vegetation codes: SS = sandy seashore; SF = saline flats; AF = freshwater herbland swamp; MS = freshwater *Melaleuca* swamp; RI = riparian forest; LR = littoral rainforest; RF = rainforest; OF = eucalypt open forest; BS = sandy shore beach scrubs; RS = rocky shore vegetation; DS = disturbed, roadside, cleared, etc. vegetation.
Origin of Introduction: O = ornamental; E = economic crop or pastoral; A = accidental; U = unknown.