Management of indigenous and alien Malvaceae on islands near Perth, Western Australia

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Abstract *Malva dendromorpha*, European tree mallow, has not previously been described as a serious environmental weed. Over the last two to three decades tree mallow has invaded seabird nesting islands off the West Australian coast, growing in dense clumps to 3m tall and outcompeting native perennial species including *Malva australiana*, the Australian native hollyhock. As a result of excessive growth of tree mallow on small islands there has been a serious loss of biodiversity. The stands of biennial tree mallow have no understorey and die back in the hot, dry summer, exposing the soil to erosion by the strong sea breezes and also rendering it vulnerable to invasion by annual weeds. The habitat may then be less suitable for nesting bird colonies. Control measures on Seal Island over two years included regular mechanical removal and stump treatment with Roundup (glyphosate). Subsequently weedmat was laid down and some native species were planted. While eradication was not possible, control produced an ecologically-desirable outcome. There has been a 70% reduction in the cover of tree mallow and the native hollyhock has re-established itself locally. Other planted native species failed to survive amidst heavy growth of annual invading alien grasses and herbs which included *Malva parviflora* (marshmallow). Similar invasions by tree mallow have occurred on islands in South Australia and Victoria. In South Australia, management options were investigated but adequate resources to put them into practice were not available. In Victoria, regular hand removal of tree mallow over a seven year period has virtually eliminated tree mallow and the native hollyhock is flourishing. The problems we encountered are summarised and future directions outlined.

Keywords Tree mallow, *Malva dendromorpha*; native hollyhock, *Malva australiana*; island vegetation, weed management.

INTRODUCTION

The islands

In 1997 we surveyed the vegetation of four islands in the Shoalwater Islands Marine Park, some 40 km south of Perth, Western Australia: Penguin Island (12.5 ha), Middle Shag Island (0.4 ha), Seal Island (1.2 ha) and Bird Island (0.9 ha) (Rippey *et al.* 1998) (Fig. 1).

These islands are composed of aeolianite limestone, residuals of an old dune system, which was inundated some 6000 years ago when sea levels rose (Playford 1988). The islands were isolated and now form part of the present parallel limestone reef system. A variable layer of calcareous sand overlies the limestone forming beaches and dunes.

On Penguin Island public access is restricted to the beaches, a picnic area, and boardwalks that cross the island in two places. No landing is permitted on the smaller islands.

The problems

We were concerned about the changes in the vegetation pattern on the smaller islands for three reasons:

- There was a loss of biodiversity chiefly at the expense of native species. Notably, the Australian native holly-

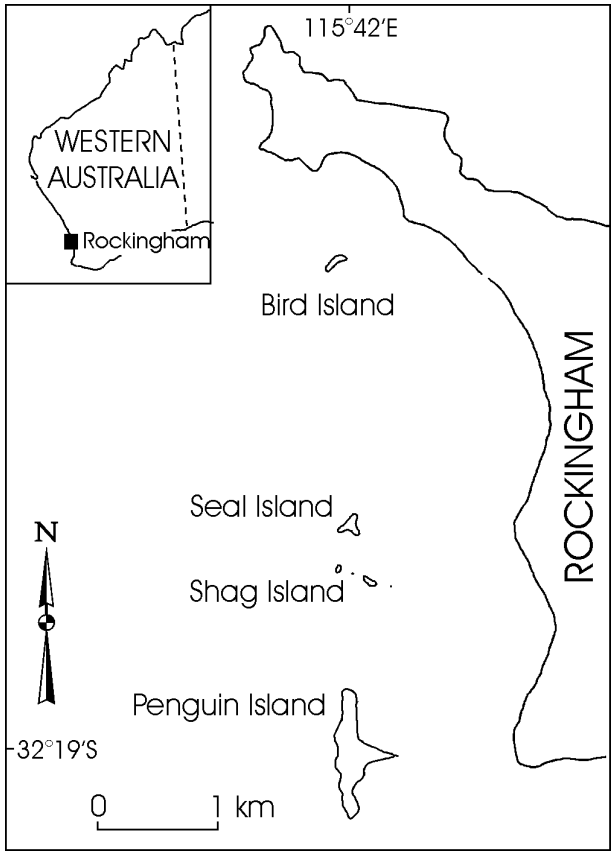

Fig. 1 The Shoalwater Islands off the coast of Western Australia

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hock (*Malva australiana*) appeared to be becoming locally extinct.

- Habitat change due to the thickets of European tree mallow (*M. dendromorpha*) could render the islands unsuitable for some nesting seabirds. Crested and Caspian terns that nest in the open are closed out by the canopy, and little penguins (*Eudyptula minor*) and bridled terns (*Sterna anaethetus*) are excluded by the lack of undergrowth.
- The risk of erosion was increased by the loss of native perennial shrubs which are constantly green and stabilise and maintain the shallow sandy topsoil. Tree mallow tends to die off leaving bare earth. Unstable soil is also unsuitable for burrowing birds.

The birds on the islands

Eleven species of seabirds have been reported nesting on these islands (Rippey *et al.* 1998). Little penguins, little shearwaters (*Puffinus assimilis*) and white-faced storm-petrels (*Pelagodroma marina*) nest in burrows or natural cavities among rocks or vegetation. A variety of terns nest on the surface of the ground; crested terns (*Sterna bergii*), bridled terns, Caspian terns (*S. caspia*) and occasionally roseate terns (*S. dougallii*). Silver gulls (*Larus novaehollandiae*) nest on open soil between plants. Pied cormorants (*Phalacrocorax varius*) nest, by preference, on top of perennial shrubs, especially *Nitraria billardierei.* Pelicans (*Pelecanus conspicillatus*) have nested on the northern promontory of Penguin Island since 1998. Feral pigeons (*Columba livia*) now nest in rock crevices on all of the islands.

Large amounts of guano are deposited by these birds. Pied cormorants and pelicans are the major guano-producing species of the region, and their numbers have tripled on these islands in the last ten years (E. Rippey, pers. obs.; Orr and Pobar 1992). Guano has raised the phosphorus levels of the soil of some of these islands to approximately 10%, the level of commercial fertilisers. The sands of the adjacent mainland shores are low in nutrients; Quindalup sands have phosphorus levels of 170 - 290 mg/kg (McArthur 1991), that is 0.017% - 0.029%.

Table 1 Reduction in total number of native and introduced plant species on Shoalwater Islands since 1975.

Island	Number of species 1975[1]	Number of species 1997[2]	Percentage Reduction
Penguin	81	76	6%
Seal	32	17	47%
Bird	31	14	55%
Middle Shag	22	16	27%

[1] (Abbott and Black 1980)
[2] (Rippey *et al.* 1998)

Fig. 2 Tree mallow (*Malva dendromorpha)* on Bird Island in October 1999 illustrating the lack of understorey.

The vegetation

There had been a marked diminution in the number of plant species found on the three smaller islands since the previous survey carried out in 1975 (Abbott and Black 1980; Rippey *et al*. 1998).

During the same period European tree mallow (*Malva dendromorpha,* formerly *Lavatera arborea*) (Ray 1995) had spread to all of these islands. The 1997 survey found it growing in profusion on the three smaller islands, forming dense stands of closely-packed upright stems up to 3 m tall (Fig. 2).

Four species of *Malva* are found on the islands, the Australian native hollyhock (*Malva australiana*) of the island variety (formerly *Lavatera plebeia* var. *tomentosa*) (Ray 1995), and three introduced species: European tree mallow (*M. dendromorpha*), marshmallow (*M. parviflora*), and Cretan mallow (*M. linnaei*). This last species will not be discussed in this paper as it currently occurs very infrequently on the Shoalwater Islands.

The native hollyhock and the tree mallow are similar and appear to hybridise (Rippey and Rowland 1995) although the hybrid seems to be sterile (E. Rippey, pers. obs.). Tree mallow, however, germinates earlier and has a less marked dormancy than the native hollyhock, which gives it an early advantage. This exotic species is also larger and grows more rapidly and profusely than the native hollyhock. It can completely overshadow any other vegetation and nothing will grow beneath it.

Tree mallow (*M. dendromorpha*) originated in the Mediterranean region and is found in coastal situations, often at the top of cliffs or on islands in association with bird colonies or in disturbed areas (Cook 1996). It is salt-tolerant and can excrete salt through glands on the leaves although it does not require salt for growth (A. J. C. Malloch, pers. comm.). It requires high levels of phosphorus and nitrogen and hence thrives in soil with a high guano content. It

is not tolerant of frost. It has spread widely across the globe and now occurs in coastal sites with a Mediterranean or warm temperate climate in the United States, Chile, South Africa, and along the south-western and southern coast lines of Australia.

It is a palatable plant, sometimes used in Europe for animal fodder (Laghetti 1998), and is not found on the larger islands off Perth (Rottnest and Garden Islands) where there are grazing wallabies. On Penguin Island growth is sporadic around bird nesting areas but there is not massive overgrowth as there is on the smaller Shoalwater Bay islands. On some other small islands (Dyer Island and Green Island) in the Perth region, dense stands of tree mallow can be found, and it is also present on Carnac Island.

Tree mallow has fruits that drop to the ground beneath the plants (barochorous dispersal (E. Vidal pers. comm.)). They are too heavy to be blown over a great distance. Fruits can float in seawater for long periods and germination can take place following prolonged immersion in sea water (Ray 1995). The seed has a hard impermeable outer case (or testa) and can remain viable for many years. Silver gulls, numerous on all the affected islands, probably transport the seeds.

The native hollyhock (*M. australiana*) which grows on islands only occurs where colonies of birds have greatly enriched the soil with nitrogen and phosphorus (Yugovic 1998). It can be found on islands along the western and southern coasts from Dirk Hartog Island in Western Australia around to South Australia, and Victoria, and in the Bass Strait.

The third member of the Malvaceae family that is common on the smaller islands is the marshmallow (*M. parviflora*). This is a smaller annual herb growing up to 1 m in height. The plant is widely distributed in Western Australia along roadsides, and in stockyards as well as on the islands. It dies off and dries out in the summer. This is another introduction to Australia from the Mediterranean which grows on enriched soil (Hussey *et al.* 1997; Marchant *et al.* 1987).

Distribution of Malvaceae on the islands

Tree mallow is a relatively recent introduction. It was recorded on Bird Island in a survey carried out in 1959 but was not then present on the other islands (Storr 1961). By the time of the next survey 16 years later, it had reached all of the islands (Abbott and Black 1980).

The Australian native hollyhock of the island variety has almost disappeared from the islands. In 1998 the last remaining plant on Bird Island died and in 1999 the last one on Seal Island. There was no native hollyhock on Penguin Island, and less than 100 plants on Middle Shag Island.

In the spring of 1999 on Bird Island, tree mallow occupied the plateau of the island to the virtual exclusion of other species (save for a few alien grasses and herbs, and some *Nitraria billardierei* on talus slopes) occupying approximately two thirds of the plateau surface. Much of the eastern plateau is kept bare by pied cormorants that roost there.

On Seal Island a large stand of tree mallow occupied 20% of the plateau.

On Middle Shag Island, tree mallow covered the central area of the plateau, occupying about half of the area, and there was a somewhat smaller area of native hollyhock which was growing much more sparsely as scattered plants around it. Tree mallow grew at a density of up to 30 plants per m^2 (first-year plants) but just two plants per m^2 for the larger second-year plants.

METHODOLOGY

We aimed to reduce or eradicate the growth of tree mallow and restore native hollyhock and other native plants on Seal Island. This was the largest of the small islands and some clumps of native vegetation remained. It was used by more species of seabirds for nesting than the other small islands. There was also an area of beach, facilitating access by boat.

Working parties of volunteers from the Friends of the Shoalwater Islands Marine Park visited Seal Island under the supervision of a ranger from the Department of Conservation and Land Management on the following dates:

11 September 1998: 10,000 tree mallows removed. Larger plants cut down and 15% glyphosate applied to stumps. Smaller ones uprooted by hand.

13 June 1999: 8000 tree mallows removed. Weed mat (5 m x 5.4 m) laid and planted with young native hollyhock plants.

3 July 1999: Native seedlings planted in and around cleared area: (*Rhagodia baccata, Myoporum insulare, Carpobrotus virescens*).

5 March 2000: 1200 tree mallows removed.

14 May 2000: Weed mat laid down and planted with *R. baccata.* Native hollyhock (six plants) planted in small (1 m x 1 m) weed mat squares. 1 m x 1 m areas adjacent to small weed mat squares tilled by turning over with a spade.

13 August 2000: 1800 tree mallows removed. Planted native hollyhock (three plants), *Frankenia pauciflora,* and *Rhagodia baccata* in small numbers. Additional unsupervised visits were made to measure growth rates and to assess the success of plantings.

RESULTS

Cutting and stump poisoning of tree mallow reduced the population from 10,000 to 3000 i.e. (70% reduction). Uprooting plants was less successful as plants could re-root to produce flowers and fruit. New germination follows soon after cutting and uprooting and growth is rapid at more than 1 cm a day during the spring months. We tried

to cut down new plants before they could fruit. Although flowering and fruiting usually occurs in the second year, a variable percentage (at least 5%) flower in the first year. Flowering takes place from August to October and fruit sets in November through to January, so removal is best carried out in July or August. However, new growth can occur from seed banks in the soil in later spring and a further session of removal in summer may be required. The seed bank is vast and *Malva* seeds are long lived, capable of germination after a century (J. Conran pers. comm.; Spira and Wagner 1983). Reducing the number of tree mallows was not enough to allow the native vegetation to re-grow; other weeds, such as the annuals *Lolium rigidum, Hordeum leporinum, Urtica urens, Chenopodium murale, C. album*, as well as the smaller marshmallow (*M. parviflora*) came in to take its place.

The weed mat was laid to prevent growth of tree mallow and other weeds in one area and to allow planted native species to grow without competition. This worked well for native hollyhock which grew in the mat from the first planting and then re-grew apparently from seed shed on to the degrading weed mat.

Tilling was undertaken because marshmallow (which is an agricultural weed of no-till farming) is controlled by cultivation (Anon 1999). Perhaps this is explained by the fact that Malvaceae seeds need to be on or very close to the surface for germination to take place (Okusanya 1979). The small experimental tilled areas on Seal Island remained clear of growth for some three months, well into spring.

Planting of natives (such as *Rhagodia baccata, Frankenia pauciflora* and *Myoporum insulare*) was not successful with no long-term survivors whether planted randomly or in weed mat. However *Carpobrotus virescens* planted on a rocky cliff top thrived.

In 2000, crested and Caspian terns nested on the island in considerable numbers, in areas formerly occupied by *M. dendromorpha.*

DISCUSSION

Assessment of the current situation on Seal Island

It seemed as though our efforts were not entirely in vain. Tree mallow was being reduced and there had been some regrowth of native hollyhock. However, revegetation with native species did not appear to be taking place and replanting with seedlings and young plants was notably unsuccessful. Weed mat was useful in preventing the excessive growth of weeds locally but only native hollyhock had been grown successfully in it, and it was an expensive way of controlling weeds.

Tilling or shallow digging over the surface seemed to work almost as well in clearing and preventing the rapid regrowth of weeds and was easier, quicker, and cheaper to implement over a wider area. Surface-nesting birds were returning to breed on the island.

Plans for future management would include:

- Continuing removal of tree mallow by hand, at least twice a year.
- Surface tilling in selected areas to reduce growth of annual weeds followed by replanting in tilled areas
- Collecting seed of native plants and hand seeding in both tilled and untilled areas.

The status of tree mallow in Australia and overseas

Tree mallow does not appear to present the same problem elsewhere as it does on the Shoalwater Islands. In the Mediterranean and in Western Europe it is appreciated for its appearance, and as it is palatable may even be used for animal fodder (Laghetti 1998).

On islands off Marseille it can grow densely in areas and a local researcher is worried because it represents an important source of water for rats (*Rattus rattus)*, which then pose a threat to the shearwater population (E. Vidal pers. comm).

British bird conservationists have used *M. dendromorpha* to provide shelter for nesting roseate terns (*Sterna dougallii*) (Avery *et al.* 1995)

In the Farallon Islands off the coast of California it is appreciated because it provides habitat for migrating land birds, but growth is controlled (C. A. Morris pers. comm.).

In South America and South Africa it grows sporadically along the west coasts, but is not a cause of concern.

State herbaria and parks and wildlife authorities in Australia were contacted by telephone. There were two areas where tree mallow had become so dominant that authorities had felt compelled to take action to control it: Mud Island in Port Philip Bay, Victoria and West Island off the coast at Victor Harbour in South Australia.

Mud Island with a land area of about 51 ha consists of Quaternary shifting sands around a lagoon. West Island, 12 ha, consists of ancient granites. Given that Seal Island, 1.2 ha, is formed of limestone, it appears that underlying substrate is not a significant influence on the growth of tree mallow.

All of the islands are used intensively by nesting birds. On Mud Island there are some 5, 000 silver gulls and about 15,000 pairs of ibis. Straw-necked ibis (*Threskiornis spinicollis)* and Australian white ibis (*T. molucca*) have nested there for the past 10 years (Yugovic 1998). On West Island large breeding colonies of little penguins, silver gulls and crested, fairy (*Sterna nereis*), and Caspian terns are found (Robinson *et al.* 1996).

All the islands have frost-free climates with rainfall concentrated in the winter, although the amounts vary considerably (Mud Island - 612 mm; West Island - 450 mm; Seal Island - 800 mm).

These islands have a history of disturbance. Mud and West Islands were quarried for guano and granite respectively. Huts have been built on them. Rabbits had grazed on both for a century or more and were eliminated only 20 or 30 years ago.

The overwhelming growth of *M. dendromorpha* appeared to be triggered on Mud and Seal Islands by the arrival of unprecedented numbers of nesting birds: ibis on Mud Island, pied cormorants on Seal Island. These are large birds that deposit a great deal of guano.

Eradication efforts on Mud Island

By 1994 over half the land area (30 ha) was occupied by tree mallow. Action was indicated to restore the habitat for nesting birds (particularly for crested, Caspian and fairy terns), and also to protect the Australian native hollyhock. In 1994 one ranger with Parks Victoria and a group of eight to twelve volunteers started monthly visits to Mud Island. They cut down the tree mallow, at first in thousands, using chainsaws to sever the 15 cm thick woody trunks. They treated the large stumps with glyphosate, and scattered the seeds of native hollyhock. Now after seven years they find only a few tree mallow seedlings on each visit and the island has large meadows of native hollyhock (Yugovic pers. comm.).

Eradication efforts on West Island

In South Australia the Department of Natural Environment and Resources initially undertook a more scientific approach. In 1994 and 1995 they trialed 10 plots with burning, cutting and spraying with the herbicide Brush-off (metsulfuron).

All approaches over the two years were effective in controlling the growth of young plants of *M. dendromorpha*, but it was apparent from continuing new germinations that the seeds were long-lived in the soil and that a long-term approach would be necessary. Some treatments although killing current growth, seemed to stimulate subsequent germination. Researchers also scattered seeds of native grasses and early observations showed successful germination. With courageous lateral thinking the introduction of tammar wallabies (*Macropus eugenii*) was considered (as mentioned the tree mallow is palatable), but black-footed rock-wallabies (*Petrogale lateralis*) introduced earlier had died out for lack of water on the island. Other biological control measures suggested were rabbits, goats or the native greater stick-nest rat (*Leporillus conditor*).

Scarcity of funds and labour have led to the abandonment of efforts to rehabilitate West Island.

Problems in management of invasive tree mallow

Lack of information

Perhaps the three separate groups attempting to control *M. dendromorpha* over seven years would have benefited from sharing information with each other. We also spent time determining the status of tree mallow in Australia and around the world.

Information about control measures is as important as knowledge of areas at risk. It seems that all seabird nesting islands on the southern coasts of Australia could be at risk. The growth of native hollyhock on these islands may be a marker for those at greater risk. Early identification of the problem could allow eradication of tree mallow at relatively little expense before it has become established.

Access

Islands mean difficult and expensive access; either a boat or a helicopter is required and some sort of landing area such as a sheltered beach is needed if there is to be all-weather access. It can add to the costs considerably if a boat has to be hired (for example A$120 to hire a ferry to transport weed mat to Seal Island; A$300-400 to hire a boat for each visit to West Island). Many domed granite islands off the south coast are accessible only by helicopter.

The presence of breeding birds can also restrict access as they can be very sensitive to disturbance. In the Shoalwater Bay Islands nesting terns can prevent access for 2-3 months in the spring and cormorants for a similar period in the autumn. Little penguins occupy their burrows for many months, from April to December in Western Australia (Pizzey 1997).

Funding

Programmes may be difficult to fund where offshore islands are seldom visited by ratepayers or voters, especially if landing is prohibited. Seabird nesting islands may not be regarded as having a high priority.

Labour

Weed control is labour intensive and long term but can be successful and rewarding as shown by the efforts on Mud Island. Here a dedicated ranger and a group of enthusiastic volunteers together with a researcher with vision, were responsible for the sustained effort which has resulted in the restoration of the native vegetation. On West Island by contrast, funds were not available, costs were high, volunteers were not considered, and the project was dropped. Using volunteers is probably the only way such programmes can be afforded. Where volunteers are used it is important that the controlling authority should be supportive both in devising a workable plan with the best available advice, and in the long-term execution of the task.

CONCLUSION

The weed tree mallow (*M. dendromorpha*) can be successfully contained simply by mechanical removal at regular intervals over a long period. Subsequent re-colonisation by Australian native hollyhock (*M. australiana*) can be facilitated by planting or seeding.

Eradication of tree mallow is not a realistic aim on the Shoalwater Islands. There is a large bank of long-lived seeds in the soil. In addition, seed rain comes from scattered plants along the metropolitan coast line, from plants growing on inaccessible cliffs on the islands, and from other islands in the vicinity that are more costly and risky to access. Some of these islands are larger and further from the mainland, some are surrounded by cliffs that have to be climbed before any plants can be reached, and some are infested with tiger snakes (*Notechis scutatus*). Thus constant vigilance will have to maintained on the Shoalwater Islands.

The wide range of annual weeds that have arrived on the islands, including marshmallow (*M. parviflora*) seem to pose less of a problem. Perhaps tilling and seeding with natives could help in the re-establishment of the original vegetation in areas where this has disappeared. However, true rehabilitation is unlikely as long as the number of birds, especially cormorants, nesting on the islands remains at present levels.

The value of vigilant volunteers has been illustrated by their role in both the early discovery and control of tree mallow.

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