Designing a plant cage to mitigate damage to seedlings by burrowing wedge-tailed shearwaters *Puffinus pacificus*, Round Island, Mauritius

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SUMMARY

During attempted habitat restoration on Round Island, in response to plants being lost during revegetation attempts due to burrowing activities of nesting wedge-tailed shearwaters *Puffinus pacificus*, plant cages were developed to enhance plant survival. With modification, the cages had additional benefits including reduction of damage due to salt spray and wind. Wedge-tailed shearwaters continue to exploit and nest in areas undergoing vegetation restoration.

BACKGROUND

Round Island, lying off the north-east coast of Mauritius, is extremely significant in terms of conservation of the endangered flora and fauna of the Mascarenes. It supports eight endangered reptile species (six until recently only surviving on Round Island: two being re-introduced to other islands in 2006). It also has internationally important seabird colonies having the only Indian Ocean breeding colony of Trindade petrel *Pterodroma arminjoniana* and the largest populations of wedge-tailed shearwater *Puffinus pacificus* and red-tailed tropicbird *Phaeton rubricauda* in the Mascarene Archipelago.

In terms of flora, Round Island supports the last remnants of lowland palm-rich forest ('Palm Savannah') that once covered parts of the Mauritian lowlands, with at least 10 species of threatened native plants (six endemic to Mauritius and its satellite islands), including several palms. The Round Island hurricane palm (Palmiste Blanc) *Dictyosperma album* var. *conjugatum*, is listed as Critically Endangered with only one surviving wild individual. The only wild population of Round Island bottle palm (Palmiste Bouteille) *Hyophorbe lagenicaulis* has a small but regenerating population, although it is still considered Critically Endangered. The Round Island fan palm (Latanier Bleu) *Latania loddigesii* is the dominant palm and still covers extensive areas of the western and northern slopes. The island also has the largest remaining population of Round Island screwpine (Vacoas) *Pandanus vandermeeschii*.

Hardwood forest once covered the upper south-eastern slopes comprising trees such as ebonies *Diospyros* spp., Bois de Buis *Fernelia buxifolia*, Bois d'Olive *Cassine orientalis*, as well as ferns and creepers. With the disappearance of the hardwood forest, only two native hardwood species, *Gagnebina pterocarpa* and one individual of Bois de Buis *Fernelia buxifolia* managed to survive on Round Island. Realistic management goals include restoration of the island's palm-rich and hardwood forests, and an intensive plant restoration programme is currently being implemented.

However, the planting programme faces several major difficulties: the island had lost most of its top soil; most plants restricted to the island were very rare; there was a high level of weed infestation since the eradication of introduced goats *Capra hircus* and European rabbits *Oryctolagus cuniculus*; freshwater was scarce; salt spray and high insolation affected plant survival; and burrowing activities of nesting wedge-tailed shearwaters disturbed and uprooted plants. Mitigating the latter's effects posed a challenge since areas suitable for planting i.e. with deep soil (>20 cm) were also those favoured areas for shearwater burrows. This case study summarises methods employed to counter the effects of shearwater activities and to enhance plant survival.

ACTION

Study site: Round Island (19°54'03''S, 57° 47'03''E) is a 219 ha offshore islet situated 22.5 km off the north-east coast of Mauritius (Indian Ocean). It is administered jointly by the National Parks and Conservation Service (NPCS) of the Government of Mauritius and the Mauritian Wildlife Foundation (MWF).

It is a crescent-shaped volcanic island reaching 280 m a.s.l. Its slopes are generally steep, particularly on the upper third of the island; about 48 % is covered in bare rock. Unlike most tropical oceanic islands, Round Island has never been colonised by rodents, explaining in part the survival of native plants and animals that have otherwise been decimated on the main island of Mauritius. Round Island was declared a Nature Reserve in 1957 in order to provide legal protection for the threatened endemic species that it harbours, and to redress the immense anthropogenic pressures the island was then subjected to, including that posed by goats and rabbits introduced around 150 years previously. The removal of goats in 1979 and rabbits in 1986 is considered to have saved much of the remaining Round Island biota and has facilitated habitat restoration. However, invasive plants that were controlled by goat and rabbit grazing flared in their absence, further imperilling the survival of some native species.

Initial plant re-introduction attempts and field station establishment: Plant re-introduction and habitat restoration started in the 1980s. Seeds were broadcast or sown, or plants brought from the mainland and planted out, but with no care in between visits, often several months and sometimes over a year. Survival and establishment was very limited. Of the few hundred thousand seeds and few thousand plants brought to Round Island from mid-1980's to late 1990's, less than 0.1% survived, due principally to competition from weeds and water stress. For example, of over 35,000 seeds of mixed native species planted in 1998 on the 'Big Helipad', only a handful of *Scaevola taccada* successfully germinated and survived. After realising that significant progress in increasing plant survival (in addition to advancing knowledge and protection of the island's other biota) could not be achieved without a permanent presence, a field station was established in 2002.

Planting: Due to quarantine restrictions, all plants are transported (by helicopter) from mainland Mauritius to Round Island as bare-rooted seedlings. They are then grown on in the nursery, transplanted in areas offering sufficient soil depth, and watered as required until established. Transplant sites are weeded of invasive species such as Southern sandbur *Cenchrus echinatus*.

Initial shearwater exclusion attempts: It was found that due to the burrowing actions of breeding wedge-tailed shearwaters, an extremely high proportion of plants failed to establish. Following low plant survivorship in 2002, discussions regarding shearwater exclusion techniques were undertaken and implemented in early 2003. An area of 3,300 m^2 underlain by topsoil was covered with 5 x 5 cm heavy duty chain-link fencing, coinciding with one of the most productive shearwater colonies on the island. The urge to obtain high plant survivorship predominated over the nesting requirements of the birds, this being seen as a small sacrifice compared to plant restoration over a much larger area than previously achieved.

This action may have compromised over 3,000 pairs of wedge-tailed shearwaters during one breeding season (based on a burrow density of 1 nest/m^2), including some burrows that were collapsed through human trampling. There were observations of shearwaters attempting to pass though the fencing, having difficulties cleaning burrows of excess soil, some were trapped in burrows, and some laid eggs on the surface where burrow access had been prevented. A total of 14 birds were trapped and died in the mesh whilst 28 others were rescued - if this technique was continued to be used, such areas would need to be visited daily for up to 10 months of the year to ensure release of any trapped birds.

When laid, the fence became tangled in mats of vegetation and was difficult to remove. If left in-situ, due to the slow and uneven degradability of the material, it was estimated that the chain-link may have represented a hazard to both shearwater chicks and adults for well over 10 years. It would also have made personnel movement difficult, the fencing was expensive and transportation by helicopter (the only effective means of transport to the island due to access difficulties) very prohibitive.

Shearwater exclusion cages: An alternative

Figure 1. MWF staff making plant cages in preparation for the planting season. The wire is purchased in rolls, cut to size, rolled into shape and covered with shade cloth.

to the fencing had to be found urgently that represented an ethical, financial and practical improvement. Circular wire guards/cages made from welded mesh were suggested. The mesh is commercially available in several widths, in a variety of mesh sizes, wire thicknesses and quality of galvanizing. Mesh in 1 m high rolls with a 2.5 x 2.5 cm grid was selected from which plant cages (0.3 m diameter, 0.45 m high) were made (Fig. 1). These are sunk into the soil to rock depth to prevent shearwaters from burrowing under the plants whilst allowing them to access and make burrows in between the guards (Fig. 2). The guard is cut at ground level once the plants have established (usually after one year) and any remains underground break down rapidly.

Weeding: A weeding strategy has also been developed. Fast growing weeds are cut with strimmers and the trimmings left in place to protect the soil from wind and rain. Some of the cut material is used to mulch within the cage which enhances moisture retention and suppresses weed growth.

Watering: Water is a precious commodity on Round Island. Although water catchments can store up to 60,000 l in total, water reserves run very low in the dry summer months and if rains are late to arrive, can compromise plant survival. The water stock is therefore strictly managed. Previously, surface irrigation was found to be wasteful due to run off. In order to make efficient use of water, a delivery system has been designed using 500 ml PET water and soft drink bottles. These are bottles containing expired soft drinks or water, the contents are emptied and those in good condition are donated to MWF. The bottom of each bottle is cut off, it is upended and dug into the soil beside a plant. Water can then be poured in.

CONSEQUENCES

Plant survival: The present improved cage system to enhance plant survival has allowed wedge-tailed shearwaters to continue to thrive amidst plant restoration sites. Use of the cages, as well as individual plant care, resulted in an unprecedented plant survivorship of 95% (up to three months) in the 2004 planting, stabilised to around 85% after 1 year. This represents an 8,500 fold improvement over the previous survivorship of less than 0.1% pre-permanent wardening (2002) and 23% without cages and the bottle watering system (see below).

Although the cages were initially designed for protection of plants solely against shearwaters, there have been several modifications that have provided additional benefits to plant survival. In order to reduce excessively high temperatures within the cages, they are lined with 40 % shade netting. This also reduces soil deposition onto leaves resulting from the shearwater burrowing activities, as well as reducing salt spray and wind damage.

Figure 2. Cage planting at 1 m spacing within a wedge-tailed shearwater colony. Shearwaters can still use burrows in between cages. A pipe brings water (from storage tanks at higher altitude) to the planting site.

Watering: The bottles reduce surface water loss while watering newly planted plants, and deliver the water close to the root zone which promotes good rooting structure and extensive rooting, thus ensuring that plants grow well. The water stock destined for planted areas can now be managed with great precision. Based on experience, all plants under 1-year old are

provided 500 ml of water weekly, unless over 10 mm of rains have been received in that period. The bottles also reduce evaporation loss and allow a precise volume of water (about 500 ml) to be provided to each plant. Around two thousand bottles are presently required annually for each 4-month planting season (January to April) each year. The bottles are re-usable from season to season.

The benefit of using recycled plastic bottles is illustrated by the great success in plant survivorship, compared to prior planting techniques.

Impact on breeding shearwaters: The plant guards proved to pose far less risks to wedge-tailed shearwaters and there have been no recorded cases of birds becoming trapped over the three planting seasons that they have been used. Shearwaters can still use burrows in between cages with little or no adverse impacts noted.

Future restoration: MWF and NPCS have now embarked on an ambitious hardwood restoration programme. Some 10,000 plants will be grown over a 4-year period for re-introduction or propagation of endangered plants. This project would not have been considered possible without the experience gained during the past five planting seasons, including methods to mitigate wedge-tailed shearwater damage and adverse environmental factors.

Conclusions: The plant cages developed to enhance plant survival have proved successful. With modification the cages also had additional benefits including reduction of damage due to salt spray and wind. Wedge-tailed shearwaters are able to continue to exploit areas undergoing plant restoration. The importance of wedge-tailed shearwaters to the ecology of Round Island (e.g. in nutrient recycling) is now better appreciated and there is great pride in asserting that Round Island is home to one of the most important wedge-tailed shearwater colonies in the world and that they are an intrinsic part of the integrated restoration plan for the island.