Ecological interactions between a common palm *Livistona australis* and a rare seabird on Cabbage Tree Island, Australia

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ABSTRACT

Australia's most widespread palm, the Cabbage Tree Palm *Livistona australis* (R. Br.) Mart. has only a few offshore populations, but one of considerable significance is on Cabbage Tree Island on the mid-north coast of New South Wales. This island is also the principal breeding site of a threatened endemic seabird, the Gould's Petrel *Pterodroma leucoptera leucoptera*. This paper outlines some of the ecological interactions between this iconic palm and this enigmatic seabird. *P. leucoptera* nests in rock cavities, under fallen palm leaves, or in hollow fallen palm trunks. It takes to the air by climbing to the top of palms and is sometimes killed by colliding with them. The eradication of the European Rabbit *Oryctolagus cuniculus* from Cabbage Tree Island in 1997 was undertaken to remove one of the threatening processes endangering *P. leucoptera*. This action has in turn released the population of *L. australis* from 91 years of unsustainable grazing pressure, helping to restore the long-term integrity of this, and other, plant species on Cabbage Tree Island.

Key words: Palm, petrel, tree-climbing.

The Cabbage Tree Palm *Livistona australis* is a common palm distributed along much of the eastern seaboard of Australia (Fig. 1), ranging from the Paluma Range in northern Queensland (19° 17' S) to Cabbage Tree Creek in East Gippsland, Victoria (37° 45' S) (Brooks 1993). In the southern limits of this distribution the species is subjected to prolonged cool temperatures. In the Southern Hemisphere, the only other palm that grows at such high latitudes is the New Zealand Nikau Palm *Rhopalostylis sapida* (43° 45' S) (Enright and Watson 1992). *L. australis* is found in near-coastal wet sclerophyll forests, gallery rainforest and their margins, as well as swamp forests dominated by paperbark *Melaleuca quinquenervia* (Rodd 1998). It is hardy and occurs on a range of soil types, sometimes locally dominant on exposed coastal slopes.

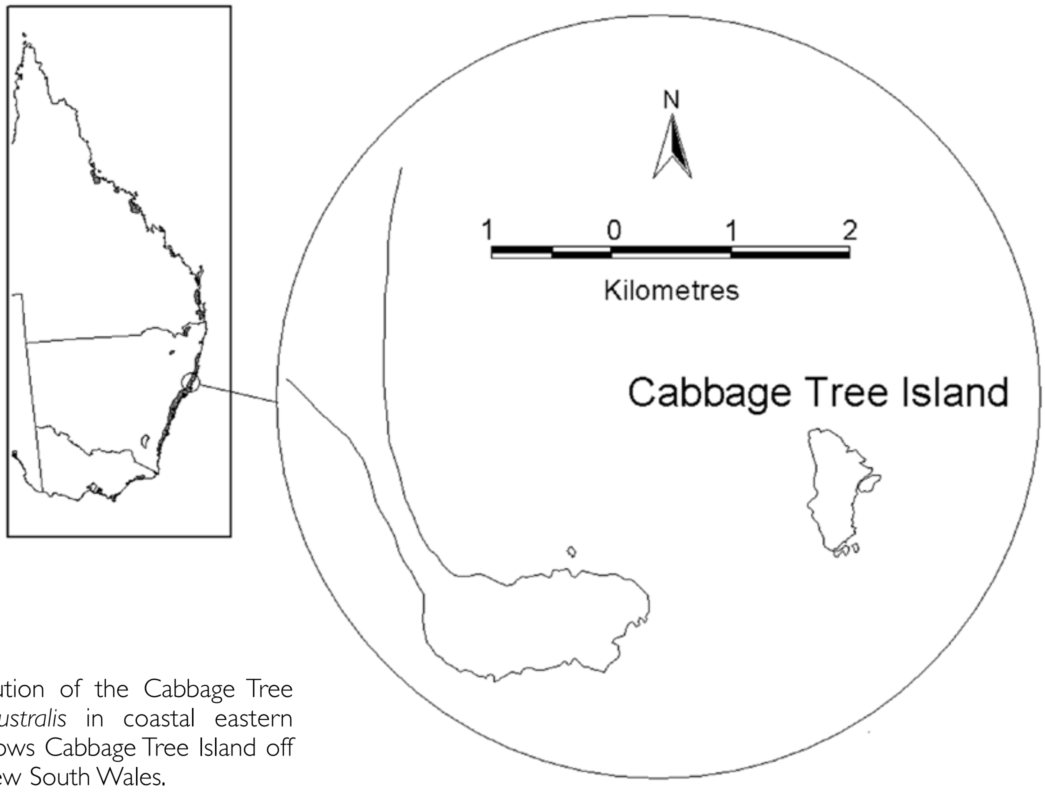

Figure 1. Distribution of the Cabbage Tree Palm *Livistona australis* in coastal eastern Australia. Inset shows Cabbage Tree Island off Port Stephens, New South Wales.

Cabbage Tree Island (32°41'S, 152°13'E; hereafter abbreviated to CTI) lies one kilometre northeast of the entrance to Port Stephens on the mid-north coast of New South Wales in eastern Australia. It is a steeply sloping island, about 1000 m long by 490 m wide and covering 30 ha (Fig. 1 inset). Steep cliffs of granitic toscanite rise along the eastern side to 123 m above sea level and are highly fractured along vertical bedding planes. Several basaltic dykes dissect the island, two of which form pronounced rock scree gullies draining moderately steeply to the western shore (Priddel et *al* 2005). Most of the island is covered in rainforest, a form of Dry Rainforest Sub-alliance 23 (*Ficus-Streblus-Dendrocnide-Cassine*) (Floyd 1990), in which *L. australis* is a dominant canopy species. The only significant human-induced impact to the island has been browsing by the European Rabbit *Oryctolagus cuniculus* during the period between its introduction in 1906 and its eradication in 1997 (Priddel et *al* 2000). Scorch marks on the trunks of the taller palms indicate past fire, although none have been recorded within the last century.

CTI is the principal nesting site of Australia's endemic and threatened Gould's Petrel *Pterodroma leucoptera leucoptera* (Priddel and Carlile 1997a). This small (body length ~30 cm; wingspan ~75 cm; weight ~200 g), black and white gadfly petrel is nocturnal on land, arriving and leaving under the cover of darkness. Once close to extinction (Marchant and Higgins 1990), the petrel population on CTI has been intensively managed during the last two decades to reduce land-based mortality and increase population size (Priddel and Carlile 1997, 2007). Action taken to identify and ameliorate all known threatening processes (see Priddel and Carlile 1995b) has greatly increased adult survivorship and breeding success. The number of breeding pairs has risen from about 250 to 1000, breeding success has improved from less than 20% to about 50%, and the number of fledglings produced each year has increased from less than 50 to more than 400 (Priddel and Carlile 2007).

CTI is protected against disturbance through its location and difficult access (Priddel et *al* 2005), its legal protection as a Nature Reserve under the *NSW National Parks and Wildlife Act (1974)* and as declared Critical Habitat (DEC 2006) for Gould's petrel under the *NSW Threatened Species Conservation Act (1995)*.

Fallen leaves provide concealment, nest sites and nesting material

The two deep, rocky gullies on the western side of CTI are dominated by *L. australis*, seedlings of which are able to establish in small pockets of soil that form within the rock scree (Fig. 2). Few other tree species appear to be able to get a foothold. Together the two gullies contain approximately 80% of the breeding population of *P. l. leucoptera*; the birds nesting in cavities among the rock scree (Priddel and Carlile 1997a). Some petrels breed outside the two gullies, and indeed on other islands (Priddel and Carlile 1997b, Carlile et *al* 2012) but the nest sites are scattered, with nests located under boulders or in small rock piles.

Figure 2. The Cabbage Tree Palm *Livistona australis* growing within rock scree on Cabbage Tree Island. Artificial nesting boxes for Gould's Petrel *Pterodroma leucoptera leucoptera* can be seen between the palm trunks.

Within the two gullies the fallen leaves of *L. australis* form a near-continuous cover over the surface of the ground, in places up to half a metre deep (Fig. 3). The interlaced leaves cover the entrances to most subterranean nest sites, providing nesting petrels, their eggs and developing young with protection from adverse weather conditions, as well as concealment from avian predators and any aggressive conspecifics that nest nearby. Some pairs nest above ground within the mat of fallen palm leaves; about 4% of nest sites are of this type. Early observations, at a time when petrels were more numerous, found that a single pile of palm leaves could provide nesting cover for up to five pairs of petrels (Hull 1911). Fragments of dead palm leaves line the nests of many petrels and are the only nesting material utilised by this species (Hindwood and Serventy 1941). Given that fallen palm leaves provide *P. l. leucoptera* with concealment as well as nest sites and nesting material, the loss of palm leaves from the forest floor as a result of wildfire could be extremely detrimental. Accordingly, current management strategies aim to prevent the occurrence and spread of fire on the island (DECC 2007).

Figure 3. Aerial view of the forest floor within the breeding habitat of Gould's Petrel *Pterodroma leucoptera leucoptera* . With the rock scree mostly devoid of undergrowth, palm leaves are often the only ground cover.

Fallen hollow palm trunks provide nest sites

The hollow trucks of mature palms that have collapsed or toppled provide additional nesting sites for the petrel (Fullagar 1976, Priddel *et al* 1995a). Between 1994 and 2003 an average of 18 pairs nested in hollow logs each year (range 13–23). Logs that were hollow at both ends sometimes contained two nesting pairs, one at each end. Unlike rock cavities, nest sites in fallen palm logs are temporary, most logs surviving only 3–5 years before they rot and collapse (Carlile and Priddel 2009). As a result of this collapsing, petrels that nest in hollow logs have lower reproductive success than those that nest in rock cavities (Priddel and Carlile unpublished data). Consequently, no attempt has been made to artificially increase the availability of logs.

The use of hollow palm logs indicated that the petrel would probably utilise any suitably sized cavity for nesting. This observation led to the development of a moulded plastic nest box that could be used to provide safe nesting sites for cavity nesting petrels (Priddel and Carlile 1995a). To aid recovery of the *P. l. leucoptera* population any pair that nested within a palm log that collapsed was encouraged to continue nesting at the same site inside a nest box. Nest boxes were installed near where the nest chamber had been located and a short piece of intact log was cut and attached to the entrance. Petrels have continued to nest in these boxes long after the logs have disintegrated and disappeared. Nest boxes now provide additional secure nesting sites on CTI as well at a newly established colony on nearby Boondelbah Island (Priddel et *al* 2006).

Palms provide launching sites

P. l. leucoptera come ashore only under cover of darkness. When landing, they crash awkwardly through the rainforest canopy before fluttering down to the forest floor and scurrying to their nest. The process of taking off is usually more difficult as this species, like most seabirds, takes flight easily only in windy conditions. Wind within the gullies on CTI is tempered significantly by the thick forest canopy. In the absence of any wind many petrels attempt to gain height before taking to the wing. Rock outcrops provide some elevation, but mature *L. australis* provide a much higher launching point. Using their wings for lift and their powerful hooked bill and clawed webbed feet for purchase, petrels climb the vertical trunks of the palms, occasionally resting using their tail feathers as a prop (Figs 4 and 5). Once at the top the birds clamber over the leaf stems before launching out of the canopy to the ocean beyond. Interestingly, this behaviour is not restricted to experienced adults; fledglings that have never before flown also use this technique to get airborne for the first time.

Figure 4. A fledgling Gould's Petrel *Pterodroma leucoptera leucoptera* climbing the vertical trunk of the Cabbage Tree Palm *Livistona australis*. The wings provide lift and the bill and clawed webbed feet work in conjunction as it 'walks' up the trunk to gain height before taking flight.

Figure 5. A fledgling Gould's Petrel *Pterodroma leucoptera leucoptera* resting during a climb of the Cabbage Tree Palm *Livistona australis*. The tail feathers are used as a prop while the tip of the bill is hooked onto the trunk and the wings wrapped around the trunk.

Tree climbing to reach an elevated take-off point has been noted in several other forest-breeding petrels (Yoshida 1981, Lindsey 1986, Telfer et *al* 1987, Sullivan and Wilson 2001). However, most species have only been reported to climb sloping tree trunks. We know of only two other petrels that climb vertical trunks. Bonin's Petrel *Pterodroma hypoleuca* on Midway Island, Hawaii, occasionally climb Ironwood Tree *Casuarina equisetifolia* (Grant et *al* 1983) and J. Madeiros (pers. comm. 2004, Bermuda Conservation Dept.) observed fledglings of the Bermuda Petrel *P. cahow* climb the same species of tree on Nonsuch Island, Bermuda. These two species probably ascend vertical trunks because, like *P. l. leucoptera*, they nest in tall forests that provide a great deal of protection from prevailing winds, making if difficult for birds to take to the air.

Palms inflict mortality

Not all interactions between *L. australis* and *P. l. leucoptera* are favourable for the petrel. Several fatal collisions of airborne petrels with palm trunks have been recorded. In addition, we have observed two incidences of petrels dying after becoming impaled on the recurved spines that occur along the margins of the petiole. The palms involved were both sub-canopy individuals with a trunk height of 4–5 m.

Injury and sometimes death of forest-nesting petrels through collision with trees is not uncommon. On CTI, it is surprising that so few birds die as a result of impaling themselves on spiny vegetation. The spines on *L. australis* are more predominant in palms under five metres in height (Rodd 1998), and the frequency of impalement may increase now that rabbits have been removed and palm regeneration can resume.

Petrels provide nutrients

Nesting seabirds bring ashore large quantities of marine-derived nutrients in the form of guano, failed eggs and the corpses of adults and chicks. These nutrients can be essential for ecosystem functioning and their loss can sometimes lead to degradation of native plant communities (Holdaway et *al* 2007). For example, the decline in health of the native forest on Norfolk Island, has been linked to the local extirpation of huge colonies of Providence Petrel *P. solandri* in the 19th Century (Christian 2005) resulting in the subsequent loss of 70 tons of guano deposited annually (Richard Holdaway unpublished data). The decline in forest health is manifest through dieback in the dominant Norfolk Island Pine *Araucaria heterophylla*. Conservation authorities on Norfolk Island aim to rectify the situation by reintroducing Providence Petrel to the island as a means of re-establishing the nutrient balance that existed prior to human colonisation (Commonwealth of Australia 2000).

The importance of marine-derived nutrients to the growth and maintenance of *L. australis* and other rainforest plants on CTI is not known. The wide tolerance of *L. australis* to soil type (Rodd 1998) tends to suggest that a decrease in nutrient content of the soil would not greatly affect the persistence of the palm population on this island. When first discovered, *P. l. leucoptera* was recorded as breeding 'in great numbers' on CTI (Gould 1865). Despite the population having declined during the 20th Century no obvious deterioration in the health of the island rainforest is apparent, other than the lack of regeneration due to rabbits. The persistence of other breeding seabirds here that appear to have not declined over recent decades (Priddel and Carlile 2004) indicates that marine derived nutrients may not have varied substantially since the decline of *P. l. leucoptera*.

Recovery actions for petrels benefit palms

Rabbits, present on the island between 1906 and 1997, probably constituted a far greater threat to the rainforest health than loss of nutrients. With rabbits now gone it is expected that the rainforest, along with the other plant communities present on CTI, will slowly recover. In the last decade the regeneration of *L. australis* has been remarkable, with cohorts of juveniles becoming established for the first time in many years (Carlile and Priddel 2009). Some apparent seedlings that emerged soon after the eradication produced adult leaves, indicating these individuals were actually established plants recovering from severe previous grazing. Although many of these plants are now several metres tall, it may be several more decades before a trunk develops (Carlile and Priddel 2009).

The regeneration of the rainforest will eventually reduce the two other land-based threats affecting the petrel: predation of nesting adults and chicks by Pied Currawong *Strepera gracilis*, and entanglement in the sticky fruits of the Birdlime Tree *Pisonia umbellifera* (Priddel and Carlile 1995b). The recovery of the rainforest understorey is reducing the ability of *S. gracilis* to forage on the forest floor. Similarly, the falling fruits of *P. umbellifera* are now more likely to get hung up in the understorey, and with less fruits falling directly to the forest floor there is less potential for petrels to become entangled.

Removal of rabbits from CTI has helped restore the ecological balance of the island and secure the future of both *P. l. leucoptera* and *L. australis*. Conservation of the petrel was the driving force behind the eradication of rabbits from CTI and it is unlikely that such action would have been taken to save the population of *L. australis* on CTI or this unique rainforest environment had the petrel not been present.

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