Constraints to Threatened Plant Recovery in Commonwealth National Parks

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Cover photos

LEFT - Phillip Island Hibiscus (*Hibiscus insularis*) ©M. Fagg. RIGHT - Ti/Norfolk Isand Cabbage Tree (*Cordyline obteta*) ©M. Fagg.

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Executive summary

This report reviews the current knowledge for a range of threatened and endangered species across Commonwealth national parks. The overall aim of this assessment was to improve our understanding of key processes that threaten the long term persistence of plants found in national parks that are currently listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). We sought to do this by:

1. Assessing the current conservation status and security of these species with respect to *in-* and *ex-situ* (living and germplasm) collections.
2. Determining knowledge gaps with respect to species distribution, reproductive biology, ecology and taxonomy to help develop and prioritise research and conservation management plans within Commonwealth national parks.
3. Building a compendium of threatening processes to understand the range of risks that are impacting on species recovery at the Park and National levels as well as to develop a more collective approach to threat management.

Using available information from 41 endangered or significant species that occur in national parks we found that

i. A large proportion of these species are only found in national parks highlighting the significant role and responsibilities that these parks play in their conservation and management.

ii. Very few of the species are held in *ex-situ* collections (living or seed bank) and collections that do exist are small indicating that opportunities to re-establish populations following extinction events are extremely limited.

iii. Very few of the species are regularly monitored and population trajectories are unclear.

iv. Too little information on the impacts of threats or species biology exists, limiting our ability to secure these species against further loss.

We also make the following broad recommendations:

Onground activities

- Survey all endangered plant species in national parks not currently part of a formal monitoring program or that have not been surveyed within the last two years.
- Partner with researchers and NGOs with restoration experience to draw on available scientific and onground knowledge to improve the outcomes of these activities.
- Consider establishing 'insurance' populations for some species outside of national parks in a similar manner to *ex-situ* breeding programs for vertebrates.
- Secure *ex-situ* collections (living and seed) of all threatened species not currently held as a matter of priority.

Research

- Initiate a five, but preferably ten, year research program dedicated to investigating the biology of endangered plants species across national parks.
- Undertake genetic assessments where this will directly benefit species recovery and ensure that *ex-situ* seed collections are genetically representative and appropriate for restoration if required.
- Explore opportunities such as partnering with research institutions and citizen science initiatives to develop long term monitoring programs (i.e. 10s of years).
- Explore opportunities with the horticulutre and nursery industries to develop rare species to broaden the current product base.
- Develop a risk framework using information about a species biology, location and threat sensitivities to help define and prioritise actions under climate change.

Training

- Provide national park staff with development opportunities to enhance their understanding and use of methodologies such as Adaptation Pathways in future planning exercises.

Abbreviations

The following abbreviations are used throughout the text:

ACT	Australian Capital Territory
ALA	Atlas of Living Australia
ANBG	Australian National Botanic Gardens (Canberra)
APC	Australian Plant Census
APII	Australian Plant Image Index
APNI	Australian Plant Name Index
ASBP	Australian Seed Bank Partnership
BNP	Booderee National Park
CHAH	Council of Heads of Australasian Herbaria
CINP	Christmas Island National Park
DNP	Director of National Parks
DoE	Department of the Environment
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
KNP	Kakadu National Park
NINP	Norfolk Island National Park
NSW	New South Wales
NT	Northern Territory
Qld	Queensland
TPWC Act	*Territory Parks and Wildlife Conservation Act 2006*
TSC Act	*Threatened Species Conservation Act 1995*
TSSC	Threatened Species Scientific Committee
UKTNP	Uluru-Kata Tjuta National Park
Vic	Victoria

1 Introduction

1.1 Threatened plants in Australia

Some 84% of plants that occur naturally in Australia are found nowhere else in the world but changes to the Australian landscape have put many of these unique species at risk (DoE, http://www.environment.gov.au/biodiversity/threatened accessed 6 January 2016). Plant species are protected nationally by the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). Plant species are listed under the *Act* in one of four categories - "Extinct", "Critically Endangered", "Endangered" and "Vulnerable". The criteria used to define these categories mostly align with the International Union for Conservation of Nature (IUCN) Red List category criteria and are based on information such as the size of the species distribution, the estimated number of mature individuals, and, whether one or both of these measures are declining.

Key threats across Australia to our plant species include ongoing habitat destruction or alteration due to human activities, the impacts of invasive species and changes to fire management, frequency and intensity. Vegetation fragmentation resulting in population reductions and isolation have also reduced genetic diversity and elevated inbreeding. This can lead to ongoing population decline by impacting on the reproductive success and recruitment of plant populations. Fragmentation can also facilitate the spread of invasive species while declines in other species such as pollinators and seed dispersers also pose a threat to the sustainability of plant populations.

1.2 Commonwealth national parks

Australia has six Commonwealth national parks that are managed by Parks Australia (Fig 1). Three of these are on mainland Australia - Booderee National Park, Kakadu National Park and Uluru-Kata Tjuta National Park with the others being on islands - Pulu Keeling National Park, Norfolk Island National Park and Christmas Island National Park. The Commonwealth Government also manages the Australian National Botanic Gardens in Canberra which holds a Living Collection and the Australian National Seed Bank. These national parks play an important role in the conservation of some of Australia's most endangered plant species, especially for species that are only found within these parks. But the ecosystems conserved in national parks are diverse and complex and have to be managed for a multiplicity of benefits such as biodiversity conservation, tourism and cultural values. This is a difficult and challenging task often requiring difficult decisions regarding the use of limited resources.

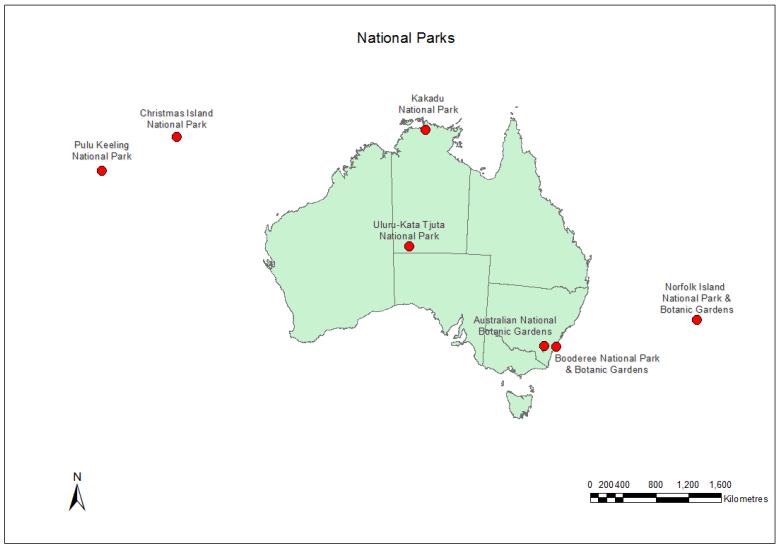

Figure 1 Location of Commonwealth national parks.

Australian National Botanic Garden

The Australian National Botanic Garden is located in Canberra and maintains a scientific collection of native plants from across Australia (http://www.anbg.gov.au/gardens/index.html). Although part of the national park estate, the ANBG differs from the other national parks in terms of plant species composition and management and was excluded from this report.

Booderee National Park

Booderee National Park is on the moist sub-tropical New South Wales south coast at Jervis Bay and sits in a transition zone between northern and southern biogeographical regions. The park covers more than 6,000 h and contains many species at the edge of their bio-geographical range. It also includes examples of several south-eastern Australian coastal communities that are threatened by a range of activities such as urban development elsewhere (DoE http://www.environment.gov.au /topics/national-parks/booderee-national-park accessed 7 January 2015).

Kakadu National Park

Kakadu National Park is located east of Darwin in Australia's tropical north and is Australia's largest terrestrial national park (almost 20,000 square kilometres). It is ecologically diverse and covers coastal and estuarine systems as well as floodplains, billabongs and lowlands to rocky ridges and stone country. Consequently, a broad range of biodiversity is found within the park including rare and endemic plants (DoE http://www.environment.gov.au/topics/national-parks/kakadu-national-park accessed 7 January 2015.

Uluru-Kata Tjuta National Park

Uluru-Kata Tjuta National Park (1,325 square kilometres) is situated in the Northern Territory southwest of Alice Springs in the Greater Sandy Desert bioregion. Despite being an arid environment, this park supports many species in habitats that range from sand dunes and spinifex plains to acacia scrubland and creek lines. The park includes representatives of several Central

Australian arid ecosystems and includes several regionally significant plant species (DoE, http://www.environment.gov.au/topics/national-parks/uluru-kata-tjuta-national-park accessed 7 January 2015).

Christmas Island National Park

This park is located on the isolated oceanic Christmas Island in the Indian Ocean some 2,600 km northwest of Perth and 360 km south of Jakarta. It covers almost two thirds of the island and supports a high proportion of endemic species, some of which are endangered. The park protects much of the island's uniquely structured rainforests, two wetlands of international importance, tens of millions of red crabs and a small but environmentally significant marine area (DoE http://www.environment.gov.au/topics/national-parks/christmas-island-national-park accessed 7 January 2015).

Norfolk Island National Park

Norfolk Island National Park is located some 1,500 km east of Brisbane and protects some 6.5 square kilometres of the Mount Pitt section on Norfolk Island and the neighbouring Phillip Island. The park has important biological significance as its flora and fauna are derived from the chance dispersal of plants and animals over vast distances of ocean. Many species on these islands are endemic including 40 of the 200 native plants (DoE http://www.environment.gov.au/topics/national-parks/norfolk-island-national-park accessed 7 January 2015).

Pulu Keeling National Park

Pulu Keeling National Park is an isolated coral atoll and part of the Cocos (Keeling) Islands found in the Indian Ocean some 2,000 km northwest of Perth. The national park is centred on North Keeling Island, which is comprised of one C-shaped island, a nearly closed atoll ring with a small opening into the lagoon. North Keeling Island is characterised by low habitat diversity with the flora and fauna forming a unique assemblage of 'travelling' species. (DoE http://www.environment.gov.au/topics/national-parks/pulu-keeling-national-park accessed 7 January 2015). No Pulu Keeling plant species are listed as threatened under the EPBC Act.

1.3 Project objective

The overall aim of this assessment was to improve our understanding of key processes threatening the long term persistence of plants found in Commonwealth national parks that are currently listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). We sought to do this by

1. Assessing the current conservation status and security of these species with respect to *in-* and *ex-situ* (living and germplasm) collections.
2. Determining knowledge gaps with respect to species distribution, reproductive biology, ecology and taxonomy to help develop and prioritise research and conservation management plans within Commonwealth national parks.
3. Building a compendium of threatening processes to understand the range of risks that are impacting on species recovery at the Park and National levels as well as to develop a more collective approach to threat management.

1.4 Background

Some 1294 plant taxa are listed under the EPBC Act at the time of this assessment with many more species protected under State and Territory legislation (Broadhurst *et al.* 2011). Optimal species conservation and recovery depends on understanding not only about threatening processes but also the biological characteristics of target species. For example, a plant's breeding system, biological interactions, dispersal, and genetic diversity can significantly impact on species persistence and influence recovery but are often rarely considered to be as critical as managing more visible threats such as weeds and vertebrate pests.

Species recovery plans which outline the state of knowledge of a species as well as research and management actions are often used to secure species against extinction. But these are often developed on a species-by-species basis and do not necessarily reflect the broader impact of threats to plant persistence that occur over spatial and temporal scales. Below we outline some of the most critical threats to plant persistence likely to impact on EPBC-listed species within Commonwealth national parks. It is important to remember that these threats do not often act alone. For example, increased storm severity may not damage plants but may also exacerbate soil erosion resulting in plant damage and/or death. After an initial assessment of threat information we identified four major threat categories likely to be impacting on species persistence and recovery across the national parks:

Climate-related effects (Climate)

The challenges of climate change are outlined in strategies prepared for each Commonwealth national park (http://www.environment.gov.au/topics/national-parks/parks-australia/climate-change, accessed 21 February 2016). The effects of climate change are likely to vary widely across the parks but some of the major changes likely to influence species persistence are considered below.

- **Droughts** occur periodically across much of Australia impacting on plant species in many ways, especially those that are less adapted to extended dry periods. This impact can include reducing plant fitness through reduced flowering and/or seed production as well as plant death (Broadhurst *et al.* 2016).
- **Severe weather events** also occur naturally across Australia (e.g. cyclones Larry in 2006 and Yasi in 2011) and can damage or destroy large tracts of vegetation (Turton 2012). This is especially challenging for species with few small populations and/or restricted geographic distributions.
- **Fire** is a common and natural phenomenon across Australian with much of the flora being fire-adapted. But climate change is expected to impact on plant population persistence through altered fire interval windows (Enright *et al.* 2015) which may impact on plants in many ways including changing vegetation composition, damaging or destroying plants and reducing opportunities for reproduction.

Biophysical effects (Biophysical)

- Soil degradation and erosion can impact on population persistence through increased nutrient loads, loss of soil and exposure of roots.

- Water usage and availability is likely to change over the coming decades as climates become hotter and drier climate. For some parks this may also include increased extraction from local water sources (e.g. aquifers) for human use which could have important effects on plants that also utilise this resource.
- Other effects including human-induced changes such as land clearing for urban and rural development, mining, or infrastructure, trampling and illegal collection can also impact on population and species persistence. These effects, however, are much less likely to occur in national parks.

Invasive species (Invasives)

Many exotic species have been introduced into Australia that have subsequently become serious threats to plant species.

- **Weeds** threaten many of our native plants through competition, changing local habitats, harbouring pests and diseases and producing chemicals that inhibit germination or growth of neighbouring plants (Gallagher and Leishman 2014; Grice *et al.* 2013).
- **Pest animals** can impact plants directly through herbivory and habitat change (Krull *et al.* 2014).
- **Diseases and pathogens** can impact on plant health and reproduction and in some cases lead to plant death. The most well-known recent example of a serious plant disease in Australia is myrtle rust (guava rust) which is a fungal disease affecting trees and shrubs in the Myrtaceae (Carnegie *et al.* 2015).

Genetic and demographic effects (Gen/Dem)

Small population size and restricted geographic distributions are characteristic of endangered plants and are often associated with

- **Low genetic diversity** (genetic erosion) which elevates inbreeding and mating among closely-related plants (Barrett and Kohn 1991) leading to poor seed production and/or seedlings that fail to thrive. It may also limit a species ability to respond to environmental change (Helenurm 1998).
- **Few population and low plant numbers** increase the vulnerability of endangered species to extinction from stochastic events such as storms or fire or through human-mediated changes such as vegetation clearing.

2 Materials and methods

2.1 Species selection

There are currently 54 EPBC-listed plant species in Commonwealth national parks (Table 1). This project initially intended to only assess those species categorized as Critically Endangered, however, the majority of species in this category (15 of 18 species) were found in the Norfolk Island National Park so using this approach would overly bias our findings towards this park. We subsequently refined our approach to include a range of species from Norfolk Island that representative of plant life histories in that park as well as all species listed in other EPBC categories from Booderee, Christmas Island, Kakadu and Uluru Kata Tjuta National Parks. In addition, we included several keystone or significant species that were identified in park management plans or by national parks staff as being important to this assessment making a total of 41 species assessed.

Table 1 EPBC-listed and significant species in Commonwealth national parks. *indicates species included in this project. VU = Vulnerable, EN = Endangered, CR = Critically Endangered, SS = Significant species.

National Park	Species	Common name	EPBC Act category
Booderee	*Cryptostylis hunteriana**	Leafless Tongue Orchid	VU
	*Syzygium paniculatum**	Magenta Lilly Pilly	VU
	*Dracophyllum oceanicum**	Jervis Bay Dragon Leaf	SS
	*Galium australe**	Tangled Bedstraw	SS
	Zieria arborescens subsp. *decurrens**	Stinkwood	SS
Christmas Island	*Asplenium listeri**	Christmas Island Spleenwort	CR
	*Pneumatopteris truncata**	a fern	CR
	*Tectaria devexa var. minor**	a fern	EN
	*Asystasia alba**	a herb	SS
	*Dicliptera maclearii**	a herb	SS
	*Grewia insularis**	a shrub or tree	SS
Kakadu	*Acacia equisetifolia**	a shrub (D19063 graveside gorge)	CR
	*Hibiscus brennanii**	a shrub	VU
	*Hibbertia brennanii**	Guinea flower	SS
	*Hibbertia pancerea**	Guinea flower	SS
	*Hibbertia tricornis**	Guinea flower	SS
	Hibbertia sp. South Magela*	Guinea flower	SS
	*Jacksonia divisa**	a shrub	SS
	*Lithomyrtus linariifolia**	sub-shrub or small shrub	SS
Norfolk Island	*Abutilon julianae**	Norfolk Island Abutilon	CR
	Achyranthes arborescens	Chaff-tree	CR
	Achyranthes margaretarum	Phillip Island Chaff-tree	CR
	Blechnum norfolkianum	Norfolk Island Water-fern	EN
	Boehmeria australis var. *australis**	Tree Nettle	CR
	*Calystegia affinis**	a creeper	CR
	*Clematis dubia**	Clematis	CR
	*Coprosma bauera**	Coastal Coprosma	EN
	*Coprosma pilosa**	Mountain Coprosma	EN
	*Cordyline obtecta**	Ti	VU
	Crepidomanes endlicherianum Renamed as *Polyphlebum endlicherianum*	Middle Filmy Fern	EN
	Dysoxylum bijugum	Sharkwood	VU
	*Elatostema montanum**	Mountain Procris	CR
	Elymus multiflorus subsp. kingianus Renamed as *Anthosachne multiflora* subsp. *kingiana**	Phillip Island Wheat Grass	CR
	Euphorbia norfolkiana	Norfolk Island Euphorbia	CR
	Euphorbia oblique	a herb	VU
	*Hibiscus insularis**	Phillip Island Hibiscus	CR
	Hypolepis dicksonioides	Downy Ground-fern	VU
	*Ileostylus micranthus**	Mistletoe	VU
	Lastreopsis calantha	Shield-fern	EN
	Marattia salicina	King Fern	EN

	Melicope littoralis	Shade Tree	VU
	*Melicytus latifolius**	Norfolk Island Mahoe	CR
	Melicytus ramiflorus subsp. *oblongifolius*	Whiteywood	VU
	Meryta angustifolia	a tree	VU
	Meryta latifolia	a tree	CR
	Muehlenbeckia australis	Pohuehue	EN
	*Myoporum obscurum**	Popwood	CR
	Pennantia endlicheri	Pennantia	EN
	Phreatia limenophylax Renamed as *Plexaure limenophylax**	an orchid	CR
	Phreatia paleata	an orchid	EN
	Pittosporum bracteolatum	Oleander	VU
	Planchonella costata	Bastard Ironwood	EN
	Pteris kingiana	King's Brakefern	EN
	Pteris zahlbruckneriana	Netted Brakefern	EN
	Myrsine ralstoniae	Beech	VU
	*Senecio australis**	a daisy	VU
	*Senecio evansianus**	a daisy	EN
	*Senecio hooglandii**	a daisy	VU
	*Streblus pendulinus**	Siah's Backbone	EN
	Taeniophyllum norfolkianum	Ribbon-root Orchid	VU
	Dendrobium brachypus	Norfolk Island Orchid	EN
	Tmesipteris norfolkensis	Hanging Fork-fern	VU
	Ungeria floribunda	Bastard Oak	VU
	*Wikstroemia australis**	Kurrajong	CR
	Zehneria baueriana	Native Cucumber	EN
Uluṟu Kata-Tjuṯa	*Eremophila alternifolia**	Narrow-leaved Emu Bush	SS
	*Eriachne scleranthoides**	Mount Olga Wanderrie Grass	SS
	*Santalum acuminatum**	Desert Quandong	SS

2.2 Information gathering

A template was developed to ensure that the information gathered was consistent for across all of the species being assessed (Appendix A). Four major threat categories were used: i). climate-related effects, ii). biophysical effects, iii). invasive species, and, iv). genetic and demographic effects. The template also included information about each species name (nomenclature), distribution, population number(s) and size(s), and insurance collections (*in-* and *ex-situ*). Information about threats identified from EPBC listing advices as well as park management and species recovery plans were documented as was information on plant traits that are potentially important for understanding the effects of threatening processes. This included information on plant pollinators, breeding systems, plant age to maturation, longevity, seed dormancy/viability, germination requirements, and genetic diversity assessments. The following data sources were used:

- Information about the EPBC listed species was sourced from the publically available SPRAT database (http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora) with links and references to other information sources on these pages also reviewed. Google (www.google.com.au) and Google Scholar (https://scholar.google.com.au/) were interrogated for published and grey literature for each species or where no information was available, searches for closely related species were undertaken. All data unless otherwise referenced was sourced directly from SPRAT.
- The validity of species names was determined using the Australian Plant Census (APC, www.anbg.gov.au/chah/apc) or the Australian Plant Names Index (http://www.anbg.gov.au/apni/).

- Ploidy information was obtained from the Tropicos Index to Plant Chromosome numbers (www.tropicos.org/Project/IPCN, Missouri Botanical Garden) and the Chromosome Counts database [http://ccdb.tau.ac.il/home/, (Rice *et al.* 2015)].
- Photographs of the species were sourced from the Australian Plant Images Index (APII, www.anbg.gov.au/photo/genus-photo-search.html) or provided by national park staff.
- Specimen data were downloaded from the Atlas of Living Australia (ALA, http://www.ala.org.au/), cleaned to removed records that were misidentified, incorrectly located, misnamed or were cultivated. Additional locations of species not represented by specimen records provided by national parks staff or found in the literature were also included and the distribution of each species within the national parks were then generated. Some records of cultivated plants were retained if these were part of a national park restoration program.
- *In- and ex-situ* holdings in the form of cultivated plants or seed collections were obtained from the Australian National Botanic Gardens, Booderee Botanic Garden and national parks staff where available. Information on collections held in other botanic gardens or seed banks was also included when available using Australian Seed Bank Partnership records (http://asbp.ala.org.au/).

These data were collated into a single Excel spreadsheet for analysis while all information sourced for each species is provided in Appendix B.

2.3 Threat and gap analyses

Information for 16 sub-categories of the four threat categories was gathered and the data ranked as being:

1. A '**Known threat'** when there was documented evidence that the threat was impacting on a species,

2. **'Data deficient'** where the threat was inferred to be a problem or following our assessment of a species biology could potentially impact on a species but for which no direct data were available, and,

3. **'No threat'** where an evaluation of a threat had occurred and was considered to be extremely unlikely or of very low impact.

These rankings were collated into a single table and used to identify major threats across the national parks as well as critical knowledge gaps. These data are provided separately in the associated Excel spreadsheet.

3 Findings

3.1 Initial observations

One of our most important observations during our literature searching was the considerable lack of in-depth and up-to-date information available for almost all of the 41 species assessed. This lack of information ranged from being unable to source verified photographs of species to having to evaluate the utility of information from closely-related species as surrogates for species for which no information existed. We were unable to source a verified photograph from Australian Plant Image Index (APII) for 13 of the EPBC listed species and 12 of the non-EPBC listed species. Park staff were able to supply photos of an additional 5 EPBC listed species and 9 non-EPBC listed species. However, the value of having images available through APII is that these can be linked to a verified herbarium specimen and we can consequently be confident that the photo is assigned to the correct species. For 7 of the EPBC listed species there was no photo available at all. ***A lack of photographic information may limit species recognition and identification in the field and reduces the ability of national park staff to engage and educate visitors about the role and importance of these species.***

Our second observation was that for just over half of the species assessed almost all of the populations primarily occur within national parks (Fig 2) making these species highly vulnerable to local extinction. In addition, the distributions of a further six species could not be rigorously determined but since these occur in CINP and NINP it is likely that populations of these species are also primarily located within national parks. ***These data highlight the critical role that national parks are playing in the conservation and management of endangered species including being responsible for an entire species in many cases. It also indicates that establishing ex-situ collections (both living and seed) is critical to provide a means for species recovery should an extinction event occur.***

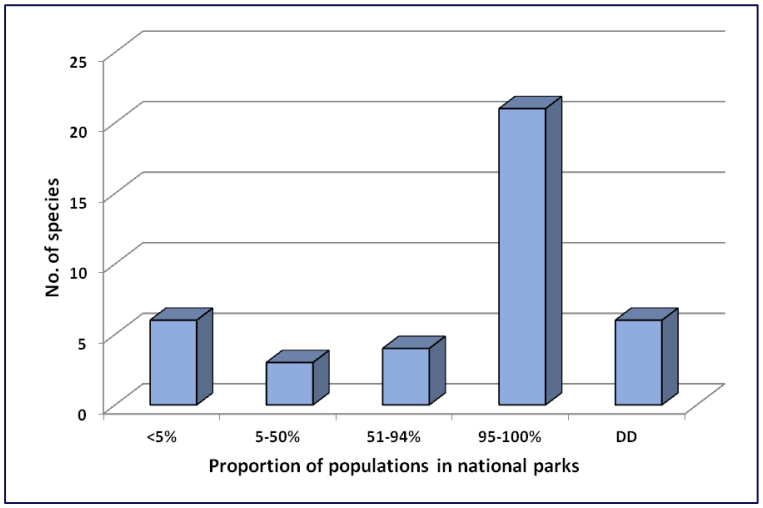

Figure 2: Number of populations of each species occurring in Commonwealth national parks. DD, data deficient.

Our third observation was that as far as we can ascertain, few of these species have been recently monitored (Fig 3) and few are subject to periodic evaluation. The large number of species surveyed in 2003 are from NINP only. ***This does not suggest that these endangered species require annual monitoring but it does suggest that regular monitoring programs would greatly assist in species recovery by providing critical information on population trends as well as threat impacts. It would also provide critical information to help improve species recovery such as recruitment, longevity, flowering and pollinators – much of which is unknown for the majority of species assessed here*** (see Section 3.3 Knowledge gaps limiting species recovery).

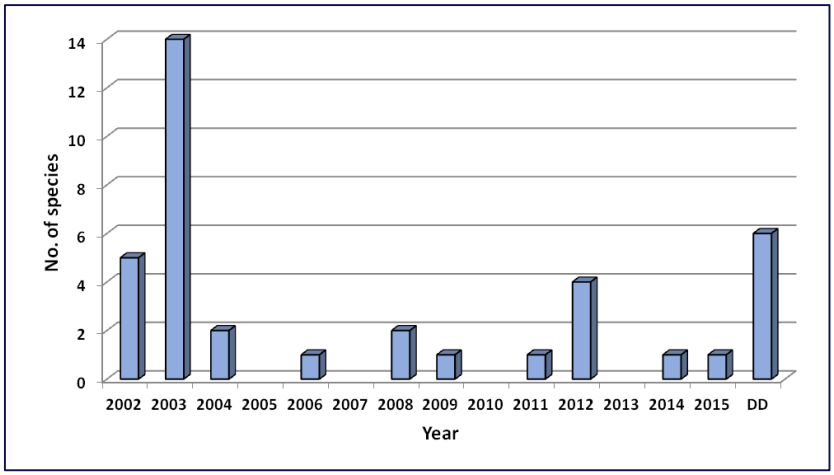

Figure 3: Year that endangered species in Commonwealth national parks were last monitored. DD, data deficient.

Our fourth observation was that we had very little information regarding the threats for these species irrespective of the park being assessed (Fig 4). For a small number of species we had clear evidence of threats impacting on species (i.e. 'Known') while for several others some threats had been evaluated and there was good evidence to suggest that there was no threat or at least a very low threat risk (i.e. "No threat"). But, for the majority of species we had no data to determine whether inferred threats were really a concern for species persistence. ***This suggests that there is insufficient information to help national park staff make critical decisions about species management and recovery.***

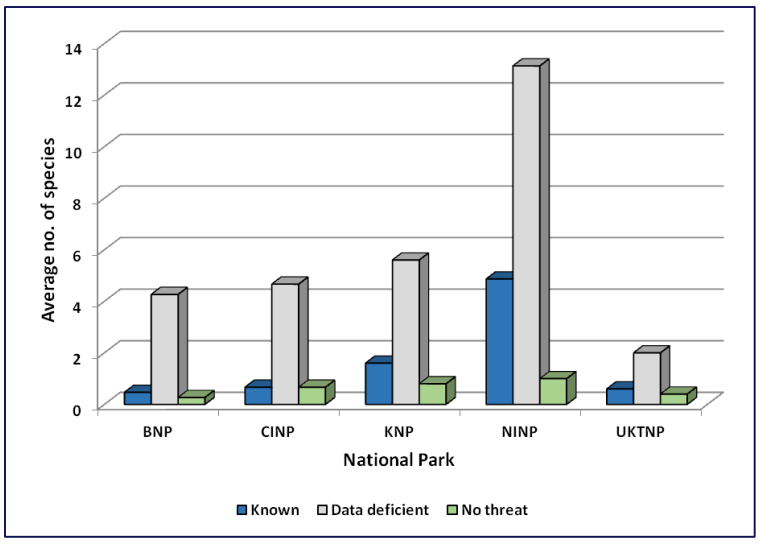

Figure 4: Average number of species in each data category for each Commonwealth national park.

Our final observation was that very few of these species are held in *ex-situ* collections outside of the national parks (Fig 5) with most of the *ex-situ* collections being held in the Australian National Botanic Garden and the National Seed Bank. Several species that are difficult to place under long term storage, such as those with recalcitrant seed, are among the species assessed here. There are also several orchids which require both the seed and their associated mycorrhizal fungi to be stored if these are to be used for re-introduction programs. The ferns assessed here pose some of the most significant challenges for storage and possible reintroduction due to the complexity of their life cycle. ***This suggests that these limited ex-situ holdings provide little security for species recovery following stochastic extinction events or ongoing population decline. This is especially concerning for species that reside solely or almost solely within national parks that have a high extinction risk due to their small population size and limited geographic distributions.***

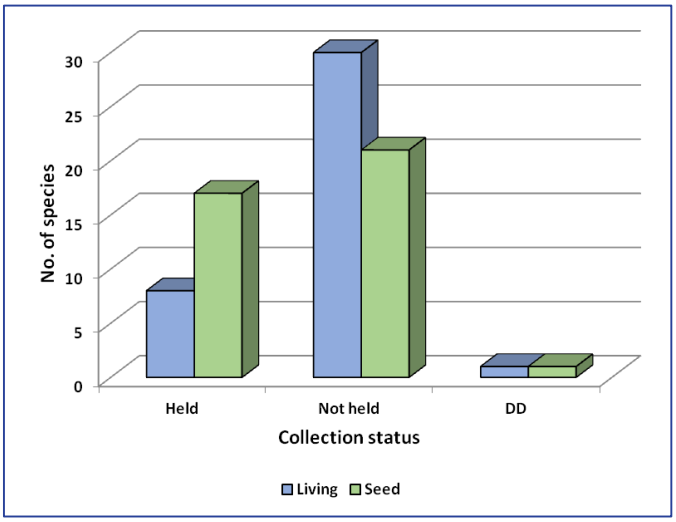

Figure 5: Number of endangered species in Commonwealth national parks held in *ex-situ* collections.

3.2 Threats common across Commonwealth national parks

While a broad range of threats were identified across these species occurring in Commonwealth national parks, here we report only on those sub-categories that were observed in four or more of the parks (Fig 6). Two of the threats for which we have the most data are limited geographic distribution and low numbers of individuals which is not unexpected given that these are two of the most frequently used listing criteria under the EPBC Act. Changing the geographic distributions for these species to remove them from EPBC listing is highly unlikely but removing or limiting threats in other sub-categories may change the status of these species to a less threatened category under the EPBC Act. For example, increasing the number of populations and their size can reduce multiple threats and may change the thresholds for listing. But increasing the number of plants within these species relies heavily on

1. Having sufficient propagules (seed and/or cuttings) to create new population or add to existing sites;
2. An appropriate location and site preparation for planting new populations;
3. Ongoing management of threats such as weeds, grazing and pests;

4. An understanding of germination and growth requirements, and;
5. For some species, an understanding the impacts of low genetic diversity and inbreeding on seed quality and seedling survival.

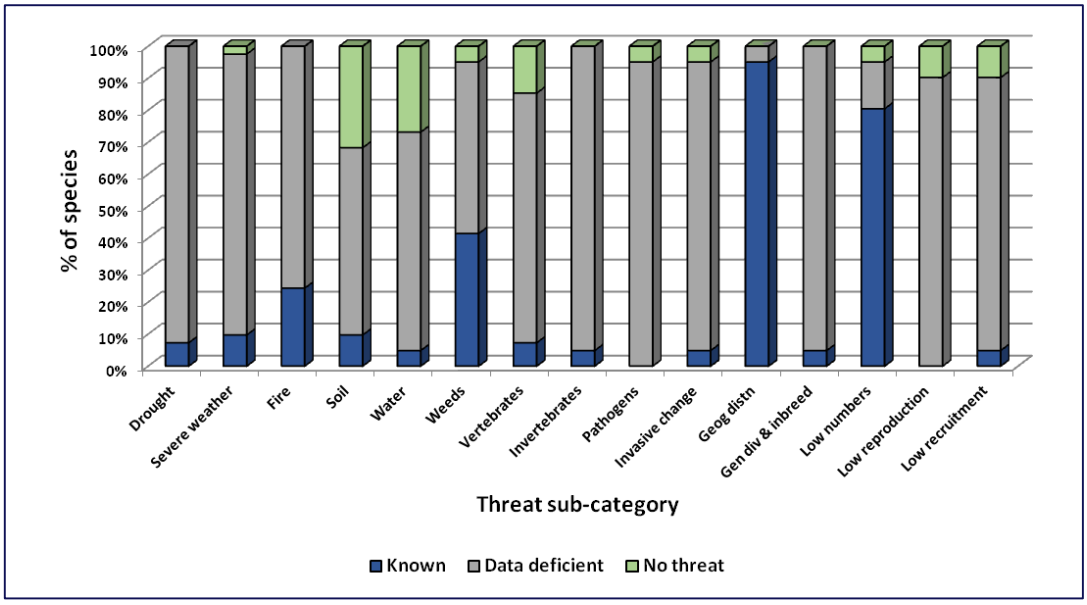

Figure 6: Percentage of endangered species in Commonwealth national parks for each threat sub-category.

The average levels of information available for species across the four major threat categories is shown in Fig 7. Very similar patterns of data availability characterised the Climate, Biophysical and Invasives categories with little data being available for the majority of species (i.e. 'Data deficient'). Higher levels of available information in the Genetic and Demographic category reflect threats associated with restricted geographic distributions. Climate-related and biophysical threats had been evaluated for several species and were considered to be of no or low threat. ***These data suggest that:***

1. ***Species are potentially being impacted by a broader range of threats than currently recognised, and,***
2. ***Management actions are possibly being undertaken to mitigate threats for which there is as yet no evidence that the action is required or that it will improve species persistence and recovery.***

These findings may reflect the age of some of the available information. This may be especially so for Species Recovery Plans which do not recognise threats that have emerged since the plans were prepared. ***This suggests that Species Recovery Plans require regular re-assessment if these are to be a useful tool to drive species recovery.***

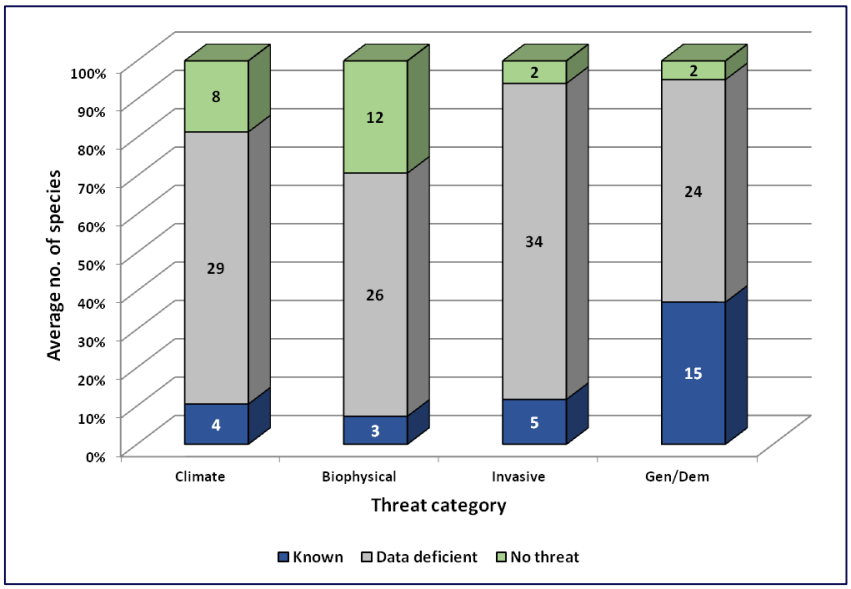

Figure 7: Average number of endangered plants found in Commonwealth national parks assigned to major threat categories. Number indicates the average number of species for each data type.

Threats across national parks for the sub-categories within the four major threat categories were extremely similar reflecting a general lack of knowledge irrespective of the type of threat (Fig 8) although the risks associated with fire are somewhat more well-known (Fig 8a). While we have limited information on the likely effects of soil degradation and erosion and water management we do not see these as being the most challenging threats to manage at the moment (Fig 8b). Weeds are the most well recognisable invasive threat (Fig 8c) but despite reports of pathogens and pests impacting on some of these plant species, very few investigations have occurred. The most pressing of these at the moment is likely to be Myrtle Rust although this is primarily a threat only to *Syzygium paniculatum* in Booderee National Park and *Lithomyrtus linariifolia* in Kakadu National Park. But some other pests have been noted in the seed of some of the species assessed here which may be impacting on species persistence. Vertebrates have been discounted as a threat in only a small number of species but vertebrate pest management is often undertaken by national parks and may only be relevant to a few species. As previously highlighted, restricted geographic distribution and low plant numbers are the best known threat in the genetic and demographic category (Fig 8d). ***This highlights the substantial lack of information available for national parks to make informed decisions regarding the impacts of threats.***

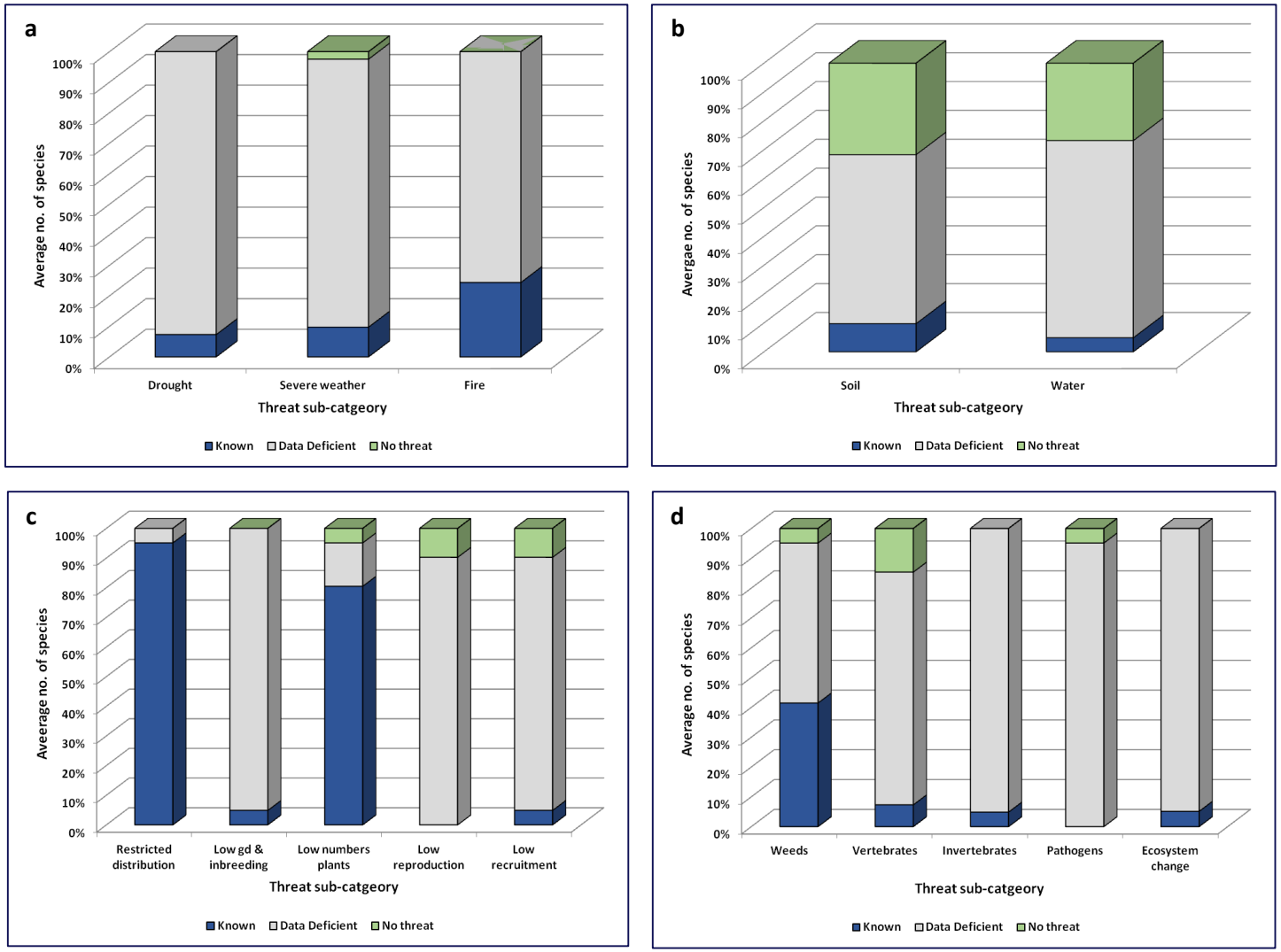

Figure 8: Average number of endangered species found in Commonwealth national parks assigned to sub-category threats for Climate (a), Biophysical (b), Invasives (c) and Genetic and demographic (d).

3.3 Knowledge gaps limiting species recovery

A synopsis of the biological knowledge gaps for the species assessed here is presented in Fig 9 with species-level gaps highlighted in Appendix C. These data were derived by assigning the available information to one of these following categories:

Information category	Information source
Available	Detailed information available for a species
Some	Some information available for a species
Inferred	Inferred using information from a closely related species or general species biology
None	No information available

Overall there was a general lack of information available on key plant traits likely to impact on persistence and recovery for most of these species. We know or could infer the main pollinators or pollinator groups to many of these species; we are also reasonable confident of the primary dispersal mechanisms. ***This does not, however, tell us whether these pollinators and dispersers necessary for species persistence still co-occur.*** This could be problematic for species that have specific plant-pollinator or -disperser associations if reduced population sizes have led to pollinator/disperser decline or extinction. A lack of pollinators is likely to lead to population decline through poor seed production while a limited disperser population will reduce opportunities for natural establishment in other parts of the national parks. ***Recovery efforts for some species are likely to be constrained if suitable pollinators and dispersers no longer exist.***

Although we have reasonable confidence in the information available on germination and dormancy mechanisms of these species these traits are best assessed under experimental conditions. ***This will be challenging since these species are producing small quantities of seed, limiting the amount of experimentation that can be undertaken.***

Other plant traits such as flowering time, reproductive strategy, clonality, longevity and polyploidy are poorly known for most species but are extremely important in terms of management and recovery. For example, knowing the reproductive strategy can help determine where new populations should be established to maintain pollinator interactions and gene flow. Polyploidy can be an issue if plants with different chromosomal background are brought together and produce sterile seed although we do not anticipate that this is a significant issue for most of these species. Understanding the longevity of these species allows parks staff to differentiate between threat-induced population decline and natural plant turnover. Knowing species flowering times can help to determine seed collection windows and may be important to track if climate change induces a shift in flowering that is not associated with a shift in pollinator activity (Parmesan 2006). If clonality

occurs naturally within a species then inbreeding and low seed production may be less of a concern. ***This lack of basic biological information is a significant constraint to the recovery of these species.***

The two categories for which we have the least information are symbiotic interactions and genetic diversity. Soil symbiotic interactions are primarily important for orchids as these require mycorrhizal fungi for germination (Arditti 1967) while legumes form associations with nitrogen-fixing bacteria; some highly restricted legumes are often associated with very specific bacterial types that are also highly geographically restricted (Thrall *et al.* 2000). Including nitrogen-fixing bacteria in restoration projects is known to have a beneficial effect on plant growth and survival (Thrall *et al.* 2005). Myrtaceous species also have mycorrhizal associations (Orians and Milewski 2007) and possibly also the ferns (Field *et al.* 2015). ***Understanding the nature, importance and role of soil symbionts will assist in the recovery of these species.***

Genetic diversity is a key factor in population persistence and recovery. Only two of the 41 species assessed here have had a genetic diversity study undertaken. For some of these species there are now so few plants that a genetic assessment is unlikely to help in their recovery but there are several species that would benefit from having genetic information. ***Establishing how much genetic diversity exists within natural populations and where this diversity is distributed in the landscape will guide seed collection and restoration protocols. Genetic assessments of restored populations will determine whether these have a sufficient genetic base to ensure species persistence. This is especially important for populations that have already been established using cuttings as this process can often narrow the genetic base.***

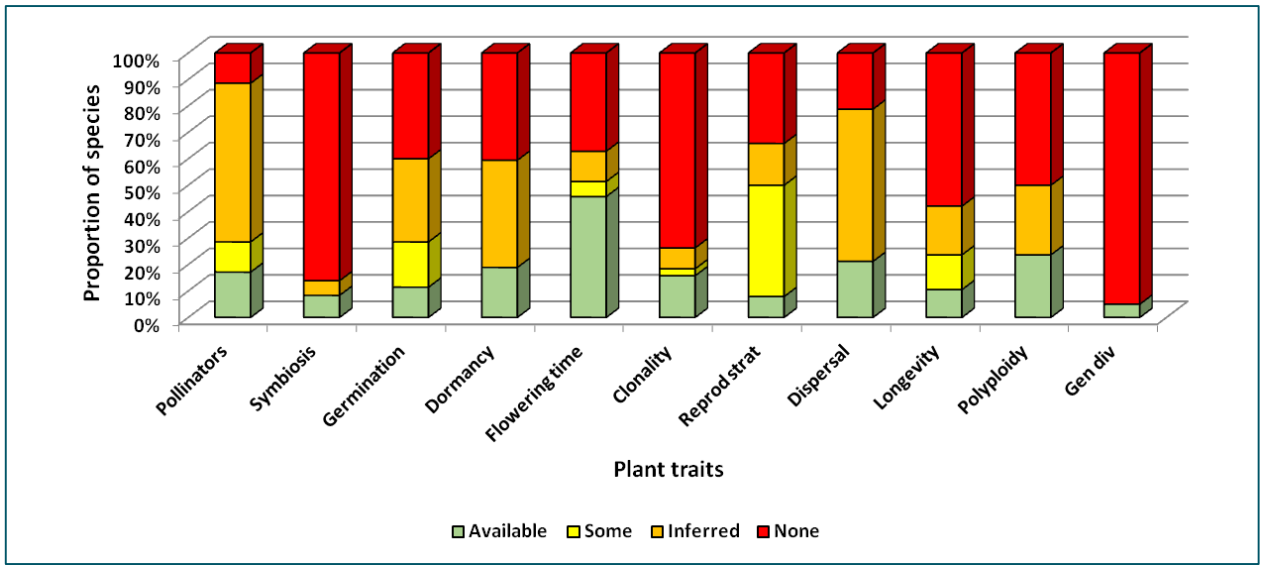

Figure 9: Information available on key plant traits that are likely to impact on species persistence.

4 Recommendations

This report does not constitute a recovery plan and it is not intended to replace existing species recovery and park management plans. Rather, it aims to identify key threats and knowledge gaps that are constraining species recovery and to provide recommendations for some of the most vulnerable plant species in Commonwealth national parks. Research recommendations are also provided to generate the critical information required to improve species management and recovery.

Not unexpectedly restricted distributions, low genetic diversity and low numbers of individuals are major threats to the persistence of many of these species in Commonwealth national parks. Although being geographically restricted will always characterise many species, especially those found on islands, increasing the number and size of populations will significantly reduce the likelihood of extinction. To do this, however, requires a basic understanding of species biology, having suitable germplasm (i.e. seed and/or cuttings), removal of threats from existing populations and appropriate restoration methods and planting sites. Consequently, we make the following recommendations:

1. **Develop a 5-10 year research program dedicated to investigating the biology of endangered plants species across national parks. To ensure the cost-effectiveness and utility of this program it will be necessary to prioritise species according to the likely improvement that this research will have on species recovery.**

2. **Undertake genetic assessments for species where understanding the reproductive strategy, levels of genetic diversity and population genetic structure will directly improve species recovery by reducing the risks of inbreeding, helping to maximise the genetic base of restoration projects, and, ensuring that *ex-situ* seed collections are genetically representative and capable of restoring populations in the event of an extinction event.**

3. **Partner with researchers and NGOs with restoration experience to draw on available scientific and onground knowledge to improve the outcomes of these activities.**

4. **Explore opportunities to engage with the horticulture and nursery industries to provide the community and trade with access to rare plants to improve the understanding of these species and biodiversity more generally.**

Climate change is predicted to have multiple consequences for endangered plants in Commonwealth national parks including an amplified risk of extinction associated with increases in drought, severe weather and fire events. Since these threats are already challenging to manage, it is unclear what actions can be taken to reduce these risks apart from spreading the likelihood of loss by increasing the number and size of populations and ensuring that *ex-situ* collections are appropriate for population re-establishment in the event of loss. At this stage climate change risks are inferred for the national parks through their climate change strategies but it is likely that some species will be less affected by change than others. Determining this, however, will be challenging

without more information about the biology of these species. We suggest the following may help improve species management and recovery in light of the predicted changes:

5. **Develop a risk framework using information about a species biology, location and threat sensitivities to help define and prioritise actions under climate change.**

6. **Provide national park staff with development opportunities to enhance their understanding and use of methodologies such as Adaptation Pathways when planning actions associated with climate change.**

7. **Secure *ex-situ* collections (living and seed) of all threatened species not currently held as a matter of priority. An understanding of the storage and germination requirements of these species is also required to ensure that these can be successfully re-established under natural conditions.**

8. **Consider the establishment of genetically diverse 'insurance' populations for some species which could be used to produce high quality seed/cuttings for re-introductions in a similar manner to *ex-situ* breeding programs for vertebrates. Including landholders and the horticultural industry in this process may help to improve community engagement and education regarding plants and their critical roles in our unique Australian ecosystems.**

It will be extremely challenging to successfully recover some of these species as plant numbers appear to be already at critically low thresholds for species persistence and we have concerns that some may already be extinct. But for many species we were unable to ascertain current population numbers and sizes or their trajectories. Consequently, we strongly recommend that:

9. **Surveys of all endangered plant species in national parks not currently part of a formal monitoring program or that have not been surveyed within the last 2 years be undertaken. This will establish baseline data to assess population trajectories and measure the success of recovery programs as well as evaluate the risk and impact of threats. Ongoing monitoring at regular intervals will then be required.**

10. **Explore opportunities for partnering with research institutions to develop long term monitoring programs (i.e. 10s of years) that will detect impacts associated with climate change, have clearly defined measures of success, and that avoid wasting resources by over-monitoring. Citizen science monitoring may also be helpful but these initiatives can require considerable time and some financial investment to be effective.**

Many of the recommendations made here are likely to be beyond the current financial resources of the parks and additional resourcing will be required. However, some of this will be 'one-off' investments (e.g. genetic assessments) that will significantly improve our ability to recover these species whereas other recommendations will require additional ongoing resourcing (e.g. monitoring).

Finally, we strongly wish to point out that this assessment should not be viewed as a criticism of national parks staff or management – our findings simply reflect the challenges of managing the

highly complex ecosystems that occur within Commonwealth national parks for multiple benefits that includes biodiversity conservation, tourism and cultural values.

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Appendix A Information gathering template

National Park		
Genus		
Species		
Family		
Common Name		
EPBC Act Category		
% in CNP		
Date last census		
POSSIBLE IMPACTS	**Climate-related**	Drought
		Habitat shifting and alteration
		Severe weather events
		Fire, including inappropriate fire regimes
	Physical and biophysical	Soil degradation and erosion
		Grazing
		Pesticides
		Water management and use
		Mining and Quarrying
		Roads and Railroads
		Residential and Commercial Development
	Human direct	Inappropriate conservation measures
		Illegal collection
		Trampling / Bushwalking
	Invasive non-native / alien species	Weeds
		Vertebrates
		Invertebrates
		Pathogens
		Ecosystem changes by invasive species
	Genetic and demographic risks	Restricted geographical distribution
		Low genetic diversity and genetic inbreeding
		Low numbers of individuals
		Low reproduction
		Low recruitment
		Hybridisation

Appendix B Species Information

The following summaries include all information and data sourced for each of the species assessed in this project. Shortened versions of this information are provided separately as Factsheets for each Commonwealth national park.

B.1 *Cryptostylis hunteriana* (Orchidaceae) – Leafless Tongue Orchid, Furred Tongue Orchid, Booderee National Park

Figure B1.1 ©Orchidaceae (sourced from the Atlas of Living Australia)

The leafless tongue orchid is a small, perennial terrestrial orchid that lacks leaves and receives its nourishment from dead organic matter (saprophytic) in particular in partnership with a mycorrhizal fungus. The only time the plant is visible is when it is in flower. The flower is dominated by an erect, narrow and very hairy maroon 'tongue' (the labellum) with a black central band. (TSSC 2008, OEH 2014)

Taxonomy: Conventionally accepted as *Cryptostylis hunteriana* Nicholls (CHAH 2015, verified 9 July 2015).

Status: Listed as Vulnerable under the EPBC Act on 16 July 2000. Listed as Vulnerable under the NSW *Threatened Species Conservation Act 1995* in May 2015. Listed as Threatened under the Victorian Flora and Fauna Guarantee Act in 2015.

Recovery Plan: Recovery plan not required, included on the 'Not Commenced' List (1 November 2009). (DoE 2009 and 2015).

This information is taken from SPRAT EPBC Listing (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

The bulk of the known populations occur in NSW in highly localised populations of single plants or small colonies. There may be several hundred plants in Victorian populations but there is no available information on population size in Queensland. Bell (2001) recorded 13 populations outside of NSW national parks while a further 10 populations of unknown size occur in NSW national parks and two in nature reserves; two populations occur in Victorian National Parks and is not known to occur in Qld reserves (TSSC 2008).

Population size – range

The range, or extent of occurrence, is 132,117 km^2 based on Australia's Virtual Herbarium data and area of occupancy is estimated at 38 km^2 based on 1 km^2 grid squares in which the species is thought to occur but these two measures are considered to have low reliability due to a lack of recent ground surveys (TSSC 2008). This species can be easily missed given that the species distribution is very broad, plants are only visible during flowering and that plants do not flower every season (Nov–Feb in NSW and Victoria; June–August in Qld; de Lacey *et al.* 2012).

Total population size is unknown but most of the populations occur in NSW. De Lacey *et al.* (2012) found this species occurred in a much wider range of habitats than previously known including heathlands, heathy woodlands, sedgelands, *Xanthorrhoea* spp. plains, dry sclerophyll forests (shrub/grass sub-formation and shrubby sub-formation), forested wetlands, freshwater wetlands, grasslands, grassy woodlands, rainforests and wet sclerophyll forests (grassy sub-formation) and across an altitudinal range of 10–1200 m ASL. De Lacey *et al.* (2012) also suggest that predictive modelling of potential habitat may be an important tool to determine other locations where this cryptic and rare species might occur.

In NSW, Alum Mountain State Forest near Bulahdelah is thought to be the largest population of this species with 104 plants north of Bulahdelah and 359 plants east of the town (TSSC 2008). It appears to be most common in the Shoalhaven area where 25 populations generally with <30 individuals occur (TSSC 2008). Plants in the South Coast populations include the Pigeon House Mountain area (20 plants) and the Manyana-Bendalong area (20 plants) were last observed or collected in 1996 and in 1970 for Lake Burrill (Bell 2001). Population information is not noted for Booderee (Jervis Bay) but population size varies between years.

In northern NSW, several coastal populations are known as well as two isolated inland sites on the tablelands in Gibraltar Range and Washpool National Parks but population sizes are unknown (TSSC 2008). Other North Coast populations of Nelson Bay (30–40 plants) and Lemon Tree Passage (50 plants) (Bell, 2001). Based on surveys in different areas of the Central Coast that took place between

1955–1999, populations are generally small or single plants. The total population size in NSW is estimated to be 1300–1500 plants. (TSSC 2008)

Victorian populations occur over 113 km in East Gippsland between Orbost and Mallacoota and are considered to consist of several hundred plants (TSSC 2008). The species is present in Croajingalong National Park, William Hunter Flora Reserve and one State Forest Estate (TSSC 2008). In Queensland the species is known from one plant near the village of Tinnanbar and four coastal populations north of the Glasshouse Mountains to Tin Can Bay (1998, Logan in TSSC, 2008). The Brisbane Herbarium and the Australian National Herbarium have records of populations occurring around Toowoomba (*the closest Australian Virtual Herbarium record was collected north east of Toowoomba in 1998*), Cooloola (2004), Maroochydore (possibly 2011 record - Emu Mtn, Cooloola National Park), D'agular Range (1998) and Tin Can Bay (1998) (AVH 2015).

Geographical distribution

Widespread but disjunct.

Figure B1.2 Distribution of Leafless Tongue Orchid in Australia. Red dots are specimen collections.

Figure B1.3 No specimen collections of Leafless Tongue Orchid exist for Booderee National Park, however, there are specimens from the adjacent Conjola National Park (not shown). The blue line is the park boundary.

A report from ngh environmental (2004) states that NSW NPWS Wildlife Atlas Database shows 18 records of this species clustered in five locations in the nearby Conjola National Park (west of Booderee across Sussex Inlet). Given the species occurrence across a wide range of habitats and its occurrence in an adjacent national park it is quite likely that this species does occur in Booderee National Park but surveying to find it might best be done 12–36 months after fire and during the flowering season (Bell, 2001).

Ex-situ collections (Living and Seed Bank)

The species is not conserved in Living Collections at the Australian National Botanic Gardens or Booderee Botanical Gardens or in the National Seed Bank (Zoe Knapp pers. comm. 12 October 2015 and Tom North pers. comm. 11 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Pollination by male Ichneumon Wasp*, Lissopimpla excelsa*.

Symbiotic relationships: The orchid is a myco-heterotroph, it requires a symbiotic relationship with a mycorrhizal fungus to provide nutrition and is dependent on this relationship for germination and growth.

Germination requirements: The EPBC listing in 2008 states that this species has not been successfully propagated (http://www.environment.gov.au/sprat). Mycorrhizal fungi are essential for germination of this orchid's seed (Anonymous, 2010, Clements and Howard 2011). Orchid seed imbibed in a petri dish can resist 'deleterious' fungi for about one month before running out of energy; if a fungi with which it could form a symbiosis arrives during that time then a germinant could survive, otherwise it will succumb to the deleterious fungi (Mark Clements pers. comm. 5 August 2015).

Dormancy class: Unknown. Some orchids have dormancy mechanisms that may allow them to take advantage of suitable germination and growing conditions or to wait until suitable fungi are available (Baskin and Baskin, 2014).

Flowering: November–February in NSW and Vic, June–August in Qld (de Lacey *et al.*, 2012). Flowering intensity may be stimulated by fire events.

Breeding system: Sexual. Pollinated through pseudocopulation by the male Ichneumon Wasp (*Lissopimpla excelsa*) which are attracted to the flower by mimicking the sex pheromones of this species. Vegetative reproduction to form localised clumps is also suggested but has been questioned by Bell (2001) due to the species' poorly developed root system. However, Mark Clements (pers. comm. 5 August 2015) suggests that almost half of the Bulahdelah population may not form clumps and may act as ephemerals while the remainder are clump-forming. This species is self-compatible (M. Clements pers. comm. 5 August 2015). At the Bulahdelah site Clements has also noticed low natural seed set with <5% of flowers ever setting seed. Seed capsules can have around 3,500 seed per capsule. While the seed have a resilient coat these do not last long in the soil. Alan Stephenson (pers. comm. 2015) has also found the species to have low natural seed set in the Booderee region based on over 30 years of observations.

Dispersal: Leafless Tongue-orchid is spread either by wind or by seed being dropped in the immediate vicinity of the parent plant once the flower head has fallen over.

Longevity: Perennial (length unknown). At the Bulahdelah site it appears that many plants (possibly 40% of the population) are acting as ephemerals by germinating rapidly, flowering within 18 months and then dying. Many plants that were dug up during translocations at this site had very small, thins stems and small, simple underground rhizomes (2–5cm long) which were often shrivelled. The other part of the population produce bigger rhizomes and form perennial clumps (M. Clements pers. comm. 5 August 2015).

Life form: Orchid.

Ploidy levels: Unknown.

Role of the plant in the environment: Unknown.

Threats

Listed Threats (EPBC Act)

- Illegal collection
- Loss or fragmentation of habitat and/ or subpopulations
- Human induced disturbance due to unspecified activities
- Competition and/or habitat degradation: Bitou Bush
- Competition and/or habitat degradation by weeds
- Predation, competition, habitat degradation and/or spread of pathogens by introduced species
- Alteration of hydrological regimes and water quality
- Inappropriate and/or changed fire regimes (frequency, timing, intensity)
- Habitat loss, modification and fragmentation due to urban development
- Pesticide application

Outside of national parks the biggest threat to populations are development pressures in many coastal regions such as earthworks, housing developments and road construction (e.g. Bulahdelah Bypass). This may be especially so if surveys have missed the presence of this species due to lack of flowering at the time of the survey or its small size. Development may also lead to site fragmentation and result in disruption to pollination and seed dispersal for this species, by creating barriers between populations. (TSSC 2008). Also, changes in drainage resulting in unsuitable soil micro-climatic conditions, and loss of the mycorrhizal fungi upon which this species entirely depends (TSSC 2008). The leafless tongue orchid does appear to be susceptible to slight changes in soil moisture content. Flowers at the Bulahdelah site sometimes wilted prior to setting seed in both dry and wet years (Mark Clements pers. comm. 5 August 2015).

Fire, which can stimulate flowering, can also damage populations if it occurs at the wrong time of the year (e.g. during flowering and before seed set). Frequent or inappropriate fire regimes, resulting in significant alteration of the site ecology will also affect populations (TSSC 2008).

This species is also potentially at risk from illegal collection and invasion by weeds such as Bitou Bush (*Chrysanthemoides monoilifera*) in some localised areas close to roads, settlements and coastal locations. This is only likely to impact on BNP populations where the two species habitats overlap.

Other Threats/Potential New threats

For Leafless Tongue Orchid to persist in an area, the size of the habitat must be large enough to support both the plant and the associated pollinator. The area needed to maintain a population of Ichneumon Wasp pollinators is estimated to be 50 ha. (A. Stephenson pers. comm. 20 December 2015).

Knowledge Gaps

Species biology and life history including symbiotic relationships, seed dormancy, seed germination, genetic diversity, time to maturity and longevity of this species are unknown or poorly understood.

There are no records that this species has been found in BNP even though it is presumed to have suitable habitat. If it does occur here, determining the current population size is necessary although surveying for this species can be difficult as it is small and does not flower every year. Preliminary work has been done on propagation but seed storage and propagation are still problematic.

Suggested research and actions

Research priorities listed in the Conservation advice (TSSC 2008) that apply to the whole of the species are:

1. Develop and implement a monitoring program.
2. More precisely assess population size, distribution, ecological requirements and the relative impacts of threatening processes.
3. Undertake survey work in suitable habitat and potential habitat to locate any additional populations.
4. Undertake seed germination and mycorrhizal association trials to determine the requirements for successful establishment of Leafless Tongue-orchid.
5. Identify pollinators (N.B. the Bulahdelah work has subsequently identified that pollination was through pseudocopulation by male Ichneumon Wasp, *Lissopimpla excelsa*).

Specific priorities for BNP:

1. Survey at the appropriate time of year in suitable habitat for presence of the Leafless Tongue Orchid in the national park. The chance of finding this species is likely to increase after fire.

Species management

Mark Clements (pers. comm. 5 August 2015) suggests that the two main management tools for successful retention of this species at a site are hand pollination and a fire frequency interval of 10–15 years. A report on implications of fire for this species (ngh environmental 2004) is only able to highlight examples where fire may be helpful for recruitment but does mention other authors (Backhouse and Jeanes 1995) who list 'altered fire regimes' as a potential threat to this species if fires occur during flowering period and prevent seed production. Given the ephemeral nature of some plants noted by Clements (2015) seed is likely to be the major method of recruitment for the species and for its persistence at a particular site. Translocation at the Bulahdelah site had a low success rate, around 2–5%, due to many plants being small with simple underground rhizomes 2–5 cm. Hand pollination on the other hand appeared to be quite successful (M. Clements pers. comm. 5 August 2015).

Figure B1.4 Hand pollination of a *Cryptostylis hunteriana* flower.
©Dr Chris Howard CSIRO science image.

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B.2 *Dracophyllum oceanicum* (Ericaceae) – Jervis Bay Dragon Leaf, Booderee National Park

Figure B2.1 *Dracophyllum oceanicum* on cliff tops at Jervis Bay NSW (left) and of flowers at Australian National Botanic Gardens (right). ©M. Fagg Australian National Botanic Gardens Photo No's. dig 33201 and dig 30757.

The NSW Flora Online (The Royal Botanic Gardens and Domain Trust 2015) describes this species as a shrub varying from low and prostrate to robust and erect and spreading in more sheltered positions. It can grow up to 2.5 m tall and stems often branch extensively near the base. Leaves (1.2–1.7 cm long and 1.4–2.1 cm wide) are erect and become recurved and sheathing at the base. The flowers are white, erect to spreading with bracts that are often distinctively rose-coloured becoming brown with age. The fruit are brown.

Taxonomy: Conventionally accepted as *Dracophyllum oceanicum* E.A.Br. and N.Streiber (CHAH 2012, verified 5 November 2015).

- Synonym: *Dracophyllum* sp. 'Jervis Bay' (Brown 98/80) (APNI).

Status: This species is not listed under the EPBC Act but is listed as a Significant Species in the Draft Booderee National Park Management Plan (2011) because it grows only in the Jervis Bay area on cliff faces at Booderee and Beecroft Peninsulas.

Recovery Plan: A recovery plan is not required for this species as it is not listed under the EPBC Act.

Number of populations inside and outside parks and reserves

Only one site of this species is known in Booderee National Park at the Cape St George Ruined Lighthouse site (S. Pedersen pers. comm., 26 November 2015). Other specimen collections have been made outside the national park on Beecroft Peninsula on the Northern side of Jervis Bay (ALA 2015).

Population size – range

This species is probably restricted to the coastal cliffs and small bays of the north and south heads of Jervis Bay (The Royal Botanic Gardens and Domain Trust 2015) but population sizes are unknown.

Geographical distribution

Regional and disjunct.

Dracophyllum occurs in Australia, New Zealand and New Caledonia with Australian *Dracophyllum* being remnants of older lineages that are now fragmented and disjunct. There are five Australian *Dracophyllum* species that appear to the remaining relicts of a more widely distributed forest flora (Wagstaff *et al.* 2010). *Dracophyllum oceanicum* is restricted to coastal cliffs and small bays on the north and south heads of Jervis Bay, NSW. It is rarely found more than 50 m from the sea typically between 10–60 m ASL (S. Pedersen pers. comm. 26 November 2015, Wagstaff *et al.* 2010). It occurs on coastal cliffs overlooking the ocean, or at the base of cliffs and on stream margins in sheltered bays on a sandstone substrate. This sandstone is of the Conjola Formation which is part of the Permian Shoalhaven group (The Royal Botanic Gardens and Domain Trust 2015).

Figure B2.2 Distribution of *Dracophyllum oceanicum* in Booderee National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Dracophyllum oceanicum is held as *ex-situ* plantings at the Australian National Botanic Gardens and Booderee Botanical Gardens but no seed collections are held at the National Seed Bank (M. Henery pers. comm. 26 November 2015). Currently four plants at Booderee Botanic Gardens have been propagated from seed with another 12 plants being propagated by cuttings (S. Pedersen pers. comm. 26 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Unknown.

Symbiotic relationships: Ericoid mycorrhizal fungi occur in the closely-related *D. secundum*, but it was hypothesised that these may be seasonal and vary with location (Allan *et al.* 1989).

Germination requirements: Australian growers have found seed from this Ericaceae sub-family (Styphelioideae) difficult to collect as seed ripen and are dispersed very quickly (ANPSA 2009). It can also be technologically difficult to work with both the seed and seedlings of the Styphelioideae as the seed is very fine and seedlings are tiny with fragile, fine hair roots (ANPSA 1999). The closely-related species, *D. secundum*, is known to be difficult to propagate from cuttings (ANPSA 2010). A study on heat and smoke effects on *D. secundum* germination showed that neither pre-treatment improved germination rates (Thomas *et al.* 2003). At Booderee National Park success with cuttings has been quite low, 10% and 20% respectively for two different events (S. Pedersen pers. comm. 26 November 2015).

Dormancy class: Unknown.

Flowering: August–December (April) (The Royal Botanic Gardens and Domain Trust, 2015).

Breeding system: Unknown.

Dispersal: *Dracophyllum* species have a capsular fruit and produce numerous small seed within each capsule; these could be dispersed by wind, birds or water (Wagstaff *et al*. 2010).

Longevity: Unknown.

Life form: Shrub.

Ploidy levels: The chromosome number of *D. oceanicum* is unknown. All *Dracophyllum* chromosome numbers available in the Chromosome Counts Database (Rice *et al.* 2015) have 2n = 26 so there is no indication of polyploidy in the genus.

Role of the plant in the environment: Unknown.

Threats

Listed Threats (EPBC Act)

As *Dracophyllum oceanicum* is not currently listed under Commonwealth or State Legislation threats to this species are unknown.

Other Threats/Potential New threats

- The populations of *Dracophyllum oceanicum* appear to be disjunct and it is likely that individual plant numbers are low.
- Small population sizes suggest that genetic diversity is low.
- Climate change is predicted to result in increasing periods of drought, increased frequency and intensity of fires, and increasing frequency and intensity of storm activity (DNP 2010, DNP 2015). Increased storm intensity could cause loss of individuals and populations given their habitat on steep cliff faces.
- Weeds – currently no infestation at sites observed at Booderee and Beecroft Peninsula (S. Pedersen pers. comm. 26 November 2015)

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed dormancy, breeding system, genetic diversity, and time to maturity and longevity of this species are unknown.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Survey suitable habitat for new populations although this may be challenging given the location on cliffs.
3. Determine key life history parameters including pollination syndrome, symbiotic relationships, seed dormancy, breeding system, age to maturity, longevity to assist with species management.
4. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should sever losses or extinction occur.
5. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding and if any genetic structure exists to assist with any future translocation program.

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B.3 *Galium australe* (Rubiaceae) – Tangled Bedstraw, Booderee National Park

Figure B3.1 *Galium australe* at Yanununbeyan State Conservation Area near Captain's Flat NSW.
© M. Fagg, Australian National Botanic Garden, Photo No. dig 21660.

Tangled Bedstraw is a straggling or intertwining perennial with weak, hairy stems up to 60 cm long; leaves (1.2 cm long and 0.4 cm wide) are in whorls of four; the flowers are white and the fruit that has many, transparent hooked hairs (The Royal Botanic Gardens and Domain Trust, 2015). Thompson (2009) indicates that the flowers are cream or greenish-cream, occasionally tinged purplish-red and are glabrous (i.e. not hairy). The fruit are dull dark brown and 1–1.3 mm long and *c*. 0.8 mm wide (Thompson 2009).

Taxonomy: Conventionally accepted as *Galium australe* DC. (CHAH 2011, verified 5 November 2015).

Status: Listed as Endangered under the NSW *Threatened Species Conservation Act 1995* (TSC Act) on 17 December 2004.

Recovery Plan: There is no recovery plan for this species. It is relatively abundant in Victoria and Tasmania with relatively large populations within reserves in those states; <10% of the species' population occurs in NSW. The NSW Office of Environment and Heritage (OEH) Species Action Statement for Tangled Bedstraw states that this species has been assigned to the Partnership species management stream under the 'Saving our Species' program. OEH are currently developing a targeted approach for managing Partnership Species, but in the interim have a range of management actions identified for this species. These include fencing of populations adjoining urban development and conserving all populations and carrying out experimental burning in a dense shrubland population (OEH 2014).

This information is taken from the NSW Department of Environment and Heritage Listing (OEH 2014) unless otherwise referenced.

Number of populations inside and outside parks and reserves

"Tangled Bedstraw is widespread in Victoria and Tasmania and is also found in South Australia and Australian Capital Territory in Jervis Bay. Following a taxonomic revision, many records in NSW have been re-determined as other species. Tangled Bedstraw has been recorded historically in the Nowra (Colymea) and Narooma areas and is extant in Nadgee Nature Reserve, south of Eden. Records in the Sydney area are yet to be confirmed." (OEH 2014).

"In NSW it is currently known from 13 locations between Sydney and Eden, with an outlying record to the north from near Byabarra on the north coast. Two populations occur in nature Reserves, four in National Parks, two in a Regional Park and the remainder on freehold and crown land. Populations of *G. australe* are generally small, comprising few individuals." (OEH 2011).

Population size – range

Tangled Bedstraw occurs in southern NSW, southern Victoria, far south-eastern South Australia and Tasmania. It grows mostly on or near coasts, often in sandy soils in shrub land and forest (Thompson 2009). The NSW Scientific Committee recommended Tangled Bedstraw for listing as Endangered in NSW and estimates the total number of plants in NSW to be <200. In Booderee National Park this species was last recorded in 2002 in the Lake Windermere area where the number of plants was estimated to be <10 (S. Pedersen pers. comm. 27 November 2015). 'Quite a bit of Tangled Bedstraw' was observed one year after fires in 2009 but it has not been observed since (N. Dexter pers. comm. 27 November 2015).

Geographical distribution

Regional and disjunct. In NSW, the species is known to occur in the following regions and habitats:

- Comboyne Plateau and Macleay Hastings regions in the Northern Rivers district.
- Cumberland and Pittwater in Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin Bioregion.

- Southern Rivers – Bateman, Bungonia (east of Shoalhaven River), Ettrema (areas not on Hawkesbury sandstone), Jervis, Kybeyan-Gourock (Part A), South east Coastal Plains and predicted to occur in the South East Coastal Ranges (Part C) in the following habitats: 1. Bangalay – Old-man Banksia open forest on coastal sands; 2. River Peppermint – Rough-barked Apple – River Oak herb/grass riparian forest of coastal lowlands; 3. Woollybutt – White Stringybark – Forest Red Gum grassy woodland on coastal lowlands; 4. Coast Banksia – Coast Tea-tree low moist forest on coastal sands and headlands; 5. Blackbutt – Turpentine – Bangalay moist open forest on sheltered slopes and gullies. (OEH 2011).

Figure B3.2 Distribution of *Galium australe* in Booderee National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

This species is not conserved in the Living Collections at the Australian National Botanic Gardens or Booderee Botanical Gardens or in the National Seed Bank (M. Henery pers. comm. 26 November 2015, S. Pedersen pers. comm. 27 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Unknown.

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Unknown.

Flowering: Spring and summer.

Breeding system: Based on the percentage of fruit set, Thompson (2009) suggests that many *Galium* species are inbreeding but that some are also outbreeding. Fruit set in Tangled Bedstraw is generally high suggesting that it is outbreeding. Rhizomes not seen (Thompson 2009).

Dispersal: Fruits are described as having numerous hooked hairs. Dempster (1981) states that these hooked (uncinate) hairs cause the fruit to stick to clothing suggesting that dispersal by vertebrate is likely.

Longevity: species in this genera can be either annual or perennial herbs (Thompson 2009) so research is required to determine Tangled Bedstraws likely life-span.

Life form: Intertwining herb.

Ploidy levels: Unknown.

Role of the plant in the environment: Unknown.

Threats

Listed Threats [NSW *Threatened Species Conservation Act* (TSC Act)]

- Critically low population numbers in some populations.
- Grazing by domestic stock.
- Absence of a forest or woodland buffer around remnants exacerbates the other threats.
- Rubbish dumping and visitor use.

Other Threats/Potential New threats

- In the final determination for Tangled Bedstraw under the NSW TSC Act the Scientific Committee identify that at least three *Galium australe* populations are potentially threatened with weed invasion, inappropriate fire regimes and other threats associated with the close proximity of urban areas (OEH 2011),.
- Predicted increases in temperature, and fire frequency and intensity with climate change are also a potential threat to *Galium australe* (DNP 2015).
- Grazing by Swamp Wallabies is also a possible threat (S. Pedersen pers. comm. 27 November 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, germination requirements, seed dormancy, breeding system, genetic diversity, and time to maturity and longevity of this species are unknown.

Suggested research and actions

1. Survey suitable habitat for new populations although this may be challenging as it is a small and insignificant plant (S. Pedersen pers. comm. 27 November 2015).
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Determine key life history parameters including time to maturity, plant longevity, seed dormancy, germination, seed soil bank parameters and response to fire to assist with species management.
4. Determine the reproductive strategy to help assess whether inbreeding is an issue for this outbreeding species.

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B.4 *Syzygium paniculatum* (Myrtaceae) – Magenta Lilly Pilly, Booderee National Park

Figure B4.1 *Syzygium paniculatum* at the Australian Botanic Garden Mount Annan NSW. © M. Fagg, Australian National Botanic Gardens, Photo No. a 9871.

Magenta Lilly Pilly is variable in size ranging from a low shrub to a medium sized tree to 15 m (but can reach 25 m) that is estimated to live for 75–200 years. It has flaky bark and shiny and dark-green leaves above that are paler underneath. The white flowers are clustered at the end of each branch and the spherical or egg-shaped magenta fruits contain a single seed.

Taxonomy: Conventionally accepted as *Syzygium paniculatum* Gaertn. (CHAH 2015, verified 10 July 2015).

Status: Listed as Vulnerable under the EPBC Act on 16 July 2000 and as Endangered under the NSW TSC Act on 31 July 2009.

Recovery Plan: NSW Recovery Plan adopted 6 July 2012 (ComLaw 2012). Plan accurate to January 2011.

This species occurs in the 'littoral rainforest and coast vine thickets' threatened ecological community listed under the EPBC Act and NSW TSC Act, 'littoral rainforest in the NSW North Coast, Sydney Basin and South East Corner bioregions (OEH 2012).

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Of the 44 subpopulations currently verified, 18 occur partly or wholly within conservation reserves (16 in NSW reserves and two in Booderee National Park). A further ten subpopulations occur entirely on private property with the remaining 16 populations found on publicly managed land or straddling public/private property boundaries (OEH 2012).

Population size – range

The total number of plants in NSW is estimated to be 1200 plants distributed in 44 subpopulations along a 400 km stretch of coastal NSW (accurate to Jan 2011 in OEH 2012) from Upper Lansdowne (north of Taree) to Conjola National Park.

Geographical distribution

Regional and disjunct.

These populations are disjunct with five metapopulations identified based on foraging range of dispersal agents (flying fox and White headed pigeon): (i) Jervis Bay; (ii) Coalcliff; (iii) Botany Bay; (iv) Central Coast; and (v) Karuah-Manning. Other potential subpopulations require further investigation. The Jervis Bay (12 subpopulations) and Central Coast (24 subpopulations) metapopulations support the largest number of individuals and subpopulations. Up to two thirds of all individuals occur in three major subpopulations on the central coast, one in Wyrrabalong National Park the other two on private property. (OEH 2012).

Figure B4.2 Full distribution of *Syzygium paniculatum* in Australia. Red dots are specimen collections.

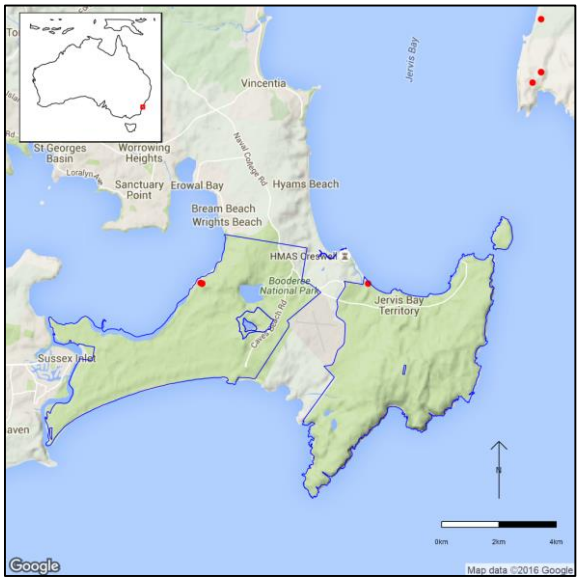

Figure B4.2 Distribution of *Syzygium paniculatum* in Booderee National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

One plant is known from the Royal Botanic Gardens Melbourne (2010) [Atlas of Living Australia (ALA) accessed 10 July 2015]. This species is also known to be in cultivation in botanic gardens located at Adelaide, Canberra, Sydney, Melbourne, Coffs Harbour, Toowoomba and Mount Annan (Quinn, 1995 in OEH 2012) but it is not known if these collections represent wild plants of known provenance (OEH 2012). There are 19 plants in the Australian National Botanic Gardens and a further 31 cuttings in the nursery and 46 plants at Booderee Botanical Gardens (Z. Knapp pers. comm. 12 October 2015, Stig Pedersen pers. comm. 16 November 2015).

Magenta Lilly Pilly is unsuitable for storage in conventional seed banks as it cannot tolerate desiccation and *ex-situ* conservation is therefore limited to living plant collections. Alternative technologies for the long term *ex-situ* storage of such species are being investigated as part of the Rainforest Seed Project at Mt Annan. (OEH 2012). There are therefore no seed stocks of this species at the National Seed Bank (T. North pers. comm. 11 September 2015).

Biology

Pollinators: Pollination is likely to be aided by nectar and pollen feeding vertebrates e.g. flying foxes, possums, honeyeaters, lorikeets as well as bees, beetles, moths and butterflies. It can also self-pollinate (OEH 2012).

Symbiotic relationships: Unknown.

Germination requirements: Rapid germination within 20 days (OEH 2012).

Dormancy class: Recalcitrant with seed longevity thought to be <3 months (OEH 2012).

Flowering: December–March (occasionally to May), fruit January–May (sometimes as late as September) (OEH 2012).

Breeding system: The species is apomictic, i.e. able to produce fertile seed both sexually (following pollination) and asexually (without pollination). The seed produced asexually (apomictically) produces plants that are clones of the maternal plant. Seed are polyembryonic, i.e. having more than one embryo in each seed. This species is also known to coppice after low intensity fire (OEH 2012).

Dispersal: Several agents are likely including water in riparian habitats subject to flooding and gravity and animals which feed on the fruits (OEH 2012).

Longevity: Perennial, estimated 75–200 years (OEH 2012).

Life form: Small tree, but variable from a low shrub to medium sized tree to 25 m (OEH 2012).

Ploidy levels: Genotyping suggests that the species is a polyploid (Thurlby *et al.* 2012).

Role of the plant in the environment: Likely to be an important food source for a range of vertebrates and invertebrates that feed on the pollen, nectar and fruit.

Threats

Listed Threats (EPBC Act and NSW TSC Act)

- Habitat loss and fragmentation (resulting from development).
- Vegetation clearing.
- Grazing in close proximity to creek lines causing root damage, prevention of seedling establishment and erosion.
- Weed invasion from common coastal weeds.
- High frequency/ intensity fires.

Habitat clearing and fragmentation

Habitat likely to support Magenta Lilly Pilly continues to be cleared for urban expansion and infrastructure development, particularly in the Central Coast and Jervis Bay regions.

Inappropriate grazing regimes

Trampling by livestock grazing in riparian areas is contributing to a decline in some of the largest subpopulations along Ourimbah Creek and watercourses in the Martinsville area. There is little or no evidence of recruitment in these areas. This is unlikely in Booderee National Park.

Weed infestations

Numerous weeds pose a threat to Magenta Lilly Pilly or its habitat, particularly Lantana and Bitou Bush. However Bitou Bush is not a threat in Booderee National Park as it prefers different habitats to Magenta Lilly Pilly. Bitou Bush prefers sand dunes and dry sclerophyll forest (sand plain Bangalay forest) whereas *Syzygium paniculatum* grows in moist gullies, wet sclerophyll forest, littoral rainforest and moist soils (S. Pedersen and N. Dexter pers. comm. 16 November 2015).

Inappropriate Fire Regimes

High frequency/ intensity fires. While the species is known to coppice after low intensity fires, high fire frequency or intensity kill or weaken plants, interfere with reproduction and alter or destroy rainforest habitat. Fires can also encourage weed invasion along remnant edges (OEH 2012).

Other Threats/Potential New Threats

Low genetic diversity

Extremely low genetic diversity was found within 11 subpopulations across the species range with a distinct north-south genetic divide centred on the Central Coast near Cams Wharf and Green Point with subpopulations sampled north of this divide having higher genetic diversity than those sampled to the south (Thurlby 2010). There was almost no genetic diversity among the southern subpopulations (OEH 2012) suggesting that this species may have difficulty adapting to future environmental change. This may be of concern for the Booderee National Park populations.

Seed produced apomictically is clonal and offspring produced this way are genetically identical. The low genetic diversity found in many populations of this species may reflect this method of reproduction which can be a means of reproductive assurance if pollinators are lacking.

Climate Change

Sea level rise could threaten some populations and low genetic diversity could mean that the species is unable to adapt to new conditions (OEH 2012).

Introduced Vertebrate Pests

Feral deer occur in many conservation reserves including Bouddi National Park and Illawarra Escarpment State Conservation Area. Browsing Javan Rusa Deer can damage or kill plants through defoliation, bark stripping and stem breaking. Deer may also disturb seedlings of other species that occur in Magenta Lilly Pilly habitat (OEH 2012). Deer do not occur in Booderee National Park and this threat is considered to be a low risk.

Recreational Activities

Some subpopulations are subjected to frequent human visitation and are threatened by the construction and maintenance of roads, walking tracks and car parks. Human visitation may impact regeneration, as trampling of the understorey and soil compaction can inhibit seedling establishment (OEH 2012).

Pathogens

Myrtle/ Guava Rust (*Puccinia psidii*) is a pathogen that affects species from the Myrtaceae family and Magenta Lilly Pilly has been identified as a known host in the field (Primary Industries Biosecurity, 2012) along with several other Myrtaceous species occurring in the same habitat. The entire distribution of Magenta Lilly Pilly occurs within the known or predicted distribution of Myrtle Rust in NSW (OEH 2012). In a study of 118 plant taxa from this family, a single experiment on cuttings of *Syzygium paniculatum* showed no sign of rust infection (Morin *et al.* 2011). Myrtle Rust does not appear to affect *Syzygium paniculatum* at Booderee National Park (S. Pedersen and N. Dexter pers. comm. 16 November 2015).

Changes to local water regimes through water extraction

Temporary supplementation of Central Coast's water supply by pumping up to four million litres per day from Ourimbah Creek was recently approved by the NSW Government. This may lead to reduction in the frequency of flood events and a drop in the water table which is likely to result in the loss of remnant riparian vegetation, including *Syzygium paniculatum*, along much of the creek's middle and lower reaches (OEH 2012).

Knowledge Gaps

The level of susceptibility to Myrtle Rust is unknown and should be investigated.

Suggested research and actions

The 2012 Recovery Plan suggests

1. Determine if viable forms of *ex-situ* germplasm storage exist.
2. Undertake further genotyping of offspring using larger sample size and greater number of populations.
3. Determine the species' effective population size.
4. Investigate the species response to potential climate change across its genetic and geographical range.
5. Research into level of susceptibility to Myrtle Rust of Booderee/other populations and associated Myrtaceous species (i.e. to determine viability of its broader habitat).
6. Investigate the species response to disturbance, including fire.
7. Include Booderee populations in this work.

It is recommended that the genetic assessment needs to include Booderee National Park.

Other actions include

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.

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B.5 *Zieria arborescens* subsp. *decurrens* (Rutaceae) – Stinkwood, Booderee National Park

Figure B5.1 *Zieria arborescens* in Booderee National Park.
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Zieria arborescens subsp. *decurrens* is a shrub to 3 m high. The leaves are entire and variable in size and shape. The white flowers are arranged in many-flowered inflorescences. This species differs from the more widespread subsp. *arborescens* being shorter and with distinctly ridged branches (The Royal Botanic Gardens and Domain Trust, 2015).

Taxonomy: Conventionally accepted as *Zieria arborescens* subsp. *decurrens* J.A.Armstr. (CHAH 2007, verified 5 November 2015).

- Synonym: *Zieria arborescens* subsp. *B* sensu Armstrong (1991) Sims (The Royal Botanic Gardens and Domain Trust, 2015).

Status: This species is not listed under the EPBC Act but is listed as a significant species in the Booderee National Park Management Plan 2015–2025 (DNP 2015).

Recovery Plan: There is no recovery plan for this species.

Number of populations inside and outside parks and reserves

This species is restricted to the Caves Beach area of Jervis Bay on the NSW south coast (Armstrong 2002).

Population size – range

The species is locally common as an undershrub growing on sandy soils in *Eucalyptus pilularis-E. botryoides* open forests with *Syncarpia glomulifera* and *Elaeocarpus reticulatus* as well as in *Eucalyptus pilularis-E. gummifera* woodland with *Acacia longifolia* and *Banksia serrata* (Armstrong 2002).

Geographical distribution

Regional and disjunct.

This species is only known to occur in the southern Jervis Bay region of New South Wales with the majority of the populations occurring in the Booderee National Park.

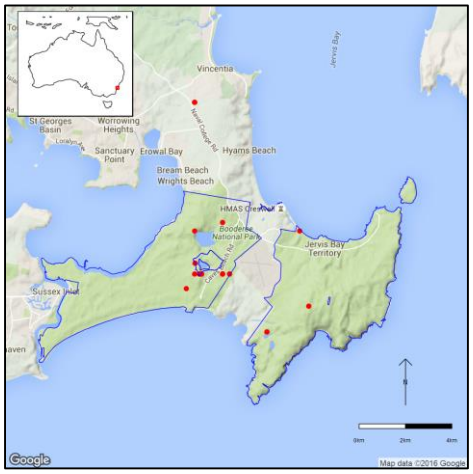

Figure B5.2 Distribution of *Zieria arborescens* subsp. *decurrens* in Booderee National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

This species is conserved in the National Seed Bank (ASBP 2016) and in Living Collections at the Australian National Botanic Gardens and Booderee Botanical Gardens (Stig Pedersen pers. comm. 27 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: *Zieria* flowers are insect pollinated with nectar- and pollen-seeking flies and pollen-seeking beetles frequently observed vectors of *Zieria* pollen. Nectar-seeking flies have been seen frequently on blossoms of subsp. *arborescens* (Armstrong 2002).

Symbiotic relationships: Unknown.

Germination requirements: Armstrong noted that embryo dormancy is suspected in *Z. arborescens* as seed failed to germinate in controlled germination experiments. This dormancy is thought to be in the embryo rather than the seed coat (Armstrong 1989 in Armstrong 2002). Armstrong (1999, 2002) suggests that the presence of a pH-sensitive enzyme in dormant-seeded *Zieria* species would explain the prolific germination that occurs in these taxa following fire. Based on this research it is likely that a pre-treatment will be required to germinate seed of this species.

Dormancy class: Possibly orthodox (the closely-related subspecies *Zieria arborescens* subsp. *arborescens* is described as having a persistent soil seedbank by Floyd (1976) and Wang (1997) in Armstrong (2002).

Flowering: Unknown.

Breeding system: *Zieria arborescens* subsp. *decurrens* is pollen fertile and genetically self-incompatible. Vegetative apomixis has not been observed and regeneration from subsurface epicormic outgrowths has not been reported (Armstrong 2002).

Dispersal: In general *Zieria* seed are forcibly ejected from the fruit along with the placental endocarp which remains attached to the mature seed as a sub-fleshy piece of tissue (elaiosome). This ant-attracting elaiosome aids in short distance seed dispersal (Armstrong 2002).

Longevity: Unknown.

Life form: Large shrub to 3 m high (Armstrong 2001).

Ploidy levels: Unknown although most *Zieria* species seem to be based on x=18 and *Zieria arborescens* is predicted to have a chromosome number of 2n=36 (Armstrong 2002).

***Role of the plant in the environment*:** This may be a post-fire colonising species as the closely-related *Zieria arborescens* subsp. *arborescens* was observed to rapidly colonise burnt sites and to mature quickly (Armstrong 2002). The 2003 Booderee fire encouraged rapid regeneration of *Zieria arborescens* subsp. *decurrens* (S. Pedersen pers. comm. 27 November 2015).

Threats

Listed threats

As *Zieria arborescens* subsp. *decurrens* is not currently listed under Commonwealth or State Legislation threats to this species are unknown. However, the species is considered to be rare and has a very restricted geographical distribution (DNP 2015) and has rarely been collected leading Armstrong (2002) to suggest that its conservation status cannot be reliably determined until more information is available.

Other Threats/Potential New threats

As *Zieria arborescens* subsp. *decurrens* is a rare species with a restricted distribution making it vulnerable to a range of threats including

- Habitat clearing and fragmentation.
- Low genetic diversity.
- Inappropriate grazing regimes.
- Inappropriate fire regimes.
- Climate change.
- Introduced vertebrate pests.
- Recreational activities.

However, it is unclear whether any or all of these are impacting this species in BNP. The taxon is also susceptible to extensive leafminer damage, sometimes leading to plant death in the *ex-situ* collections at Booderee (S. Pedersen pers. comm. 27 November 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, genetic diversity, time to maturity and longevity of this species are unknown.

Many of the biological attributes provided here are inferred from data available for the genus and may be unreliable for this subspecies.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Determine key life history parameters such as flowering, time to maturity, and longevity to assist with species management.
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.
5. Determine the fire frequency and intensity requirements for natural population turnover.
6. Develop and implement a restoration program to increase population numbers and/or sizes.

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B.6 *Asplenium listeri* (Aspleniaceae) – Christmas Island Spleenwort, Christmas Island National Park

Figure B6.1 *Asplenium listeri* from North West point on Christmas Island. ©Alasdair Grigg.

Asplenium listeri is a lithophytic fern with shortly creeping rhizomes that are covered with dark brown scales. The fronds are 3.5–9 cm long, have 8–18 pinnae and are held in a crown. The sori are linear and located along the lateral veins (Du Puy 1993).

Taxonomy: The name *Asplenium listeri* C.Chr. is accepted in the Australian Plant Census (CHAH 2015, verified 13 July 2015).

Status: Listed as Critically Endangered under the EPBC Act on 23 July 2002.

Recovery plans:

- National Recovery Plan for the Christmas Island Spleenwort *Asplenium listeri* (Butz 2004)
- Christmas Island Biodiversity Conservation Plan (Draft, DNP 2014)

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

There are six populations of *A. listeri* on Christmas Island with four of these located inside the national park boundaries at Gannet Hill, Aldrich Hill, Sydney's Dale and North West Point (Butz 2004, D. Maple pers. comm. 28 January 2016).

Population size – range

In 2002, the total number of individuals in four of the six populations was estimated to be <300 with an extent of occurrence of <100 km². A fifth population was located in 2003 by an ecologist during an environmental impact assessment for an expansion to phosphate mining but details of the exact location and plant numbers are not reported (Butz 2004). A sixth population was located during an Island wide survey in 2015; the size of this population is unknown but a site visit by CINP staff to determine this is planned (D. Maple pers. comm. 28 January 2016).

Geographical distribution

The species is widespread but with a highly fragmented distribution and occurs in small and isolated populations.

Figure B6.2 Distribution of *Asplenium listeri*. Red dots are specimen locations, blue dots are CINP survey observations, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Butz (2004) mentions that specimens of *A. listeri* were kept at a nursery on Christmas Island in 2001, however, the species is no longer cultivated (D. Maple and A. Grigg pers. comm. 9 October 2015). The species is not conserved in the Living Collection at the Australian National Botanic Gardens (Z. Knapp pers. comm. 30 September 2015) and no other *ex-situ* collections in any other Botanic Garden have been located (ASBP 2016). It is also not conserved in the National Seed Bank as ferns do not produce seed.

Biology

Pollinators: N/A

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: N/A

Flowering: N/A

Breeding system: Unknown.

Dispersal: Fern spores are usually dispersed over a few meters but can be transported over thousands of kilometres via air currents. Fern spores without developed chloroplasts and can survive for months to years (Kessler 2010).

Longevity: Unknown.

Life form: Fern.

Ploidy levels: Chromosome counts are not available for *A. listeri*. In the genus, polyploidy is frequent (CCDB, Rice *et al.* 2015).

Role of the plant in the environment: *Asplenium listeri* grows on narrow limestone cliff-top strips with an open aspect to the sea and in forest on the inland side where it is found in rock crevices, often beneath or near *Ficus microcarpa* (Butz 2004, DNP 2014).

Threats

Listed threats (EPBC Act)

- Illegal collection.
- Habitat destruction, disturbance and/or modification due to mining activities.
- Soil disturbance and/or trampling due to bushwalking.
- Invasive Non-Native/Alien Species.
- Competition and/or habitat degradation by weeds.
- Predation, competition, habitat degradation and/or spread of pathogens by introduced species.
- Inappropriate and/or changed fire regimes (frequency, timing, intensity).
- Low numbers of individuals.
- Development and/or maintenance of roads.

Genetic and demographic effects

Asplenium listeri is known from only six locations on Christmas Island and has a fragmented distribution on the island. The last available combined population size for four known locations was <300 individuals in 2002 (Butz 2004). This low number of individuals and the restricted geographical distribution make the species vulnerable to stochastic events like cyclones. The implications of low genetic diversity and inbreeding for this fern are unknown.

Climate-related factors

Climatic events such as drought and cyclones potentially threaten populations both inside and outside the national park (DNP 2014). Climate change scenarios predict an increase in annual average temperature and the number of hot days. Together with a predicted decrease in rainfall this may increase the number of days with high or extreme forest fire danger; fires could also become more frequent and severe. Furthermore, although overall cyclone activity is predicted to decrease, high intensity cyclones will become more frequent, potentially leading to vegetation damage on the island (DNP 2011).

Invasive and other problematic species

Weeds are a potential future threat to *A. listeri* should these invade this species habitat (DNP 2014). *Antigonon leptopus* (Polygonaceae) and *Pluchea indica* (Asteraceae) are two weeds already recorded as invading inland cliffs while other weeds occur throughout the island (Swarbrick and Hart 2001). No data exist to determine if weeds are impacting on this species. Another potential future threat is the invasive Giant African Snail (*Achatina fulica*). While this species does not yet occur in *A. listeri* habitat changes to the abundance and distribution of vegetation associated with this species and its complex associations with red crabs (*Gecarcoidea natalis*) and invasive yellow crazy ants (*Anoplolepis gracilipes*) (Butz 2004) have the potential to impact on *A. listeri*. Future introductions of invasive species as well as sleeper weeds already present on the island also present potential threats (DNP 2014).

Biophysical impacts

Removal or modification of habitat through vegetation clearing and disturbance such as road construction, infrastructure development and/or mining is a threat to the populations that occur outside the national park. Habitat disturbance caused by road construction is also a threat inside the national park (DNP 2014).

Direct human impacts

The Gannet Hill population is at risk from trampling as it is located close to a site frequently visited by tourists and visitors (DNP 2014). Illegal collection of *A. listeri* was considered to be a threat in the first species recovery plan (Butz 2004) but since that time there has been no indication of collection or special interest in this species by fern enthusiasts and it is now considered to be an unlikely threat (DNP 2014).

Current management

The species is currently not monitored or included in the biennial island wide survey that is conducted during the dry season. However, if found it would be reported, as was the case with the population newly located in 2015 (D. Maple pers. comm. 9 October 2015). A search for rare flora conducted in 2012 by the Australian National Herbarium did not locate this species (M. Goumas pers. comm. 6 August 2015).

Knowledge Gaps

Species biology and life history including symbiotic relationships, spore germination, spore storage, genetic diversity, and time to maturity and longevity of both life stages are unknown.

Suggested research and actions

1. Compile a comprehensive list of environmental factors (physical and biological) and use this data to develop predictive models to assist locate additional populations (Butz 2004).
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Determine life history traits such as maturity and longevity to assist with population management to assist with species management.
4. Evaluate whether long term storage of spores is possible and germination requirements.
5. Ohlsen *et al.* (2015) determined that lithophytic, limestone-dwelling *A. polyodon* populations on Vanuatu and New Caledonia were *A. listeri* indicating that the distribution of this species extends beyond Christmas Island. Genomic assessments to determine evolutionary relationships within this species complex may be useful should translocation material be required.

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B.7 *Asystasia alba* (Acanthaceae) – Christmas Island National Park

Figure B7.1 *Asystasia alba* flowers Christmas Island. ©Jeff Claussen.

Asystasia alba is an erect woody herb usually 50–75 cm high. The flowers are arranged singly or more rarely paired in an inflorescence that is 6–8 cm long. The corolla is white or violet and glandular-pubescent on the outside. The corolla tube is 14–18 mm long, the throat 8–10 mm and the corolla lobes are 4.5–7 mm. The flowers have four stamens, the longer ones usually just exserted. The fruit is a two-seeded capsule. The species is variable and probably closely-related to *A. australasica* and *A. oppositiflora* (Barker and Telford 1993).

Taxonomy: The name *Asystasia alba* Ridl. is accepted in the Australian Plant Census (CHAH 2015, verified 12 October 2015).

Status: Not listed.

Recovery Plan: A recovery plan is not required as the species is not listed.

Number of populations inside and outside parks and reserves

Asystasia alba has been collected from locations in the western and north-eastern parts of Christmas Island. A survey in 2002 located four populations in the western part of the island (Holmes and Holmes 2002). Most of the populations appear to be located within the national park.

Population size – range

Ridley (1906) described *A. alba* as being locally abundant. A total of about 200 plants were recorded in the four populations in 2002 and the number of individuals was inferred to be declining (Holmes and Holmes 2002).

Geographical distribution

The species is endemic to Christmas Island where it has a localised distribution.

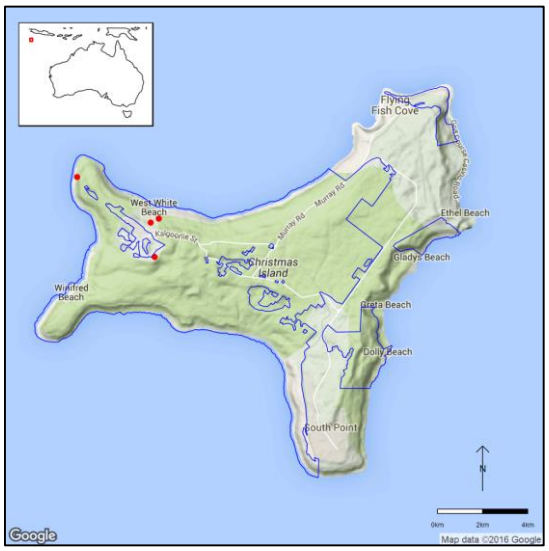

Figure B7.1 Distribution of *Asystasia alba* on Christmas Island. Red dots indicate specimens, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (M. Henery pers. comm. 5 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: The species is probably insect-pollinated. The long corolla tube indicates that the pollinators probably have long tongues and Barker (1986) suggests that moths and butterflies as probable pollinators for this type of flower.

Symbiotic relationships: Unknown.

Germination requirements: Unknown. In a germination study for *A. gangetica*, seed that were older than 135 days germinated at room temperature. However, fresher seeds could only be germinated following treatment such as alternations in temperatures (Akamine *et al.* 1947).

Dormancy class: Unknown. *Asystasia gangetica* was shown to have dormant seed with the cause of dormancy possibly being in the seed coat (Akamine *et al.* 1947).

Flowering: Unknown.

Breeding system: Unknown.

Dispersal: *Asystasia alba*, like many other Acanthaceae, has capsules with an exploding mechanism, ejecting the seeds (Ridley, 1906).

Longevity: Unknown.

Life form: Woody herb (Du Puy 1993).

Ploidy levels: Unknown.

Role of the plant in the environment: *Asystasia alba* grows on phosphatic soils in forests of the terraces where the canopy is less dense (Holmes and Holmes 2002).

Threats

Listed Threats

As *Asystasia alba* is not currently listed under Commonwealth or State Legislation threats to this species are unknown.

Other Threats/Potential New threats

- Genetic and demographic effects.
- Climate related effects.
- Invasive weed species.
- Invasive vertebrates.

Genetic and demographic effects

The relatively small population sizes and distribution area probably make *A. alba* vulnerable to inbreeding effects associated with low genetic diversity. The species is also vulnerable to destructive stochastic events. The population appears to have declined significantly within the last century.

Climate-related factors

Dry periods may have reduced the population size (Holmes and Holmes 2002). Climate change is predicted to lead to lower rainfall and higher temperatures and probably more dry periods as well as an increased forest fire risk (DNP 2011).

Invasive and other problematic species

Holmes and Holmes (2002) state that the species might be vulnerable to predation by native crabs as well as competition from invasive weeds. The introduced weeds *Mikania micrantha* (Asteraceae) and *Clausena excavata* (Rutaceae), which are spreading in the north-west of the island, could potentially compete with *A. alba*, especially in areas with a less dense canopy (D. Maple pers. comm. 9 October 2015).

Current management

The species is currently not monitored and not included in the biennial island wide survey.

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, and time to maturity and longevity of this species are unknown.

Suggested research and actions

1. Assess whether EPBC listing is required (D. Maple pers. comm. 9 October 2015).
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Survey suitable habitat for new populations.
4. Determine life history traits including flowering, breeding system, maturity and longevity to assist with species management.
5. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
6. Determine the appropriate conditions for long term storage and seed germination.
7. Develop and implement a restoration program to increase population numbers and/or sizes.

References

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B.8 *Dicliptera maclearii* Hemsl. (Acanthaceae) – Christmas Island National Park

Dicliptera maclearii is an erect herb up to 1 m high. The pink flowers are densely clustered in leaf axils and subtended by pairs of bracts. The corolla tube is *c.* 3.5 mm long and the corolla lobes *c.* 5.5 mm long. The species is morphologically similar to *D. ciliata* (Barker and Telford 1993).

Taxonomy: The name *Dicliptera maclearii* Hemsl. is accepted in the Australian Plant Census (CHAH 2015, verified 14 October 2015).

Status: Not listed.

Recovery Plan: No recovery plan is required for this species as it is not listed.

Number of populations inside and outside parks and reserves

The current distribution of *D. maclearii* on Christmas Island is unknown. Historically it has been described as common on the lower terraces at Flying Fish Cove, Waterfall and Cemetery Rd and at North West Point. A few historical collections exist from Toms Ridge, Phosphate Hill and North West Point but a survey in 2002 was unable to locate any populations (Holmes and Holmes 2002).

Population size – range

The species was apparently quite abundant at the beginning of the last century as E. G. Baker described *D. maclearii* as being "common on shore platforms" (Andrews 1900) while Ridley (1905) considered it to be "very common on the lower terraces". However, no plants of *D. maclearii* were found in a survey conducted in 2002 (Holmes and Holmes 2002). According to collection information available in GBIF.org (2015), the species was last collected in 1984.

Geographical distribution

The species is endemic to Christmas Island. There are no specimen records of this species in Australian Herbaria and Fig B8.1 is based on locations mapped by Holmes and Holmes (2002) from specimens located in overseas Herbaria.

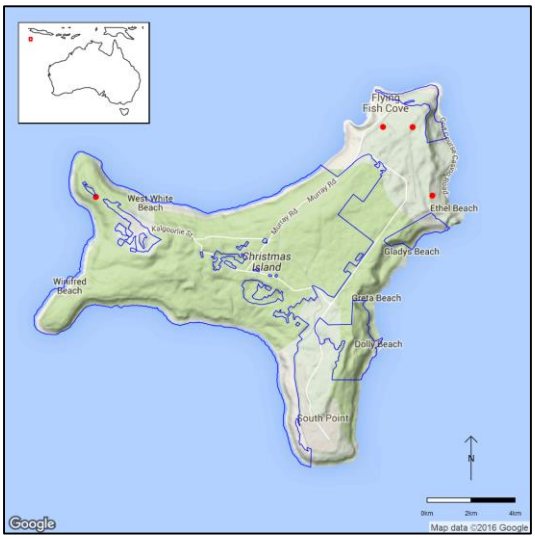

Figure B8.1 Historic records of *Dicliptera maclearii* distribution on Christmas Island. Red dots indicate specimens from overseas Herbaria (as mapped in Holmes and Holmes 2002) (DuPuy 1993), blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (M. Henery pers. comm. 5 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Unknown. The corolla size, shape and colour suggest that this species is insect-pollinated. Barker (1986) describes the flower as a flag blossom and mentions moths, butterflies, larger bees, and pollen-collecting bees as possible pollinators.

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Unknown.

Flowering: Unknown.

Breeding system: Some *Dicliptera* species have cleistogamous flowers that do not open but self-pollinate while still closed, e.g. the closely-related species *D. ciliata* (Barker and Telford 1993).

Dispersal: The capsule is small and falls off enclosed in the broad bracts and adheres to cloth (Ridley 1906) suggesting that these many be vertebrate-dispersed.

Longevity: Unknown.

Life form: Unknown.

Ploidy levels: Unknown.

Role of the plant in the environment: *Dicliptera maclearii* has been reported to grow on phosphatic soils in terrace forests to an elevation of about 200 m (Holmes and Holmes 2002).

Threats

Listed Threats

As *Dicliptera maclearii* is not currently listed under Commonwealth or State Legislation threats to this species are unknown.

Other Threats/Potential New threats

- Genetic and demographic effects.
- Climate related effects.
- Invasive weed species.
- Invasive vertebrates.

Genetic and demographic effects

Since the population has seriously declined at some time during the last century, a significant loss of genetic diversity is highly likely which could have significant consequences for population persistence through inbreeding if the species still exists on Christmas Island. The small population size and distribution also make it vulnerable to loss through stochastic events.

Climate-related factors

Dry periods may have played a role in reducing the population (Holmes and Holmes 2002).

Invasive and other problematic species

Holmes and Holmes (2002) suggest that the species might be vulnerable to predation by native crabs as well as competition by invasive weeds.

Current management

The species is currently not monitored and not included in the biennial island wide survey. A survey for populations is planned (D. Maple pers. comm. 9 October 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, and time to maturity and longevity of this species are unknown.

Current locations and population sizes are unavailable.

Suggested research and actions

1. Assess whether EPBC listing is required (D. Maple pers. comm. 9 October 2015).
2. If the proposed survey relocates this species establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Determine key life history parameters including pollinators, symbiotic relationships, dormancy, flowering, dispersal and longevity to assist with species management.
4. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
5. Determine the appropriate conditions for long term storage and seed germination.
6. Evaluate whether populations of pollinators and dispersal agents still exist.
7. Develop and implement a restoration program to increase population numbers and/or sizes if possible.
8. Evaluate the need to establish 'insurance' populations off-park until stable populations have been established on-island.

References

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B.9 *Grewia insularis* (Malvaceae) – Christmas Island National Park

Figure B9.1 *Grewia insularis* Christmas Island a) flowers and b) leaves and flowers. ©Jeff Claussen.

Grewia insularis is a shrub or tree with a dense cover of stellate hairs on the tips of the branchlets, petioles and inflorescences. The leaves are lanceolate to ovate with the lamina 2–7 cm long and 0.5–3 cm wide. The inflorescences are umbels of mostly 1–3 flowers and there are usually several umbels per leaf axil. The sepals are linear (6–8 mm), pubescent and yellow. The petals are *c.* 3 mm and the fruit is purple (Du Puy and Telford 1993).

Taxonomy: The name *Grewia insularis* Ridl. is accepted in the Australian Plant Census (CHAH 2015, verified 15 October 2015).

Status: Not listed.

Recovery Plan: A recovery plan is not required for this species as it is not listed.

Number of populations inside and outside parks and reserves

Grewia insularis has been reported to grow singly or in small groups or dispersed stands (Holmes and Holmes 2002). The last survey does not report how many locations or populations were found or how many of these were located inside the national park (Holmes and Holmes 2002).

Population size – range

Ridley (1906) found the species at "North East point, fairly common". In a 2002 survey, a total of 66 plants were found, 49 of which were mature (Holmes and Holmes 2002).

Geographical distribution

The species is endemic to Christmas Island where it has a localised distribution.

Figure B9.1 Distribution of *Grewia insularis* on Christmas Island.
Red dots indicate specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (M. Henery pers. comm. 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Probably insect-pollinated. Flowers of other *Grewia* species (*G. eriocarpa* and *G. asiatica*) were observed to be visited mostly by several bee species as well as beetles, flies and butterflies (Kato *et al.* 2008, Wani *et al.* 2015).

Symbiotic relationships: Unknown.

Germination requirements: Unknown. The seed of the related *Grewia asiatica* germinated readily after separation from the fruit (Wani *et al.*, 2015).

Dormancy class: *Grewia asiatica* seed does not exhibit any signs of dormancy (Wani *et al.* 2015).

Flowering: Unknown.

Breeding system: Unknown. *Grewia asiatica* is self-compatible (Wani *et al.* 2015).

Dispersal: Unknown.

Longevity: Unknown.

Life form: Shrub or tree.

Ploidy levels: Unknown.

Role of the plant in the environment: This species grows mainly in terrace forests (Holmes and Holmes 2002).

Threats

Listed Threats

As *Grewia asiatica* is not currently listed under Commonwealth or State Legislation threats to this species are unknown.

Other Threats/Potential New threats

Genetic and demographic effects

The low number of individuals counted in the last survey and small distribution of this species make it vulnerable to inbreeding effects associated with low genetic diversity. The species is also vulnerable to destructive stochastic events.

Holmes and Holmes (2002) state that they found “no conceivable current threats” to *G. insularis* during their survey.

Current management

The species is currently not monitored and not included in the biennial island wide survey.

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown.

Suggested research and actions

1. Assess whether EPBC listing is required (D. Maple pers. comm. 9 October 2015).
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Survey suitable habitat for new populations.
4. Determine key life history parameters including pollination, symbiotic relationships, flowering, breeding system, maturity and longevity to assist with species management.
5. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
6. Determine the appropriate conditions for long term storage and seed germination.
7. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding and if any genetic structure exists to assist with any future translocation program.

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B.10 *Pneumatopteris truncata* (Thelypteridaceae)– Christmas Island fern, Christmas Island National Park

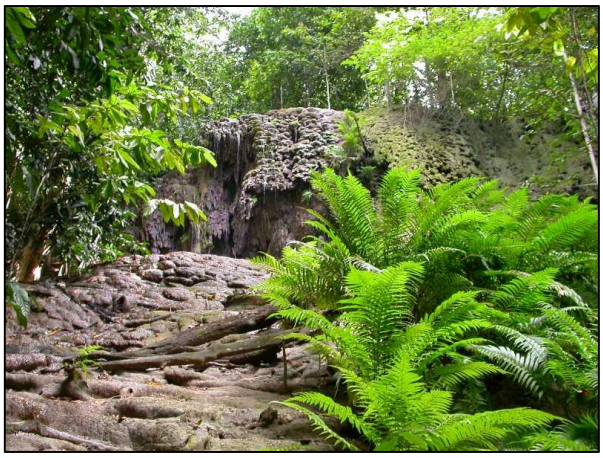

Figure B10.1 *Pneumatopteris truncata* Christmas Island. Photo credit – ©Dion Maple.

Pneumatopteris truncata is a large terrestrial fern with erect rhizomes. The bipinnatifid fronds are 80–120 cm long and held in a crown. The sori are circular and distributed in rows on either side of the midveins of the pinna lobes (Du Puy 1993).

Taxonomy: The name *Pneumatopteris truncata* (Poir.) Holttum is accepted in the Australian Plant Census (CHAH 2015, verified 13 July 2015).

Status: Listed as Critically Endangered under the EPBC Act on 6 July 2004.

Recovery Plan: Christmas Island Biodiversity Conservation Plan (Draft DNP 2014).

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Two known populations are located on the south-west side of the island at Hugh's Dale and Blowholes Ravine. All known occurrences occur inside the national park boundaries (DNP 2014).

Population size – range

A 2002 survey recorded 45 mature individuals, 30 in one location and 15 in the other (Holmes and Holmes 2002, TSSC 2004). The extent of occurrence for these two populations was estimated to be 0.4 km² (TSSC 2004). The population size has since declined and as few as five individuals now occur at the High's Dale site and possibly <5 at Blowholes Ravine (D. Maple pers. comm. 9 October 2015).

Geographical distribution

Apart from Christmas Island, the species also occurs from India and southern China, through Indo-China and western Malesia, to the Philippines, the Lesser Sunda Islands and the Mariana Islands (Du Puy 1993). The species has a widespread but fragmented distribution. The distribution on Christmas Island is localised and fragmented.

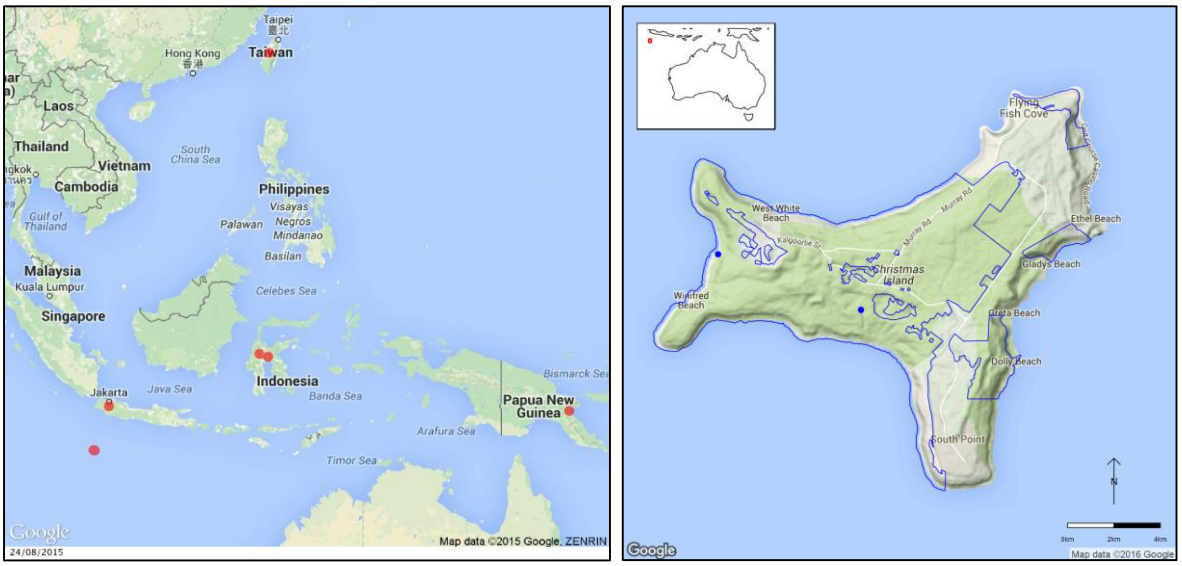

Figure B10.1 Distribution of *Pneumatopteris truncata* in SE Asia (left) and distribution on Christmas Island (right). Blue dots indicate locations verified by CINP Staff, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Z. Knapp pers. comm. 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: N/A

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: N/A

Flowering: N/A

Breeding system: Unknown.

Dispersal: Fern spores are usually dispersed over a few meters, but transport over thousands of km via air currents is possible. Fern spores without developed chloroplasts and can survive for months to years (Kessler 2010).

Longevity: Unknown.

Life form: Fern

Ploidy levels: Unknown.

Role of the plant in the environment: *Pneumatopteris truncata* grows in semi-deciduous forest in 50–140 m elevation. Here, it forms colonies on permanently moist sites (DNP 2014).

Threats

Listed threats (EPBC Act)

- Low numbers of individuals.

Genetic and demographic effects

The very low population size and small distribution area on Christmas Island suggest that limited genetic diversity exists which may be even lower if the plants are reproducing clonally. This may make is susceptible to inbreeding but the effects of this in ferns is unknown. It is also vulnerable to stochastic events such as cyclones.

Other Threats/Potential New threats

Climate-related factors

Cyclones occur in the vicinity of Christmas Island on average about once a year and plants growing along waterways can be swept away or their substrate eroded. Wind damage to the canopy during cyclones and severe tropical storms can also lead to falling branches destroying plants and create canopy gaps that make the habitat unsuitable for the Christmas Island Fern (TSSC 2004). Although overall cyclone activity is predicted to decrease under climate change, high intensity cyclones will become more frequent, potentially leading to vegetation damage on the island (DNP 2011).

Fire is a potential threat to *P. truncata* (DNP 2014). Climate change scenarios predict an increase in annual average temperature and of the number of hot days. Together with a predicted decrease in rainfall amounts this leads to an increase in the number of days with high or extreme forest fire danger, and fires could become more frequent and severe (DNP 2011).

Invasive and other problematic species

Several weeds occur in the forests of Christmas Island such as *Clausena excavata* (Rutaceae, Swarbrick and Hart 2001) but no data exist to assess if any weeds threaten this species. Invasive species such as the invasive Giant African Snail (*Achatina fulica*) present a potential threat for *P. truncata*. Future introduction of invasive species as well as sleeper weeds also present potential threats (DNP 2014).

Biophysical impacts

Outside the national park, road construction, development or mining pose potential threats to any undiscovered *P. truncata* populations (DNP 2014).

Current management

Not currently monitored or included in the biennial island-wide survey, but if found it would be reported. A rare flora search was conducted in 2012 by the Australian National Herbarium and the species was not found (M. Goumas pers. comm. 6 August 2015).

Knowledge Gaps

Species biology and life history including symbiotic relationships, spore germination, spore storage, genetic diversity, time to maturity and longevity of both life stages are unknown.

Habitat preferences are not well defined.

Suggested research and actions

1. Researching the ecology and habitat requirements of *P. truncata* is included under the proposed Action 6.2 in the Christmas Island Biodiversity Conservation Plan (DNP 2014).
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Determine life history traits such as maturity and longevity to assist with population management to assist with species management.
4. Evaluate whether long term storage of spores is possible and germination requirements.
5. A broader phylogenetic study would determine relatedness between this population and the nearest neighbours in the event that translocation programs were required.
6. Develop and implement a restoration program to increase population numbers and/or sizes.
7. Evaluate the need to establish 'insurance' populations off-park.

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B.11 *Tectaria devexa* var. *minor* (Dryopteridaceae) – A fern, Christmas Island National Park

Figure B11.1 *Tectaria devexa* var. *minor* Christmas Island. Photo credit – ©Dion Maple.

Tectaria devexa is a fern with procumbent or nearly erect rhizomes with dark brown scales that are 6–9 mm long. The tripinnatisect leaves (fronds) are 20–40 cm, arching and arranged in a crown. They have anastomosing veins. The sori are small and circular, with a reniform indusium. The var. *minor* occurring on Christmas Island has leaves with lower sides that are mainly hairy on the veins. In Australia the only occurrences of var. *devexa*, which differs by having leaves that are hairy on the whole lower surface, are in Queensland (Du Puy and Orchard 1993).

Tectaria devexa is very similar to *Tectaria dissecta*, a species also occurring on Christmas Island, however, *Tectaria dissecta* has less finely divided leaves without anastomosing veins (Du Puy and Orchard 1993).

Taxonomy: The name *Tectaria devexa* (Kunze ex Mett.) Copel. var. *minor* (Hook.) Holttum is accepted in the Australian Plant Census (CHAH 2015, verified 13 July 2015).

Status: The species (including both of varieties) was listed as Endangered under the EPBC Act on 16 July 2000.

Recovery Plans:

- National Recovery Plan for *Tectaria devexa* (Butz 2004)
- Christmas Island Biodiversity Conservation Plan (Draft, DNP 2014)

This information is sourced from the SPRAT webpage associated with this species (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

The species is currently known from eleven locations (D. Maple pers. comm. 9 October 2015) most of which are located inside the national park. However, the distribution of *Tectaria devexa* on Christmas Island is not well known and unknown population are suspected to exist (DNP 2014, D. Maple pers. comm. 9 October 2015).

Population size – range

In 2002, population sizes ranged from 210 individuals in one population, 170 in another with the remaining plants distributed among small and scattered colonies. In 2004, the total number of mature individuals of var. *minor* on Christmas Island was estimated to be <500 (Butz 2004). In the last few years, more populations have been found (D. Maple and A. Grigg pers. comm. 9 October 2015) but current species numbers are not available.

Geographical distribution

Outside of Christmas Island, *T. devexa* var. *minor* also occurs in Sri Lanka (Holttum 1988). It has a fragmented distribution on Christmas Island (DNP 2014).

Figure 11.1 Distribution of *Tectaria devexa* var. *minor* on Christmas Island. Blue dots indicate locations verified by CINP Staff, red dots are specimen collections, blue is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Z. Knapp pers. comm. 30 September 2015). It is also not conserved in the National Seed Bank as ferns do not produce seed.

Biology

Pollinators: N/A

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: N/A

Flowering: N/A

Breeding system: Unknown.

Dispersal: The tendency of the species to be found in clumps on Christmas Island indicate vegetative propagation but this has not been confirmed (Butz 2004). Fern spores are usually dispersed over a few meters, but transport over thousands of kilometres via air currents is possible. Fern spores without developed chloroplasts and can survive for months to years (Kessler 2010).

Longevity: Unknown.

Life form: Fern.

Ploidy Levels: Unknown.

Role of the plant in the environment: *Tectaria devexa* var. *minor* grows in the evergreen tall closed forest growing on the plateau of Christmas Island, where it may be the only forest floor species in some places (DNP 2014).

Threats

Listed threats (EPBC Act)

- Illegal collection.
- Restricted geographical distribution.
- Habitat destruction, disturbance and/or modification due to mining activities.
- Competition and/or habitat degradation by weeds.
- Low numbers of individuals.

Genetic and demographic effects

The likely low population size and its restricted geographical distribution make *Tectaria devexa* var. *minor* vulnerable to stochastic events such as cyclones (DNP 2014). It may also be vulnerable to inbreeding although the effects of small population size are not well known for ferns.

Invasive and other problematic species

Weeds that are reported to occur in the evergreen rainforest include *Castilla elastica* (Moraceae), *Hevea brasiliensis* (Euphorbiaceae) and *Clausena excavata* (Rutaceae, Swarbrick and Hart 2001) but it is unknown if these woody weeds pose a direct threat to *T. devexa* var. *minor*. Competition by the very hardy native Scurfy Sword Fern (*Nephrolepis multiflora*, Lomariopsidaceae) and Broad Sword Fern (*N. biserrata*) is also a possible threat.

While the invasive Giant African Snail (*Achatina fulica*) does not yet occur in *T. devexa* var. *minor* habitat it may pose a problem if it does become invasive. Future introduction of invasive species as well as sleeper weeds already present on Christmas Island are also potential threats (DNP 2014).

Biophysical impacts

Outside of the national park, road construction, development and mining pose could impact on populations not yet discovered.

Direct human impacts

Illegal collection was considered a threat by Butz (2004) but is now considered unlikely to occur (DNP 2014).

Other Threats/Potential New threats

Climate-related factors

Populations of *Tectaria devexa* var. *minor* are generally threatened by droughts and cyclones (DNP 2014). Since climate change is predicted to lead to a decrease in rainfall and a rise in temperature, droughts might become more severe or frequent. Furthermore, although overall cyclone activity is predicted to decrease, high intensity cyclones will become more frequent, potentially leading to vegetation damage on the island (DNP 2011).

Fire is a potential threat to *T. minor* var. *devexa* (DNP 2014). Climate change scenarios predict an increase in annual average temperature and of the number of hot days. Together with a predicted decrease in rainfall amounts this leads to an increase in the number of days with high or extreme forest fire danger, and fires could become more frequent and severe (DNP 2011).

Current management

The taxon is included in the biennial island-wide survey. A rare flora search conducted in 2012 by the Australian National Herbarium (pers. comm. M. Goumas 6 August 2015) does not appear to have found this species.

Knowledge Gaps

Species biology and life history including symbiotic relationships, spore germination, spore storage, genetic diversity, and time to maturity and longevity of both life stages are unknown. This species habitat requirements is poorly understood.

Suggested research and actions

1. Researching the biology and ecology of *T. devexa* var. *minor* is included under the proposed Action 6.2 in the Christmas Island Biodiversity Conservation Plan (DNP 2014).
2. Clarify whether the current monitoring program is providing sufficient data to determine population trajectories and the relative impacts of threatening processes.
3. Cultivation of *Tectaria devexa* var. *minor* may assist with understanding the life cycle as well as habitat and regeneration requirements (DNP 2014).
4. Evaluate whether long term storage of spores is possible and germination requirements.

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B.12 *Acacia equisetifolia* (Fabaceae) – Graveside Gorge Wattle, Kakadu National Park

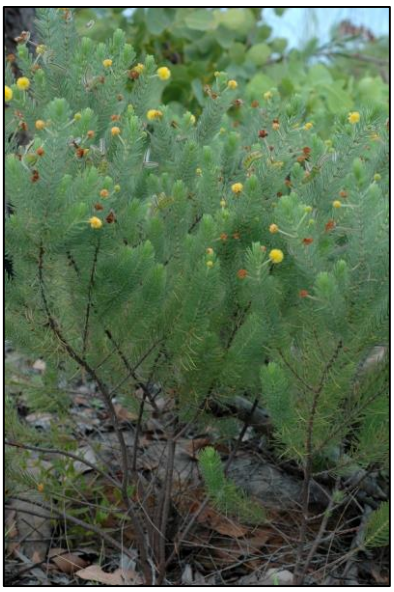

Figure B12.1 *Acacia equisetifolia* Kakadu National Park. ©K Brennan.

Acacia equisetifolia is a shrub up to 1 m tall. The hairy phyllodes are arranged in crowded whorls of 10–17. The yellow flowers are arranged into globular inflorescences, with inflorescences solitary on whorls of phyllodes (Maslin and Cowie 2014).

Taxonomy: The name *Acacia equisetifolia* Maslin and Cowie is accepted in the Australian Plant Census (CHAH 2015, verified 13 July 2015).

Status: Listed as Critically Endangered under the EPBC Act on 14 August 2006 as *Acacia* sp. Graveside Gorge (V.J.Levitzke 806). Listed as Critically Endangered under the *Territory Parks and Wildlife Conservation Act* 2000 (Northern Territory) on the 2012 list as *Acacia* sp. Graveside Gorge (V.J.Levitzke 806) NT Herbarium.

Recovery Plan: Recovery Plan not required, included on the Not Commenced List (1 November 2009). Management prescriptions and research recommendations are included in 'A strategy for the conservation of threatened species and threatened ecological communities in Kakadu National Park' (Woinarski and Winderlich 2014).

This Information is sourced from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

When the species was first collected in 1981 only vague locality data was given. Surveys found one population (Kerrigan 2004) and later a second population about 1 km away (Kerrigan *et al.* 2007). Both known populations are inside Kakadu National Park.

Population size – range

Population sizes apparently strongly fluctuate. The first known population consisted of one mature plant and about 20 seedlings in 2004 (Kerrigan 2004) but in 2006 150 plants, many flowering and fruiting, were found at the same location; the second population consisted of 700–800 individuals (Kerrigan *et al.* 2007). The total population size of the species was thus estimated as 850–950 individuals with an extent of occurrence of <1 km² (Cowie and Liddle 2014).

Geographical distribution

The species has a localised distribution.

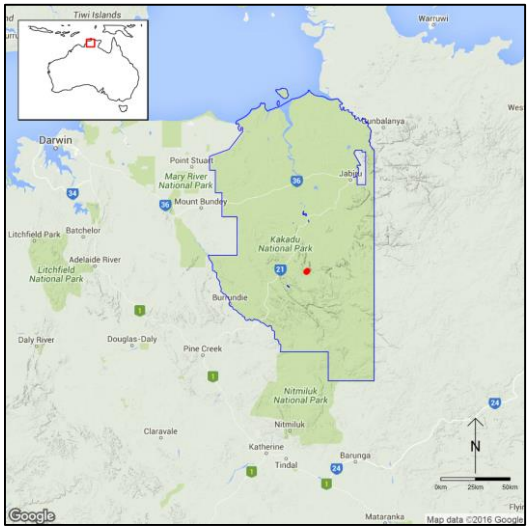

Figure B12.1 Distribution of *Acacia equisetifolia*. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens (ANBG) (Z. Knapp pers. comm. 30 September 2015). Kakadu and the ANBG have a collaborative project to collect seed for storage in the National Seed Bank (O'Dea 2014) and this species has been identified as a priority target for collection, propagation and experimental translocation (KNP TS Project 4, M. Goumas pers. comm. 6 August 2015). One seed accession (21.2 g) is held at the National Seed Bank and collection from the second population is planned for April 2016 (Tom North pers. comm. 11 September 2015). The George Brown Darwin Botanic Gardens, Northern Territory, currently holds seed collections of this species (Wedd 2013). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Acacias support an array of insect species (Bernhardt 1989).

Symbiotic relationships: Unknown but likely to have associations with nodulating nitrogen-fixing bacteria.

Germination requirements: This species apparently produces mass recruitment from soil-stored seed following a fire (Cowie and Liddle 2014). Seed of the related species *A. porcata*, which occurs in the same section of the genus, are easily germinated by scarifying the seed coat or soaking in boiling water; fire might break dormancy (Leverington 2001).

Dormancy class: Orthodox.

Flowering: Not precisely known but flowers at anthesis have been collected in February (Maslin and Cowie 2014).

Breeding system: This species probably only reproduces sexually (Kerrigan *et al.* 2007). The flowers are bisexual. It is likely to be self-incompatible (Kenrick *et al.* 1986, Kenrick and Knox 1989).

Dispersal: Unknown but the seed have an aril (Maslin and Cowie 2014) suggesting that they might be dispersed by ants.

Longevity: Unknown. The time to maturity in other obligate seeder species of the same section of *Acacia* is 2–4 years (Russell-Smith *et al.* 2010). In *A. equisetifolia*, time to maturity is probably 1–2 years (Kerrigan 2004, Kerrigan *et al.* 2007).

Life form: Shrub.

Ploidy levels: Unknown.

Role of the plant in the environment: The species grows on west- to southwest-facing rocky sandstone slopes and ledges at the top of cliff lines (Woinarski and Winderlich 2014).

Threats

Listed threats (EPBC Act)

- Restricted geographical distribution (area of occupancy and extent of occurrence)
- Inappropriate and/or changed fire regimes (frequency, timing, intensity)
- Low numbers of individuals

Genetic and demographic effects

Population sizes can apparently fluctuate strongly and although further plants have been located since the time of listing, this species still has a relatively low number of individuals overall (Kerrigan *et al.* 2007). Small population sizes can reduce genetic diversity and lead to inbreeding. In *Acacia dealbata* this resulted in reduced seed set in small populations (Broadhurst and Young 2006). Selfed seed can sometimes be produced in acacias but the seedlings are often less fit and fail to thrive (Moffat and Nixon 1974, Harwood *et al.* 2004). The species also has a very restricted distribution making it vulnerable to stochastic events such as fire.

Climate-related factors

The main threat to *A. equisetifolia* is fire, especially those that are too frequent or intense. Too frequent fires could kill the plants before they have had a chance to reproduce (DOE 2008). Climate change is predicted to lead to a significantly higher number of hot days (>35°C) in the Top End region, as well as more frequent and intense extreme weather events and possibly increased rainfall during the wet season. These conditions might in turn lead to higher fuel loads and more frequent and severe fires (Hyder Consulting 2008).

Other Threats/Potential New threats

Invasive and other problematic species

The invasive pasture grasses *Andropogon gayanus* (Gamba Grass) and *Cenchrus pedicellatus* (Annual Mission Grass) have been observed growing on sandstone could spread to the habitat of *A. equisetifolia* in the future. Significant populations of these invasive grasses would lead to the build-up of higher fuel loads and more severe wildfires (Woinarski and Winderlich 2014).

Current management

A monitoring plot was established in 2004 and re-sampled in 2005 and 2006 but there has been no subsequent monitoring. The species also receives consideration in the Stone Country fire management plan where the objective is to reduce fire frequency and patch size for the protection of the highly localised threatened species (Petty *et al.* 2007, cited in Woinarski and Winderlich 2014).

Knowledge gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood. The role of fire and other ecological processes in the distribution and abundance of the species are also unknown.

Suggested research and actions

1. Continue monitoring to assess of population size, distribution, fire ecology and the relative impacts of threatening processes (DoE 2008).
2. Survey for additional subpopulations (Woinarski and Winderlich 2014).
3. Determine key life history parameters such as age to maturity, longevity and seed survival should be determined to be able to help establish fire regime thresholds (Woinarski and Winderlich 2014).
4. The species is morphologically similar to *Acacia hippuroides* from the Kimberley region in Western Australia, and it has been suggested it might be possible treat *A. equisetifolia* as an infraspecific taxon within *A. hippuroides* (Maslin and Cowie 2014). While this could be investigated the listing status would probably not change.
5. Assessing population genetic structure would determine whether the two populations are genetically distinct and assist with making decisions regarding mixing seed and translocations of material.

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B.13 *Hibbertia brennanii*, *H. pancerea*, *H. tricornis* and *Hibbertia* sp. South Magela (K.G.Brennan 896) (Dilleniaceae) – four Guinea flowers, Kakadu National Park

Figure B13.1 *Hibbertia pancerea* Kakadu National Park. ©K Brennan.

- *Hibbertia brennanii* is a low spreading subshrub to 0.3 m. The branches are wiry, becoming stiffly woody when older.
- *Hibbertia pancerea* is a spreading shrub to 1.5 m with angular or ridged branches.
- *Hibbertia tricornis* is a more or less prostrate and little branched subshrub to 0.2 m high.
- These three species have one-flowered axillary inflorescences. The yellow petals are lobed and 3.6–4.2 mm long in *H. brennanii*, 4–5.6 mm long in *H. pancerea* and 7–8.9 mm long in *H. tricornis* (Toelken 2010).
- *Hibbertia* sp. South Magela is a pendulous multi-stemmed subshrub, with stems up to 0.5 m long. The flowers are bright yellow (Westaway and Cowie 2012d).

Taxonomy: The names *Hibbertia brennanii* Toelken, *H. pancerea* Toelken and *H. tricornis* Toelken are accepted in the Australian Plant Census (CHAH 2015, verified 23 September 2015).

- *Hibbertia brennanii* was formerly known under the phrase name *Hibbertia* sp. Stellate above (J.L.Egan 4812).
- *Hibbertia pancerea* was formerly known as *Hibbertia* sp. Fire Plot 121 (K.G.Brennan 3821).

Status: All four species are listed as Vulnerable under the Northern Territory TPWC Act (Woinarski and Winderlich 2014).

Recovery Plan: A recovery plan does not exist. Management prescriptions and research recommendations are included in the conservation strategy for threatened species and ecological communities in Kakadu National Park (Woinarski and Winderlich 2014).

Number of populations inside and outside parks and reserves

It is estimated that about 50% of *Hibbertia brennanii* populations, 90% of *Hibbertia* sp. South Magela and all *Hibbertia pancerea* and *H. tricornis* populations occur the national park (Cowie and Liddle 2014).

Population size – range

Hibbertia brennanii has an estimated extent of occurrence of 18 km² and a population size of >1000 mature individuals (K. Brennan pers. comm. 2010, cited in Westaway and Cowie 2012a). *Hibbertia pancerea* has an estimated extent of occurrence of 2 ha and an unknown but probably very small population size. The extent of occurrence and the population size of *Hibbertia tricornis* is unknown but presumed to be very small. *Hibbertia* sp. South Magela has an estimated extent of occurrence of 1 km² and a population size of <1000 mature individuals (Westaway and Cowie 2012a,b,c,d, Cowie and Liddle 2014).

Geographical distribution

All the species have a very localised distribution.

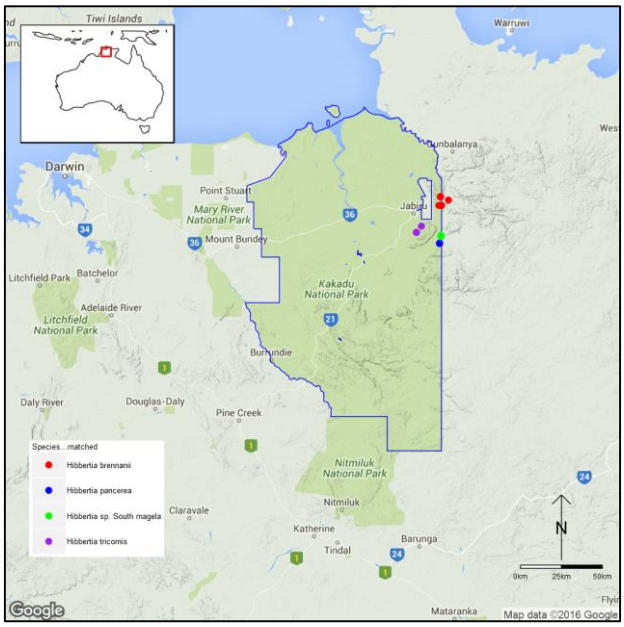

Figure 13.1 Distribution of *Hibbertia brennanii* (red), *H. pancerea* (blue), *H. tricornis* (purple) and *H.* sp. South Magela (green) in Kakadu National Park. Locations based on specimen records, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Seed of *H. brennanii* and *H.* sp. South Magela are held in the National Seed Bank and the other species have been identified as priority species for collection, propagation and experimental translocation (KNP TS Project 4, M. Goumas pers. comm. 6 August 2015). None of the species are conserved in Living Collection at the Australian National Botanic Gardens (M. Henery pers. comm. 5 November 2015). No other *ex-situ* collections within any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: The species are insect-pollinated, most likely by bees since many *Hibbertia* species are pollinated by large bees (>7-22 mm long) that use thoracic vibration to shake pollen out of the anthers; other species have loose pollen that is collected by smaller bees or eaten by hoverflies (syrphids, Tucker and Bernhardt 2000). *Hibbertia* species do not generally produce nectar, but the anthers can have a strong smell (Keighery 1975). The pollination syndrome of these species in unknown.

Symbiotic relationships: Unknown.

Germination requirements: Germination in the few *Hibbertia* species that have been studied indicates that some pre-treatment is required. Some species responded weakly to smoke treatment (Kingsley *et al.* 1995) while seed coat removal or scarification has led to higher germination which can be improved further by smoke treatment in some species (Roche *et al.* 1997, Allen *et al.* 2004). However, germination requirements apparently vary among species *Hibbertia*, even those growing in the same region (Hidayati *et al.* 2012).

Dormancy class: The seed of *Hibbertia* species seem to be dormant, probably at least partly due to physical dormancy (Roche *et al.* 1997).

Flowering: Many *Hibbertia* species flower opportunistically, so that flowering is sparse throughout the year whenever conditions are suitable. The main flowering times for these species are unknown and too few herbarium specimens exist to provide any information (Toelken 2010).

Breeding system: The flowers are bisexual. It is unknown if these species are able to reproduce vegetatively (Westaway and Cowie 2012a,b,c) but are reported to be obligate seeders (Cowie and Liddle 2014).

Dispersal: Three of these species have a fleshy aril attached to their seed (Toelken 2010), suggesting dispersal by ants. It seems likely that the fourth species, *Hibbertia* sp. South Magela, also has this feature but this is yet to be confirmed.

Longevity: Unknown.

Life form: Shrub.

Ploidy levels: There are different ploidy levels in the genus *Hibbertia*, and sometimes also within the same species. Known chromosome numbers are 2n=16,18,32,64 (Chromosome Counts Database, ccdb.tau.ac.il). Chromosome numbers are unavailable for these four *Hibbertia* species.

Role of the plant in the environment: All four species grow in different habitats in the sandstone shrubland complex (Toelken 2010, Cowie and Liddle 2014).

Threats

Listed Threats (Northern Territory TPWC Act)

- Restricted to an area of less than 20 km^2.
- Known from a single location (*H. brennanii*); fewer than five known locations (*H. pancerea*, *H. tricornis* and *H.* sp. South Magela).
- Threats from human activities and inappropriate fire regimes.

Genetic and demographic effects

The small or very small distribution areas and low numbers of individuals suggest that these species have low genetic diversity and may be vulnerable to inbreeding. A small population size and the limited geographical distribution also make these species vulnerable to further loss through stochastic events such as fires (Westaway and Cowie 2012a,b,c,d).

Other Threats/Potential New threats

Climate-related factors

Although these *Hibbertia* species partly grow in very rocky habitats where they may have some protection from fire (especially *Hibbertia* sp. South Magela, Westaway and Cowie 2012d), fire is the main threat to these species. Frequent, severe late dry season fires, could kill populations of obligate seeder species (Westaway and Cowie 2012a,b,c,d; Cowie and Liddle 2014) but the precise fire response of these *Hibbertia* species is unknown.

Climate change is predicted to lead to a significantly more hot days (> 35 C) in the Top End region of Australia, as well as more frequent and intense extreme weather events and possibly increased rainfall during the wet season. These conditions might in turn lead to more frequent and more severe fires (Hyder Consulting 2008).

Invasive and other problematic species

Generally, an invasion of the *Hibbertia* species habitat by exotic pasture grasses could lead to higher fuel loads and more severe or frequent fires (Cowie and Liddle 2014).

Current management

There is no specific management protocol in place for these species, but the four species are included broadly in the Stone Country fire management plan (Petty *et al.* 2007, cited in Woinarski and Winderlich 2014). *Hibbertia pancerea* occurs on one of the fire monitoring plots in Kakadu National Park that are monitored every five years (Westaway and Cowie 2012b). Therefore it is included in the fire plot monitoring program described in Edwards *et al.* (2003). Baseline monitoring has been performed for *Hibbertia* sp. South Magela (Cowie and Liddle 2014).

Knowledge gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood. It is also unclear what effects fire would have and how likely it is in the species' habitats.

Suggested research and actions

1. Continue or establish monitoring programs to data for determining population trajectories and the relative impacts of threatening processes.
2. Determine key life history parameters including age to maturity, longevity, survival of seed should be determined to be able to provide fire regime thresholds and improve species management.
3. Monitor fire and weeds in the vicinity of the populations.
4. Determine the appropriate conditions for long term storage and seed germination.

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B.14 *Hibiscus brennanii* (Malvaceae) – Brennan's Hibiscus, Kakadu National Park

Figure B14.1 *Hibiscus brennanii* Kakadu National Park. ©K Brennan.

Hibiscus brennanii is a shrub up to 3 m tall with grey-green hairy leaves and pink flowers (Kerrigan 2004).

Taxonomy: The name *Hibiscus brennanii* Craven and Fryxell is accepted in the Australian Plant Census (CHAH 2015, verified 13 July 2015).

Status: Listed as Vulnerable under the EPBC Act on 14 August 2006. Listed as Vulnerable under the Northern Territory *Territory Parks and Wildlife Conservation Act 2000* on the 2012 list.

Recovery Plan: Recovery Plan not required, included on the Not Commenced List (1 November 2009). Management prescriptions and research recommendations are included in the conservation strategy for threatened species and ecological communities in Kakadu National Park (Woinarski and Winderlich 2014).

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

The species is restricted to the Mt Brockman outlier of the western Arnhem Land sandstone massif (Kerrigan and Cowie 2006). Only one population is known and is located inside Kakadu National Park.

Population size – range

In 2003, the population size was estimated to be 432 individuals. In 2004, a further survey found an additional nine mature individuals and 87 seedlings along a transect of approximately 2 km. The extent of occurrence was estimated to be approximately 1.5 km² (Kerrigan 2004).

Geographical distribution

Hibiscus brennanii has a localised distribution.

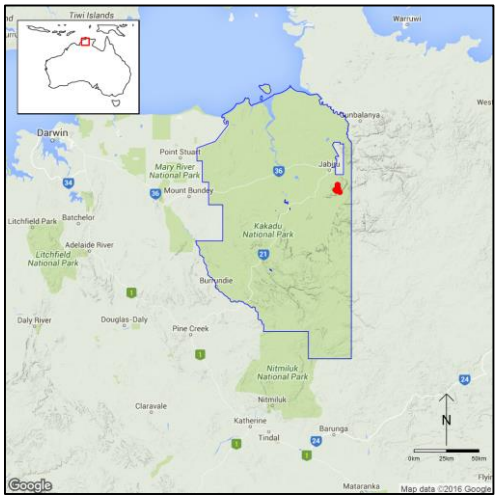

Figure B14.1 Distribution of Brennan's Hibiscus in Kakadu National Park. Red dots are specimen collections and the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species has been identified as a priority target for Seed Bank collection, propagation and experimental translocation (KNP TS Project 4, M. Goumas pers. comm. 6 August 2015). An accession of 9.82 g of seed was collected by ANBG staff and is held in the National Seed Bank. Further collection by ANBG staff is planned for April 2016 (Tom North pers. comm. 11 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Unknown, but observations in other *Hibiscus* species suggest that bees are a potential pollinator (Armstrong 1976).

Symbiotic relationships: Unknown.

Germination requirements: Unknown. The species seems to have a long-lived soil seed bank (Cowie and Liddle 2014). Seed of other *Hibiscus* species stored in the USDA NPGS collection had a germination rate of 66% or higher after nearly 40 years storage (Walters *et al.* 2005). Seed of *H. sturtii* need a fire-related cue to break dormancy (e.g. boiling water, potassium nitrate or 10% smoke water, Gamage *et al.* 2014).

Dormancy class: Orthodox.

Flowering: March–May (Kerrigan and Cowie 2006).

Breeding system: Probably only reproduces sexually (Craven and Fryxell 1993, Kerrigan and Cowie 2006).

Dispersal: Unknown.

Longevity: "short-lived perennial" (Kerrigan and Cowie 2006).

Life form: Shrub.

Ploidy levels: Unknown.

Role of the plant in the environment: *Hibiscus brennanii* grows on sandstone cliffs, in gullies and on broken sandstone pavement (Woinarski and Winderlich 2014).

Threats

Listed threats (EPBC Act)

- Restricted geographical distribution (area of occupancy and extent of occurrence).
- Inappropriate and/or changed fire regimes (frequency, timing, intensity).
- Low numbers of individuals.

Genetic and demographic effects

The small or very small distribution areas and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and the limited geographical distribution also make this species vulnerable to stochastic events (DoE 2008).

Climate-related factors

The main threat to *H. brennanii* is fire, especially if this is too frequent or intense. Too frequent fires could kill the plants before they have had a chance to reproduce (DoE 2008). Climate change is predicted to lead to significantly more hot days (> 35C) in the Top End region of Australia, as well as more frequent and intense extreme weather events and possibly increased rainfall during the wet season. These conditions might lead to more frequent and more severe fires (Hyder Consulting 2008).

Other Threats/Potential New threats

Invasive and other problematic species

The invasive pasture grasses *Andropogon gayanus* (Gamba Grass) and *Cenchrus pedicellatus* (Annual Mission Grass) have been observed growing on sandstone and could spread to the habitat of *H. brennanii* in the future. Significant populations of these invasive grasses would lead to the build-up of higher fuel loads and more severe wildfires (Woinarski and Winderlich 2014).

Current management

No monitoring is currently conducted. A baseline for monitoring was established by R. Kerrigan in 2003 and 2004, but there has been no subsequent resampling. There is no also targeted management of this species (M. Goumas pers. comm. 6 August 2015), however, it is broadly included in the Stone Country fire plan (Petty *et al.* 2007, cited in Woinarski and Winderlich 2014).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, breeding system, genetic diversity, seed dispersal, and time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Monitoring should be recommenced to phenology, reproductive success, response of seeds and adults to fire, and time to reach maturity (Kerrigan and Cowie 2006).
2. Determine seed longevity, conditions required for recruitment, life history parameters to help develop optimum fire free periods (Cowie and Liddle 2014).
3. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding and if any genetic structure exists to assist with any future translocation program.

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B.15 *Jacksonia divisa* (Fabaceae) – Kakadu National Park

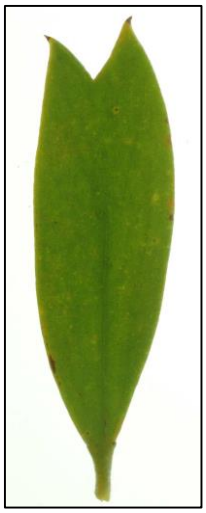

Figure B15.1 *Jacksonia divisa* cladode Kakadu National Park. ©K Brennan.

Jacksonia divisa is a shrub up to 3 m high with yellow flowers and pods that are around 9 mm long (O'Dea 2014). The leaves are reduced and inconspicuous but the plant has grey-green phyllodes with a bifid or trifid apex (Cowie and Westaway 2012).

Taxonomy: The name *Jacksonia divisa* Chappill is accepted in the Australian Plant Census (CHAH, 2015, verified 22 September 2015). The species was formerly known under the phrase name *Jacksonia* sp. Bloomfield Springs (K.Menkhorst 349) (Chappill *et al.* 2007).

Status: Listed as Vulnerable under the Northern Territory *Territory Parks and Wildlife Conservation Act 2000* (Woinarski and Winderlich 2014).

Recovery Plan: A recovery plan does not exist. Management prescriptions and research recommendations are included in the conservation strategy for threatened species and ecological communities in Kakadu National Park (Woinarski and Winderlich 2014).

Number of populations inside and outside parks and reserves

The species is known from one general location along the edges of a gorge on the western margin of the Marrawal Plateau near Bloomfield Springs (Cowie and Westaway 2012) where it occurs at two sites (K. Brennan, cited in Cowie and Westaway 2012). The whole population is located within Kakadu National Park (Cowie and Westaway 2012).

Population size – range

Jacksonia divisa has a very small extent of occurrence of about 2 km² and limited available habitat suggesting that the area of occupancy is probably much smaller than this. Seemingly very similar habitat to the south at Douglas Springs and to the east at Kekwick Springs is not occupied by *J. divisa*. Additional subpopulations might exist but none were not located in an intensive survey of adjoining Nitmiluk National Park (Cowie and Westaway 2012). One site is recorded as having "probably only hundreds of individuals" (K. Brennan cited in Cowie and Westaway 2012) and the total number of mature individuals is estimated to be <1000 (Cowie and Westaway 2012). Population trends in recent years are unknown (Woinarski and Winderlich 2014).

Geographical distribution

The species has a localised distribution.

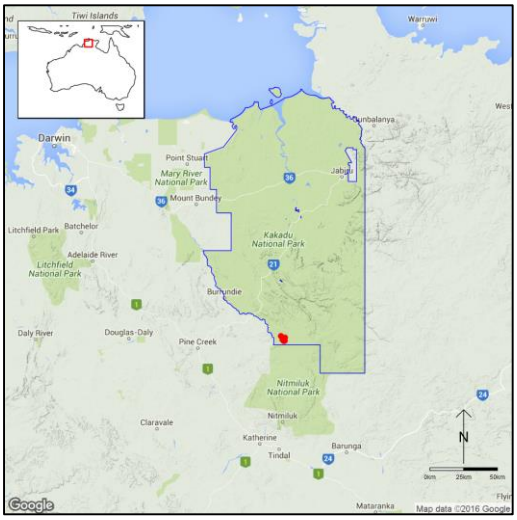

Figure B21.1 Distribution of *Jacksonia divisa* in Kakadu National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (M. Henery, pers. comm. 5 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Probably insect-pollinated.

Symbiotic relationships: Legume nodules as well as ectomycorrhiza and vesicular-arbuscular mycorrhiza were observed in the related species *J. dilatata* collected from the Kakadu area (Reddell and Milnes 1992). Legume nodules are present in most Fabaceae and therefore probably also in *J. divisa*.

Germination requirements: *Jacksonia* species are commonly propagated from seed. After the seed coat has been removed to allow water absorption, seed germinate readily (Evans and English 1999).

Dormancy class: Some *Jacksonia* species probably have long-lived soil seed banks and can show mass recruitment following fire (Cowie and Liddle 2014).

Flowering: Flowering and fruiting occurs from April–June (Chappill *et al.* 2007).

Breeding system: The species is considered to be an obligate seeder (Cowie and Westaway 2012).

Dispersal: Unknown.

Longevity: Unknown.

Life form: Shrub.

Ploidy levels: To date, all species counted in the genus had 2n=18 (Chappill *et al.* 2007, Chromosome Counts Database http://ccdb.tau.ac.il/) but no counts are available for *J. divisa*.

Role of the plant in the environment: This species grows in shrubland on sandy kaolinite clay (Cowie and Westaway, 2012).

Threats

Listed Threats (Northern Territory *Territory Parks and Wildlife Conservation Act*)

- Number of mature individuals <1000.
- Restricted to a very small area (<2 km2) with fewer than five locations.
- A plausible threat from inappropriate fire regimes that could drive the taxon to Critically Endangered or Extinct in a very short time period.

Genetic and demographic effects

The small or very small distribution areas and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and the limited geographical distribution also make these species vulnerable to further loss through stochastic events such as fires (Cowie and Westaway 2012).

Climate-related factors

Because the species probably is an obligate seeder, too frequent fires might kill the plants before these can set seed, threatening species persistence (Cowie and Westaway 2012). Severe effects of fire have been observed in one location (K. Brennan, cited in Cowie and Westaway 2012). Climate change is predicted to lead to a significantly higher number of hot days (> 35 C) in the Top End region of Australia as well as more frequent and intense extreme weather events and possibly increased rainfall during the wet season. These conditions might in turn lead to more frequent and more severe fires (Hyder Consulting 2008).

Other Threats/Potential New threats

Invasive and other problematic species

Invasive pasture grasses could spread into the habitat of *J. divisa* in the future and lead to more severe and frequent fires if these become more prevalent (Woinarski and Winderlich 2014).

Current management

A specific management protocol for this species does not exist but it is included broadly in the Stone Country fire management plan (Petty *et al.* 2007, cited in Woinarski and Winderlich 2014).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood. The species is considered an obligate seeder (Cowie and Liddle 2014), but fire response has not been studied to verify that the species does not resprout after fire.

Suggested research and actions

1. Monitoring should continue to provide ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Key life history parameters including age to maturity, longevity, survival of seed should be determined to be able to provide fire regime thresholds and to improve species management.
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.
5. Evaluate the need to establish 'insurance' populations off-park.

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B.16 *Lithomyrtus linariifolia* (Myrtaceae) – Kakadu National Park

Figure B16.1 *Lithomyrtus linariifolia* Kakadu National Park. ©K Brennan.

Lithomyrtus linariifolia is a subshrub or small shrub, usually low spreading and sprawling over sandstone boulders and rubble, 10–20 cm tall. Rarely, erect plants up to 1 m tall can be found (Kerrigan and Cowie 2006). The species has stringy, brown to orangish bark. The leaves are opposite, linear and coriaceous, about 10–51 x 1–3 mm. The pink petals are 5–7 mm long. The fruit is fusiform, 8.5–11 mm long and 3.5–4 mm wide, glabrescent and yellow-green to olive-green (Snow and Guymer 1999).

Taxonomy: The name *Lithomyrtus linariifolia* N.Snow and Guymer is accepted in the Australian Plant Census (CHAH 2015, verified 8 October 2015).

Status: Listed as Vulnerable under the Northern Territory *Territory Parks and Wildlife Conservation Act 2000* (Woinarski and Winderlich 2014).

Recovery Plan: A recovery plan does not exist. Management prescriptions and research recommendations are included in the conservation strategy for threatened species and ecological communities in Kakadu National Park (Woinarski and Winderlich 2014).

Number of populations inside and outside parks and reserves

Lithomyrtus linariifolia is known from 14 locations, however, some of these are very close together and may not represent different populations. The species occurs mostly in Kakadu National Park but is also found in Arnhem Land and Nitmiluk National Park (Kerrigan

2004). According to the spatial data available from Herbarium collections, approximately two thirds of the known locations have been collected from within Kakadu National Park.

Population size – range

In 2002, *Lithomyrtus linariifolia* was known from only seven collections in five localities but surveys in 2003 identified 132 mature individuals from ten localities. Surveys in 2004 identified >200 mature plants from 14 locations. The extent of occurrence was estimated to be 3411 km² at that time (Kerrigan 2004).

Geographical distribution

The species has a regional, fragmented distribution.

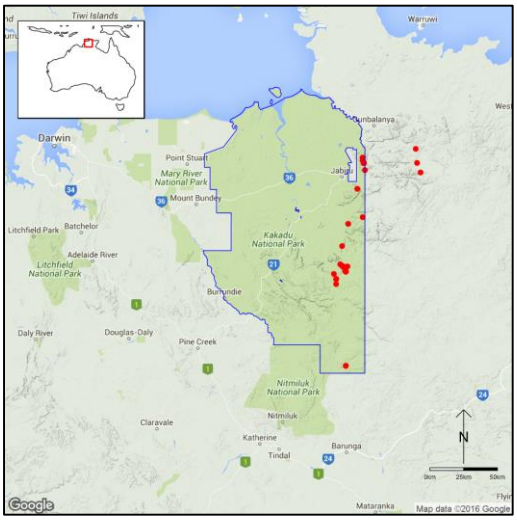

Figure B22.1 Distribution of *Lithomyrtus linariifolia* in Kakadu National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (M. Henery, pers. comm. 5 November 2016). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Probably insect-pollinated.

Symbiotic relationships: Unknown.

Germination requirements: Unknown and attempts to germinate seven other *Lithomyrtus* species were unsuccessful (Snow and Guymer 1999).

Dormancy class: The fruits are fleshy and the seed might be short-lived (Cowie and Liddle 2014). The seed coats are hard but have openings possibly for the radicle to grow through (Snow and Guymer 1999).

Flowering: March-April with fruiting specimens known from April (Snow and Guymer 1999).

Breeding system: Bisexual flowers.

Dispersal: Unknown.

Longevity: Unknown.

Life form: Subshrub or small shrub.

Ploidy levels: Unknown.

Role of the plant in the environment: *Lithomyrtus linariifolia* grows on sandy or skeletal soils in heaths or eucalypt woodlands of sandstone escarpments (Snow and Guymer 1999). It is often found along margins of *Allosyncarpia ternata* (An-binik, Myrtaceae) stands and mostly growing amongst *Triodia microstachya* (Poaceae, Kerrigan 2004).

Threats

Listed Threats (NT TPWC Act)

- Small population size estimated at <1000 mature individuals (listed as Vulnerable on this basis by Snow and Guymer 1999)

Genetic and demographic effects

Lithomyrtus linariifolia seems to be relatively widespread but uncommon. The small population sizes suggest that this species has low genetic diversity and may be vulnerable to inbreeding. The relatively low population size also make the species vulnerable to further loss through stochastic effects.

Other Threats/Potential New threats

Climate-related factors

Lithomyrtus linariifolia is probably a fire-sensitive plant as it is only found in unburnt and fire protected locations among sandstone boulders and outcrops (A. Gibbons and I. Cowie pers. obs. cited in Kerrigan and Cowie 2006). It also seems to be an obligate seeder. Fire is therefore assumed to be a threat (Kerrigan and Cowie 2006). Climate change is predicted to lead to a significantly more hot days (> 35C) in the Top End region of Australia as well as more frequent and intense extreme weather events and possibly higher rainfall during the wet season. These conditions might lead to more frequent and more severe fires (Hyder Consulting 2008).

Invasive and other problematic species

Seed predation may be an issue since Snow and Guymer (1999) state that ripe *Lithomyrtus* fruit are often attacked by insects.

As with other fire-sensitive species growing in the stone country of Kakadu National Park, the risk of severe or frequent fires would become higher if invasive pasture grasses spread to this habitat in the future (Cowie and Liddle 2014).

Current management

A specific management protocol for this species does not exist but it is included broadly in the Stone Country fire management plan (Petty *et al.* 2007, cited in Woinarski and Winderlich 2014).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood. Fire sensitivity is also largely unknown.

Suggested research and actions:

1. The importance of fire in shaping the species' distribution area should be studied (Kerrigan and Cowie 2006).
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Determine key life history parameters including age to maturity, longevity, survival of seed to improve species management.
4. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
5. Determine the appropriate conditions for long term storage and seed germination.
6. Assess the impact of seed predation since Snow and Guymer (1999) state that ripe *Lithomyrtus* fruit are often attacked by insects.
7. Survey suitable habitat for new populations.
8. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding and if any genetic structure exists to assist with any future translocation program.
9. Evaluate the need to establish 'insurance' populations off-park.

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B.17 *Abutilon julianae* (Malvaceae) – Norfolk Island Abutilon, Norfolk Island National Park

Figure B17.1 *Abutilon julianae* in the Norfolk Island Botanic Gardens.
©M. Fagg Australian National Botanic Gardens Photo No ni.86.

Abutilon julianae is a subshrub up to 1 m tall. The leaves are heart-shaped and hairy below. The solitary flowers are yellow (DNP, 2010).

Taxonomy: The name *Abutilon julianae* Endl. is accepted in the Australian Plant Census (CHAH 2015, verified 24 July 2015).

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010)

Information in this fact sheet is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Both populations (Norfolk Island and Phillip Island) occur within the Norfolk Island National Park.

Population size – range

In 1988, there were three main patches on Phillip Island, one of approximately 100 plants, one of 18 and one with approximately 10 plants (Sykes and Atkinson 1988). In 2003, the total number of mature individuals was estimated to be less than 50 (TSSC 2003). The population on Phillip Island is increasing since the eradication of rabbits. The population on Norfolk Island was temporarily extinct,

but plants from Phillip Island have been used in rehabilitation programs (DNP 2010). On Phillip Island, the species has been planted in several locations and occurs in several main areas of the island (Mills 2009).

Geographical distribution

The species has a localised and fragmented distribution.

Figure B17.2 Distribution of *Abutilon julianae* in the Norfolk Island National Park. Red dots are specimen collections, blue line is park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Garden or in the National Seed Bank (Z. Knapp pers. comm. 30 September 2015), however, it is planted in the Norfolk Island Botanic Garden (Mills 2009) but it is unclear whether this is from cuttings or seed. One seed collection from cultivated individuals by ANBG staff is stored on Norfolk Island (T. North pers. comm. 11 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Unknown.

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Probably orthodox

Flowering: The species flowers and sets seed annually (Lydia Guja pers. comm. 10 September 2015). Flowering has been observed from September-March and fruiting from October-March (Mills 2007).

Breeding system: Unknown. Bisexual flowers, not showy.

Dispersal: Unknown.

Longevity: Perennial.

Life form: Low, spreading subshrub, to about 1 m tall and 5 m wide (Mills 2009).

Ploidy levels: *Abutilon julianae* is probably an octoploid since most *Abutilon* species seem to be based on x=7 and the chromosome number of *A. julianae* was counted as 2n=56 (de Lange and Murray 2003).

Role of the plant in the environment: *Abutilon julianae* grows in open vegetation among grasses. The species has been used in rehabilitation work on Norfolk Island (DNP 2010).

Threats

Listed threats (EPBC Act)

- Competition and/or habitat degradation by weeds.
- Low numbers of individuals (TSSC 2003).

Invasive and other problematic species

Competition by weeds is a major threat to *A. julianae* (DNP 2010). A moth species identified on Phillip Island feeds on a range of plants from the Malvaceae family (DNP 2010) but it is unknown whether this species is also a threat to *A. julianae*. Future introductions of weeds, competitors or pathogens are a potential problem to the flora of NINP in general (DNP 2008).

Other Threats/Potential New threats

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. Propagation by cuttings may increase inbreeding if limited clonal diversity is used. A small population size and limited geographical distribution also make these species vulnerable to further loss through stochastic events such as cyclones.

Soil degradation

Grazing by feral animals removed almost all the vegetation on Phillip Island and as a result lost most of its topsoil through erosion, this reduced the ability of Norfolk Island Abutilon to colonise the island.

Climate-related factors

The lack of vegetation and severe erosion on Phillip Island makes this island more vulnerable to the impacts of heavy rain. Climate change is predicted to increase the frequency and intensity of storms, which might lead to further erosion on Phillip Island (Hyder Consulting 2008).

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

The species has been extensively planted on Norfolk Island in the national park in open areas and the population is now increasing with active management and use of this species in rehabilitation works (M. Goumas pers. comm. 6 August 2015) although no monitoring program of this species is in place (Joel Christian pers. comm. 4 August 2015). Mills (2009) indicates that the species is successfully regenerating naturally on Phillip Island, so further planting is not a priority. Weed management is also conducted in the national park.

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Genetic assessment of levels of genetic diversity and inbreeding in natural and planted populations to ensure that planted populations contain sufficient genetic diversity to become self-sustaining over time and that inbreeding populations have not been created.
2. Endeavour to secure additional seed collections off-island to reduce the risk of stochastic loss of the NINP seed collections (e.g. destruction by a tropical cyclone).
3. Develop and implement a restoration program to increase population numbers and/or sizes.
4. Evaluate the need to establish 'insurance' populations off-park.

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B.18 *Anthosachne multiflora* subsp. *kingiana* (Poaceae) – Phillip Island Wheat Grass, Norfolk Island National Park

This is a short lived, tufted perennial grass, 30–100 cm tall with a low, spreading habit and narrow glaucous (waxy) leaves 3–5 mm wide.

Taxonomy: Conventionally accepted as *Anthosachne multiflora* subsp. *kingiana* (Endl.) Barkworth and S.W.L. Jacobs (CHAH 2015, verified 22 July 2015).

- Synonyms:
  Anthosachne kingiana (Endl.) Govaerts subsp. *kingiana* (EPBC listing page uses this name 22 July 2015)
  Elymus multiflorus subsp. *kingianus* (Endl.) de Lange and R.O.Gardner (EPBC listed under this name)

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003 as *Elymus multiflorus* var. *kingianus* (listed name updated 15 December 2008 to *Elymus multiflorus* subsp. *kingianus*). Listed as Critically Endangered under the NSW *Threatened Species Conservation Act 1995* in October 2015 as *Elymus multiflorus* subsp. *kingianus*.

Recovery Plans: Norfolk Island Region Threatened Species Recovery Plan, 2010.

Lord Howe Island Biodiversity Management Plan, 2007.

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

In 2003 there were <50 individuals of Phillip Island Wheat Grass growing on Phillip Island. It is thought to have been confined to Phillip Island in the Norfolk group where it was believed to have become extinct due to grazing by rabbits, goats and pigs. Following removal of these feral animals Phillip Island Wheat Grass was able to recolonise the area and was rediscovered on Phillip Island in

1987 where it grows on north-facing slopes in higher areas in a herb community dominated by pigface (*Carpobrotus glaucescens*, DNP 2010). The species is presumed to have survived on the steep cliffs around the island which were inaccessible to grazing animals. A specimen of Phillip Island Wheat Grass was discovered on Norfolk Island in 1963 but current occurrences on Norfolk Island are possibly due to propagation and translocation of specimens from Phillip Island.

This sub-species also occurs on Lord Howe Island where the population is also extremely small and is estimated to be <50 mature plants (Auld *et al.* 2011). At the species-level this plant is also found in New Zealand (de Lange *et al.* 2005) and coastal eastern Australia (Auld *et al.* 2011). On Lord Howe Island the subspecies occurs between exposed basalt-derived cliffs and upslope littoral rainforest and is often found growing with *Melaleuca howeana*, *Poa poiformis*, Bully Bush (*Cassinia tenuifolia*), Sand Couch (*Sporobolus virginicus*), Sticky Hop-bush (*Dodonaea viscosa*), *Melanthera biflora* and Coast Beard Heath (*Leucopogon parviflorus*).

Population size – range

On Phillip Island this species was found in several small patches on the upper part of the island in 1988. In 2003 it was reported that there were <50 mature individuals but no indication of their range was provided. In 2009 two populations were found, one on a cliff edge on the southern side of Stony Valley and one above 'the dykes' (Director of National Parks 2010). Only a few plants were found in each location (Mills 2009). Information on the species from Lord Howe Island suggests that plant numbers can rapidly change from year to year (Auld *et al.* 2011).

Geographical distribution

Localised on Phillip Island and Lord Howe Island.

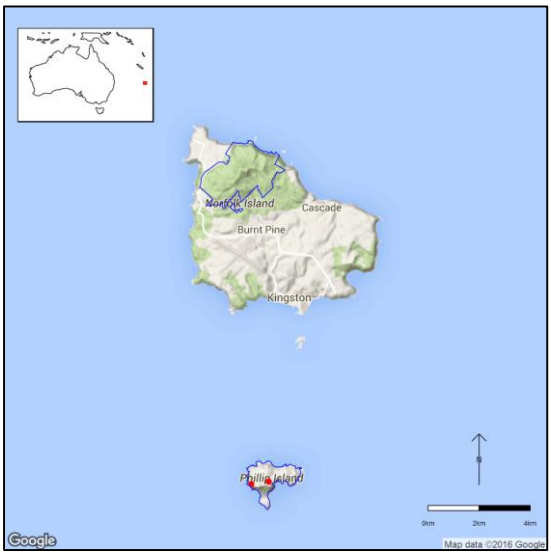

Figure B18.1 Distribution of Phillip Island Wheat Grass in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Zoe Knapp pers. comm. 12 October 2015 and Tom North pers. comm. 11 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Likely to be wind-pollinated like most grasses.

Symbiotic relationships: Unknown.

Germination requirements: Unknown but seed dormancy as well as water and temperature impacts on germination have been observed in a related species, *Anthosachne scabra* (Auld *et al.* 2011).

Dormancy class: Possibly dormant based on data from a related species *Anthosachne scabra* (Auld *et al.* 2011).

Flowering: Unknown.

Breeding system: Unknown but It is unlikely to clonal based on related species *Anthosachne scabra* from Lord Howe Island (Auld *et al.* 2011).

Dispersal: The long awns suggest that the seed are adhesive and are dispersed by vertebrates. Auld *et al.* (2011) also note that there are no mammals on Lord Howe Island except for a bat, so the ability of this species to move to potential habitat around its current locations is unknown.

Longevity: Perennial but likely to be short-lived (Auld *et al.* 2011).

Life form: Grass.

Ploidy levels: Unknown.

Role of this plant in the environment: Unknown.

Threats

Listed Threats (EPBC Act)

- Grazing pressures and associated habitat changes.
- Competition and/or habitat degradation by weeds (e.g. Kikuyu and Buffalo Grass).
- Low numbers of individuals.

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also make these species vulnerable to further loss through stochastic events.

Invasive and other problematic species

In the past this species was threatened by grazing of feral rabbits, goats and pigs but these have been removed from Philip Island. However, erosion due to loss of vegetation from over-grazing has reduced opportunities for this species to recolonise.

Other Threats/Potential New threats

Climate-related factors

The lack of vegetation and severe erosion on Phillip Island makes this island more vulnerable to the impacts of heavy rain. Climate change is predicted to increase the frequency and intensity of storms, which might lead to further erosion on Phillip Island (Hyder Consulting 2008).

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current Management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Monitoring in late spring (DNP 2010) to provide ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Determine key life history parameters including pollination syndrome, symbiotic relationships, flowering, breeding system, maturity and longevity to improve species management.
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.
5. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding and if any genetic structure exists in association with populations from Lord Howe Island and New Zealand to determine whether the regions to assist with any future translocation program.
6. Evaluate the need to establish 'insurance' populations off-park.

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B.19 *Boehmeria australis* subsp. *australis* (Urticaceae) – Tree Nettle/ Nettletree, Norfolk Island National Park

Figure B19.1 *Boehmeria australis* subsp. *australis* in the Norfolk Island National Park.
©M. Fagg Australian National Botanic Garden Photo No. ni. 94.

It is a large spreading shrub or tree to 5 m tall. The sandpapery textured leaves (8–12 cm long) have a serrated margin with prominent veins and a silvery or pale grey underside. The species is monoecious but with male and female flower separate but found on the same tree). Tree Nettle flowers from September–January and fruits from March–April. It is a rapidly growing species with a short life span. Tree Nettle is similar to the closely-related sub-species, *Boehmeria australis* subsp. *dealbata*, which occurs on the Kermadec Islands (New Zealand) (DNP 2010, Coyne 2011 and DoE 2015, DNP Brochure).

Taxonomy: Conventionally accepted as *Boehmeria australis* Endl. subsp. *australis* (CHAH 2015, verified 22 July 2015).

- Synonyms: *Boehmeria australis* Endl. var. *australis. Procris splendens* Lindl.

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003

Recovery Plan: Norfolk Island Threatened Species Recovery Plan, 2010

This Information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

In 2003 there were 33 mature individuals, the majority of the population is located within the Norfolk Island National Park.

Population size – range

In 2003 there were only 33 mature plants surviving in the wild, with a few healthy trees occurring in the northeast corner of the national park (DNP 2010).

Geographical distribution

This species is endemic to Norfolk Island.

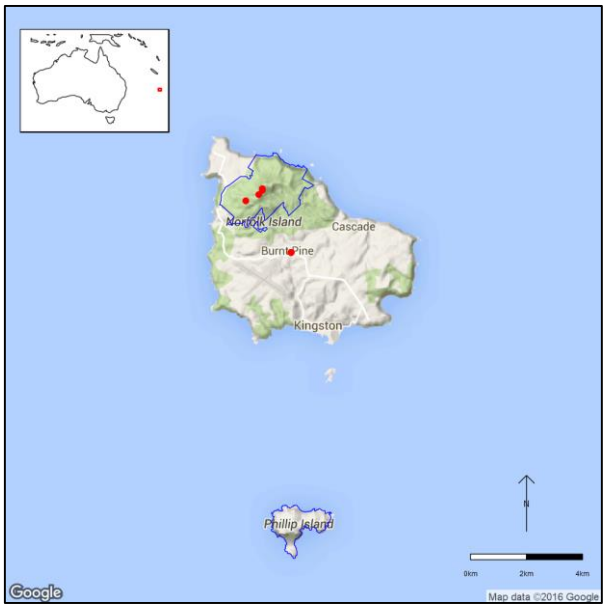

Figure 19.2 Distribution of *Boehmeria australis* subsp. *australis* in Norfolk Island National Park. Red dots are specimen collections and the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank, however, one seed collection is stored on Norfolk Island (Zoe Knapp pers. comm. 12 October 2015 and Tom North pers. comm. 11 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Most likely bees and insects (Cassandra Jones pers. comm. 6 November 2015).

Symbiotic relationships: Unknown.

Germination requirements: It can be propagated from seed (DNP 2010) this has been done with fresh mature seed. Cuttings have not been tried (Cassandra Jones pers. comm. 6 November 2015).

Dormancy class: Unknown.

Flowering: Observed in September–January, March–April and in June. Fruit was observed December–January and March–April. (Mills 2007).

Breeding system: Unknown.

Dispersal: Most likely to be by wind (Cassandra Jones pers. comm. 6 November 2015)

Longevity: Perennial.

Life form: Large spreading shrub or small tree.

Ploidy Levels: The chromosome number of another subspecies, *B. australis* subsp. *dealbata*, was counted as 2n=28 (CCDB). This seems to be the diploid chromosome number in the genus. In other *Boehmeria* species triploids, tetraploids and pentaploids have been recorded (i.e. 2n=28, 42, 56, 70).

Role of the plant in the environment: Colonises open sites but is now being replaced by introduced colonising species.

Threats

Listed Threats (EPBC Act)

- Grazing pressures and associated habitat changes.
- Invasive non-native/ alien species: competition and/or habitat degradation by weeds such as Lantana, wild tobacco tree, mist-flower.
- Low numbers of individuals.

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also make these species vulnerable to further loss through stochastic events.

Invasive and other problematic species

Threatened by weeds which colonise open sites rapidly, competing for its habitat. It is highly palatable to stock and especially susceptible to insect attack. The species is adapted to colonising open sites where the ground has been bared. (DNP 2010)

Other Threats/Potential New threats

Climate-related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Pests and diseases

Cultivated plants all seem to be susceptible to insect plaque which appears as lumps on the leaves. This is currently being investigated by Australian Quarantine staff (Cassandra Jones pers. comm. 6 November 2015).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. The Norfolk Island Recovery Plan suggests that this species should be propagated and planted as part of the rehabilitation and weed control program where it can be used as a colonising species (DNP 2010).
3. Determine key life history parameters including pollination, breeding system, maturity and longevity to assist with species management.
4. Determine seed germination and long term storage requirements.
5. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
6. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding to assist with any future translocation program.
7. Investigate the impacts of pathogens observed on cultivated trees.
8. Develop and implement a restoration program to increase population numbers and/or sizes.
9. Evaluate the need to establish 'insurance' populations off-park.

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B.20 *Calystegia affinis* (Convolvulaceae) – Norfolk Island National Park

Figure 20.1 *Calystegia affinis* at Mount Pitt, Norfolk Island. (left, ©G. Butler Australian National Botanic Gardens Photo No. ni.9) and *Calystegia affinis* Norfolk Island (right, ©C. Jones).

Calystegia affinis has thin climbing or creeping stems with sagittate (arrow-shaped) leaves and solitary flowers. The white corolla is shortly funnel-shaped but pink with five creamy longitudinal bands on Lord Howe Island (Flora of Australia 1994, DoE 2015).

Taxonomy: The name *Calystegia affinis* Endl. is accepted in the Australian Plant Census (CHAH 2015, verified 14 July 2015).

Plants from Lord Howe Island, at least those found at Old Settlement, differ from those found on Norfolk Island in several morphological characters suggesting that two subspecies may be present (Flora of Australia 1994, NSW Scientific Committee 2007). The species may also be of hybrid origin with *C. soldanella* and *C. marginata* as parental species (Papadopulos *et al.* 2011). Hybridisation is known to occur between *Calystegia* species (Ushimaru and Kikuzawa 1999).

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003. Listed as Critically Endangered in New South Wales under the *Threatened Species Conservation Act 1995* on 16 November 2012.

Recovery Plans:

- Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).
- Lord Howe Island Biodiversity Management Plan (DECC 2007).

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

An unknown number of populations occur on Norfolk Island but all known locations appear to be within the national park. Older specimens have been collected more broadly across the island.

Population size – range

In 2003, the total population was estimated to be about 45 mature individuals (TSSC 2003). On Norfolk Island, 95% of the plants are found in the open higher parts of Mt Pitt and Mt Bates.

Geographical distribution

The species is endemic to Norfolk Island and Lord Howe Island and has a fragmented distribution.

Figure 20.2 Distribution of *Calystegia affinis* in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank but seed has been collected by the ANBG and is stored on Norfolk Island (Collection No. TGN036, M. Goumas pers. comm. on 6 August 2015, T. North pers. comm. 11 September 2015, Z. Knapp pers. comm. 30 September 2015). A Living specimen is held by the Royal Botanic Gardens and Domain Trust (http://asbp.ala.org.au/occurrence/5901e3f5-0f7d-4df0-9d3e-9a141fa7e1ea). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Probably insect-pollinated as other *Calystegia* species are primarily visited by different bee species (Ushimaru and Kikuzawa, 1999).

Symbiotic relationships: Unknown.

Germination requirements: Seed should be set out in shady areas but plants need light to grow (DNP 2010).

Dormancy class: Orthodox. Apparently forms a soil seed bank (DNP 2010).

Flowering: Flowering has been observed in September, October and December and fruit in December (Mills 2007).

Breeding system: Bisexual flowers (NSW Scientific Committee 2002). Some *Calystegia* species are largely self-incompatible (Ushimaru and Kikuzawa 1999). *Calystegia affinis* is likely to reproduce clonally, since it is sprawling and can root at the nodes. Seed set and germination have been observed on Lord Howe Island (NSW Scientific Committee 2007 and references therein).

Dispersal: Seed of some *Calystegia* species (e.g. *C. soldanella*) can float on water while other are considered to be gravity dispersed (Ushimaru and Kikuzawa 1999).

Longevity: Unknown.

Life form: Climbing or creeping vine.

Ploidy levels: The chromosome number of this species is unknown but there is no indication for polyploidy in the genus from the chromosome numbers available (CCDB accessed September 2015).

Role of the plant in the environment: The species is mostly found in the higher parts of mountain tops (DNP 2010), where it occurs in rather open areas (Sykes and Atkinson 1988 cited in DECC 2007).

Threats

Listed Threats (EPBC Act)

- Habitat loss, modification and/or degradation.
- Restricted geographical distribution.
- Competition and/or habitat degradation by weeds.
- Low numbers of individuals.

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also make these species vulnerable to further loss through stochastic events such as cyclones.

Invasive and other problematic species

The main threat on Norfolk Island is competition from invasive weeds. Currently, Cairo Morning Glory (*Ipomoea cairica*) and Blue Morning Glory (*Ipomoea indica*, Convolvulaceae) are the most problematic weeds competing with *C. affinis* (C. Jones pers. comm. 05/11/2015). Weeds are also a major problem on Lord Howe Island (DECC 2007) where Kikuyu grass (*Pennisetum clandestinum*, Poaceae) and Crofton weed (*Ageratina adenophora*, Asteraceae) are the major threats although Buffalo grass (*Stenotaphrum secundatum*, Poaceae) is also invading *C. affinis* habitat (Hutton *et al.* 2008). Habitat clearance is also a threat but unlikely to occur within the national park (DNP 2010).

On Lord Howe Island the introduced beetle *Arsipoda parvula* feeds on *Calystegia affinis* and may be affecting flower and seed production (DECC 2007). Rodents (especially rats) also consume seed and inhibit reproduction (OEH 2014); rats also occur on Norfolk Island and could impact this species. Future introductions of pathogens, weeds or predators also present a risk on Lord Howe Island (OEH 2014) which also holds true for Norfolk Island.

Other Threats/Potential New threats

Climate-related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

The prediction of increased frequency and intensity of storms, which has been recognised as a threat for this species on Lord Howe Island through damage or loss of plants is also likely to apply on Norfolk Island (OEH, 2014).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Develop and implement a restoration program to increase population numbers and/or sizes.
3. Determine key life history parameters including pollination, flowering, breeding system, maturity and longevity to assist with species management.
4. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
5. Determine the appropriate conditions for long term storage and seed germination.
6. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding to assist with any future translocation program.
7. Determine genetic relationships between the populations on Norfolk and Lord Howe Islands to assist with translocation programs should a catastrophic event occur on either island.
8. Develop and implement a restoration program to increase population numbers and/or sizes.
9. Evaluate the need to establish ‘insurance’ populations off-park.

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B.21 *Clematis dubia* (Ranunculaceae) – Clematis, Norfolk Island National Park

Figure B21.1 *Clematis dubia* on Norfolk Island. ©G. Sattler Australian National Botanic Gardens Photo No. ni.149.

Clematis dubia is a woody climber with simple or more rarely trifoliate glabrous leaves. The flowers are white and hairy (DNP 2010).

Taxonomy: The name *Clematis dubia* (Endl.) P.S.Green is accepted in the Australian Plant Census (CHAH 2015, verified 14 July 2015).

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

The species was once common in the area of Mt Pitt and Mt Bates. The Norfolk Island Threatened Species Recovery Plan states that all locations are within the National Park but also records the species in an area called "North of Cascade" outside of NINP (DNP 2010).

Population size – range

Clematis dubia grows in small, isolated subpopulations. In 2003, there were about 15 mature plants (TSSC 2003). Flora of Australia (1994) states that the species was formerly widespread.

Geographical distribution

Localised and fragmented distribution.

Figure B21.2 Distribution of *Clematis dubia* in Norfolk Island National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Z. Knapp pers. comm. 30 September 2015. No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Probably insect-pollinated.

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Possibly orthodox. Seed viability is apparently very variable (L. Guja pers. comm. 10 September 2015).

Flowering: Unknown. Flowering plant specimens in the Australian national herbarium have been collected in April, May and June (four specimens in total) and a fruiting plant has been collected in July.

Breeding system: The inflorescences of *C. dubia* are unisexual (Flora of Australia 1994). The species can be grown from cuttings (DNP 2010).

Dispersal: *Clematis dubia* rarely sets seed (every 4–5 years, DNP 2010). The small achenes (seed) are probably dispersed by wind.

Longevity: Unknown.

Life form: Climbing vine.

Ploidy levels: Unknown.

Role of the plant in the environment: *Clematis dubi*a grows in light gaps, on forest margins and in clearings (DNP 2010).

Threats

Listed Threats (EPBC Act)

- Competition and/or habitat degradation by weeds.
- Low numbers of individuals.

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also make these species vulnerable to further loss through stochastic events such as cyclones.

Invasive and other problematic species

Competition by weeds is a major threat to *Clematis dubia* (DNP 2010).

Other Threats/Potential New threats

Climate-related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Biophysical impacts

The soil around Mt Pitt is prone to landslip after heavy rain (Hyder Consulting 2008).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring to assess population size, distribution, and the relative impacts of threatening processes.
2. Improved weed control where possible.
3. Determine key life history parameters including age to maturity, longevity, survival of seed should be determined to be able to establish population thresholds and natural demographic cycles.
4. Determine seed germination and long term storage requirements.
5. Secure seed collections both on NINP and at the ANBG or a suitable second Seed Bank to mitigate against the loss of populations in the wild and/or destruction of the NINP Seed Bank.
6. Determine reproductive strategy to determine if inbreeding is an issue and contributes to low seed set.
7. Develop and implement a restoration program to increase population numbers and/or sizes.
8. Evaluate the need to establish 'insurance' populations off-park.

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B.22 *Coprosma baueri* and *Coprosma pilosa* (Rubiaceae) – Coastal Coprosma and Mountain Coprosma, Norfolk Island Nation Park

Figure 22.1 Female flowers of *Coprosma baueri* growing in the ANBG (left, ©M. Fagg Australian National Botanic Gardens Photo No. dig. 9922) and *Coprosma pilosa* on Norfolk Island (right, ©K. Mills, supplied by NINP staff).

Coprosma baueri (Coastal coprosma) is a shrub or small tree with small green flowers and orange, egg-shaped fruits. The leaves are light green and glossy (Flora of Australia 1994). On exposed cliff habitat it usually forms compact shrubs to 1.5 m, but can grow taller and rather spindly in sheltered places under trees (Mills 2009).

Coprosma pilosa (Mountain coprosma) is a shrub or small tree growing up to 6 m tall. It has small green flowers and dark bluish-purple fruits (Flora of Australia 1994).

Taxonomy: The names *Coprosma baueri* Endl. and *Coprosma pilosa* Endl. are accepted according to the Australian Plant Census (CHAH 2015, verified 10 September 2015).

Status: Listed as Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).

Number of populations inside and outside parks and reserves

Coprosma baueri occurs on both Phillip and Norfolk Island. On Norfolk Island it mainly occurs outside the national park and is reported form the Anson Bay-Duncombe Bay area, Selwyn Reserve, Two Chimneys Reserve and Kingston Common Reserve (DNP 2010). However, it has been planted as part of rehabilitation works along the Mt Pitt Road (DNP 2010).

The entire population of *C. pilosa* occurs inside the Mt Pitt section of Norfolk Island National Park (DNP 2010).

Population size – range

At the time of listing, there were 228 mature individuals of *Coprosma baueri* (TSSC 2003). On Phillip Island, *Coprosma baueri* was observed to be very common along the southern and western cliffs in 2007 with a good range of plant sizes including seedlings suggesting a healthy population (Mills 2009). Due to plantings in the national park (DNP 2010) it seems to occur in good numbers in both sections of the park (C. Jones pers. comm. 11 November 2015).

187 mature individuals of *C. pilosa* were known at the time of listing (TSSC 2003).

Geographical distribution

Coprosma baueri occurs on Norfolk Island as well as Phillip Island. *Coprosma pilosa* is endemic to Norfolk Island (DNP 2010). Both species have a localised distribution.

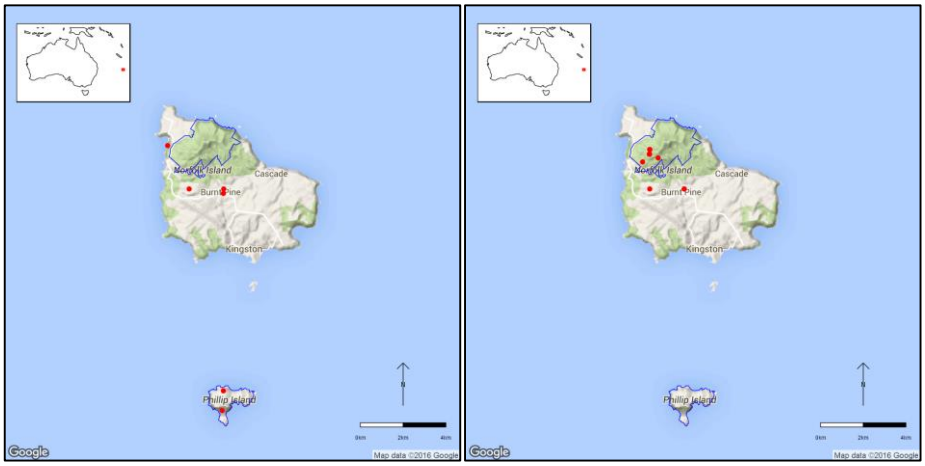

Figure B22.2 Distribution of *Coprosma baueri* (left) and *C. pilosa* (right) in Norfolk Island National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Three seed collections (277, 187 and 440 seed) of *C. baueri* are held at the National Seed Bank (T. North pers. comm. 11 September 2015). Seed of both *Coprosma* species are also held on Norfolk Island (L. Guja pers. comm. 10 September 2015). However, due to hybridisation between *C. baueri* and the non-native *C. repens* on Norfolk Island, seed collections from Phillip Island are required (L. Guja pers. comm. 10 September 2015). Eight plants of *C. baueri* are cultivated in the Living Collection of the Australian National Botanic Gardens (Z. Knapp on 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Both *Coprosma* species are wind-pollinated (DNP 2010).

Symbiotic relationships: Both species have domatia on their lower leaf surfaces (Flora of Australia 1994). Domatia are also found in many other *Coprosma* species and are part of a plant – mite mutualism. These small pits or pouches are found in the axils of leaf veins and provide shelter for mites and act as mite nurseries. The mites protect the leaf by feeding fungal hyphae, fungal spores, pollen and partly also small herbivorous arthropods. This leads to a longer life span of the leaves, as shown in a study on the New Zealand species *C. lucida* (Monks *et al.* 2007). The EPBC listed mistletoe *Ileostylus micranthus* favours *C. pilosa* as its host (DNP 2010) which suggests that at least one bird species is also reliant on this *Coprosma*.

Germination requirements: Not known. Seedlings were observed on Phillip Island in November 2007 (Mills 2009).

Dormancy class: Unknown.

Flowering: *Coprosma baueri* is reported to flower and set seed annually (L. Guja pers. comm. 10 September 2015) whereas *C. pilosa* sets seed only occasionally (DNP 2010). Specimens at the Australian National Herbarium indicate that both species flower winter-spring and have fruits spring-summer.

Breeding system: Both species are dioecious (DNP 2010).

Dispersal: The seed of both species are dispersed by birds who eat the fruits (DNP 2010).

Longevity: Unknown.

Life form: shrub or small tree

Ploidy levels: *Coprosma baueri* is diploid (2n=44) whereas *C. pilosa* is hexaploid (2n=132, Beuzenberg 1983).

Role of the plant in the environment: *Coprosma baueri* mostly grows near the coast, including areas that are affected by salt water spray. It is sometimes severely chewed by insects (DNP 2010). On Phillip Island, it grows on cliff edges, where it can be a co-dominant species (Mills 2009). Here, it thrives well in nesting habitat of wedge-tailed shearwaters (*Puffinus pacificus*, Procellariidae) that fertilise the soil and keep it loose and the habitat open with their burrowing (Sykes and Atkinson 1988).

Coprosma pilosa is found in the palm forests of sheltered mountain gullies and upper slopes in the Mt Pitt Section of the National Park that are dominated by Norfolk Island Palm (*Rophalostylis baueri*, Arecaceae).There is a suggestion that it might be adapted to a certain altitude, as it does not grow well in the nursery (C. Jones pers. comm. 11 November 2016). *Coprosma pilosa* is a favoured host of the mistletoe *Ileostylus micranthus* which is also listed under the EPBC Act (DNP 2010).

Threats

Listed threats (EPBC Act)

- Restricted geographical distribution.
- Competition and/or habitat degradation by weeds.
- Wind damage (*C. baueri* only).
- Negative impacts caused by insects (*C. baueri* only).
- Reduction of genetic integrity of a species due to hybridisation (*C. baueri* only).
- Competition and/or habitat degradation by *Ileostylus micranthus* (*C. pilosa* only).
- Low numbers of individuals (*C. pilosa* only).

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that both species have low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also makes these species vulnerable to further loss through stochastic events such as cyclones (DNP 2010). The genetic integrity of *C. baueri* is possibly threatened by hybridisation with *C. repens*, a species introduced from New Zealand (DNP 2010).

Invasive and other problematic species

Competition from weeds is a major threat to both Coprosma species (DNP 2010). The mistletoe *Ileostylus micranthus* favours *Coprosma pilosa* as its host and is able to kill the host with heavy infestations (DNP 2010). Seed predation is occurring in *Coprosma pilosa* (L. Guja pers. comm. 10 September 2015). *Coprosma baueri* leaves are often severely chewed by insects (DNP 2010), but it is not known whether this is a threat to the species.

Other Threats/Potential New threats

Climate-related factors

Climate change is predicted to lead to an increased frequency of storm events and to changes in rainfall patterns (Hyder Consulting 2008) potentially increasing climate-related threats. *Coprosma baueri* is threatened by strong wind that can damage plants growing in exposed coastal locations (DoE 2015). Good self-regeneration of *C. baueri* populations might be impacted during drought (Mills 2009). *Coprosma pilosa* seems to be quite restricted in its habitat preferences at higher elevations since it cannot be easily grown in the nursery suggesting that increasing temperatures associated with climate change are a potential threat to this species.

In addition, fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015). *Coprosma baueri* has been planted in the Mt Pitt section of the national park as part of a rehabilitation program as the species is very hardy and survives planting in rehabilitation areas very well (C. Jones pers. comm. 6 November 2015). Mills (2009) indicates that *C. baueri* is successfully regenerating on Phillip Island so further planting is not a priority.

Knowledge Gaps

Species biology and life history including seed germination, flowering, breeding system, genetic diversity, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Determine key life history parameters including age to maturity, longevity, flowering and fruiting and reproductive strategy to assist with species management.
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.
5. Determine reproductive strategy to determine if inbreeding is an issue that contributes to low seed set in *C. pilosa* and/or poor propagation of C. *baueri.*
6. Establish the biological linkages between Mountain coprosma, the mistletoe and associated bird(s) to ensure that this group of species is collectively managed.
7. A better understanding of the mites including what species co-occur and how these are dispersal may better inform rehabilitation programs to ensure that this important species is included in these programs.
8. Determine the growing requirements of Mountain coprosma to ensure to improve the success of propagated material.

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B.23 *Cordyline obtecta* (Asparagaceae) – Ti/ Norfolk Island Cabbage Tree, Norfolk Island National Park

Figure 23.1 *Cordyline obtecta* flowers at ANBG (left, ©M. Fagg Australian National Botanic Gardens No. dig.14369) and on Norfolk Island (right, ©G. Sattler Australian National Botanic Gardens No. ni.151).

This species has been described as a tree lily and grows up to 10 m tall with strap-like leaves and lily-like flowers. Plants are occasionally multi-stemmed. Can grow very tall (>8 m) with numerous stems and branching with several heads (Cassandra Jones pers. comm. 6 November 2015). The white flower are borne on an erect pyramidal flower spikes about 30 cm long on the top of the

stem. It has grey bark and bluey purple fruit. (Ho 2006, DNP 2010). This species is now considered to be synonymous with the New Zealand Three Kings Cabbage Tree (*C. kaspar*) (de Lange 2005).

Taxonomy: Conventionally accepted as *Cordyline obtecta* (Graham) Baker (CHAH 2006, verified 12 August 2015).

Family is given as Agavaceae on EPBC listing page, however, in APNI site it is Asparagaceae

Cordyline kaspar W.R.B.Oliv. is a synonym of *Cordyline obtecta*, this species is listed as At Risk/Range restricted in New Zealand (de Lange 2005)

Status: Listed as Vulnerable under the EPBC Act on 3 November 2003

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan, 2010.

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Most populations of this species occur inside Norfolk Island National Park. This species occurs in hardwood sub-tropical rainforest areas of Norfolk Island on the upper slopes of Mt Pitt-Mt Bates and occasionally on sheltered ridges, slopes and in gullies at lower altitudes.

Population size – range

At the time of listing in 2003 there were 818 mature individuals (TSSC 2003) with 65% of these occurring within the national park. Due to the ease with which it can be propagated this species has been planted in several public areas and on Phillip Island. The population was reported to have greatly increased since 2003 (McCoy in DNP 2010) but it is not clear whether this was done with seedlings, cuttings or a mixture of both.

Geographical distribution

Localised, discontinuous. Found in open areas as well as forest understorey.

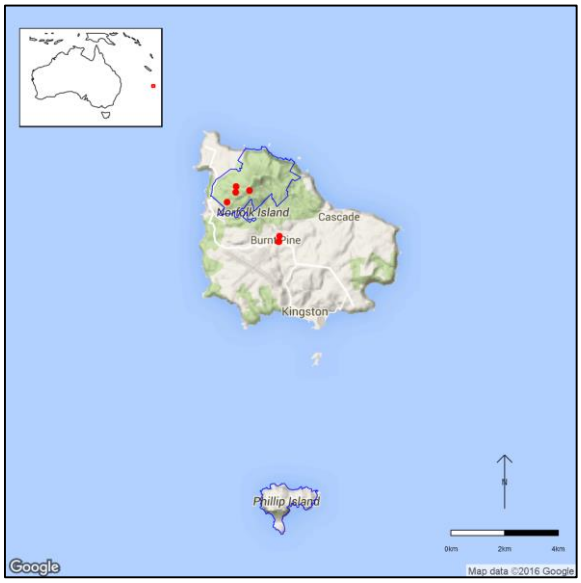

Figure 23.2 Distribution of *Cordyline obtecta* (Ti) in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

This species is currently conserved in the Australian National Botanic Gardens (97 plants) and the National Seed Bank (two accession) with additional seed collections are proposed in 2016 (T. North pers. comm. 11 September 2015, Z. Knapp pers. comm. 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Probably insect and/or bee pollinated as *C. kaspar*, *C. australis* and hybrids were visited by many insects and honey bees (Beever 1981).

Symbiotic relationships: Unknown.

Germination requirements: No pre-treatment required (Ho 2006).

Dormancy class: Orthodox, said to live for several years in the soil (Arkins 2003, in Lough 2006).

Flowering: Flowers were observed by Mills (2007) from September-November and fruit in November-January, March, April and June and produce copious amounts of nectar (Beever 1981).

Breeding system: *C. kaspar*, now believed to be synonymous with *C. obtecta*, is self-incompatible (Beever 1981) but also produces parthenocarpic (seedless) fruit. A large amount of fruit is produced on each tree (Cassandra Jones pers. comm. 6 November 2015). The plant is easy to strike from cuttings and broken sections have been found to send down roots and grow (Cassandra Jones pers. comm. 6 November 2015).

Dispersal: In New Zealand the seed fall when ripe or are eaten by birds (Beever 1981).

Longevity: Unknown.

Life form: Tree lily.

Ploidy levels: 2n = 38 (Moore and Edgar 1970, CCDB).

Role of the plant in the environment: The older larger trees often hollow out and are one of the favourite nest sites for the Green Parrot (*Cyanoramphys cookii*) (C. Jones pers. comm. 6 November 2015).

Threats

Listed Threats (EPBC Act)

- Grazing pressures and associated habitat changes
- Competition and/or habitat degradation by weeds
- Low numbers of individuals

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that both species have low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also makes these species vulnerable to further loss through stochastic events such as cyclones.

Invasive and other problematic species

Grazing by cattle outside the park and weed competition threaten natural recruitment.

Other Threats/Potential New threats

Climate-related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Determine key life history parameters including pollination, reproductive strategy, flowering and fruiting times, maturity and longevity to assist with species management
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.

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B.24 *Elatostema montanum* (Urticaceae) – Mountain Procris, Norfolk Island National Park

Elatostema montanum is a perennial herb or subshrub with a straggling growth of up to 1 m. The plant is fleshy with a succulent stem. The leaves are falcate or obliquely oblanceolate, 7–15 cm long and 2–5 cm broad, with abundant cystoliths. Male inflorescences are 1–2 cm long, female inflorescences shortly pedunculate and globose (Flora of Australia 1994).

Taxonomy: The name *Elatostema montanum* Endl. is accepted according to the Australian Plant Census (CHAH 2015, verified 16 September 2015).

- Synonym: *Procris montana* (Endl.) Steud.

Status: Listed as Critically Endangered under the EPBC Act on 03 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

At the time of listing, *Elatostema montanum* was known from seven locations, all situated within the Mt Pitt section of Norfolk Island National Park (TSSC 2003), but currently there are only three known locations (L. Guja pers. comm. 10 September 2015).

Population size – range

At the time of listing, there were 76 mature individuals of *Elatostema montanum* in seven locations. The extent of occurrence was estimated at 0.399 km². The single locations contained mostly six or less plants with the highest number of individuals in one location being 26 (TSSC 2003). More recently, there are only three locations with a total of <20 plants (L. Guja pers. comm. 10 September 2015).

Geographical distribution

The species has a localised and very fragmented distribution (TSSC 2003).

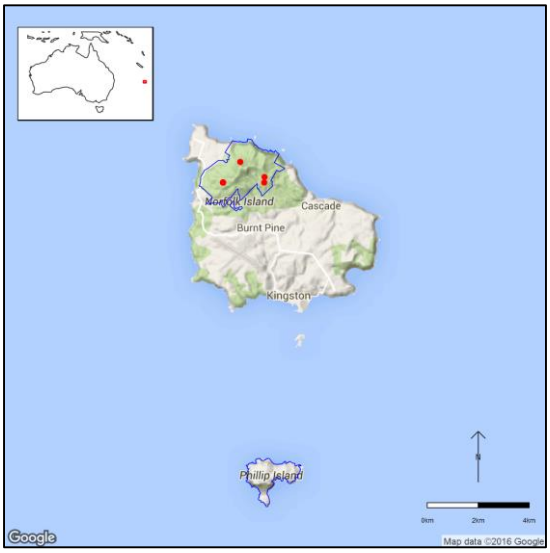

Figure 24.1 Distribution of *Elatostema montanum* in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Z. Knapp pers. comm. 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Wind-pollinated. In the family Urticaceae, stamens are inflexed in the bud and bend outwards suddenly and elastically when the flowers open, facilitating an explosive pollen release (Berg 1989).

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Unknown.

Flowering: Unknown.

Breeding system: *Elatostema montanum* is monoecious but with male and female inflorescences (Flora of Australia 1994). The species rarely sets seed but can be propagated from cuttings (DNP 2010).

Dispersal: The achenes in *Elatostema* are ejected by the staminodes of the female flowers (Berg 1989).

Longevity: Possibly relatively short-lived.

Life form: Perennial herb.

Ploidy levels: Unknown.

Role of the plant in the environment: The species is confined to a few damp, shaded localities (Flora of Australia 1994). It is apparently very site specific and is restricted to very steep rocky bands and cliffs in shaded valley bottoms that do not dry out. The species is dependent on the erosion regime of the island. Streams might open up new sites, but could also wash population's away (Sykes and Atkinson 1988, cited in DNP 2010).

Threats

Listed threats (EPBC Act)

- Grazing pressures and associated habitat changes.
- Climate change altering atmosphere/hydrosphere temperatures, rainfall patterns and/or frequency of severe weather events.
- Loss and/ or fragmentation of habitat and/ or subpopulations.
- Restricted geographical distribution.
- Competition and/ or habitat degradation by *Ageratina riparia* (Mist Flower) and *Lantana camara* (Lantana) and other weeds.
- Low numbers of individuals.

Genetic and demographic effects

The small population size at the time of listing and the very small extent of occurrence make the species vulnerable to stochastic disturbance events such as cyclones (TSSC 2003). The apparent reduction in population size since 2003 has probably led to a loss of genetic diversity in this species potentially increasing inbreeding and reducing reproductive output and/or seed quality. This may impact on this species ability to respond to changes in the environment.

Climate-related factors

Severe weather events such as storms or cyclones can damage or eradicate very small populations (TSSC 2003). The preferred habitat along drainage lines in steep terrain makes this species susceptible to flood damage (TSSC 2003).

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Invasive and other problematic species

Habitat competition by weeds, especially *Lantana camara* (Lantana) and *Ageratina riparia* (William Taylor) threaten *E. montanum* populations (TSSC 2003). Seed predation by black rats (*Rattus rattus*) is also a possible threat to *E. montanum* (Department of the Environment 2015).

Biophysical impacts

Between surveys undertaken in 1984 and the time of listing, some populations have apparently been destroyed by cattle grazing (TSSC 2003) but it is unclear if these sites were located within the national parks boundaries.

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015). Weed control must be undertaken with care to maintain a shady habitat for *E. montanum* shady (DNP 2010).

Knowledge Gaps

Species biology and life history including symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions:

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Determine key life history parameters including symbiotic relationships, flowering, breeding system, maturity and longevity to assist with species management.
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.
5. Undertake a genetic assessment to determine the reproductive strategy and levels of genetic diversity to assist with any future translocation program.

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B.25 *Hibiscus insularis* (Malvaceae) – Phillip Island Hibiscus, Norfolk Island National Park

Figure B25.1 *Hibiscus insularis* in the Australian National Botanic Gardens.
©M. Fagg Australian National Botanic Gardens Photo no. dig.5897.

Hibiscus insularis is a shrub or small tree up to 2.5 m tall. The solitary flowers are pale yellow with a green tinge and a red throat that turn purple with age (DNP 2010). The leaves are highly variable in shape (Mills 2009).

Taxonomy: The name *Hibiscus insularis* Endl. is accepted in the Australian Plant Census (CHAH 2015, verified 24 July 2015).

Status: Critically Endangered under the EPBC Act (3 November 2003).

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010)

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

One population located inside Norfolk Island National Park (Phillip Island section).

Population size – range

At the beginning of the 20th century, visitors to Phillip Island recorded a "few" plants in not very good condition (Maiden 1903, Laing 1914). In 1939 there were 13 known plants (Flora of Australia 1994) and in 1988 it was restricted to one site with a major and a minor

patch on the northern slopes of the island (Sykes and Atkinson 1988). In 2003, the total number of mature individuals was estimated to be <50 (TSSC 2003) but by 2010 over 100 plants were known on Phillip Island (DNP 2010).

Geographical distribution

Localised and fragmented distribution.

Figure B25.2 Distribution of *Hibiscus insularis* in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary. Specimens located outside of the national park are cultivated not natural plants.

Ex-situ collections (Living and Seed Bank)

Four seed accessions (1394, 843, 48 and 142 seed) are held by the National Seed Bank (T. North pers. comm. 11 September 2015). Two of these collections are from known wild source locations. Additionally, ten *H. insularis* plants sourced from the wild are growing in the Living Collection of the Australian National Botanic Gardens (Z. Knapp pers. comm. 30 September 2015). The species is cultivated in the Norfolk Island Botanic Gardens and other botanic gardens in Australia and is also commonly planted in home gardens on Norfolk Island (Mills, 2009).

Biology

Pollinators: Nectar-feeding birds are thought to be the main pollinators, however, no nectar-feeding birds currently occur on Phillip Island. Possible pollinators in the past may have been two Silvereye species (*Zosterops albogularis* and *Z. tenuirostris*) that occur on Norfolk Island and may have also existed on Phillip Island. Another possible pollinator could have been the Norfolk Island Kaka (*Nestor productus*), a large parrot that became extinct around 1800 and is reported to have fed on "hibiscus" flowers (Groeneveld 1989). The Lord Howe Island Gecko (*Christinus guentheri*) has been observed feeding on *H. insularis* nectar but it is unclear if this species is a significant pollinator (Groeneveld 1989, DNP 2010).

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Probably orthodox.

Flowering: Long flowering season.

Breeding system: Self-compatible. *Hibiscus insularis* has bisexual flowers but the female and the male stage of the flower are separated by one day with the flower being in a female phase first. When the male stage if fertile, self-pollination is possible (Groeneveld 1989).

Dispersal: The capsules stay on mother plants and degrade over time to release the seed which probably fall to the ground as there are no specialised dispersal mechanisms apparent. The species also reproduces vegetatively in the wild by rooting of branches that touch the ground. It can also be propagated by stem-layering (Groeneveld 1989).

Longevity: Individuals are mature after approximately 18 years when grown from seed but less when vegetatively propagated (DNP 2010).

Life form: Perennial shrub or small tree up to 2.5 m (DNP 2010).

Ploidy levels: Unknown.

Role of the plant in the environment: The larvae of two moth species (*Pectinophora scutigera* and *Anisoplaca cosmia*) destroy the seed and may be reducing reproductive success. Observations also revealed two wasp species, possibly parasites of the moth larvae occur on this species while invasive ants (*Plagiolepis alluaudi*) are frequently found nesting in seed capsules but probably do not have a significant detrimental effect on seed number (Groeneveld 1989).

Threats

Listed Threats (EPBC Act)

- Drought.
- Restricted geographical distribution.
- Competition and/ or habitat degradation by *Olea europaea* subsp. *cuspidata* (African Wild Olive).
- Low genetic diversity and genetic inbreeding.
- Low numbers of individuals.

Genetic and demographic effects

The species has a very restricted distribution and a low number of individuals, making it more susceptible to stochastic loss. The current population is probably derived from only two individuals (DNP 2010) and is therefore highly likely to have very low genetic diversity (Groeneveld 1989).

Invasive and other problematic species

Invasive weeds, especially *Olea europaea* subsp. *cuspidata* (African Wild Olive) compete with *Hibiscus insularis*. Future introductions of weeds, competitors or pathogens are a potential problem to the flora in general (DNP 2008).

Other Threats/Potential New threats

Climate-related factors

Hibiscus insularis is affected by drought which often occurs during El Niño events. The lack of vegetation and severe erosion on Phillip Island make this island more vulnerable to the effects of heavy rains.

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, genetic diversity, seed dispersal and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes
2. Determine how critical this species is for the life cycle of the two moth species.
3. Evaluate whether pollinators should/can be reintroduced to Phillip Island.
4. A genetic assessment of *ex-situ* holdings and nursery cultivars may uncover additional genetic diversity that could be re-introduced to Norfolk Island.

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B.26 *Ileostylus micranthus* (Loranthaceae) – Mistletoe, Norfolk Island National Park

Ileostylus micranthus is a bushy epiphyte with green flowers and yellow fruits (DNP 2010).

Taxonomy: The name *Ileostylus micranthus* (Hook.f.) Tiegh. is accepted according to the Australian Plant Census (CHAH 2015, verified 5 August 2015).

- Synonym: *Loranthus micranthus* Hook.f.

Status: Listed as Vulnerable under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

All known locations on Norfolk Island are inside the national park boundaries (DNP 2010). In New Zealand, the plant is more common and not threatened.

Population size – range

At the time of listing, there were less than 500 mature plants on Norfolk Island (TSSC 2003).

Geographical distribution

Ileostylus micranthus occurs on Norfolk Island and in New Zealand. It is thought to have arrived on Norfolk Island during the 1930s, since it was not known from the island before. On Norfolk Island, it is found above 200 m on the upper slopes of Mt Pitt and along the track leading to Red Road on Mt Bates (DNP 2010). The species has a localised distribution on Norfolk Island and is widespread in New Zealand.

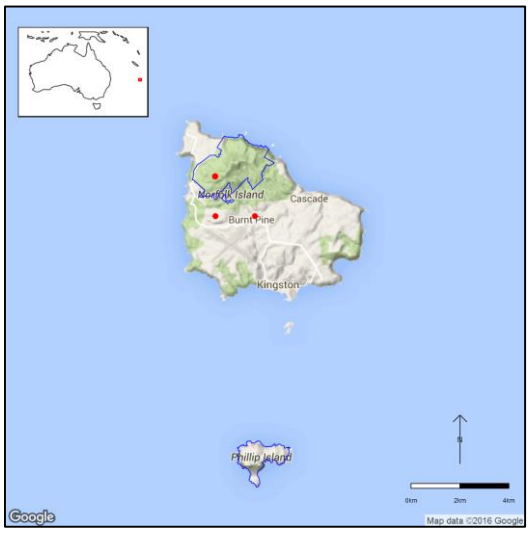

Figure B26. Distribution of *Ileostylus micranthus* in Norfolk Island National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Z. Knapp pers. comm. 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Insect-pollinated (Ladley 1997).

Symbiotic relationships: Unknown.

Germination requirements: Usually, the fruit is ingested by birds and the skin is removed as it passes through the gut. If a seed is defecated on a branch, it can germinate (Ladley 1997). Propagation is difficult and it is best to use fresh fruit. The seed should be squeezed out gently, preferably on the same host plant the seed has been collected from. While most seed germinate, not all seedlings manage to attach to a host plant (de Lange 2011).

Dormancy class: Recalcitrant.

Flowering: In New Zealand, the species flowers from September-December (de Lange 2011).

Breeding system: In New Zealand, male, female and hermaphroditic plants have been reported (de Lange 2011) with hermaphroditic plants often being self-compatible (Ladley *et al.* 1997).

Dispersal: The fruit is a one-seeded berry produced between December-July in New Zealand (de Lange 2011). The berries are eaten by birds and thus dispersed. In New Zealand, bellbirds (*Anthornis melanura*) feed on fruits of *I. micranthus* and seem to have a high preference for this species (MacFarlane 2012). Silvereyes (*Zosterops lateralis*), tui (*Prosthemadera novaeseelandiae*), and a gecko have also been recorded eating the fruit (Dopson 1997). Silvereyes occur on Norfolk Island.

Longevity: A study to investigate non-destructive age indices in mistletoes sampled plants that were up to 16–17 years old (Norton *et al.* 1997).

Life form: Perennial bushy epiphyte.

Ploidy levels: 2n=22 (de Lange 2011), diploid.

Role of the plant in the environment: This species has a wide range of host plants, but favours *Coprosma pilosa* (Mountain Coprosma, Rubiaceae) as its host, a species listed as Endangered under the EPBC Act. Heavy infestations with *I. micranthus* can kill the *Coprosma* hosts (DNP 2010). In New Zealand, there are a number of moth species (native moths from the families Geometridae and Yponomeutidae and some generalist moths (e.g. *Liothula omnivora*) that use mistletoes as host species (Patrick and Dugdale 1997).

Threats

Listed Threats (EPBC Act)

- Climate change and severe weather i.e. causing storm damage or habitat modification, destruction and alteration due to changes in land use patterns.
- Low numbers of individuals.

Genetic and demographic effects

The small distribution area and low numbers of individuals suggest that this species has low genetic diversity and may be vulnerable to inbreeding. A small population size and limited geographical distribution also makes these species vulnerable to further loss through stochastic events such as cyclones.

Climate-related factors

Ileostylus micranthus is susceptible to storm damage and other irregular disturbance events (DNP 2010). Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Other Threats/Potential New threats

Biophysical impacts

A decline in the general health of the forest due to diverse threats would also threaten *I. micranthus* (DNP 2010).

Current Management

There is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, time to maturity and longevity of this species are unknown or poorly understood.

It is unclear whether this species occurs naturally on Norfolk Island and it could be a recent introduction (in accordance with the hypothesis that it was introduced during the 1930's, DNP 2010, Mills 2010). However, given the species biology it is unclear how this species could have arrived on Norfolk Island, found a suitable host and established a new population; the successful plants would also have to be hermaphrodites or both male and female plants to successfully reproduce. If this is a recent migrant to Norfolk Island EPBC listing may not be appropriate. This would also enable national park staff to remove *I. micranthus* from heavily infested plants of the Critically Endangered *Coprosma pilosa*.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. A genetic assessment of Norfolk Island and New Zealand populations may shed light on whether this is a recent migrant to Norfolk Island.
3. Determine if the moths utilising this species in New Zealand also occurs on Norfolk Island.
4. Evaluate the role this species is playing as a food source for island birds.

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B.27 *Melicytus latifolius* (Violaceae) – Norfolk Island Mahoe, Norfolk Island National Park

Figure B27.1 *Melicytus latifolius* in the Australian National Botanic Gardens. ©M. Fagg Australian National Botanic Gardens Photo No. dig.992.

Melicytus latifolius is a small tree that usually grows up to 4 m high but can sometimes reach 9 m (DNP 2010).

Taxonomy: The name *Melicytus latifolius* (Engl.) P.S.Green is accepted in the Australian Plant Census (CHAH 2015, verified 3 August 2015).

Status: Critically Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Melicytus latifolius occurs inside the Mt Pitt section of the National Park but is also found in several areas outside of the national park (Anson Bay-Duncombe Bay, Mission Road North and Steels Point). These areas are protected to varying degrees (DNP 2010).

Population size – range

In 2003, the number of mature plants was 17 (TSSC 2003) and the species was thought to be rare prior to that report (DNP 2010, and references therein).

Geographical distribution

Melicytus latifolius has a localised distribution and is endemic to Norfolk Island.

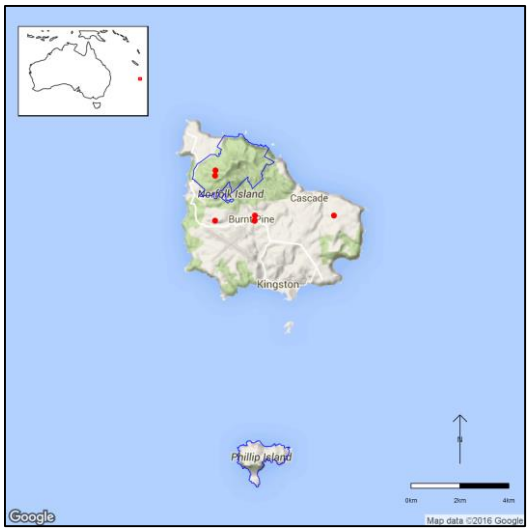

Figure B27.2 Distribution of *Melicytus latifolius* in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Seed of *M. latifolius* is stored on Norfolk Island (L. Guja pers. comm. 10 September 2015) and staff from the ANBG plan to collect this species in February 2016 (T. North pers. comm. 11 September 2015). Eighteen *Melicytus latifolius* plants sourced directly from known wild locations are held in the Living Collection at the ANBG (Z. Knapp pers. comm. 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Insect-pollinated. *Melicytus crassifolius*, a New Zealand plant with similarly shaped flowers, is visited mostly by flies (Heine 1937).

Symbiotic relationships: Unknown.

Germination requirements: Unknown.

Dormancy class: Orthodox in *M. ramiflorus* (Herron and Clemens 2001). *Melicytus dentatus* seed are also orthodox and have physiological dormancy (saseedbank.com.au).

Flowering: Unknown.

Breeding system: Dioecious, therefore self-pollination is not possible.

Dispersal: Unknown. The fruit is a berry, and seed of some *Melicytus* species have elaiosomes (Feng 2005) and may be dispersed by ants.

Longevity: Unknown.

Life form: Tree, up to 4 m, but can reach 9 m.

Ploidy levels: 2n=32. Most other *Melicytus* species have recorded chromosome numbers of 2n=32. The basic chromosome number in neighbouring genera is x=8, so *M. latifolius* could be regarded as tetraploid (Mitchell *et al.* 2009).

Role of the plant in the environment: *Melicytus latifolius* grows in moist shaded valleys and on broad ridges. It can tolerate dense shade, but is sometimes found at the edges of canopy gaps (Sykes and Atkinson 1988).

Threats

Listed Threats (EPBC Act)

- Drought.

- Competition and/ or habitat degradation by *Solanum mauritianum* (Wild Tobacco), *Psidium cattleianum* (Cherry Guava) and other weeds.
- Low fecundity, reproductive rate and/or poor recruitment.
- Low numbers of individuals.

Genetic and demographic effects

Melicytus latifolius has very low numbers of individuals and consequently also a very small area of occupancy, which makes the species vulnerable to stochastic events. The species flowers and sets seed only rarely, leading to poor recruitment (DNP 2010). Low seed set may reflect low mate availability and high inbreeding impacting on seed production.

Invasive and other problematic species

A major threat to *M. latifolius* is competition from weeds, especially *Solanum mauritianum* (Wild Tobacco) and *Psidium cattleianum* (Cherry Guava, DNP 2010). Seed/fruit predation occurs in *Melicytus ramiflorus* (L. Guja pers. comm. 10 September 2015) and may also be a threat.

Other Threats/Potential new threats

Climate-related factors

The species does not flower and reproduce well during drought (DNP 2010). Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Determine the appropriate conditions for long term storage and seed germination.
3. Develop and implement a restoration program to increase population numbers and/or sizes.
4. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding to assist with any future translocation program.
5. Determine whether pollinators and dispersers of this species still exist.
6. Evaluate the need to establish 'insurance' populations off-park.
7. Explore whether a soil seed bank exists if ants are found to be dispersing seed and assess whether opportunities exist to stimulate this to encourage germination.

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B.28 *Myoporum obscurum* (Scrophulariaceae) – Popwood, Sandalwood, Norfolk Island National Park

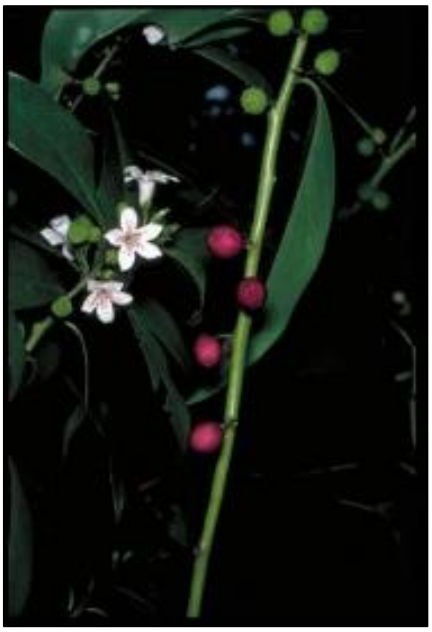

Figure B28.1 *Myoporum obscurum* in the Norfolk Island Botanic Gardens.
©M. Fagg Australian National Botanic Gardens Photo No. ni.109.

This species often grows as a shrub or small spreading tree to 7 m tall. The leaves are smooth, shiny green with a black tip and often black margins. It has prolific, scented white flowers which are followed by pea-sized purple berries (DNP 2010, DNP Brochure).

Taxonomy: Conventionally accepted as *Myoporum obscurum* Endl. (CHAH 2015, verified 22 July 2015).

Family is given as Myoporaceae on EPBC listing page, however on APC site it is given as Scrophulariaceae

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan 2010

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

The entire natural population is now to be found in the Mt Pitt section of the national park where only five mature seed-producing trees were found in 1995 and which had increased to seven in 2003 at the time of EPBC listing. A planting program began in 1995 and the species has been planted throughout the national park (DNP 2010) as well as outside (Coyne 2011).

Population size – range

This species currently only occurs on Norfolk Island but in the 1830's Cunningham recorded this species on Phillip Island as well (Coyne 2011). Only seven mature wild trees were recorded on Norfolk Island in 2003 (TSSC 2003) but it has subsequently been planted across Norfolk Island (DNP 2010, Coyne 2011).

Geographical distribution

Localised.

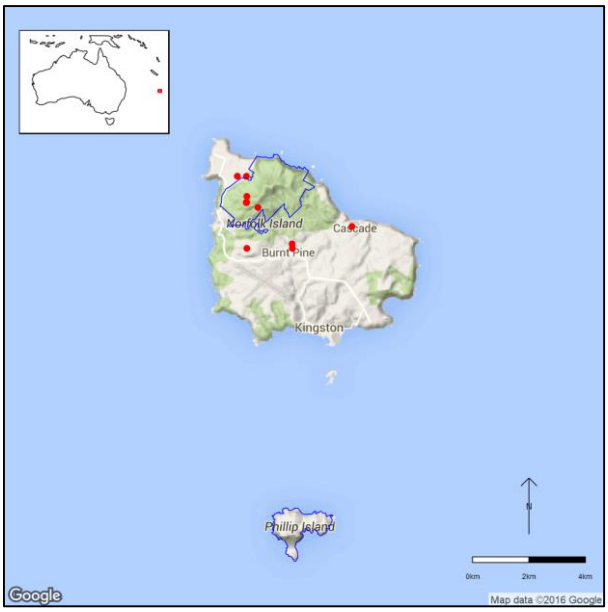

Figure B28.2 Distribution of *Myoporum obscurum* in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank but there are plans to collect seed in February 2016 (Zoe Knapp pers. comm. 12 October 2015 and Tom North pers. comm. 11 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Flowers of the related *M. laetum* were observed to be visited by flies and moths as well as bees, beetles and thrips (Heine 1937).

Symbiotic relationships: Unknown.

Germination requirements: Cassandra Jones (pers. comm. 6 November 2015) advises that it has never been propagated by cuttings but they have had success with seed and no pre-treatment was required.

Dormancy class: Unknown.

Flowering: Flowers in summer. Mills (2007) observed flowers on *M. obscurum* in September, December, January, March, April and June. Fruit were observed in September, December, January, March and April (Mills 2007).

Breeding system: Unknown.

Dispersal: Unknown.

Longevity: Unknown.

Life form: Shrub or small spreading tree to 7 m.

Ploidy levels: Unknown.

Role of the plant in the environment: This species is intolerant of much shade and away from the coast grows on forest margins and in clearings or canopy gaps or open areas (Sykes and Atkinson 1988 in DNP 2010).

Threats

Listed Threats (EPBC Act)

- Competition and/or habitat degradation by weeds.
- Low numbers of individuals.
- Reduction of genetic integrity due to hybridisation*.

*The inclusion of the listed threat, reduction of genetic integrity due to hybridisation, is questioned in the Norfolk Island Species Recovery Plan (DNP 2010) since *M. insulare* is the species cited as being most likely to hybridise with *M. obscuru* and it is considered to be unlikely to occur on the Norfolk Island Group.

Invasive and other problematic species

Weed competition is a major threat. The small population size makes this species vulnerable to stochastic events (DNP 2010). Inbreeding may also be an issues given the extremely low number of plants in the natural population. Propagated trees are also likely to have a very low genetic base and also suffer from inbreeding effects.

Other Threats/Potential New threats

Climate related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, seed dispersal, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Regular systematic census for all plants (DNP 2010).
2. Determine the appropriate conditions for long term storage and seed germination.
3. Determine whether pollinators and dispersers still occur on the island.
4. Develop and implement a restoration program to increase population numbers and/or sizes.
5. Evaluate the need to establish 'insurance' populations on Phillip Island and off-Island.

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B.29 *Plexaure limenophylax* (Orchidaceae) – Norfolk Island National Park

A small, tufted, epiphytic orchid growing to 3–6 cm high with 2–3 cm a long inflorescences of many tiny greenish–white flowers, growing on the branches of trees (DNP 2010).

Taxonomy: Listed as *Plexaure limenophylax* Endl. on APNI (not listed on the APC website), accessed APC and APNI 20 June 2015

- Synonym: *Phreatia limenophylax*

Status: Critically Endangered under the EPBC Act (3 November 2003) as *Phreatia limenophylax*

Recovery Plan: Norfolk Island Threatened Species Recovery Plan 2010 (as *Phreatia limenophylax*). There is a draft National Recovery Plan being prepared for this species.

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

In 2003 there were five mature plants surviving in the wild, all occurring within in the Norfolk Island National Park.

Population size – range

Five mature plants (TSSC 2003). The species has been recorded from Anson Bay but all currently known plants are within the Mt Pitt section of the national park (DNP 2010).

Geographical distribution

Localised.

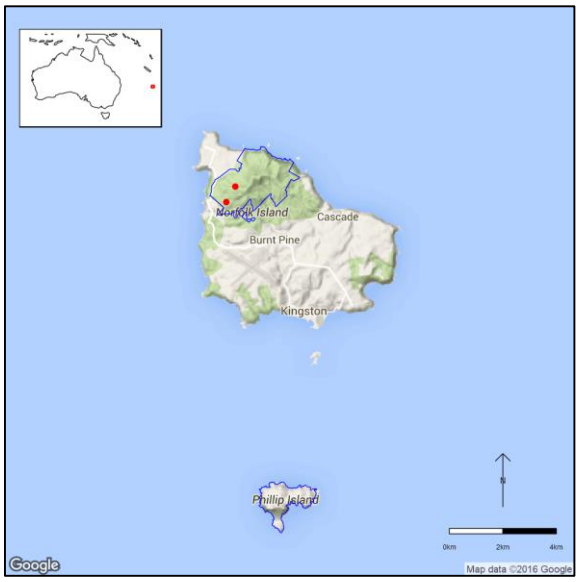

Figure B29.1 Distribution of *Plexaure limenophylax* in Norfolk Island National Park. Red dots are specimen collections, the blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (Zoe Knapp pers. comm. 12 October 2015 and Tom North pers. comm. 11 September 2015).No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Species of *Plexaure* have tiny flowers that are relatively short-lived. Little is known of their pollination syndrome with some species probably self-pollinating while others are possibly pollinated by rain splash (Jones *et al.* 2006).

Symbiotic relationships: Unknown for this species but many orchids utilise a fungal symbiont for germination and all orchids require these fungi for growth of the protocorm that precedes root and leaf development (Baskin and Baskin 2014).

Germination requirements: Unknown.

Dormancy class: Unknown for this species but some orchids have forms of dormancy to allow them to take advantage of the appropriate conditions for growth or when the correct fungi are available (Baskin and Baskin 2014).

Flowering: January–April (Jones *et al.* 2006).

Breeding system: Some species of the closely-related *Phreatia* have cleistogamic flowers (Uphof 1938) which are almost always self-fertilised. Reproduction of *Plexaure* species is solely from seed with these being dispersed 1–2 months after pollination. Apomixis is unknown in the genus. Natural hybrids are unknown in these orchids. (Jones *et al.* 2006).

Dispersal: Not observed for this species, but likely to be wind or water. Orchid seeds are very small, dust like seeds, in general, with a high seed/embryo volume ratio making them very buoyant so they can float on water or be carried by wind (Baskin and Baskin 2014).

Longevity: Perennial (how long is not known).

Life form: Epiphytic orchid (very small 3–6 cm high, grows on the branches of trees).

Ploidy levels: Unknown.

Role of the plant in the environment: Unknown.

Threats

Listed Threats (EPBC Act)

- Climate Change and Severe Weather i.e. storms and cyclones leading to habitat destruction and flora mortality.
- Alteration of hydrological regimes and water quality – changes to the hydrology of the forest.
- Low numbers of individuals.

Alteration of hydrological regimes and water quality

As moisture dependent sub-tropical plant species any changes to the hydrology of Norfolk Island would affect most species (DNP 2010).

Other Threats/Potential New threats

Climate related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Restore and maintain the health of the forest rough weed control and rehabilitation work (DNP 2010). Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015). The threatened species recovery plan also states that for all epiphytic orchids, likely areas of the national park should be monitored after storms and any fallen specimens should be rescued and an attempt to cultivate them in the botanic garden be made (DNP 2010).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, seed dispersal, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions:

1. Research propagation and establishment techniques (DNP 2010) (i.e. seed germination and mycorrhizal fungal relationships) to increase local population size.
2. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
3. Secure genetically representative *ex-situ* seed collections, in multiple locations if appropriate, to mitigate against the loss of natural populations and provide for re-establishment should severe losses or extinction occur.
4. Determine the appropriate conditions for long term storage and seed germination.
5. Determine whether the pollinators of this species still occur on the island.
6. Develop and implement a restoration program to increase population numbers and/or sizes.
7. Evaluate the need to establish 'insurance' populations off-park.

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B.30 *Senecio evansianus*, *Senecio australis* and *Senecio hooglandii* (Asteraceae) – Daisies, Norfolk Island National Park

All three *Senecio* species are probably annuals or short-lived perennials. The stem bases of *S. evansianus* and *S. australis* are known to become woody. *Senecio evansianus* is the smallest of the three species, mostly only reaching 10–20 cm. The other two species can grow taller, *S. hooglandii* up to 60 cm and *S. australis* up to 90 cm. The capitula (flower heads) are few per plant in *S. evansianus* and *S. australis*, and numerous in *S. hooglandii*. The outer flowers per head are ligulate in *S. australis*, narrowly funnel-shaped in *S. evansianus* and filiform in *S. hooglandii* (Belcher 1994).

Taxonomy: The names *Senecio evansianus* Belcher, *Senecio australis* Willd. and *Senecio hooglandii* Belcher are accepted according to the Australian Plant Census (CHAH 2015, verified 7 August 2015).

Status: Listed as Endangered (*Senecio evansianus*) and Vulnerable (*Senecio australis* and *S. hooglandii*) under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan (DNP 2010).

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Numbers of populations/locations are not provided in the species recovery plan. *Senecio evansianus* has been recorded from Rocky Point, Bumbora Reserve above Creswell Bay, and Bloody Bridge (Belcher 1994, DNP 2010). *Senecio australis* has been recorded from several areas outside the national park, namely Barney Duffy, Anson Bay, the Chord at Duncombe Bay, Hundred Acres Reserve, the Creswell Bay area, Two Chimneys Reserve and Ball Bay (Belcher 1994, DNP 2010). Inside national park boundaries, it occurs on Phillip Island (DNP 2010). *Senecio hooglandii* has been recorded from near the cemetery on Norfolk Island, from the Point Hunter Reserve, and from the north side of Phillip Island (Belcher 1994, DNP 2010).

Population size – range

In 2003, there were <200 mature plants of *S. evansianus* (TSSC 2003a), <500 mature plants of *S. australis* and <550 mature plants of *S. hooglandii* (TSSC 2003b).

Geographical distribution

Senecio evansianus and *S. hooglandii* are endemic to the Norfolk Island Group whereas *S. australis* also occurs in New Zealand where it is thought to be indigenous (de Lange *et al.* 2014). *Senecio evansianus* is only known from Norfolk Island itself (Belcher 1994). *Senecio australis* and *S. hooglandii* were widely sown on Phillip Island for revegetation (Mills 2009) and *S. hooglandii* was probably only introduced to Phillip Island during this process (Belcher 1994). *Senecio australis* also occurs on Nepean Island (DNP 2010).

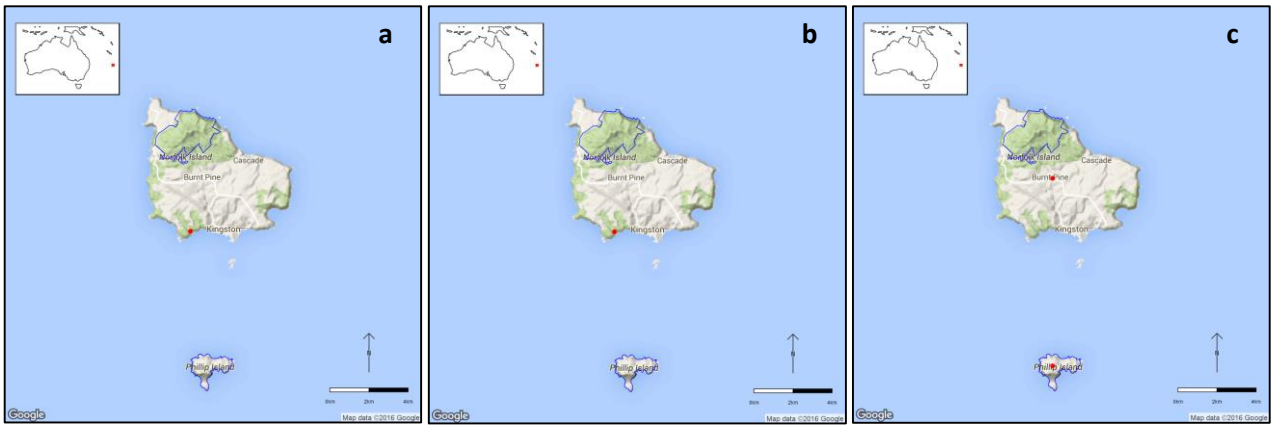

Figure B30.1 Distributions of *Senecio evansianus* (a), *S. australis* (b) and *S. hooglandii* (c) in Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Seed of *S. australis* has also been collected by ANBG staff and is currently held on Norfolk Island. Seed collection of the other two species is planned for 2016 (T. North pers. comm. 11 September 2015). The species is not conserved in the Living Collection at the Australian National Botanic Gardens (Z. Knapp pers. comm. 30 September 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Insect-pollinated. Lawrence (1985) observed native bees, honeybees and to a lesser extent hoverflies on other outbreeding Australian *Senecio* species. Thrips also occurred on the capitula in large numbers, but whether these are effective pollinators is unknown (Lawrence 1985).

Symbiotic relationships: Unknown.

Germination requirements: Several *Senecio* species show improved germination under light than in the dark (Robinson 2003).

Dormancy class: Unknown.

Flowering: Unknown.

Breeding system: The ray florets in *S. australis* and the marginal florets of the other two species are female, while the disc florets are bisexual (Belcher 1994). In Australian *Senecio* species studied by Lawrence (1985), perennial species with showy capitula were mostly self-incompatible outbreeders. However, self-compatibility has not been studied in these three species.

Dispersal: For *Senecio australis*, seed dispersal by sea birds was suggested (de Lange *et al.* 2014). The pappus hairs probably also facilitate wind dispersal.

Longevity: *Senecio australis* is an annual or short-lived perennial (Belcher, 1994) while the other two species are probably also annuals or short-lived perennials. All perennial Australian *Senecio* species studied by Lawrence (1985) reached maturity in the first year and this probably holds true for the three species discussed here.

Life form: Herbs.

Ploidy levels: *Senecio evansianus* and *S. australis* have a chromosome number of 2n=80 (de Lange and Murray 2003, de Lange *et al.* 2004) and can be considered to be octoploid since the basic chromosome number in the genus is x=10. Polyploidy is very common in the genus (Lawrence 1980). *Senecio hooglandii* may have the same chromosome number since the species are considered closely-related (Belcher 1992).

Role of the plants in the environment: *Senecio evansianus* seems to be restricted to well-watered clay soils beneath open stands of Norfolk Island pine (Belcher 1994) but the habitats or habitat requirements of the other two species are not known.

Threats

Listed threats (EPBC Act)

- Restricted geographical distribution (area of occupancy and extent of occurrence).
- Competition and/or habitat degradation by *Pennisetum clandestinum* (Kikuyu Grass) and other weeds.
- Low numbers of individuals.

Genetic and demographic effects

All three *Senecio* species have relatively low numbers of individuals and a relatively restricted geographical distribution area which probably makes them vulnerable to stochastic events. These species may also have low genetic diversity and may be vulnerable to inbreeding.

Invasive and other problematic species

The three *Senecio* species are threatened by competition from weeds, especially *Pennisetum clandestinum* (Kikuyu Grass, Poaceae).

Other Threats/Potential New threats

Climate related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and/or indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, flowering, breeding system, seed dispersal, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Up to date information regarding locations and population sizes is not available.

Suggested research and actions

1. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Genetic assessment of levels of genetic diversity and inbreeding in natural and planted populations to ensure that planted populations contain sufficient genetic diversity to become self-sustaining over time and that inbreeding populations have not been created.

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B.31 *Streblus pendulinus* (Moraceae) – Siah's Backbone, Norfolk National Park

Figure B31.1 *Streblus pendulinus* male flowers. ©Australian Tropical Rainforest Plants Key, Australian Plant Image Index No. rfk.3487.

This species is a dioecious tall shrub or tree to around 6 m. It has discolorous leaves which are rough and lumpy (scabrous) with finely serrated margins. The leaves are 3–15 cm long and 2–5 cm wide. The male flowers are 20 cm long catkins, while female flowers are solitary or with a few in a spike and 5–10 mm long. It has red, fleshy somewhat globular fruit around 5 mm long. It exudes a white latex when damaged. (Conn 2015, DNP 2010, Flora of Australia 1994).

Taxonomy: Conventionally accepted as *Streblus pendulinus* (Endl.) F.Muell. (CHAH 2015, verified 18 November 2015).

Previously, subpopulations on mainland Australia and in Melanesia, Micronesia and Polynesia have variously been included with *Streblus pendulinus*, however, *S. brunonianus* has been reinstated for non-Norfolk Island populations with *S. pendulinus* now treated as a Norfolk Island endemic. (DoE 2015a, Conn 2015).

Status: Listed as Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Threatened Species Recovery Plan 2010.

Information in this fact sheet is taken from the SPRAT Listing Page (DoE 2015b) unless otherwise referenced.

Number of populations inside and outside parks and reserves

The majority of known individuals occur in the Norfolk Island National Park (NINP). In 2003, 167 of the 187 mature individuals were located inside the national park (TSSC 2003, DNP 2010). Outside the park the species has been found in the Mission Road rainforest remnants, near Steels Point and in the Ball Bay reserve (DNP 2010) and also occurs on private property as isolated paddock trees (Mills 2007 in DoE 2015a). More than 95% of mature individuals occur in Norfolk Island National Park (Mills 2015 pers. comm. in DoE 2015a).

Population size – range

Streblus pendulinus is a Norfolk Island endemic. The extent of occurrence is 4.41 km² with an area of occupancy of 16 km² (DoE 2015a). Transect surveys in NINP observed 107 *Streblus pendulinus* plants along 15 km of transects (Mills 2012 in DoE 2015a). Based on this, Mills (2015 pers. comm. in DoE 2015) estimates that there are between 250 and 1000 mature plants on Norfolk Island.

Geographical distribution

Localised, discontinuous.

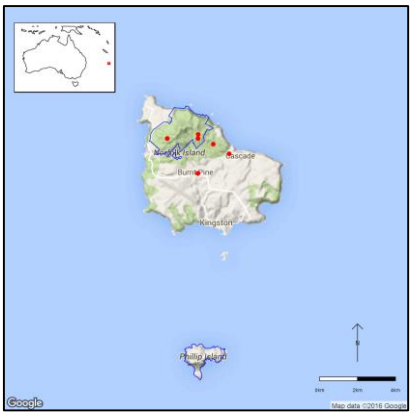

Figure B31.2 Map of distribution of Siah's Backbone based on herbarium specimens (not necessarily indicative of current populations). Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

This species is currently conserved in the Living Collection at the Australian National Botanic Gardens (Z. Knapp pers. comm. 30 September 2015) but not in the National Seed Bank (T. North pers. comm. 11 September) but ANBG staff plan to collect it in February 2016 (T. North pers. comm. 11 September). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Although insect pollination may occur for this species, *Streblus* species have a flower structure that is specialised for wind pollination (Datwyler and Weiblen 2004, Williams and Adam 2010, cited in DoE 2015a).

Symbiotic relationships: Unknown.

Germination requirements: Germinates readily (DoE 2015a).

Dormancy class: Unknown.

Flowering: It has been observed flowering on Norfolk from December to February and in April (Mills 2007). Closely-related mainland Australian species, *S. brunonianus*, flowers from September to May (Floyd 1989).

Breeding system: Siah's backbone is usually dioecious (plants are either male or female) DNP 2010; many trees are male and therefore do not produce seed (Sykes and Atkinson 1988, Cited in DNP 2010).

Dispersal: Fruit is palatable to birds (DNP 2010) and seed of other *Streblus* species are known to be dispersed by birds (White *et al.* 2003 in DoE 2015a). Fruit of related mainland Australian species, *Streblus brunonianus* ripens January to April (Royal Botanic Gardens and Domain Trust 2015).

Longevity: Perennial. Some remaining large trees on NI are probably decades old (Mills 2015, pers. comm. in D0E 2015a) and trees in all age classes are observed on the island, which indicates that the species is regenerating (Mills 2012 pers. comm. in DOE 2015a).

Life form: Large shrub or tree to 6 m.

Ploidy levels: The chromosome number of *S. pendulinus* is unknown but for those *Streblus* species that have been studied (e.g. *S. smithii* (NZ); *S. banksia* (NZ) and *S. ilicifolius*) a chromosome numbers of 2n=28 has been recorded. The basic chromosome number of *S. asper* is x=14 which would suggest that it is likely they are a diploid genus. (Tropicos.org).

Role of the plant in the environment: Unknown.

Threats

Listed Threats (EPBC Act)

- Grazing pressures and associated habitat changes

- Restricted geographical distribution (area of occupancy and extent of occurrence)
- Competition and/or habitat degradation by weeds
- Infection by parasites
- Low numbers of individuals

Other Threats/Potential New threats

Pests and diseases

A parasite appears to be stopping seed set in many individuals (DNP 2010) but it is unclear what type of parasite this is.

Genetic and demographic effects

Outside the national park when old trees die they are not being replaced as grazing and weeds suppress recruitment (Mills 2015 pers. comm. in DoE 2015a).

Human intervention

Historic clearing has significantly reduced the area of suitable habitat and it is likely that the species occurred in higher densities in the lowland rainforest, a vegetation association that has mostly been cleared on the island (Mills 2015 pers. comm. in DoE 2015a).

Climate related factors

Climate change is predicted to bring about an increasing frequency and intensity of droughts and cyclonic activity. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Current management

Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, seed dispersal, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood. It is also unclear whether the parasite poses a significant threat to the species and, if so, how it can be managed.

Suggested research and actions

1. Avoid actions that are likely to exacerbate weed invasion in this species habitat and continue broad scale weed control in the national park (DoE 2015a).
2. Undertake rehabilitation of native vegetation in Norfolk Island National Park and Norfolk Island public reserves (DNP 2010, DoE 2015a).
3. Investigate whether the parasite that may be preventing seed set is a significant threat to the species and, if necessary, determine the best method of treating the parasite (DNP 2010 in DoE 2015a).
4. Establish an *ex-situ* subpopulation and investigate options for linking, enhancing or establishing additional subpopulations. (DoE 2015a).
5. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
6. Determine the appropriate conditions for long term storage and seed germination.

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B.32 *Wikstroemia australis* (Thymelaeaceae) – Kurrajong, Norfolk Island National Park

Figure 32.1 *Wikstroemia australis* in Norfolk Island National Park. ©C. Jones 2015.

Kurrajong is a shrub or small tree to 4 m or more tall with very tough, fibrous bark. The tubular flowers are greenish yellow and occur in groups of 3–10. The leaves are hairless, 3–7cm long and 2–3cm wide. The fruit are a berry like drupe, 4 mm long and reddish in colour (FoA 1994, DNP 2010, DoE 2015).

Taxonomy: Conventionally accepted as *Wikstroemia australis* Endl. (CHAH 2005, verified 8 September 2015).

Previously known as *Wikstroemia cunninghamii* Meisn.

Status: Listed as Critically Endangered under the EPBC Act on 3 November 2003.

Recovery Plan: Norfolk Island Region Threatened Species Recovery Plan, 2010.

This information is taken from SPRAT (DoE 2015) unless otherwise referenced.

Number of populations inside and outside parks and reserves

Endemic to Norfolk Island, it was once widespread over much of Norfolk Island but since the 1930's has been declining. Most of the population now occurs in scattered pockets inside Norfolk Island National Park (DNP 2010).

Population size – range

155 mature individuals recorded at time of listing (TSSC 2003).

Geographical distribution

Localised and discontinuous.

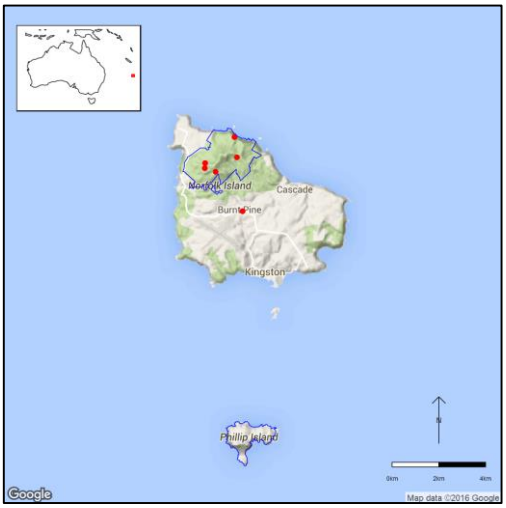

Figure B32.2 Distribution of *Wikstroemia australis* in the Norfolk Island National Park. Red dots are specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Seed of this species is conserved in the National Seed Bank (five collections from cultivated sources grown from unknown wild plants) with plans to collect this species in February 2016 as well as nine plants from an unknown source in Booderee National Park (T. North pers. comm. 11 September 2015 and Z. Knapp pers. comm. 12 October 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Unknown.

Symbiotic relationships: Mycorrhizal fungi association.

Germination requirements: Difficult to propagate, will not grow from cuttings, requires high light for establishment, low levels of natural recruitment have been observed. (DNP 2010).

Dormancy class: Unknown.

Flowering: Mills (2007) observed flowering in *Wikstroemia australis* in September, November, December, March and April. Fruit were observed in December (Mills 2007).

Breeding system: Unknown.

Dispersal: Unknown.

Longevity: Probably short lived (DNP 2010).

Life form: Small tree to 4 m.

Ploidy levels: Unknown.

Role of the plant in the environment: It is found growing on ridges and upper sides of valleys in forest areas, most often in canopy gaps or alongside tracks and roads.

Threats

Listed Threats (EPBC Act)

- Loss and/or fragmentation of habitat and/or subpopulations.

- Restricted geographical distribution.
- Competition and/or habitat degradation by weeds, in particular *Psidium cattleianum* (Cherry Guava).
- Competition and/or predation by rats.
- Presence of pathogens and resulting disease.
- Low fecundity, reproductive rate and/or poor recruitment.
- Low numbers of individual.
- Population senescence and lack of recruitment.

Invasive and other problematic species

A key problem weed is red guava which competes for habitat and is also thought to change soil acidity making recruitment difficult for some species (J. Christian pers. comm. 4 September 2015).

Other Threats/Potential New threats

Competition and/ or habitat degradation by vertebrates

High levels of seed predation by rats are noted in the EPBC listing advice (TSSC 2003)

Pests and Diseases

A survey in 1989 suggested that decline was ongoing and many diseased plants were observed (disease not identified) (Gilmour and Helman 1989 in DNP 2010).

Climate related factors

The soil around Mt Pitt is susceptible to land slip after heavy rain, such as that associated with cyclones which Norfolk Island experiences. This poses a threat to Kurrajongs that grow in this area. Climate change predictions of increased drought and storms and tropical cyclones may impact on this species as it prefers protected sunny and moist areas while landslips associated with increased rainfall may damage or kill trees.

Climate change is also predicted to bring about an increasing frequency and intensity of droughts. Given the small population size, these events may directly and indirectly impact this species. Fire which does not currently occur in the national park, may become a threat. Invasive weeds and pests will be more likely to establish due to increased disturbance and less suitable conditions for local species. (DNP 2010, DNP 2011).

Human intervention

Kurrajong is potentially threatened by habitat alteration associated with land use change; this is primarily a threat to trees outside of the national park. These changes may be suppressing the mycorrhizal fungi associated with the species. This change may also increase the vulnerability of Kurrajong to soil-based fungi and bacterial pathogens (TSSC 2003).

Current management

Weeds are a problem throughout the park and a major threat to *Wikstroemia australis* and many other native species. (DNP 2010). Weed management is conducted in the national park but there is no monitoring program for threatened species (J.Christian pers. comm. 4 August 2015). A rat control program has been implemented within Norfolk Island National Park since 1992 and in March 2006 predation by exotic rats on Australian offshore islands of <1,000 square kilometres (100,000 h) was listed as a key threatening process under the EPBC Act (DNP 2008).

Knowledge Gaps

Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, seed dispersal, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood. Inbreeding depression is a possible cause of the difficulty experienced in germinating seed and of the low recruitment being experienced. Identification of diseases and affecting this species and the impact this is having is also required.

Suggested research and actions

1. Study by an arborist to identify the causal agent for the disease and possible management of it (DNP 2010).
2. Clearing of red guava and other woody weeds around reproductively mature trees and maintaining gaps created to facilitate establishment of young *Wikstroemia australis* (DNP 2010).
3. Establish a monitoring program to provide baseline and ongoing data for determining population trajectories and the relative impacts of threatening processes.
4. Research into seed storage and germination and other methods of propagation (DNP 2010).
5. Determine key life history parameters including pollination, symbiotic relationships, breeding system, maturity and longevity to assist with species management.

6. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding to assist with any future translocation program.

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B.33 *Eremophila alternifolia* (Scrophulariaceae) – Narrow-leaved Emu Bush, Uluṟu-Kata Tjuṯa National Park

Figure B33.1 *Eremophila alternifolia* at the Burrendong Arboretum Wellington, NSW. ©M. Fagg Australian National Botanic Gardens Photo No. a.20000).

Eremophila alternifolia is an erect shrub to 3 m high. The leaves are linear-terete, 2–5.5 cm long and 1–1.5 cm wide. The flowers are solitary in leaf axils. The pedicels are 13–20 mm long. The corolla is 18–30 mm long and of variable colour. It can be carmine or more rarely pink or yellow, with or without spots and glabrous outside. The fruit is woody, glabrous and 5–7 mm long (The Royal Botanic Gardens and Domain Trust 30 October 2015).

Taxonomy: The name *Eremophila alternifolia* R.Br. is accepted in the Australian Plant Census (CHAH 2015, verified 30 October 2015).

Status: Listed as 'Near Threatened' under the Northern Territory *Territory Parks and Wildlife Conservation Act 2000* (TPWC Act, Northern Territory Herbarium 2015).

Recovery Plan: A recovery plan does not exist.

Number of populations inside and outside parks and reserves

The number of populations is unknown. The only population in Uluru-Kata Tjuta National Park is found in drainage lines to the East of Uluru (Uluru-Kata Tjuta National Park 2015 unpublished data).

Population size – range

The species is considered to be rare in the Northern Territory, and population size is thought to be declining. A survey of four areas within Uluru-Kata Tjuta National Park found 200 plants with overall numbers remaining steady during the three years covered by the study (Uluru-Kata Tjuta National Park 2015 unpubl. data).

Geographical distribution

The species is widespread in Australia.

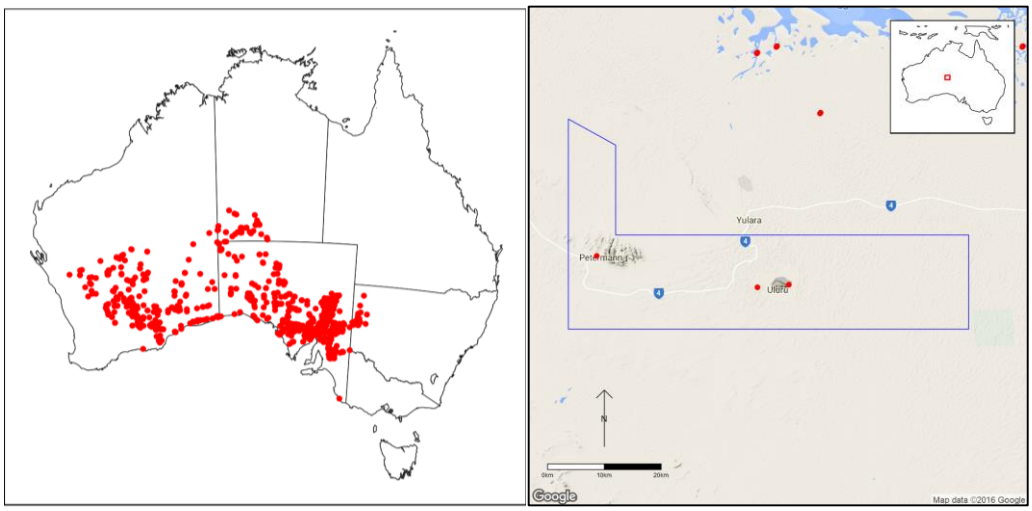

Figure B33.2 Distribution of *Eremophila alternifolia* across Australia (left) and within Uluru Kata-Tjuta National Park (right). Red dots indicate specimen collection, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

The species is propagated in the national park nursery for cultural use by the Mutitjulu community (Uluru-Kata Tjuta National Park 2015 unpubl. data). The species is also held in the Living Collection at the Australian National Botanic Gardens (M. Henery pers. comm. 5 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: Bird-pollinated (Chinnock 2007).

Symbiotic relationships: Unknown.

Germination requirements: Seed of the genus *Eremophila* generally germinates poorly. In natural populations, the seeds germinate after heavy rain in autumn and winter (Richmond and Chinnock 1994). However, seed of *Eremophila alternifolia* germinated readily in the nursery at Uluru-Kata Tjuta National Park (K. Bennison pers. comm. 23 November 2015).

Dormancy class: The seeds exhibit physical dormancy from the hard woody fruits. There may also be a chemical mechanism (Richmond and Chinnock 1994).

Flowering: The species flowers more or less all year round, fruits have been observed from April–October (Northern Territory Herbarium 2015).

Breeding system: Unknown.

Dispersal: Emus are considered to be the primary dispersers of *Eremophila* seed (Moore 2005).

Longevity: Perennial.

Life form: Shrub.

Ploidy levels: According to the available chromosome counts, *E. alternifolia* is diploid with 2n=36 although tetraploid and hexaploid taxa are known with a few species having more than one ploidy level (Barlow 1971).

Role of the plant in the environment: In Uluru-Kata Tjuta National Park, the species grows on red, loamy soil in drainage lines (Uluru-Kata Tjuta National Park 2015 unpubl. data). Like other *Eremophila* species, *E. alternifolia* is traditionally used for medicinal and

cultural purposes by Aboriginal people. *Eremophila alternifolia* may be the most important one of the species and is used both internally and externally (Richmond 1993).

Threats

Listed threats

As *Eremophila alternifolia* is not currently listed under Commonwealth or State Legislation threats to this species are unknown.

Other Threats/Potential New threats

- Climate related factors.
- Invasive weed species.

Climate-related factors

Climate change is predicted to bring higher temperatures and a potential increase in the frequency and severity of drought conditions due to higher evaporation (Hyder Consulting, 2008). The risk of fire might also increase.

Invasive and other problematic species

In many parts of the Northern Territory where *E. alternifolia* is distributed, Buffel Grass (*Cenchrus ciliaris*) and other invasive plants can out-compete native plant species (DNP 2010).

Current management

Fire management, erosion control and invasive species control are undertaken in Uluṟu-Kata Tjuṯa National Park (DoE 2015). Four survey areas were established in 2008 and surveyed for three consecutive years. As numbers remained stable over the survey period, the species is now not surveyed regularly. However, the population is easily accessible and close to a road, so that changes in the population would be recognised (K. Bennison pers. comm. 23 November 2015). The species is propagated in the national park nursery to be planted in the Mutitjulu community for cultural medicinal use (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data)

Knowledge Gaps

The tolerance to fire and fire response are unknown (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data). Species biology and life history including pollination syndrome, symbiotic relationships, seed germination, seed dormancy, breeding system, seed dispersal, genetic diversity, seed dispersal, time to maturity and longevity of this species are unknown or poorly understood.

Suggested research and actions

1. Undertake a fire response trial (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data).
2. Regularly monitor survey areas established in 2008 to provide ongoing data for determining population trajectories and the relative impacts of threatening processes.

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B.34 *Eriachne scleranthoides* (Poaceae) – Mount Olga Wanderrie Grass, Uluru-Kata Tjuta National Park

Figure 34.1 *Eriachne scleranthoides* at Kata Tjuta, NT. ©K. Thiele Australian National Botanic Gardens Photo No. a.1626.

Eriachne scleranthoides is a perennial grass with a shrubby growth 60–105 cm high. The culms are strongly branched and woolly, the leaves mostly glabrous. The leaf blades are up to 2.5 cm long, recurved and up to 1.5 cm wide with scabrous or tuberculate margins and ending in a spine. The inflorescence is a raceme of 1–3 spikelets. The glumes are 3.5–4 mm long and diverge widely at maturity (Lazarides *et al.* 2005). The species is morphologically similar to xerophytic forms of *E. mucronata*, but has florets that are longer than the glumes, recurved leaf blades and reduced and scarcely exserted inflorescences (Lazarides *et al.* 2005).

Taxonomy: The name *Eriachne scleranthoides* F.Muell. is accepted in the Australian Plant Census (CHAH 2015, verified 28 October 2015).

- Synonym: *Eriachne mucronata* subsp. *scleranthoides* (F.Muell.) Domin.

Status: Listed as 'Near Threatened' under the Northern Territory TPWC Act (Northern Territory Herbarium 2015).

Recovery Plan: A recovery plan does not exist.

Number of populations inside and outside parks and reserves

According to Lazarides *et al.* (2005), the species is endemic to the Northern Territory and specimens collected from other regions of Australia are misidentifications that are likely to be *E. mucronata*. *Eriachne scleranthoides* is known from Kata Tjuta (Mt Olga) and Mt Currie (Lazarides *et al.* 2005) with only Kata Tjuta being inside the National Park.

Population size – range

A baseline survey conducted in 2008 at Kata Tjuta estimated approximately 1943 plants along the Valley of the Winds walking track and 5122 plants in Walpa Gorge. The survey was mostly restricted to within 30 m of either side of the walking tracks (Uluru-Kata Tjuta National Park 2015 unpubl. data).

Population sizes at Mount Currie are unknown.

Geographical distribution

The species has a localised distribution in the national park.

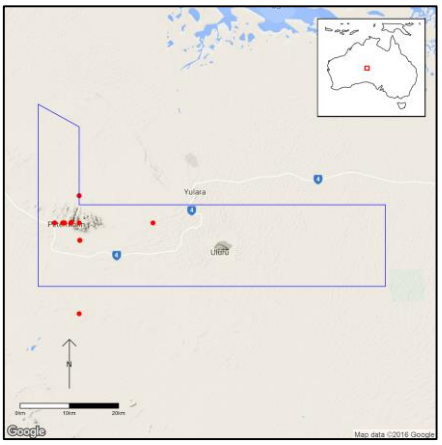

Figure B34.2 Distribution of *Eriachne scleranthoides* in Uluru Kata-Tjuta National Park. Red dots are specimen collections, blue line is park boundary.

Ex-situ collections (Living and Seed Bank)

Seed collections are stored at Uluru-Kata Tjuta National Park (Uluru-Kata Tjuta National Park, 2015 unpubl. data) although the quantity and condition are unknown (K. Bennison pers. comm. 23 November 2015). *Eriachne scleranthoides* is not conserved in the Living Collection at the Australian National Botanic Gardens or in the National Seed Bank (M. Henery pers. comm. 5 November 2015). No other *ex-situ* collections in any other Botanic Garden or Seed Bank have been located (ASBP 2016).

Biology

Pollinators: The species is probably wind-pollinated, like the vast majority of grass species.

Symbiotic relationships: Unknown

Germination requirements: Unknown. Seed from the related species *E. mucronata* has physical dormancy when still enclosed in the spikelets. Following removal seed up to three year old seed germinates well on filter paper under 12 h night at 25°C and 12 h day at 35°C (Silcock *et al.* 1990). Seed older that three years do not germinate well (Silcock *et al.* 1990).

Dormancy class: Seed of the related species *E. mucronata* exhibit physical.

Flowering: Primarily in May and then from August–October (Lazarides *et al.* 2005).

Breeding system: Unknown.

Dispersal: Seed of related species *E. helmsii*, *E. mucronata* and *E. pulchella* were reported to be wind-dispersed (Jurado *et al.* 1991).

Longevity: Perennial. Other perennial *Eriachne* species were reported to live for <20 years (*E. helmsii*) and <50 years (*E. mucronata*, Jurado *et al.* 1991).

Life form: Grass

Ploidy levels: No chromosome counts of any *Eriachne* species are available.

Role of the plant in the environment: *Eriachne scleranthoides* grows on conglomerate monoliths, mostly on the seepage areas of scree slopes, at the base of domes as well as in chasms and crevices (Uluru-Kata Tjuta National Park 2015 unpubl. data). The substrate is shallow sand, gravel or shallow stony red soil (Lazarides *et al.* 2005). The species is susceptible to a fungal disease, *Eriachne* smut (*Macalpinomyces eriachnes*, Ustilaginaceae), that has been found on several other *Eriachne* species.

Threats

Listed threats

As *Eriachne scleranthoides* is not currently listed under Commonwealth or State Legislation threats to this species are unknown.

Other Threats/Potential New threats

- Genetic and demographic effects
- Climate related factors
- Invasive weed species
- Direct human impacts

Genetic and demographic effects

The small distribution area and moderately low numbers of individuals suggest that this species is vulnerable to loss through stochastic events such as fires and prolonged drought.

Climate-related factors

Although the species is well adapted to dry and hot conditions, an increase in the severity and length of droughts due to climate change (Hyder Consulting 2008) might affect the species in its exposed habitats. However, not enough is known to confirm this as a potential threat. Similarly, it is not known if fire is a threat to the species, since fire does not usually occur in *E. scleranthoides* habitat (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data). The threat of competition by invasive Buffel Grass (*Cenchrus ciliaris*) might increase with higher CO_2 concentrations associated with climate change (DNP 2012).

Invasive and other problematic species

Buffel Grass (*Cenchrus ciliaris*) is an invasive pasture grass that occurs in the area and has the ability to out-compete native plants. Invasion of Buffel Grass and other weeds are a potential threat to *E. scleranthoides* (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data). Infection with *Eriachne* smut may impair seed development but this has not been assessed.

Direct human impacts

Kata Tjuṯa is frequented by tourists and plants growing directly adjacent to footpaths can be affected by trampling (K. Bennison pers. comm. 23 November 2015).

Current management

Because of the high numbers of individuals found in the 2008 survey at Kata Tjuṯa, the species is not regularly surveyed. Weeds are removed from Walpa Gorge when present (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data).

Knowledge Gaps

Seed traits such as seed longevity and germination requirements might be similar to those in *E. mucronata*, but this could warrant further investigation. Longevity and ploidy level of the plants are not known.

Suggested research and actions

1. Establish a monitoring program to provide ongoing data for determining population trajectories and the relative impacts of threatening processes.
2. Undertake a fire response trial (K. Bennison pers. comm. 23 November 2015).
3. Determine the appropriate conditions for long term storage and seed germination.
4. Undertake a genetic assessment to determine if any genetic structure exists to assist with any future translocation program.

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B.35 *Santalum acuminatum* (Poaceae) – Desert Quandong, Uluṟu-Kata Tjuṯa National Park

Figure B35.1 *Santalum acuminatum* at Gammon Ranges National Park, Flinders Ranges, South Australia. (left) and *Santalum acuminatum* flowers (right), ©M. Fagg Australian National Botanic Gardens Photo No's dig.32146 and dig.36540)

Santalum acuminatum is a shrub or small tree to 6 m high, with spreading to pendent branches. The leaves are lanceolate, often falcate, 3–9 cm long and 0.3–1.5 cm wide. The inflorescences are mostly terminal panicles and consist of numerous flowers. The tepals are ovate and 1–2 mm long. The fruit is a globose drupe, 15–25 mm long, red or rarely yellow and edible (The Royal Botanic Gardens and Domain Trust 30 October 2015).

Taxonomy: The name *Santalum acuminatum* (R.Br.) A.DC. is accepted in the Australian Plant Census (CHAH 2015, verified 30 October 2015).

Status: Listed as Vulnerable under the Northern Territory TPWC Act (Northern Territory Herbarium 2015).

Recovery Plan: A recovery plan does not exist.

Number of populations inside and outside parks and reserves

Santalum acuminatum is widespread throughout southern Australia. In the Northern Territory, it occurs in many locations south and west of Alice Springs. Populations also occur within in Uluṟu-Kata Tjuṯa National Park and Watarrka National Park (Nano *et al.* 2012). The plants conserved in Uluṟu-Kata Tjuṯa National Park are only a tiny fraction of the total population of this species.

Population size – range

Most populations in the Northern Territory are small with less than ten plants that are probably often part of one clone. The population in Watarrka National Park is the largest with more than 120 plants recorded in 2012 (Nano *et al.* 2012). In Uluṟu-Kata Tjuṯa National Park, most trees occur near buildings or residential areas. In 2011, only 13 wild individuals were known, and only seven of these were in a healthy condition. In 2014, ten wild *S. acuminatum* plants were left (Uluṟu-Kata Tjuṯa National Park 2015 unpubl. data).

Geographical distribution

Santalum acuminatum is common and widespread in Victoria, South Australia and south-western Western Australia. It also occurs in New South Wales and Queensland, and has the northernmost extent of its range in the Northern Territory (Nano *et al.* 2012).

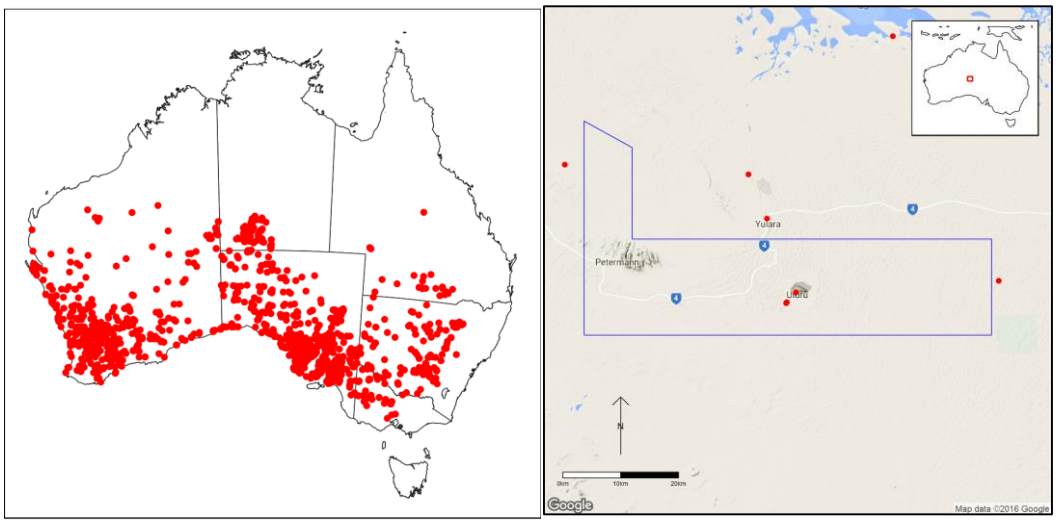

Figure B35.2 Australian distribution of *Santalum acuminatum* (left) and distribution of *Santalum acuminatum* in Uluru-Kata-Tjuta National Park (right). Red dots indicate specimen collections, blue line is the park boundary.

Ex-situ collections (Living and Seed Bank)

Seed collections were made in 2011 and are stored in Uluru-Kata Tjuta National Park (Uluru-Kata Tjuta National Park, 2015, unpubl. data). The Australian National Botanic Gardens in Canberra have *S. acuminatum* plants in the Living Collection as well as several seed collections from Uluru-Kata-Tjuta National Park in the National Seed Bank (M. Henery pers. comm. 5 November 2015 and ASBP 2016). No other *ex-situ* collections taken from the national park have been located in any other Botanic Garden or Seed Bank (ASBP 2016).

Biology

Pollinators: Not known. Possible pollinators might be native bees or flies (K. Bennison, pers. comm. 23 November 2015). Bees, butterflies and beetles are known to pollinate the related species, *S. album* (Veerendra and Padmanabha 1996).

Symbiotic relationships: Unknown.

Germination requirements: To germinate fresh seed, gibberellin GA4 applied by vacuum filtration has been successful as has cracking the seed coat. Applying gibberellic acid by vacuum filtration also increases the germination rate of already cracked seed. Higher germination rates have been observed in older seed and can be enhanced by gibberellin GA4 (Loveys and Jusaitis 1994). In wild populations, seedling emergence and establishment are low (Nano *et al.* 2012).

Dormancy class: *S. acuminatum* seed has a hard seed coat and does not germinate readily. Abscisic acid is likely involved in the expression of dormancy. The seed do not survive high temperatures (Loveys and Jusaitis 1994).

Flowering: The species flowers predominantly from September–January (Nano *et al.*, 2012), and fruits mostly in August–October (Nano *et al.* 2012), however, flowers and fruits have been found in most months (Northern Territory Herbarium 2015).

Breeding system: *Santalum acuminatum* is possibly self-compatible (Segley 1982). The related species, *S. album*, has been found to be predominantly outbreeding although selfing can occur (Veerendra and Padmanabha 1996).

Dispersal: The species can spread clonally by root/rhizome suckering with suckers up to 10 m long. It can also resprout strongly after fire although this response probably varies among populations and it is suggested that large adult trees are less able to resprout (Nano *et al.* 2012). The seed are most likely dispersed by emus (Nano *et al.* 2012) which swallow the fruit whole without damaging the seed (Calviño-Cancela *et al.* 2006).

Longevity: In cultivation, seedlings take at least four years to reach reproductive maturity (Nano *et al.* 2012). Basal resprouts in the wild take up to eight years to mature and have been reported to be fast-growing with a growth rate of about 25 cm per year (Nano and Schubert unpubl. data 2010 cited in Nano *et al.* 2012).

Life form: Shrub or tree.

Ploidy levels: The base chromosome number in *Santalum* is x=10 with four ploidy levels from diploid to octoploid recorded in the genus. All *Santalum acuminatum* specimens examined so far are diploid with 2n≈20 (Harbaugh 2008).

Role of the plant in the environment: Like most Santalaceae, *S. acuminatum* is hemiparasitic, extracting xylem sap from host plant species. The species can use a wide variety of host plants such as *Acacia* and *Casuarina* species, but also other shrubs and trees, and even herbs and grasses (Tennakoon *et al.* 1997). The species is found in dune swales, along creeks, on plains and low rises, only rarely growing on hills. It mostly occurs on sandy and loamy soils on limestone or sandstone. The soils can be relatively shallow (Nano *et al.* 2012).

Threats

Listed Threats (Northern Territory TPWC Act)

- Suspected past and future population reduction where causes have not ceased based on
  - Direct observation.
  - Decline in Area of Occupancy and Extent of Occurrence and habitat quality (weed invasion, fire and camels).
  - Exploitation due to wood harvesting.
    - Effects of introduced taxa (viz. Buffel Grass and camels).
    - Small population size (<10,000 mature individuals) and continuing decline of at least ten percent in ten years or three generations.
    - <1,000 mature individuals in each subpopulation.

Genetic and demographic effects

The very small population that exists in Uluru-Kata Tjuta National Park is susceptible to inbreeding and ongoing genetic decline and any loss of plants through grazing by camels and/or severe fires will further erode genetic diversity. It is also vulnerable to stochastic loss.

Invasive and other problematic species

Invasive weeds, especially Buffel Grass (*Cenchrus ciliaris*), can lead to a diminished habitat quality. Buffel Grass invasion was identified as a threat to some plants in surveys of wild *S. acuminatum* in Uluru-Kata Tjuta National Park (Uluru-Kata Tjuta National Park 2015 unpubl. data).

Camels eat *S. acuminatum* leaves, tear off branches and destroy seedlings, resprouting plants and even adults. Rabbits also feed on *S. acuminatum* (Nano *et al.* 2012, Uluru-Kata Tjuta National Park 2015 unpubl. data). Camels are a known threat to plants in Uluru-Kata Tjuta National Park with surveyed plants being damaged by camel grazing. This damage can impact on plant health and lead to a cessation of flowering (Uluru-Kata Tjuta National Park 2015 unpubl. data).

Santalum acuminatum appears to be more readily colonised by mistletoes (Loranthaceae) than other woody species in the area (K. Bennison pers. comm. 23 November 2015). Infestation by mistletoes could be another factor reducing the fitness of *S. acuminatum* individuals.

Climate-related factors

Shorter plants may be vulnerable to the effects of grass fires and also produce fewer seed. Fire is therefore seen as a threat to *S. acuminatum* (Nano *et al.* 2012). Inappropriate fire regimes can damage plants, for example, one surveyed plant in Uluru-Kata Tjuta National Park was severely burned in a protection burn and died as a result. A few other individuals also show signs of fire damage (Uluru-Kata Tjuta National Park 2015 unpubl. data). In a study set in south Western Australia, it was reported that whole clones died after particularly intense fires (Tennakoon *et al.* 1997). The risk of frequent and severe fire is predicted to increase with climate change, as a result of higher temperatures and possible higher fuel loads (DNP 2012).

Surveys in Uluru-Kata Tjuta National Park found that *S. acuminatum* plants drop leaves during times of low rainfall and do not flower or produce fruit (Uluru-Kata Tjuta National Park 2015 unpubl. data).

Direct human impacts

Santalum acuminatum plants have sometimes been cut to harvest the wood for carving (Nano *et al.* 2012).

Current management

The *Santalum acuminatum* plants in Uluru-Kata Tjuta National Park are regularly surveyed. The first seed germination trials with over 100 seeds only produced two seedlings so collected seed is being stored until better germination methods are developed (Uluru-Kata Tjuta National Park 2015 unpubl. data). There are measures in place to restrict wood harvesting for carving (T. Guest pers. comm., cited in Nano *et al.* 2012). Fire management, erosion control and invasive species control are undertaken in Uluru-Kata Tjuta National Park (DoE 2015).

Knowledge Gaps

The genetic diversity of individual populations and the genetic variation between populations are not known. It is also unclear whether the species is self-compatible. Further research is also required into the species' preferred and, other possible host plants and their influence on *S. acuminatum* (e.g. differences in growth, *cf*. Radomiljac *et al.* 1999 for *S. album*), including how well the species grows without a host.

Suggested research and actions

1. Develop and implement a restoration program to increase population numbers and/or sizes.
2. Determine the appropriate conditions for long term storage and seed germination.

3. Undertake a genetic assessment to determine the reproductive strategy, levels of genetic diversity and inbreeding to assist with any future translocation program.

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Appendix C Gap analysis for individual species

National Park	Species	Common Name	Life form	Pollinators	Symbiosis	Germination	Dormancy	Flowering time	Clonality	Reproductive Strategy	Dispersal	Longevity	Polyploidy	Genetic diversity
BNP	*Cryptostylis hunteriana*	Leafless Tongue Orchid	Orchid											
	Dracophyllum oceanicum		Shrub											
	Galium australe	Tangled Bedstraw	Herb											
	Syzygium paniculatum	Magenta Lilly Pilly	Tree											
	Zieria arborescens subsp. *decurrens*		Shrub											
CINP	*Asplenium listeri*	Christmas Island Spleenwort	Fern	N/A			N/A	N/A						
	Asystasia alba		Herb											
	Dicliptera maclearii		Herb											
	Grewia insularis		Vine											
	Pneumatopteris truncata		Fern	N/A			N/A	N/A						
	Tectaria devexa var. *minor*		Fern	N/A			N/A	N/A						
KNP	*Acacia equisetifolia*		Shrub											
	Hibbertia brennanii		Shrub											
	Hibbertia pancerea		Shrub											
	Hibbertia tricornis		Shrub											
	Hibiscus brennanii		Shrub											
	Jacksonia divisa		Shrub											
	Lithomyrtus linariifolia		Shrub											

Key

- Good information
- Some information
- Inferred
- No information

National Park	Species	Common Name	Life form	Pollinators	Symbiosis	Germination	Dormancy	Flowering time	Clonality	Reproductive Strategy	Dispersal	Longevity	Polyploidy	Genetic diversity
NINP	***Abutilon julianae***	Norfolk Island Abutilon	Shrub											
	Anthosachne kingiana* subsp. *kingiana	Phillip Island Wheat Grass	Grass											
	Boehmeria australis* var. *australis	Tree Nettle	Shrub/small Tree											
	Calystegia affinis		Creeper											
	Clematis dubia	Clematis	Creeper											
	Coprosma baueri	Coastal Coprosma	Shrub											
	Coprosma pilosa	Mountain Coprosoma	Shrub/small Tree											
	Cordyline obtecta	Ti	Shrub/ Tree											
	Elatostema montanum	Mountain Procris	Herb											
	Hibiscus insularis	Phillip Island Hibiscus	Shrub/small Tree											
	Ileostylus micranthus	Mistletoe	Epiphytic mistletoe											
	Melicytus latifolius	Norfolk Island Mahoe	Small Tree											
	Myoporum obscurum	Popwood	Tree											
	Plexaure limenophylax		Orchid											
	Senecio australis		Herb											
	Senecio evansianus		Herb											
	Senecio hooglandii		Herb											
	Streblus pendulinus	Siah's Backbone	Shrub/small Tree											
	Wikstroemia australis	Kurrajong	Tree											

Key

- **Good information**
- **Some information**
- **Inferred**
- **No information**

National Park	Species	Common Name	Life form	Pollinators	Symbiosis	Germination	Dormancy	Flowering time	Clonality	Reproductive Strategy	Dispersal	Longevity	Polyploidy	Genetic diversity
UKTNP	*Eremophila alternifolia*	Narrow-leaved emu bush	Shrub											
	Eriachne scleranthoides		Grass											
	Santalum acuminatum	Native peach	Tree											

Key

Good information
Some information
Inferred
No information

FOR FURTHER INFORMATION

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