

**NATIONAL RECOVERY PLAN  
FOR  
*Tectaria devexa***



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**Natural Heritage Trust**

*Helping Communities Helping Australia*

An Australian Government Initiative

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## **PART A: SPECIES INFORMATION AND GENERAL REQUIREMENTS**

### **A.1 Species**

This recovery plan addresses the management requirements for conservation of *Tectaria devexa*, a terrestrial fern that is known from two varieties:

- var. *devexa* occurs in southern Asia from Sri Lanka to Thailand, south China and Taiwan, the Philippines, Malesia to Vanuatu, and the Rockhampton area of central coastal Queensland; and
- var. *minor* is known from Sri Lanka and from Christmas Island (Indian Ocean) (DuPuy & Orchard 1993; Bostock 1993; Holttum 1960).

### **A.2 Taxonomy**

*Tectaria devexa* (Kunze ex Mett.) Copel. *Philipp. J. Sci. (Bot.)* 2C:415 (1907)

Family Dryopteridaceae: Polypodiatae: Plantae

*Tectaria* is a pan-tropical genus of about 150 species, most diverse in Asia, Malesia and the Pacific region (Bostock 1993). The genus was named from Latin *tectum* (a roof), referring to a membrane that covers the sori. Species from Latin *devexus* (sloping, hanging down) referring to pendulous habit.

**Previously:** *Aspidium devexum* Kunze *Bot. Zeitung* (Berlin) 6:259 (1848) nom. nud., C. Christensen *Ind. Fil.* 71 (1905);

*A. intermedium* Mett. *Farngett.* 4:119 (1858), non Willd. (1810); *A. devexum* Mett. *Ann. Mus. Bot. Lugduno-Batavum* 1:237 (1864) (Bostock 1993)

*Pleocnemia devexa* (Kunze et Mett.) Alderw. *Malayan Ferns* :174 (1908) (Holttum 1991)

*A. membranaceum* Hook. *Spec. Fil.* 5:105 in footnote (1864); *Pleocnemia membranacea* (Hook.) Bedd. *Ferns Brit. Ind. Suppl.* 15: Handb. 225 (1876) (Holttum 1960; 1991)

#### **Known varieties:**

- *Tectaria devexa* (Kunze ex Mett.) Copel. var. *devexa*
- *Tectaria devexa* var. *minor* (Hook.) Holttum *Kew Bull.* 43:486 (1988)  
Previously as *Aspidium giganteum* Bl. var. *minor* Hook., *Spec. Fil.* 4:50 (1862); this was later included in genus *Heterogonium*  
*Sagenia gigantea* var. *minor* Bedd. *Ferns Brit. Ind.* t.243 (1870) (Holttum 1988)

### **A.3 Conservation Status**

#### **Current listings:**

- as *Tectaria devexa* - (Commonwealth) *Environment Protection and Biodiversity Conservation Act* 1999 - Endangered (previously listed under the *Endangered Species Protection Act* 1992).
- as *Tectaria devexa* var. *devexa* - (Queensland) *Nature Conservation Act* 1992 – Endangered; Schedule 2 *Nature Conservation (Wildlife) Regulation* 1994.

Available information indicates continued eligibility of the species (both varieties) for listing:

- The Rockhampton distribution is very restricted and precarious for survival of the species, and the Christmas Island distribution is restricted;
- The total number of mature individuals of var. *devexa* in Rockhampton is less than 50, unless the known populations are able to recover after drought. Evidence suggests this number is likely to continue to decline as aridity increases;
- The total number of mature individuals of var. *minor* on Christmas Island appears to be less than 500, with each single population less than around 150 individuals.

Actions recommended in this plan will provide more accurate data to re-assess the species against the conservation status criteria, if a re-assessment is warranted in the future.

### **A.4 Meeting objects of the EPBC Act**

The EPBC Act requires that recovery plans must have regard to the objects of that Act:

- a) to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance; and

- b) to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources; and
- c) to promote the conservation of biodiversity; and
- d) to promote a co-operative approach to the protection and management of the environment involving governments, the community, land-holders and indigenous peoples; and
- e) to assist in the co-operative implementation of Australia's international environmental responsibilities; and
- f) to recognise the role of indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity; and
- g) to promote the use of indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

The Threatened Species Scientific Committee (TSSC) considers that objects a), b), and c) are inherently addressed by virtue of the purpose of a recovery plan. The remaining objects are addressed specifically below.

#### **A.4.1 International Obligations**

*Tectaria devexa* is not listed under any international agreement specified in the EPBC Act.

The implementation of Australia's international obligations is not affected by this plan.

*Tectaria devexa* is not included in the list of species under CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) that had effect from 11 January 2002.

#### **A.4.2 Affected interests**

The following interested parties were provided with draft material for comment during the preparation of this plan:

<b><i>Christmas Island</i></b>	
Parks Australia North Department of the Environment & Heritage	Australian Government agency responsible for management of Christmas Island National Park and of listed species in the Territory under the EPBC Act and Regulations
Department of Transport & Regional Services	Australian Government agency responsible for providing State-type services in the Territory, including management of Crown Land
Shire of Christmas Island	Elected body
Christmas Island Phosphates	Company mining phosphate
Asia Pacific Space Centre	Company proposing to build spaceport
Department of Finance and Administration	Australian Government agency managing Immigration Reception and Processing Centre
Union of Christmas Island Workers	Industrial union
Island Care Inc	Community based organisation
<b><i>Rockhampton area, Queensland</i></b>	
Ken and Ann Augusteyn	Owners of Capricorn Caves
Queensland Parks & Wildlife Service Environmental Protection Agency	Managers of Mount Etna Caves National Park (Rockhampton)
Mount Etna Caves Management Advisory Committee	Group to make recommendations concerning management of the national park (members from industry, community, tourism and government)
Cement Australia (Pacific Lime)	Company extracting limestone from Mount Etna area (Rockhampton)
Darumbal-Noolar Murree Aboriginal Corporation	Traditional owners (Rockhampton)
Livingstone Shire Council	Local government body responsible for the Capricorn Caves/Mt Etna Caves area (Yeppoon)
Fitzroy Basin Association	Regional NRM body for Rockhampton area
Fitzroy Catchment Group	Local catchment body for Rockhampton area

Queensland Herbarium (BRI) Environmental Protection Agency	Custodians of specimens and databases (Brisbane)
Queensland Museum	Involved in palaeoecological research in Mount Etna area
Central Queensland Speleological Society	Community based organisation; expertise in cave and karst management; history of involvement with Mount Etna mining issues
Queensland Conservation Council	Community based organisation; history of involvement with Mount Etna mining issues
Capricorn Conservation Council	Community based organisation; involvement in Central Queensland issues

### A.4.3 Indigenous people

#### *Christmas Island*

Christmas Island does not have an indigenous population. The first settlement from 1888 was by workers for the Clunies-Ross family who held the Cocos (Keeling) Islands. These were a mix of Javanese people and Cocos-Malays. In addition, Chinese labourers were employed in mining from the late 1890's. In the 1996 census the population was 1,906 - about 70% of Chinese descent, about 20% of European or Australian descent and about 10% of Malay descent (DoTaRS 2002).

#### *Queensland*

The Rockhampton area is part of land traditionally owned by the Darumbal people. The interests of the traditional owners are looked after by the Darumbal-Noolar Murree Aboriginal Corporation.

A native title claim has been lodged over an area which includes the Mount Etna Caves National Park (QPWS 2003). Any consultation with local Indigenous people that is required to implement this plan will be conducted in conjunction with the Queensland Parks & Wildlife Service.

The Rockhampton area is located in the lower reaches of the Fitzroy Basin. Across this very large catchment, the Fitzroy Basin Elders Committee works as a voluntary group of Elders to improve the ability of Aboriginal people to plan and manage projects on their own land, to improve cooperation between Aboriginal and non-Aboriginal communities in cultural and natural resource management, and to raise the profile of Aboriginal interests and aspirations in mainstream natural resource management (CRCCZEWM 2003).

### A.5 Benefits to other species

No negative impacts or perceived negative impacts are likely to affect non-target species or an ecological community arising from implementation of this plan.

In the **Rockhampton** area, actions to protect the vegetation surrounds of the localities at Capricorn Caves and nearby are likely to benefit conservation of semi-evergreen vine thicket communities which are regionally restricted, and which are listed under the EPBC Act as an endangered ecological community (listed 4 April 2001).

This may also serve to improve protection for the vine species *Heterostemma acuminatum* (listed as Rare in Queensland *Nature Conservation (Wildlife) Regulation 1994*), which is known to grow in close proximity to the *Tectaria devexa* site (Barry & Thomas 1996). Queensland agencies identify some fifteen threatened (endangered, rare or vulnerable) plant species that are associated with semi-evergreen vine thickets (CRCCZEWM 2003).

There is additional potential to benefit the conservation of bird fauna associated with these communities, as well as specialised fauna (particularly invertebrates) that occupy caves and associated habitats (QPWS 2003).

On **Christmas Island** actions to protect the vegetation surrounds of some localities are likely to benefit conservation of a number of species of limited distribution which are also found in the vicinity. These include:

- the orchids *Flickingeria nativitatis* (endemic) and *Bryobium pubescens*;
- the ferns *Pneumatopteris truncata* (current nomination for EPBC listing as critically endangered), *Pteridys symmatica*, *Arthropteris palisotii*, *Christella subpubescens*, and *Pteris pacifica* (new record); and
- *Blumea lanceolaria*, *Ipomoea mauritiana*, *Huperzia phlegmaria* and *Ficus saxophila* (Holmes & Holmes 2002).

## A.6 Social and economic impacts

Although most of the known localities of *Tectaria devexa* are outside areas of current economic activity, there is some potential for the presence of the species to constrain economic activity or development. However, this arises from the listing of the species under the EPBC Act, which invokes a range of protective provisions and offences where a population is to be affected, rather than from the provisions of this plan. The magnitude of this potential constraint is unknown, as it will vary with the location, size and extent of an affected population, and the nature and extent of the activity, proposed or current.

Actions arising from this plan that may have some potential to constrain economic activity or development include:

- possible location of additional populations of *Tectaria devexa* in the **Rockhampton** area, where this affects areas currently available to limestone mining or areas proposed for future developments
- possible future additions to the **Christmas Island** National Park specifically to protect an occurrence of *Tectaria devexa*
- identification of *Tectaria devexa* as a component of ecological character in a Ramsar Information Sheet (**Christmas Island**)
- possible identification of *Tectaria devexa* as an element in the heritage values or attributes of a place on the Register of the National Estate or a future heritage listing under the EPBC Act; and
- possible future listing of an area on the Register of Critical Habitat established under the EPBC Act, which affords an additional layer of protection under that Act in Commonwealth areas.

Proposed educational and awareness raising activities based on the species in the **Rockhampton** area (see D.4 and D.5 below) may have a positive impact by enhancing nature based tourism opportunities and promotion in the district.

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## PART B: DISTRIBUTION AND LOCATION

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### B.1 Distribution

*Tectaria devexa* var. *devexa* is known from Sri Lanka to south China and Taiwan, the Philippines, Malesia to Vanuatu, and the Rockhampton area in central coastal Queensland (Bostock 1993).

Var. *minor* is known only from Sri Lanka and Christmas Island. It differs from var. *devexa* in having fronds that are almost hairless beneath, although the veins are hairy (DuPuy & Orchard 1993).

#### B.1.1 Distribution of *Tectaria devexa* in Rockhampton area

In Queensland *Tectaria devexa* is found only on limestone in The Caves area about 23 kilometres north of Rockhampton at approximately 23°10'S 150°30'E (topographic 1:100,000 8951 Ridgeland). In that area the species is known only from two very small populations.

The first official record was from Olsen's Capricorn Caves, collected by S T Blake and L J Webb in April 1945, and noted as according with a specimen in the Queensland Herbarium from the Malay Peninsula (Smith 1946).

This population was recorded in some detail in April 1993 (Barry & Thomas 1996 [summary data sheet]). At that time it included adults and progeny, with some fertile fronds noted, and occupied about 100 square metres (about 50 x 20 metres) in four small discrete populations:

- Camel Cave - 5 individuals
- Vestibule Cave entrance - 16 individuals on the cave floor
- Fern Cave - 9 individuals on the cave wall; and
- passage between Vestibule and Fern Caves – 9 individuals on the cave wall.

Despite speculation that the species was likely to be located in other limestone areas in northern Queensland [e.g. Smith (1946)], Capricorn Caves remained the only known locality until April 2001, when an additional population was located at another cave in the district. The second population comprised about four mature individuals, five or six very small plants and about twelve that had recently germinated (Vavryn (a) *in litt.*).

The discovery of a second and disjunct population almost certainly rebuts a suggestion that the population at Capricorn Caves may have been introduced there (presumably from south-east Asia). It seems improbable that such a highly restricted species would have been able to spread naturally to this second locality, nor is it at all likely that it would have been artificially introduced to that site.

It is clear that the Capricorn Caves population has declined both in historic memory and in recent years. In the mid-1990's, commenting on the only known population at the time, it was noted that the species once covered large sections of the cavern walls but was then isolated to four small areas, with a total estimated population of about 39 adult/sub-adult plants (Barry & Thomas 1996). A noticeable decline in the population was apparent from the mid-1980's to late 1990's (Vavryn *pers. comm.*) and was similarly reported between 2002 and 2003 (Spate *pers. comm.*).

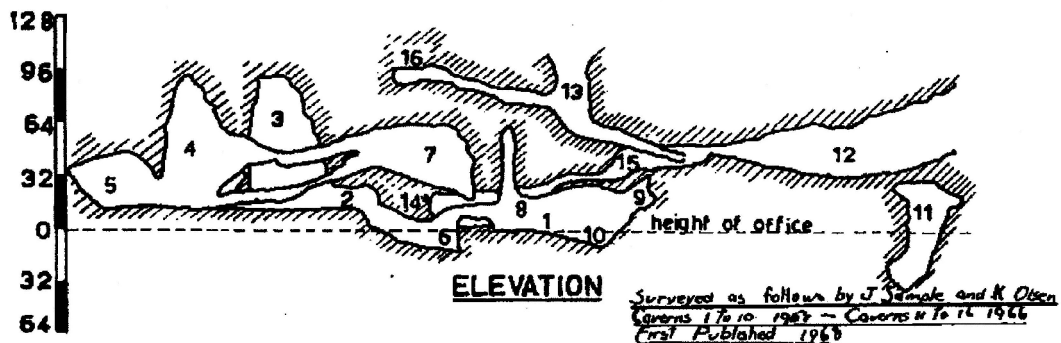
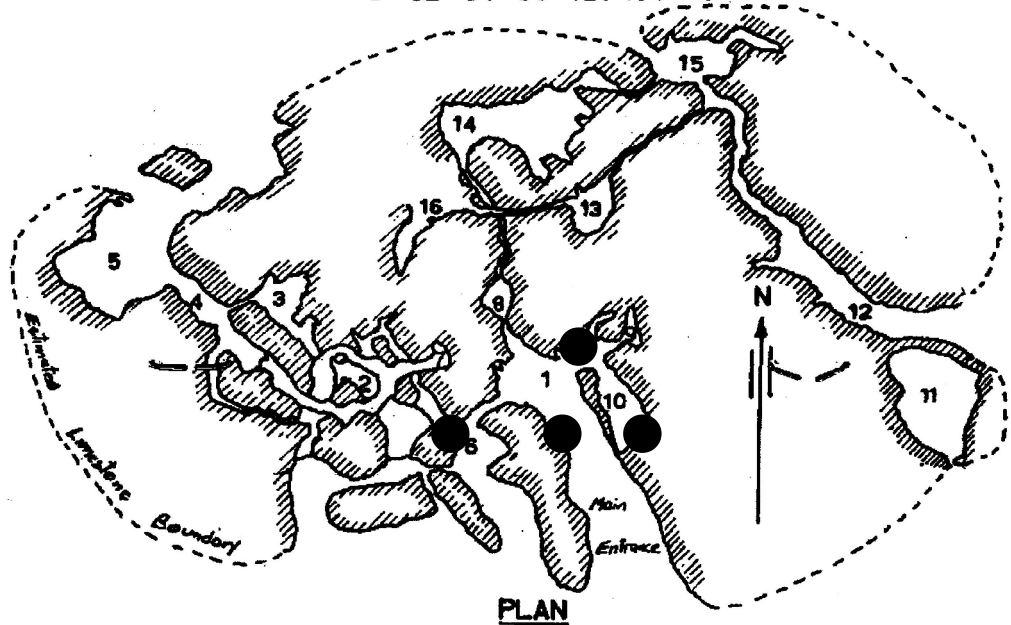
The second population in this area was photographed in about May 2001 but had suffered significant frond mortality by July 2001 (Bostock *pers. comm.*; Vavryn (b) *in litt.*). When visited in July 2003, there was near-total frond mortality, and the only visible individuals were four to five very small sporelings in the deepest recesses of the cave entrance beyond the reach of direct sunlight.

There are reports that *Tectaria devexa* was once more widespread in this district, having previously been found in several locations around the caves, especially on limestone outcrops and in limestone creek channels. Precise locations have not generally been documented, but are attested to by long-term residents (O'Sullivan *in litt.*). There is additional comment on this in B.3.1 below.

The Rockhampton area populations are separated and genetically isolated from other known populations by thousands of kilometres and the species is at the southern limit of its distribution here (Barry & Thomas 1996).

Figure 2 Localities for *Tectaria devexa* – Capricorn Caves

1 Vestibule	cave	<b>LAYOUT OF OLSEN'S CAVES</b>	9 Ice	cave
2 Junction	cave		10 Fern	cave
3 Cathedral	cave		11 Deep vault	cave
4 High dome	cave		12 Horse head	cave
5 Belfrey	cave		13 Flower pot	cave
6 Camel	cave		14 Courthouse	cave
7 Devil's coach	house		15 North	cave
8 Fairy	cave		16 Look out	cave



Base map from Olsen (1976)

● Known localities

○ Potential localities for (re)introduction

Notes: Scale and Elevation shown in feet  
12 Horse head now known as Colosseum



## B.1.2 Distribution of *Tectaria devexa* on Christmas Island

*Tectaria devexa* var. *minor* is described as growing in shaded positions in the primary rainforest on the plateau, usually in areas of deep soil, where it may be the only forest floor species (DuPuy & Orchard 1993). It is also described as occurring mainly on the plateau, in primary rainforest, above 80 metres elevation (Holmes & Holmes 2002).

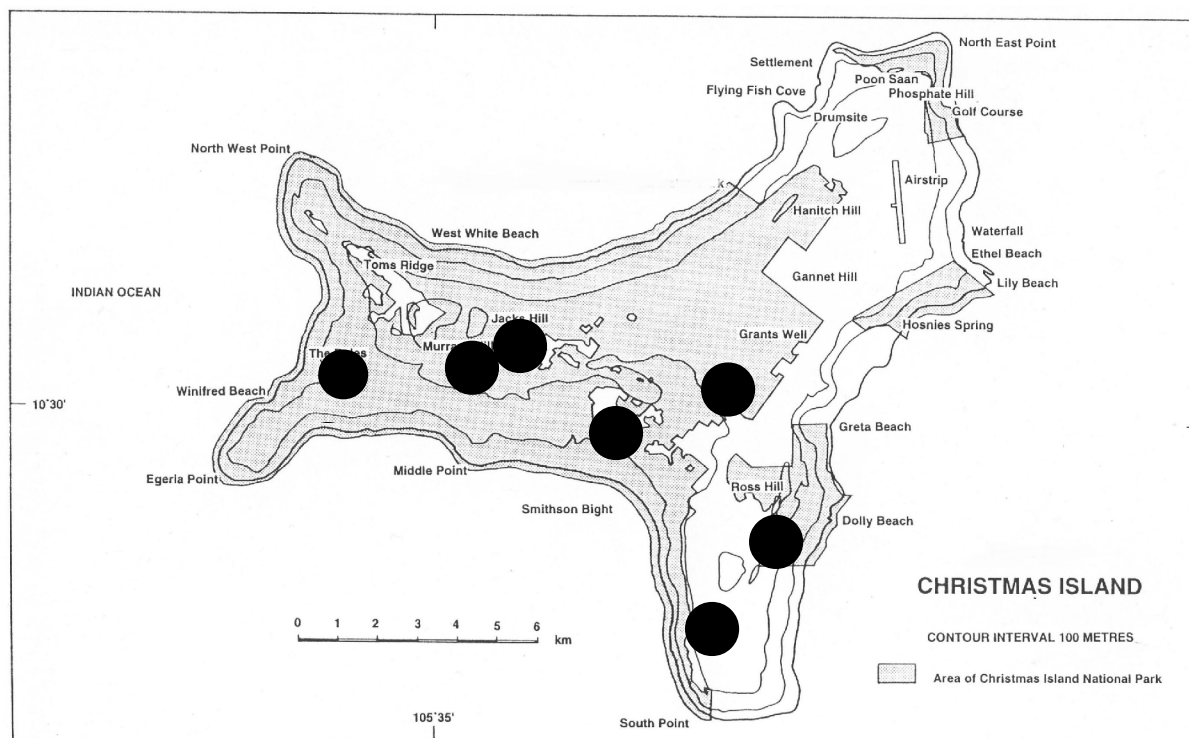
Published records refer to the sources of specimens in broad terms as Flying Fish Cove and the south side of the island on (drill) Line 256 (DuPuy & Orchard 1993).

Recent survey work has provided more precise localities:

- A survey of flora in March-April 2002 notes just over 400 individuals from 16 sites in eight broad locations (some with up to five sites), from near Sydney's Dale at the western end of the island along the length of the central plateau to Limestone Hill in the south-east towards South Point (Holmes & Holmes 2002).
- A survey carried out as part of environmental assessment for proposed expansion of phosphate mining located three plants in a small tree fall gap with filtered light conditions on the southern part of the plateau; a precise location is to be provided once the report is released (Reddell; Zimmermann *pers. comm.*).

The species does not appear to be very widespread and is nowhere abundant, occurring in very small clumped populations (Zimmermann & Reddell *pers. comm.*), with the most specific and recent records listing populations ranging from 1 to about 150 individuals (Holmes & Holmes 2002).

**Figure 1** Localities for *Tectaria devexa* – Christmas Island



Base map © Commonwealth of Australia

● Known localities

### Possible confusing species

Some verbal indications were given that the species may be quite common across the plateau. This is probably incorrect, given the relative paucity of precise locations, relatively low populations, and the contrary indications of biologists experienced with the flora.

It is possible that there is some confusion with *Tectaria dissecta* (G. Forst.) Lellinger. This species is described as not uncommon in deep soil on the plateau and upper terraces in deeply shaded positions under the primary rainforest.

*Tectaria dissecta* specimens are noted from Phosphate Hill, Murray Hill track, Aldrich Hill, Headridge Hill and the south side of the island on Line 256 (DuPuy & Orchard 1993). Most of these are also locations for *T. devexa*. The overlap of habitat preferences between the two is shown in the most recent survey (Holmes & Holmes 2002), in which 8 of the 44 sites recorded for *T. dissecta* also contained *T. devexa* (these being 8 of the 16 recorded locations for *T. devexa*).

*Tectaria dissecta* bears a reasonably close resemblance to *T. devexa* var. *minor*. The two may be confused without close examination, since *T. dissecta* is distinguished by having less finely divided fronds with no anastomosing veins (DuPuy & Orchard 1993). *Tectaria dissecta* appears to be the only species on the island with which *T. devexa* could be confused (Reddell *pers. comm.*).

## B.2 Important populations

An important population is one that is necessary for the species' long-term survival and recovery. This may include populations that are:

- key sources for reproduction and dispersal
- necessary for maintaining genetic diversity
- near the limit of the range of the species.

In the **Rockhampton** area, both known occurrences need to be regarded as important populations, in view of:

- the highly restricted range
- uncertainty about the factors in limited distribution
- low population sizes
- decline in numbers at Capricorn Caves and significant fluctuations in the second population
- separation and genetic isolation from other known populations (of a different variety) by thousands of kilometres; and
- location at the southern limit of distribution.

Any additional populations in the area that are recorded during the life of this plan also need to be regarded as important populations.

On **Christmas Island**, in view of low numbers and uncertainty about the factors in limited distribution, it would be prudent to consider all occurrences as important populations.

Two localities in particular warrant attention, being by far the largest known groupings of plants and containing about 90% of the known population (Holmes & Holmes 2002):

- an aggregation of six sites near Murray Hill, totalling about 210 plants; and
- two sites near Sydney's Dale, totalling about 170 plants.

## B.3 Habitat

### B.3.1 Defining habitat

Most published information offers relatively little (and some contradiction) regarding habitat factors:

- Copeland (1907) [cited by Barry & Thomas 1996] refers in a taxonomic review (based on Asian material) to *Tectaria* as a genus of 'tropical ferns the specialization of which for the most part is in adaptation to moist and windless habitats'.
- Holttum (1960) describes *Tectaria devexa* as confined to limestone rocks in Malaysia and also in southern China, and speculates that it may be confined to this habitat.
- Smith (1964) states [of var. *devexa* at Capricorn Caves] that it occurs 'on ledge in crevice in limestone hill supporting monsoon forest' and 'appears to prefer a calciferous substrate'.
- Jones & Clemesha (1981) cite its habitat in Australia as limestone formations under rainforest or dense cover on ledges or crevices where litter and humus collects.

- Holttum (1988) notes that var. *devexa* is ‘always on limestone, usually at the bases of limestone cliffs, not in crevices’ and notes of var. *minor* that ‘there is no record of the occurrence of this on limestone; Christmas Island consists largely of rock phosphate’.
- Andrews (1990) cites its Queensland occurrence as ‘on ledges in crevices of limestone hills’.
- DuPuy (1993a) locates it on Christmas Island only in primary rainforest, where it is ‘occasional’.
- DuPuy & Orchard (1993) state that on Christmas Island it grows in shaded positions in the primary rainforest on the plateau, usually in areas of deep soil, where it may be the only forest floor species in this type of habitat.
- Holmes & Holmes (2002) describe it on Christmas Island as growing colonially, mainly on the plateau, in primary rainforest (tall and largely undisturbed), above 80 metres elevation; both in deeper soils and as a lithophyte (on mossy pinnacles at the base of a slope, a wet site).

In the **Rockhampton** area, *Tectaria devexa* var. *devexa* is clearly restricted to limestone, generally in thin soil pockets in walls and floors of cave entrances, and at times deeper within caves where light penetrates only occasionally.

At Capricorn Caves the species grows in virtual isolation from other vascular plants. Soil in crevices and ledges is shallow (even skeletal), while that in the floors is acid dark brown sandy clay loam of pH 5.5. The acid nature of the soil is ascribed to the accumulation of bat guano in the cave floor (Barry & Thomas 1994). This occurrence is well sheltered, facing south, with a surround of semi-evergreen vine thicket.

In the second occurrence in the area the species grows in a similar situation, in small ledges and crevices on the walls of a collapse cave entrance. Although this opens to the north-northwest, it is largely sheltered by a surround of semi-evergreen vine thicket. Recent mortality at this site may have been exacerbated by loss of some of the canopy cover in the north-west sector of the surrounding vegetation. There are no data regarding acidity of the soil at this site or its use by bats.

The semi-evergreen vine thicket around both localities was once widespread but is now in small isolated remnants. It is characterised by tall emergent trees above a continuous canopy of lower trees and shrubs with a wide variety of vines (Kay ?1994).

It seems likely that the disjunct distribution of *Tectaria devexa* is due to the retreat and fragmentation of rainforests in the post-Tertiary period due to increased aridity and seasonal climatic fluctuation (Barry & Thomas 1996). Further drying of the climate may have encouraged semi evergreen vine thickets, which can tolerate low rainfall (down to 70-100mm per annum). In such scrubs, ferns are generally rare or absent (Kay ?1994), and the species may have retreated further - into cave entrances, where light and wind are diminished and moisture is conserved. On northerly aspects, this may have favoured retreat to collapse cave entrances which offer a deeper level of protection.

Anecdotal reports suggest that *Tectaria devexa* was previously more widespread in the area, alongside streams flowing north from Mount Etna (Barry & Thomas 1996), or on limestone outcrops and along limestone creek channels (O’Sullivan *in litt.*).

These reports may indicate historical confusion with *Tectaria muelleri* (= *T. confluens*). This species is described in the literature as being endemic to north-eastern Queensland, from Cooktown to just south of Mackay – a widespread terrestrial fern in various types of rainforest, usually in gullies (Bostock 1993). However, other (secondary) sources cite the Mount Etna/Limestone Ridge area as the southern limit of *Tectaria muelleri* (AHC n.d.).

The anecdotal reports are significant either way. Whether they indicate retreat of *Tectaria muelleri* to the north or the retreat of *Tectaria devexa* to sheltered cave entrances, they suggest the effects of environmental change in the surrounding district. If they do refer to *Tectaria devexa*, this may enlarge the area of potential habitat, although this can still be confined to the extent of the limestone.

On **Christmas Island**, *Tectaria devexa* has been documented adjacent to old drill lines where more light can penetrate to the forest floor but where it remains reasonably sheltered from winds. This may suggest that it favours locations where the canopy of the primary rainforest has been disturbed to some extent, with small gaps formed by treefall due to wind damage or by selective clearing. Relative to rainforests in nearby parts of south-east Asia, the Christmas Island flora includes few gap specialists of

this sort (Reddell *pers. comm.*). This is likely to be due to a comparatively lower and more sparse rainforest canopy on the island, providing (in the main) well-filtered medium light levels (Holmes *pers. comm.*).

Certainly in the Christmas Island rainforests, the species is recorded also from undisturbed areas, indicating that on that island it is not confined to functioning as a pioneer species or gap-specialist (Holmes *pers. comm.*; Claussen *pers. comm.*).

Despite their very different environments, the populations in the Rockhampton area and on Christmas Island seem to exhibit much the same fundamental habitat requirements:

- limestone substrate (although on soils of quite different depth, and possibly different acidity)
- moisture
- moderated or filtered light (in preference to deep shade); and
- considerable protection from wind.

### **B.3.2 Potential habitat**

The highly restricted current habit of *Tectaria devexa* in the **Rockhampton** area suggests a species that has retreated from increasing regional aridity (and possibly to some extent from vegetation clearance and pesticide runoff), and that is declining in numbers due to drought over recent years.

Nonetheless, the recent discovery of a second population at a cave entrance not far from the previous sole locality at Capricorn Caves is most significant because it indicates a potential for further populations in the karst landscapes of the Rockhampton area (covering about 1,150 hectares).

Highest potential would be sheltered cave entrances with a southerly aspect, offering multi-angled rock structures and walls with areas that are highly micro-textured due to water flow, and (possibly) also deep floor sediments at the base of cliffs. There is also potential on more northerly aspects in collapse cave entrances with similar form.

The nearest broadly comparable karst habitat is the Chillagoe-Mungana area west of Cairns, about 1,100 kilometres to the north-west (Barry & Thomas 1996). The flora of that area have been well documented through decades, and *Tectaria devexa* has not been reported there (Bostock *pers. comm.*)

On **Christmas Island** all plateau rainforest might be considered potential habitat.

In considering whether canopy gaps are of any significance to distribution and population sizes of the species on that island, any enquiries should take into account gaps:

- due to storm damage and treefall
- around larger limestone outcrops; and
- along old drill lines across the central plateau.

It has been suggested that potential habitat on the central plateau may include artificially moist areas near the water supply works, such as Jedda Cave and Jane-Up (Sewell *pers. comm.*). However, these sites have previously been surveyed for *Tectaria devexa*, with none being located (Claussen *pers. comm.*).

## **B.4 Habitat that is critical to the survival of the species**

### **B.4.1 Defining and mapping habitat that is critical to the survival of the species**

Definition of habitat that is critical to the survival of *Tectaria devexa* needs to take into account the following matters from EPBC Regulation 7.09:

- habitat used in periods of stress
- habitat used to meet essential life cycles
- habitat used by important populations
- habitat necessary to maintain genetic diversity and long-term evolutionary development
- habitat necessary to ensure the long-term future of the species through reintroduction or re-colonisation.

There is insufficient information at this time on the biophysical needs of the species to identify with confidence the location and extent of habitat critical to the survival of the species.

The precautionary approach taken is to delineate around each known population a buffer of 50 metres in which there should be little or no change permitted to the biophysical parameters without careful consideration for protection of the species (although this could include deliberate disturbance to favour the species).

The environs of any additional populations that are either newly confirmed or newly located or more precisely defined within the term of this plan need to be similarly regarded, and defined with a buffer of 50 metre radius as habitat critical to their survival.

Due to the potential threats (see Section C) the precise locations of any populations and their habitat surrounds should remain confidential in any listing or public record, with the exception of the well-known location at Capricorn Caves. As an aid to confidentiality, a buffer of at least 1 kilometre around each known locality should be applied in publicly available mapping for EPBC referral and enquiry purposes.

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## **PART C: THREATS**

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### **C.1 Biology and Ecology relevant to threatening processes**

*Tectaria devexa* at Capricorn Caves has survived periodic droughts, sometimes for a number of years, although possibly only as spore (Barry & Thomas 1994). This apparent hardiness needs to be balanced against the historical (and apparently continuing) decline in population size at Capricorn Caves and the recent rapid decline of the second population in the Rockhampton area.

Little is known of the general biology, life history or growth requirements of *Tectaria devexa* beyond its obligate use of a limestone substrate (Holtum 1960; 1988).

It has been suggested that the species may exhibit asexual reproduction such as vegetative propagation or production of seeds without fertilisation. Vegetative reproduction has not been reported, and plants do not develop buds on the fronds, stem or roots (Bostock *pers. comm.*). The tendency of the species to be found in clumps on Christmas Island (Reddell *pers. comm.*) may result from vegetative propagation, but this is not confirmed.

The species is known to germinate from spore, given adequate conditions of moisture, temperature and light (Barry & Thomas 1994). Broader cultivation of the species is largely unknown, but may not be difficult in a soil mix containing lime (Jones & Clemesha 1981).

There is doubt that on Christmas Island *Tectaria devexa* necessarily functions as a gap specialist (see B.4.1 above). Where a species functions in this way, it is likely that it can survive at low densities, with spore available on the forest floor for whenever a suitable opportunity arises. Once a canopy gap appears, the species grows abundantly and very quickly to exploit the opening for as long as it remains open, and then senesces, leaving more spore latent on the forest floor (Bostock *pers. comm.*). For such pioneer species, the period to senescence may be as short as five years (Chinnock *pers. comm.*). It must be noted that because *Tectaria devexa* is not confined to canopy gaps on Christmas Island, it is by no means certain that these characteristics can be applied to the species in that habitat.

### **C.2 Identification of threats**

#### **C.2.1 Rockhampton area - threats**

It is clear that both recorded populations in this area have declined in recent years, and anecdotal reports suggest a broader decline in historic memory.

Potential threats include:

- stochastic events
- clearing of native vegetation in the surrounding landscape
- degradation of native vegetation by fire or weeds
- pesticide runoff
- unauthorised collecting
- impact by human visitors (direct disturbance or pathogens)
- mining of guano and other non-tourist uses
- mining of limestone; and
- scientific (palaeoecological) enquiry.

#### **Stochastic events**

Fluctuations involving flood events alternating with periods of prolonged drought have been cited as a factor in recent declines at Capricorn Caves (Barry & Thomas 1994). Drought is similarly cited as a likely factor in the decline of the second population near Rockhampton, although spores or desiccated gametophytes may be preserved in dried moss and soil pockets (Bostock *pers. comm.*).

In average monthly conditions, evaporation in the district exceeds rainfall, except in February when they are roughly equal. In the fourteen months from December 2001 to January 2003 serious to severe rainfall deficiencies were recorded over most of Queensland including Central Queensland (CRCCZEW 2003).

The owners of Capricorn Caves relate that most of the years since 1988 have been very dry, punctuated by extreme events of short duration such as the 1991 floods caused by a cyclonic weather pattern, which resulted in the rise of groundwater within the caves. Such fluctuations may have prevailed for much of the past century, since a history written by a third-generation Olsen family member cites dry weather patterns causing trees to fall over (Augusteyn *pers. comm.*).

The anecdotal accounts are supported by data which suggest that the central Queensland region exhibits a high degree of variation in climate, with the most marked effect recorded closer to the coast (BoM 2000). The trend over the last century has been for mean annual rainfall to reduce by an average 40 to 50mm per decade, with most of this decline in the last 50 years (Stone *pers. comm.*).

Mean annual rainfall for Rockhampton is about 820mm, based on data for the last few decades. Because of skewed distribution, the modal or median rainfall may provide a better indication of typical rainfall at about 680mm, based on the period 1871-2000. Over this 130-year period, average annual rainfall at Rockhampton has declined by about 300mm with a steady downward trend (Dayton 2002).

In addition to lower rainfall, CSIRO data show a general trend to increased temperatures which brings with it increased evaporation. When the effect of these is taken into account, net effective annual rainfall at Rockhampton is projected to decline by the year 2060 to about 200mm, being 600mm rain less 300-500mm increased evaporation (Dayton *pers. comm.*).

The regional trend to increasingly unreliable rainfall appears to pose a significant threat to continued survival of *Tectaria devexa*. The species appears to be adapted to a tropical wet and dry season cycle, dying back in the dry, germinating from spore reserves with the arrival of the wet, and producing more spore before the onset of the next dry. Rockhampton's climate has not functioned in quite this way for decades, and it seems likely that germination has occurred in heavy rainfall episodes ('false wets') and has then been followed by a return to drought. If specimens desiccate before new spore can be produced, the reserves of spore may be rapidly exhausted.

#### **Clearing of native vegetation**

An estimated 63% of the native vegetation in the Fitzroy Catchment has been cleared since European settlement (CRCCZEW 2003). As elsewhere in the Fitzroy Basin, with most of the land used for grazing, cropping or agriculture, this clearing has been focused on low relief areas with deeper soils of alluvium or colluvium, leaving remnant areas fragmented (Fitzroy Basin Association n.d.). More locally, about 40% of the original vegetation remains on the Capricorn Caves block of 32 hectares (Kay ?1994).

There are no data to indicate whether vegetation clearance on the limestone ridges of the district has contributed to the highly restricted distribution of *Tectaria devexa* through destruction of habitat. However, this is proposed as a factor in the anecdotal decline in area occupied by the species in the district (O'Sullivan *in litt.*).

It seems likely that vegetation such as vine thickets in the vicinity of a population would have an effect on microclimate, providing dappled light and some amelioration of drying that may favour the species (Bostock *pers. comm.*). Inspection of the second population in the area noted mortality in a significant tree crown in the vine thicket on the northern side of the cave entrance. This allowed an increase in direct sunlight striking the walls of the entrance (particularly in the afternoon), and may in turn have contributed to the near-total mortality of the population.

There are no indications that any known locality of *Tectaria devexa* is likely to be affected by vegetation clearance.

#### **Degradation of native vegetation by fire or weeds**

There are indications that a variety of threatening processes, including fire and weeds, have contributed to historic degradation of native vegetation in the district.

There are no data to confirm that fire has had a direct or indirect impact on *Tectaria devexa*, but a threat may be inferred. Fire generally destroys dry rainforest structure (QPWS 2003), and this has the potential to directly and adversely affect a population of *Tectaria devexa*. There may also be an indirect threat, since loss of dry rainforests due to burning on karst areas usually leads to rapid and prolific weed invasion, mostly by lantana (QPWS 2003).

The owners of Capricorn Caves cite numerous weeds in the forest and thickets, including madeira vine (*Anredera cordifolia*), lantana (*Lantana camara*), rubber vine (*Cryptostegia grandiflora*), mother of millions (*Bryophyllum tubiflorum*) and coral berry (*Rivina humilis*) (Capricorn Caves n.d.). Of these, lantana and rubber vine are Weeds of National Significance (Weeds Australia 2003).

There are no data to confirm that any of these weeds have had a direct or indirect impact on *Tectaria devexa*, but a threat may be inferred.

Madeira vine occurs in the Fitzroy Catchment and is targeted as a high priority for eradication, to avoid the devastating impact it has had on many vine thicket and rainforest ecosystems in south-east Queensland (CRCCZEWM 2003). This species is suggested as a factor (along with lack of rainfall) in reduced density of vine thickets at Capricorn Caves (Kay ?1994).

Rubber vine is said to have the potential to destroy all deciduous vine thickets in northern Australia (Mackey n.d.), and although this may be less of a threat in central Queensland, there is potential in the Rockhampton area for vine thickets to be overtaken by rubber vine. Should this occur near The Caves, a cave entrance harbouring *Tectaria devexa* may quickly become choked (as reported at the Undara lava tubes south-west of Cairns). However, the owners at Capricorn Caves indicate that recent drought years may have kept the spread of such weeds in check (Augusteyn *pers. comm.*).

Weed control programs involving herbicides may have a significant impact on *Tectaria devexa* and on other karst dependent biota, although rubber vine is being attacked with a biological control agent (a rust), which may also have contributed to weed suppression in recent years (Melzer *pers. comm.*).

Rehabilitation of former mined areas in the vicinity of a population of *Tectaria devexa* has some potential to introduce weed species or to create a different (perhaps unfavourable) vegetation structure. There are no records of the species in any formerly mined areas.

#### **Pesticide runoff**

This is proposed as a factor in the anecdotal decline in area occupied by the species in the district, which is said to have included limestone outcrops and creek channels (O'Sullivan *in litt.*). There are no data to confirm this.

#### **Unauthorised collecting**

There is no evidence of unauthorised collecting of *Tectaria devexa*. There is potential for collecting of specimens or propagules of rare species by or on behalf of fern enthusiasts. The likelihood or extent of such a demand cannot be predicted. However, in view of the small population numbers known, any such predation could pose a significant threat to the survival of *Tectaria devexa*.

#### **Visitor impact**

It is not known whether historic tourist use of the Capricorn Caves area has contributed to the highly restricted distribution of *Tectaria devexa* through direct or indirect impact.

According to Olsen (1976), early visitors and pioneers left significant remains behind near the main entrance, noting that 'thousands of pieces of glass' from broken bottles are buried at the base of nearby limestone cliffs, having been smashed against the rocks. Noting the comment from Holtum (1988) that var. *devexa* is found 'usually at the bases of limestone cliffs', it is possible that the species would have been impacted by such practices.

A possible factor cited in historic decline of the species is the impact of carbon monoxide emissions in the caves when petrol generators were used to power lights. This refers to use of a generator to power electric lights in Fern Cave from the 1920's (Barry & Thomas 1996). Apparently the ferns in this cave declined to such an extent that this cave would not be so named today (Augusteyn *pers. comm.*). The generator was subsequently removed to an external structure, and no threat of this nature continues.

After World War II, the sealing of the Bruce Highway from Brisbane to Cairns bolstered visitor numbers and the caves became a regular tourist attraction. The Olsen family sold the caves to Ken and Ann Augusteyn in 1988, and visitor numbers doubled from 1988 to 2000. A broader range of visitor experiences was introduced, including educational packages and adventure cave tours. The area was redeveloped to include a visitor centre, swimming pool, barbecues, a wheelchair ramp into Cathedral



cave, a caravan park with 20 powered sites, modern facilities, a self-contained bungalow for guests, and an eco adventure lodge to sleep 50, with conference facilities (Capricorn Caves n.d.).

The owners have demonstrated sound environmental practice in their management, recognised by their achieving Advanced level eco-tourism accreditation and being winners of several Queensland awards for tourism and landcare (Capricorn Caves n.d.).

Potential impacts from visitor use include direct impact or disturbance to plants growing in the cave floor or close to tourist paths or boardwalks, including trampling, soil compaction, and potential illegal collecting (Barry & Thomas 1994). There would now appear to be minimal risk from such impact, since visitors are generally in small groups and always accompanied by a guide, and most of the ferns are not in locations where direct contact is possible (the exception being the narrow passage between the Vestibule and Fern caves) (Augusteyn *pers. comm.*).

Another possible factor in decline is inadvertent introduction by visitors of pathogens (CRCCZEW 2003). There is no evidence of this as an agent of decline, or of any studies to determine its relevance.

As an indication of the scale of visitation, numbers recorded for other attractions in the Mount Etna Caves area include:

- guided tours to Bat Cleft – showing numbers per season ranging from about 200 to about 400
- Cammoo Caves (when a privately run tourist operation) – showing numbers from about 10,000 in 1993 falling to about 5,000 in 1998.

Recognising visitor demand, the Queensland Parks & Wildlife Service is proposing to develop and promote part of the Cammoo Caves as a self-guided visitor experience. The working draft management plan proposes the development of a major visitor park entrance in the Cammoo area and a range of additional developments for access, recreation and environmental education. These have the potential to increase visitor numbers to Mount Etna Caves National Park to an estimated 10,000 per annum (QPWS 2003). It is not clear whether any of the areas likely to be subject to increased visitation have been surveyed for *Tectaria devexa*.

The recent decline apparent in the second population in the Rockhampton area suggests that it may be prudent to avoid disturbance by visitors of dried moss and soil pockets which may protect spores or desiccated gametophytes during drought (Bostock *pers. comm.*). This may require restriction of use of certain entrances, and/or prohibition of climbing of rock walls in some areas.

### **Mining of guano and other non-tourist use**

Historically, the caves have experienced a variety of potentially degrading uses. The Capricorn Caves were leased for mining of bat guano (to be used as fertiliser) around the turn of the 20<sup>th</sup> century. A mining map in 1903 shows guano deposits in a number of the main chambers, including the Belfry, Cathedral, Junction, Camel, Vestibule, Deep Vault, Colosseum, Courthouse and North caves. The deposit in the Courthouse was said to be 20 metres deep and it was proposed to blast open a new access to that cave. Although this modification was not permitted, some infrastructure was built to extract guano, including a tunnel between the Belfry and Cathedral caves, and a loading ramp from the Belfry entrance (Augusteyn 1995).

There are no data to confirm that *Tectaria devexa* was impacted by guano mining, however some of the areas directly affected by extraction and processing (such as the collapse entrance of the Belfry) are areas where the species might reasonably be expected to have grown.

The Mount Etna Caves (also known as Johanssen's Caves) experienced guano mining from 1914 to 1939 (QPWS 2003), and according to Olsen (1976) 'blasting of rock and associated industrial activity utterly destroyed these beautiful caves', which had formerly been open for public tours. The Olsen family were strong advocates for prohibition of guano mining in the area, and this was finally achieved as late as 1968. It is not known whether *Tectaria devexa* was impacted in this area.

During World War II thousands of American soldiers were stationed in the area at Camp Caves, which was in use until early in 1944, and parts of the Capricorn and Mount Etna caves were apparently used by commandos for training, and to store guns and ammunition (QPWS 2003). It is not known whether *Tectaria devexa* was impacted by these activities.

### **Mining of limestone**

It is not known whether historic mining of limestone in the area has contributed to the highly restricted distribution of *Tectaria devexa* through destruction of habitat, or whether current or future mining may pose a threat to potential habitat.

Mining for cement production has been occurring at Mount Etna since 1925, and from at least the 1980's this activity sparked concern about the conservation of the caves, and particularly ghost bat (*Macroderma gigas*) and little bent-winged bat (*Miniopterus australis*) populations. Bat Cleft is Australia's largest known maternity site for little bent-wing bats, with 80% of the total population reliant on this cave (AHC n.d.). Parts of the area were protected in the Fitzroy Caves National Park in 1976 and select parts were later included in small reserves for scientific purposes (QPWS 2003).

Parts of the limestone area at Mount Etna are listed for their natural heritage value on the Register of the National Estate as 'Fitzroy Caves area, The Caves Qld' (listed 25 August 1981) (AHC n.d.).

Mount Etna became the focus of a significant conflict between conservation and speleological groups on one hand and the mining company and government on the other – a conflict which ran for more than 25 years. Some highly significant caves were destroyed by blasting and large areas degraded until a High Court ruling in 1989 led to a new approach to balance production with conservation and to rehabilitate degraded areas. The Mount Etna Caves National Park was established in 1990, and subsequently enlarged when Queensland Cement Ltd (Pacific Lime) helped to purchase Cammoo Caves in 1999 and donated additional land for the park (QPWS 2003).

Limestone from the region is used primarily for cement or lime, as well as flux for smelters such as that at Gladstone. Statewide trends suggest a steady increase in limestone production, fuelled in part by the construction of Australia's largest cement plant at nearby Gladstone (Bruvel 1999). However, mining of limestone near Mount Etna is likely to cease altogether by the end of 2003, with another 5 to 10 years committed to rehabilitation works (White *pers. comm.*).

No mention has been located of the possibility of *Tectaria devexa* being found in the Mount Etna mining area, or of survey for the plant before mining or rehabilitation operations are undertaken. However, those responsible for collection of propagating material for rehabilitation operations may be in the best position to locate additional populations, once they are familiar with the species (Berrill *pers. comm.*).

### **Scientific (palaeoecological) enquiry**

In the 1990's the Mount Etna/Limestone Ridge area was found to have highly significant fossil fauna that illustrate prehistoric environmental change, in similar fashion to the World Heritage-listed Riversleigh fossil site in north-west Queensland. Bone deposits from a number of different caves (one subsequently destroyed by mining activity) are now known to record a change from wet rainforest to arid/semi-arid environments, and one of the deposits may be Australia's only known Pleistocene rainforest locality. Together these represent the broadest array of recently extinct ecosystems in Australia (Hocknull 2000).

Although the vertebrate palaeontology of the caves remains largely unexplored, about 40 caves are considered to be potentially important sources for vertebrate fossils (AHC n.d.). The Queensland Museum is working to extend this significant research in cooperation with Cement Australia (Pacific Lime) (White *pers. comm.*) and the Queensland Parks & Wildlife Service (QPWS 2003).

There is some potential for excavation and removal of fossil material to impact on *Tectaria devexa* in the Mount Etna/Limestone Ridge area through direct impact from human traffic, dust deposition or modification of cave entrances or vegetation structures in the vicinity. The Queensland Parks & Wildlife Service is not likely to permit the enlargement of a cave entrance within the national park for removal of fossil material (Toop *pers. comm.*). However, no source has been located that mentions the possibility of *Tectaria devexa* being found in the vicinity of a cave that is of interest for its fossil remains, nor is there mention of a need to survey for the presence of the species before such operations are undertaken.

## C.2.2 Christmas Island - threats

Potential threatening processes for *Tectaria devexa* to be considered below include:

- removal of actual or candidate habitat by phosphate mining or by construction of roads or other developments
- weed invasion arising from rehabilitation of mined areas or from construction
- predation by exotic species or changes in native species composition arising from activity of exotic species
- unauthorised collecting of specimens
- stochastic disturbance events e.g. cyclones, severe dry seasons
- decline in canopy gaps as forest tracks (drill lines) revegetate.

### Mining of phosphate

Mining of phosphate-rich soils from between limestone pinnacles began near Phosphate Hill in 1899 and has continued in most years to the present day. The original mining took place on the eastern side of the island and spread westwards with associated construction of access roads. In the late 1960's drill line surveying to map accurately the phosphate reserves resulted in a parallel grid of lines being cleared every 120 metres over most of the central plateau (CofA 2002).

Rehabilitation of mining fields has been carried out in several phases. The earliest efforts involved levelling of pinnacles, reintroduction of stockpiled low phosphate overburden, and planting with exotic tree and shrub species. In later phases, replanting utilised only native species. Old mining fields in the geographic area of the national park were excluded from the park to allow them to be worked out, subject to environmental controls. In February 1998 a lease was signed to allow mining activities to continue for a further 21 years (CofA 2002).

It is not known whether past mining, roading or drill line surveying have contributed to the restricted distribution of *Tectaria devexa*.

During the environmental assessment for a proposed expansion of mining, one small population of *Tectaria devexa* was found within a proposed mining lease.

### Construction

There are several recent, current or potential developments involving construction activity in areas associated with the potential habitat for *Tectaria devexa*. These include:

- proposed expansion of nine sites for **phosphate mining** (EPBC referral 2001/487) - the environmental assessment for proposed expansion of mining is due to be released in 2005. *Tectaria devexa* is found in at least one of the sites being considered and protective measures are proposed [see above] (Reddell *pers. comm.*).
- construction of the **Asia Pacific Space Centre** near South Point - the Centre is primarily located in former mined areas; survey has not located any specimens (APSC 2003), and it is not likely to affect a population. The construction environmental management plan states that any specimens of threatened species identified on the site would be retained (APSC 2003).
- associated construction of **common use infrastructure** including a new port facility between Waterfall and Norris Point on the east coast (referral 2001/435), upgrade of the Linkwater Road between the new port and Lily Beach Road (referral 2001/436) and an expansion of the airport (referral 2001/434) - the environmental assessment reports for these comment on the presence of a number of endemic and listed plant species but *Tectaria devexa* was not recorded or expected (GHD 2002a; 2002b; 2003).
- construction of an **Immigration Reception and Processing Centre** (IRPC) on the central plateau area towards North West Point and associated infrastructure (exempt from the EPBC Act by Ministerial decision 3 April 2002) - this construction may have had the potential to affect a population on the central plateau, noting the proximity of the important aggregation of sites near Murray Hill, which contains more than half the total known population (Holmes & Holmes 2002). However, most of the activity was within a former mined area (ML 138 and ML 139) (Exemption notice April 2002).

a **radio system upgrade** for the Australian Federal Police at Murray Hill (referral 2002/718) - no additional information located.

- possible extension or modification of the **Christmas Island Tourism Resort and Casino** on the eastern coast north of Ethel Beach (closed in 1998 but may be redeveloped) – no additional information located.

### **Weeds**

It is unclear whether weed invasion has contributed to the restricted distribution of *Tectaria devexa* through competition, nor is there any reference to weed species in records of known localities. Numerous species of weeds are known to have invaded forest margins along roads and tracks and around mining fields (CofA 2002). In such sites, there is potential for *Tectaria devexa* to face competition from weed species and potential for weed control to inadvertently affect *Tectaria devexa*.

There may be potential for competition from the very hardy native ferns *Nephrolepis multiflora* (scurfy sword fern) and *Nephrolepis biserrata* (broad sword fern) which compete strongly with other plants (Swarbrick 1997). *N. multiflora* is particularly noted as an invader of mining fields (CofA 2002) where it can form dense thickets more than 2 metres tall in damper, more shaded gullies towards the margins of old mines (DuPuy 1993b). Sheltered parts of these margins may be potential habitat for *Tectaria devexa*. *N. biserrata* is well established along old railway routes, which would also be potential habitat for *Tectaria devexa*.

No Weeds of National Significance are known to affect any populations of *Tectaria devexa* on Christmas Island.

### **Exotic fauna**

There are no records indicating any direct threats from the activity of exotic fauna.

The species occasioning most concern on the island in recent times is the yellow crazy ant (*Anoplolepis gracilipes*), which was introduced accidentally between 1915 and 1934. In recent years it has undergone a population explosion and the ants have formed multi-queened ‘supercolonies’. This has had a marked impact on other terrestrial fauna such as land crabs and in turn has changed the vegetation profile in some forest types. This impact is not considered likely to affect the areas associated with *Tectaria devexa* (Claussen *pers. comm*; Hart *pers. comm.*). However, to the extent that canopy gaps may be relevant to the species, there is potential for the impact of the ants on land crabs to cause reduced availability of gaps that have been kept open by the browsing activities of crabs (Sewell *pers. comm.*)

Of greater potential impact may be the giant African snail (*Achatina fulica*) which feeds on a wide variety of plants but may be expected to take refuge in moist locations, including those favoured by ferns. It is not known whether this species has had or is likely to have any impact on *Tectaria devexa*.

Although the presence of land crabs appears to restrict the distribution of the snail, this controlling effect may be compromised by reduced crab populations brought about by the yellow crazy ant infestation (CofA 2002). Crazy ant populations are responding to a program of aerial baiting, however there may be a gap of many years before land crabs recover to a level sufficient to control snail populations. The potential for increased spread of the snail may be inferred. Parks Australia monitor presence/absence of the snail during surveys for crazy ant populations, and these data could be related to the distribution of *Tectaria devexa* to assess any interactions (Jeffery *pers. comm.*).

Also of potential concern is an exotic millipede which feeds on vegetable matter and occurs in very high densities in certain areas (Sewell *pers. comm.*). No additional information was located on this.

### **Unauthorised collecting**

There is no evidence of unauthorised collecting of *Tectaria devexa*.

There is potential for collecting of specimens or propagules of rare species by or on behalf of fern enthusiasts. The likelihood or extent of such a demand cannot be predicted. However, in view of the small population numbers known, any such predation could pose a significant threat to the survival of *Tectaria devexa*.

### **Stochastic events**

There are insufficient data to suggest what impact severe rainfall events or contrasting severe dry seasons, or creation of canopy gaps by severe winds may have on *Tectaria devexa*.

### **Decline in canopy gaps**

The park management plan notes that most of the former forest tracks (drill lines) have been, or will be, closed and allowed to revegetate, except for a few selected tracks to be maintained for recreational uses (CofA 2002) [p.106]. As the tracks revegetate naturally, the canopy gaps will close up. There is differing opinion on whether this may impact on *Tectaria devexa*.

## **C.3 Areas and populations under threat**

In the **Rockhampton** area, the Capricorn Caves population is clearly in decline but not enough is known of the species or its habitat requirements to identify specific threats apart from drought.

The other known population in the area has not been under any apparent threat, apart from drought, but it has certainly declined and may have been lost altogether.

Potential habitat in the district may face threats from vegetation clearance and/or altered vegetation structure due to rehabilitation following limestone mining.

No **Christmas Island** populations of the species are known to be under particular threat, and there is no evidence or inference of a decline in populations.

However, environmental assessments are yet to be completed for some proposed developments with potential impact, and their findings may alter this conclusion.

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## PART D: OBJECTIVES, PERFORMANCE CRITERIA AND ACTIONS

### D.1 Recovery objectives, performance criteria and timelines

The overall goal is **to improve the conservation status of the species**.

We will know we have achieved this when at least one of the parameters that warrant the listed conservation status is improved sufficiently to consider an improved status.

This particular goal and criterion are worded to reflect the possibility that *Tectaria devexa* might be listed under the EPBC Act at the higher category of critically endangered to reflect the precarious nature of the Rockhampton area populations of var. *devexa*. However, for such time as the category remains at endangered, the lower level listing sought by this goal would be the vulnerable category.

Specific objectives in the life of the plan include:

Objectives	Performance criteria
<b><u>Objective 1:</u></b> <b>To reduce the rate of decline in the species</b>	Monitoring demonstrates no net decline in populations
<b><u>Objective 2:</u></b> <b>To increase the number and area of occurrences</b>	Systematic surveys to determine whether there are any additional populations have been completed.
<b><u>Objective 3:</u></b> <b>To abate and avert threats to the species</b>	No population of the species is significantly impacted by a threatening process
<b><u>Objective 4:</u></b> <b>To improve knowledge of factors in the restricted distribution of the species</b>	A comprehensive list of habitat requirements (physical and biological) is developed to assist location of additional populations
<b><u>Objective 5:</u></b> <b>To develop capability for enrichment planting or reintroduction of the species</b>	The species (var. <i>devexa</i> ) has been cultivated <i>ex situ</i> as a precaution against extinction in the wild in the Rockhampton area
<b><u>Objective 6:</u></b> <b>To improve community awareness of the species and its conservation status</b>	There is active presentation, and heightened awareness, of the status of the species and its role in illustrating regional (and continental) environmental change

### D.2 Evaluation of success or failure

Performance against all objectives will be evaluated annually, and assessed overall as part of the five-year review of this plan, by a recovery team comprising representatives of Australian Government and Queensland Government agencies and community interests, supported by independent scientific advice.

The proposed member organisations include:

#### ***Christmas Island***

- Parks Australia North
- Shire of Christmas Island
- Island Care Inc
- Dept of Transport & Regional Services
- Australian National Herbarium
- Christmas Island Phosphates

#### ***Queensland***

- QPWS Central Region
- Queensland Herbarium
- Capricorn Caves
- possible future inclusion - Cement Australia (Pacific Lime); see **Note 6** in **D.5** below.

### D.3 Actions within the life of this plan

Objective / Action		Suggested timing
<b><u>Objective 1: To reduce the rate of decline in the species</u></b>		
1.1	Quantify and monitor populations in the Rockhampton area and on Christmas Island [See <i>Note 1</i> below]	Rockhampton – Year 2; Christmas Is. – Year 4; then continuing
<b><u>Objective 2: To increase the number and area of occurrences</u></b>		
2.1	Survey potential habitat for more populations in the Rockhampton area and on Christmas Island [See <i>Note 2</i> below].	Rockhampton – Year 2; Christmas Is. - by Year 4
2.2	Encourage reporting of new localities to assist on-going review of conservation status	Continuing
<b><u>Objective 3: To abate and avert threats to the species</u></b>		
3.1	Maintain confidentiality for precise locations in the Rockhampton area (other than Capricorn Caves) and on Christmas Island [See <i>Note 3</i> below]	Continuing
3.2	Review on-site protection and active management measures at Capricorn Caves and improve if necessary. [See <i>Note 4</i> below]	Initially in Year 1; then continuing
3.3	Pursue a (State) Nature Refuge agreement or a Commonwealth (EPBC) voluntary conservation agreement with the owners of Capricorn Caves to provide assistance for on-site protection and active management measures. [See <i>Note 5</i> below]	Initially by Year 3; then continuing
3.4	Ensure that visitor facilities or visitor use in Mount Etna Caves National Park do not impact on any populations or compromise important potential habitat.	Initially Year 1; then continuing
3.5	Ensure inclusion of <i>Tectaria devexa</i> in all guidelines and specifications for environmental assessment and standards on Christmas Island, particularly on the central plateau.	Continuing
3.6	Ensure inclusion of <i>Tectaria devexa</i> in all guidelines and specifications for environmental assessment and management standards in the limestone area near Rockhampton, including rehabilitation of former mined areas. [See <i>Note 6</i> below]	Continuing
3.7	Objectively examine differences in specialist opinion regarding the extent to which canopy gaps may be important to <i>Tectaria devexa</i> on Christmas Island [See <i>Note 7</i> below].	Initially Year 1
3.8	Update The Dales Ramsar Information Sheet and description of ecological character to note the population of <i>Tectaria devexa</i> near Sydney's Dale [See <i>Note 8</i> below]	Year 1
3.9	Update the Register of the National Estate description for Fitzroy Caves to note (with location confidential) any population of <i>Tectaria devexa</i> found within the listed area. Consider enlarging the listed area to incorporate any additional population found within Mount Etna Caves National Park. Extend this action to any future heritage listing under the EPBC Act.	As soon as relevant
3.10	Expand content about <i>Tectaria devexa</i> (and other listed plant species) in future Christmas Island National Park management plans in line with recovery plans and relevant threat abatement plans. [See <i>Note 9</i> below]	Next revision of park management plan – 2007-8

Objective / Action		Suggested timing
<b><u>Objective 4: To improve knowledge of factors in the restricted distribution of the species</u></b>		
4.1	Investigate all known occurrences of <i>Tectaria devexa</i> to compile a comprehensive list of habitat requirements (physical and biological) to assist location of additional populations [See <i>Note 10</i> below]	Rockhampton – Year 2; Christmas Is. - by Year 4; then continuing
<b><u>Objective 5: To develop capability for enrichment planting or reintroduction of the species</u></b>		
5.1	Examine the need for, and potential and risks of, <i>ex situ</i> cultivation of both varieties, with priority to be given to var. <i>devexa</i> [See <i>Note 11</i> below]	By Year 2
5.2	Examine potential for enrichment planting or (re)introduction of <i>Tectaria devexa</i> into Rockhampton area habitat [See <i>Note 12</i> below]	By Year 5 for review of plan
<b><u>Objective 6: To improve community awareness of the species and its conservation status</u></b>		
6.1	Develop interpretive and educational material/displays for presentation at Capricorn Caves that tell the story of regional (and continental) environmental change, linked to the work of the Queensland Museum in the area [See <i>Note 13</i> below]	By Year 3

The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved, and may also be constrained by the need to address other conservation priorities. Approved recovery actions may be subject to modification due to changes in knowledge and changes in conservation status.

## D.5 Notes on Actions

1.1	Quantify and monitor populations in the Rockhampton area and on Christmas Island	Rockhampton – Year 2; Christmas Is. - by Year 4; then continuing
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*Note 1:* Although decline is reported only in the Rockhampton populations, it would be prudent to remedy the lack of quantitative data for Christmas Island populations.

Measurement and monitoring need to include demography to quantify population dynamics and phenology to correlate with climatic factors.

In the Rockhampton area, with so few individuals, this needs to be quite frequent and sufficiently detailed to encompass an annual count of individual plants and their condition (noting fertile fronds), photography from fixed monitoring points, and quantification of the effects of any active management (such as watering).

On Christmas Island, this may be less frequent (perhaps twice in the term of this plan) but should include a count of individuals and photographic monitoring.

In both cases, an investment may be required to establish and document monitoring methodology, but this may subsequently be carried out by volunteers (subject to adequate documentation and training to aid consistency in recording and reporting).



2.1	Survey potential habitat for more populations in the Rockhampton area and on Christmas Island.	Rockhampton – Year 2; Christmas Is. - by Year 4
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**Note 2:** Higher priority should be given to dedicated survey of potential habitat in the Rockhampton area, where the current distribution of *Tectaria devexa* var. *devexa* is considered precarious for its survival. Particular attention should be paid to the Mount Etna Caves National Park, adjacent areas subject to limestone mining [see also **Note 6** below], and adjacent private land that carries native vegetation structure on limestone substrate.

This effort should be preceded by research within the local community to examine anecdotal evidence of historic distribution and abundance, since this has a direct bearing on the extent and nature of potential habitat and in turn the area to be surveyed.

On Christmas Island the distribution of var. *minor* appears to be less precarious. As a result, and noting that a dedicated survey was only recently undertaken (Holmes & Holmes 2002), further survey beyond opportunistic and geographically limited environmental assessments of development proposals might not be accorded high priority. However, because the species is listed under the Endangered category every effort should be made to expand knowledge of its population through survey and recording on the plateau. It may be particularly useful to survey specific microhabitats in self-maintaining canopy gaps such as those adjacent to open limestone outcrops in plateau rainforest.

3.1	Maintain confidentiality for precise locations in the Rockhampton area (other than Capricorn Caves) and on Christmas Island	Continuing
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**Note 3:** It is imperative that any new populations located in the Rockhampton area be reported promptly to the Queensland Environmental Protection Agency and to the Australian Government Department of the Environment and Heritage with precise coordinates. However, precise locations should remain confidential in both agencies' databases.

3.2	Review on-site protection and active management measures at Capricorn Caves and improve if necessary.	Initially Year 1; then continuing
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**Note 4:** Active management at Capricorn Caves may include supplemental watering, although concern has been expressed about this practice in the past.

The species has probably been able to survive droughts because of spore reserves in soil and crevices of the limestone. Supplemental watering may germinate spore prematurely and deplete the reserves available for recovery in more favourable (wetter) years.

This would be particularly damaging if regional drought necessitates withdrawal of watering of sporelings before the plants have had time to develop new spore (Barry & Thomas 1994; 1996; Bostock 1993; Chinnock *in litt.*).

It is recommended that watering be used only as an emergency measure if mortality due to drought reaches a critical point. Even then, watering should:

- be confined to the largest, most vigorous plants and to a limited percentage of the total population;
- use water that has permeated through or over the limestone, in preference to rainwater or water from another source (Chinnock *in litt.*).

The effects of watering should be very carefully monitored, and the practice discontinued if it appears to be ineffective or in any way detrimental.

3.3	Pursue a (State) Nature Refuge agreement or a Commonwealth (EPBC) voluntary conservation agreement with the owners of Capricorn Caves to provide assistance for on-site protection and active management measures.	Initially by Year 3; then continuing
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**Note 5:** Voluntary conservation agreements should also be offered to any owners of private land containing populations of *Tectaria devexa* located during the term of this plan.

3.6	Ensure inclusion of <i>Tectaria devexa</i> in all guidelines and specifications for environmental assessment and management standards in the limestone area near Rockhampton, including rehabilitation of former mined areas.	Continuing
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**Note 6:** Noting that a new population of *Tectaria devexa* has recently been located in the area, particular attention should be paid to developments or other activities that impact on the limestone country in the vicinity of The Caves. This should include proposals for vegetation clearance.

Although due to cease by the end of 2003 (White *pers. comm.*), limestone mining at Mount Etna may have significant potential impact on habitat availability and should be examined for possible controls or conservation measures.

It is noteworthy that Cement Australia (Pacific Lime) has made a significant effort to strengthen its environmental credentials through improved rehabilitation practices, offering land up for reservation, and cooperative work with the Queensland Museum to protect recent fossil finds. The current emphasis may be favourable for negotiating a cooperative approach to locating and protecting new locations for *Tectaria devexa*, and exploring options for modifying rehabilitation practice to create or enhance potential habitat for the species.

If new populations are located, or potential habitat created or enhanced, in the area subject to mining or rehabilitation, the possibility of a Nature Refuge or similar voluntary conservation agreement should be explored, and a representative of Pacific Lime might be included on the recovery team.

3.7	Objectively examine differences in specialist opinion regarding the extent to which canopy gaps may be important to <i>Tectaria devexa</i> on Christmas Island	Year 1
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**Note 7:** There is insufficient evidence to draw firm conclusions at this time about the importance to *Tectaria devexa* of canopy gaps on Christmas Island. A precautionary approach requires that opinion that the species may be favoured by gaps is not dismissed out of hand for want of certainty.

Objective examination of specialist opinion should take place early in the life of this plan and should draw at least on Claussen, Reddell, Zimmermann, Sewell and Holmes, all of whom have recent experience in botanical surveys on that island.

The Christmas Island National Park management plan (CofA 2002) contains provisions relating to forest tracks (drill lines) [pp.106-7; 114]. If it is found that *Tectaria devexa* is favoured by canopy gaps, careful consideration needs to be given in the Track Management Plan [p.114] to selective retention of some gaps along former drill lines to maintain known locations and possibly to provide potential habitat nearby. This may affect the choice of tracks which are retained and/or the way they are maintained for access (being careful not to destroy populations at the margins).

Although consideration might be given to management interventions to simulate natural treefall and retain some gaps along those tracks that are not maintained, such actions (even experimental):

- should not be undertaken prior to, or independent of, action to gather more information about the requirements of the species [Action 4.1/**Note 10**]
- must not compromise practices designed to reduce windshear that may affect nesting, roosting or reproductive success of the endangered Abbott's booby (*Papasula abbotti*) and other seabirds; and
- should be accorded a lesser priority than location and protection of any populations in gaps that are naturally self-maintaining, such as open limestone outcrops amongst plateau rainforest.

3.8	Update The Dales Ramsar Information Sheet and description of ecological character to note the population near Sydney's Dale	Year 1
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**Note 8:** Conservation of threatened species is one of the criteria for Ramsar listing, and when such species are newly located in a listed site, the Ramsar Information Sheet and description of ecological character need to be updated. The EPBC criteria for significant impact on a Ramsar site relate to the statement of ecological character, and updating of this ensures the most robust protective framework under the Act.

3.10	Expand content about <i>Tectaria devexa</i> (and other listed plant species) in future Christmas Island National Park management plans in line with recovery plans and relevant threat abatement plans.	Next revision of park management plan – 2007-8
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**Note 9:** The current Christmas Island National Park management plan offers few explicit management practices relating to threatened plant species compared with those for threatened animal species. Recent work on the island has led to one new plant listing and there is potential for additional listings among (for example) the eighteen known endemic plant species and other species that in the Australian jurisdiction are found only on Christmas Island.

Numerous opportunities exist to improve the linkage between the park management plan and recovery plans and threat abatement plans, particularly in sections such as: 7; 10; 11; 12; and 13. Content needs to draw on Part E Management Practices below.

4.1	Investigate all known occurrences of <i>Tectaria devexa</i> to compile a comprehensive list of habitat requirements (physical and biological) to assist location of additional populations	Rockhampton – Year 2; Christmas Is. - by Year 4, then continuing
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**Note 10:** Measurement and monitoring of population dynamics [**Note 1**] should be related to measurement and monitoring of habitat requirements and condition. This information will aid development of predictive models of habitat to assist location of additional populations of *Tectaria devexa*. It will also be vital to assessing the relative importance of canopy gaps [**Note 7**] and to assessing the suitability and likely success of any future enrichment planting or (re)introduction to additional locations [**Note 11**]. Cultivation of var. *minor* may assist study of life cycle, and habitat and regeneration requirements.

5.1	Examine need for, and potential and risks of, <i>ex situ</i> cultivation of both varieties, with priority to be given to var. <i>devexa</i>	By Year 2
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**Note 11:** In view of the precarious nature of the Rockhampton area populations, it would be prudent to examine the possibility of *ex situ* cultivation of *Tectaria devexa* var. *devexa*. It is noted that any specimens cultivated *ex situ* will need to be returned to the wild as soon as possible to avoid any significant change in their genetic constitution. This suggests the need for some research to ascertain the maximum number of generations of *ex situ* cultivation that should occur prior to (re)introduction to the wild (Sewell *pers. comm.*).

Priority should be given to removal of some recently germinated sporelings for cultivation under controlled conditions. Media trialled should include soil from the site of origin but could also trial more standard fern soil mixes to determine whether the species is absolutely confined to calcareous substrates (Chinnock *in litt.*).

A first step in advancing this action would be identification of a suitable scientific institution to carry out the work. Chinnock (*pers. comm.*) suggests that both spore germination and tissue culture be trialled at more than one institution. Barry & Thomas (1996) suggest a trial propagation by tissue culture at the Biology Department of the Central Queensland University. Any such approach needs to be negotiated with Queensland Environmental Protection Agency (Threatened Species & Ecosystems Unit and Queensland Herbarium) in the first instance and then with the desired institution(s).

If tissue culture is not feasible, consideration could be given to *ex situ* propagation using material of the same variety from Asia. However, this should not be undertaken without prior genetic studies to assess differentiation between the Rockhampton area populations and those from Asia. It may be of value to assess in similar fashion the differentiation between the varieties at Rockhampton and Christmas Island. Genetic information may be vital to assessing the suitability and likely success of any future enrichment planting or (re)introduction to additional locations [**Note 12**].

However, this kind of investment may not be accorded a high priority because:

- the likelihood of success is very difficult to determine
- the value of investing significant resources in such a ‘non-keystone’ species (a species on which other biota do not appear to depend) is questionable; and
- alteration of the natural gene pool may reduce the survival chances of the ‘pure’ variety that is the object of recovery actions (Sewell *pers. comm.*).

Although survival of *Tectaria devexa* var. *minor* appears to be less precarious, *ex situ* cultivation of this variety may also be warranted to assist study of life cycle, habitat and regeneration requirements.

5.2	Examine potential for enrichment planting or (re)introduction of <i>Tectaria devexa</i> into Rockhampton area habitat	By Year 5 for review of plan
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**Note 12:** The confined crevices, ledges and rubble sometimes occupied by *Tectaria devexa* in the Rockhampton area offer considerable challenges for successful planting.

Collection of spore from a wild population should only be undertaken by a person experienced in such collection and should draw spore from different sub-populations to maintain genetic diversity.

See comments [**Note 11**] regarding the need to undertake genetic studies before material grown *ex situ* is used in any enrichment planting or (re)introduction for the Rockhampton area populations. If the material is found to be differentiated, then every effort must be made to prevent mixing of different genetic stock by inter-planting or by natural exchange.

Any additional sites to which the species is introduced need to be carefully noted in State and Commonwealth databases, to avoid misleading records of natural distribution.

No enrichment planting or (re)introduction appears warranted on Christmas Island. However, if monitoring of populations suggests such a need then the same principles should be applied to any intervention of this kind on the island.

6.1	Develop interpretive and educational material/displays for presentation at Capricorn Caves that tell the story of regional (and continental) environmental change, linked to the work of the Queensland Museum in the area	By Year 3
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**Note 13:** *Tectaria devexa* offers a valuable subject for raising awareness of species threatened by climatic change. This is based on the inference that as wet rainforests declined in Queensland the species retreated until it was restricted to cave entrances with a physical form that was analogous to its original moist, windless habitat under canopy gaps in dense rainforests [see C.2.1].

There is a particular opportunity to relate this interpretation to the findings of palaeoecological enquiry being carried out by the Queensland Museum based on bone breccias from caves in the Mount Etna-Limestone Ridge area, which document recent extinction of ecosystems in the face of increased regional (and continental) aridity – a trend which may be continuing [see C.2.1].

The story derived from this material would complement the considerable interpretive and educational material/displays that are currently offered to visitors at Capricorn Caves. Considerable interest may be generated by portraying extinct fauna species, however as an extant species ('a survivor') *Tectaria devexa* offers a complementary medium for illustrating much the same story, and it is one to which some visitors may relate more directly.

Capricorn Caves is recommended as the location for an interpretive and educational effort because:

- it is the only location for *Tectaria devexa* that is not to be kept confidential; and
- it currently offers effective and supervised interpretive and educational facilities; and
- there is uncertainty surrounding the nature and timing of future visitor facilities development at Mount Etna Caves National Park (Cammoo Caves).

The owners of Capricorn Caves may not require direct funding for this effort, but may instead be supported through a partnership between the Queensland Parks & Wildlife Service, regional natural resource management body (Natural Heritage Trust funds), Queensland Museum, and Pacific Lime to develop and maintain the materials.

## **PART E: MANAGEMENT PRACTICES**

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All occurrences of *Tectaria devexa* are considered to be important populations, and their environs are considered to be habitat critical to their survival. Because the numbers are so low and the range is so restricted, any impact on any population of the species may be significant.

A significant impact on a critically endangered or endangered species may arise from:

- reducing the size of, or fragmenting, a population of the species
- reducing the area occupied by the species
- adversely affecting or decreasing availability or quality of habitat critical to survival of the species
- introducing invasive species that compete with, modify habitat for, or prey on, the species.

Any proposed development activity in the vicinity of a known occurrence of *Tectaria devexa* or in an area identified as potential habitat needs to be preceded by:

- survey for the species; and
- wherever it is found, comprehensive documentation of the population and site factors; and
- detailed attention to measures to avoid or mitigate such impacts on the population.

Specific attention needs to be paid to proposed developments in areas of known or potential habitat that may increase vulnerability of the species to:

### **Rockhampton area**

- clearing of native vegetation or alteration of vegetation structure (including rehabilitation) on limestone areas
- pesticide runoff, fire, weed invasion, mining or excavation
- unauthorised collecting; or
- direct impact by human visitors on caves and karst areas.

### **Christmas Island**

- mining or excavation
- road construction, widening and maintenance
- clearing of native vegetation, weed invasion, exotic fauna
- unauthorised collecting; or
- reduction in canopy gaps in the vicinity (pending further investigation of the importance of gaps).

Mapping for EPBC public enquiry purposes needs to remain coarse, with at least a 1 kilometre buffer around known localities. If predictive models are developed, potential habitat should be mapped in a similar fashion for public enquiry.

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## PART F: DURATION AND COSTS

### F.1 Duration and costs

Cost estimates (and potential contributors) to implement this plan are:

Action	Year 1	Year 2	Year 3	Year 4	Year 5
Quantification and monitoring - Rockhampton area [1.1; 4.1]	\$2,000 [R]	Then annual Minimal cost [R]			
Quantification and monitoring - Christmas Island [1.1; 4.1]			\$2,500 [P]	Then annual Minimal cost [P]	
Survey of potential habitat - Rockhampton area [2.1] (timing dependent on seasonal conditions)	\$3,000 [R; Ce]				
Survey of potential habitat - Christmas Island [2.1]			\$5,000 [P]		
Encourage reporting of new localities to assist on-going review of conservation status [2.2]	Continuing – minimal cost				
Maintain confidentiality for locations (other than Capricorn Caves) [3.1]	Continuing – no cost				
Review of on-site protection and active management measures at Capricorn Caves [3.2]	\$1,500 [R; Ca]	Continuing costs depend on findings			
Pursuit of a voluntary conservation agreement to provide assistance on private land – Rockhampton area [3.3]	Costs depend on number of landholders and nature of assistance [Q]				
Ensure visitor facilities/use in Mt Etna Caves National Park do not impact on populations or potential habitat [3.4].	Minimal cost	Continuing – minimal cost			
Inclusion in guidelines/specifications for environmental assessment/standards on Christmas Island [3.5] and in limestone area near Rockhampton, including former mined areas [3.6]	Continuing – no cost				
Examination of the extent to which canopy gaps may be important to the species on Christmas Island [3.7]	Minimal [P]				
Update of The Dales Ramsar Information Sheet and description of ecological character [3.8]	Minimal [P]				
Update of Register of the National Estate description for Fitzroy Caves. Consider enlarging listed area. Extend to any future heritage listing under the EPBC Act [3.9]	As soon as relevant - minimal cost				
Expanded content in future Christmas Island National Park management plans [3.10]					Next revision Minimal [P]

Comprehensive list of habitat requirements (physical and biological) to assist location of additional populations [4.1]		\$2,000 [R]		\$3,000 [P]	
Examination of <i>ex situ</i> cultivation - Rockhampton area [5.1]		\$2,000 [R]	Continuing costs depend on findings [R; Ce; Ca]		
Examination of enrichment planting, (re)introduction - Rockhampton area [5.2]			\$2,000 [R]	Continuing costs depend on findings [R; Ce; Ca]	
Interpretive and educational material/display at Capricorn Caves [6.1]		\$3,000 [Ca; R; Ce]			
Communication costs associated with annual evaluation by the recovery team	Annual Minimal cost [R; P]				
Review and revise recovery plan					\$5,000 [R; P]

Key to potential contributors: **Q**ueensland Parks & Wildlife Service; **P**arks Australia; **R**egional NRM body; **C**ement Australia (Pacific Lime); **C**apricorn Caves

No allowance made for currency value changes.

The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved, and may also be constrained by the need to address other conservation priorities. Approved recovery actions may be subject to modification due to changes in knowledge and changes in conservation status.

## F.2 Resource allocation

### Rockhampton area

Efficiencies may be gained by:

- combining the effort for actions 1.1 and 4.1
- combining the effort for actions 5.1 and 5.2
- seeking volunteer effort and sponsorship where possible
- integration of continued data collection with other Natural Heritage Trust programs and relevant environmental assessments in the area, noting that the species is accorded a high priority for management action (CRCCZEW 2003)
- integration of actions with implementation of other recovery plans e.g. the plan for semi-evergreen vine thickets in the Brigalow Belt (EPBC endangered ecological community listed 4 April 2001).

### Christmas Island

Estimated costs assume that much of the work can be carried out by personnel on Christmas Island (i.e. no allowance is made for airfares or accommodation). Although some external assistance may be required to design survey/documentation methods and review results, this may not need to be on-site.

Efficiencies may be gained by:

- combining the effort for actions 1.1 and 4.1
- combining these with surveys of crazy ant populations which note also giant African land snails
- ensuring that future versions of the Christmas Island National Park management plan incorporate actions arising from this recovery plan and from all others in force for the island
- integration of continued data collection with other Natural Heritage Trust programs and relevant environmental assessments on the island; and
- use of a single recovery team on the island to implement and evaluate all recovery plans for threatened plant species and any relevant threat abatement plans.

## REFERENCES

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- AHC [Australian Heritage Commission] (n.d.) Register of the National Estate Database – Fitzroy Caves Area, The Caves Qld [www.ahc.gov.au/register/easydatabase/database.html](http://www.ahc.gov.au/register/easydatabase/database.html)
- Andrews, S B (1990) *Ferns of Queensland* pp.42-45 Qld Department of Primary Industries, Brisbane
- APSC [Australia Pacific Space Centre] (2003) *Christmas Island Space Launch facility: Construction environmental management plan for South Point* [with GHD] Feb 2003
- Augusteyn, Ann (1995) *History of Olsen's Capricorn Caverns 1882-1994* the author
- Barry, S J and Thomas, G T (1994) *Threatened vascular rainforest plants of South-east Queensland: a conservation review* Unpublished report to Australian Nature Conservation Agency
- Barry, S J and Thomas, G T (1996) *Conservation Statement no.4: Tectaria devexa* (Kunze ex C.Chr.) Copel., Aspidiaceae Qld Department of Environment and Heritage, Brisbane [also with 'DEH Endangered Species Summary Data Sheet' n.d.]
- Bennett, Mark *in litt.* 'Draft National Recovery Plan for *Tectaria devexa*: CIP [Christmas Island Phosphates] comments' [March 2004]
- BoM (2000) *Climatic atlas of Australia: Rainfall*, Bureau of Meteorology, Melbourne.
- Bostock, Peter D (1993) *Tectaria* [Dryopteridaceae] in Commonwealth of Australia (1993) *Flora of Australia vol.48 Ferns, Gymnosperms and allied groups* pp. 394-398 Australian Government Publishing Service, Canberra
- Bruvel, Fred (1999) *Limestone [Mineral Information leaflet No.11]* Qld Department of Mines & Energy, Brisbane [www.nrm.qld.gov.au/mines/pdf/lime.pdf](http://www.nrm.qld.gov.au/mines/pdf/lime.pdf)
- Capricorn Caves (n.d.) [www.capricorncaves.com.au/](http://www.capricorncaves.com.au/)
- Chinnock, R J – letter to Dr G Guymer Queensland Herbarium - 7 May 1993
- CofA [Commonwealth of Australia] (2002) *Christmas Island National Park management plan* Environment Australia
- CRCCZEWM [Cooperative Research Centre for Coastal Zone Estuary & Waterway Management] (2003) *Central Queensland information paper to support regional natural resource management planning* Indooroopilly Vol.1 Chs.4, 5; Vol.6 Ch.10 Fitzroy catchment
- Dayton, Gene (2002) Course notes 'Physical geography of Australia' Central Queensland University, Rockhampton [particularly Week 4: Australian climates and accompanying Fig.7] [www.ahs.cqu.edu.au/humanities/geography/GEOG11023/week\\_4.htm](http://www.ahs.cqu.edu.au/humanities/geography/GEOG11023/week_4.htm)
- DuPuy, D J (1993a) Christmas Island in Commonwealth of Australia (1993) *Flora of Australia vol.50 Oceanic islands 2* pp. 1-30 Australian Government Publishing Service, Canberra
- DuPuy, D J (1993b) Davalliaceae in Commonwealth of Australia (1993) *Flora of Australia vol.50 Oceanic islands 2* pp.:564-568 Australian Government Publishing Service, Canberra
- DuPuy, D J and Orchard, A E (1993) Dryopteridaceae in Commonwealth of Australia (1993) *Flora of Australia vol.50 Oceanic islands 2* pp. 558-562 Australian Government Publishing Service, Canberra
- Fitzroy Basin Association (n.d.) [www.fba.org.au/keyissues/](http://www.fba.org.au/keyissues/)
- GHD [Gutteridge Haskins & Davey] (2002a) *Christmas Island – additional port; Public Environmental Report* [for DoTaRS] Perth WA July 2002
- GHD [Gutteridge Haskins & Davey] (2002b) *Christmas Island – Linkwater Road upgrade: Environmental assessment and management plan* [for DoTaRS] Perth WA August 2002
- GHD [Gutteridge Haskins & Davey] (2003) *Christmas Island – Airport upgrade: Environmental Impact Statement* [for DoTaRS] Perth WA April 2003
- Hocknull, Scott (2000) Precious pieces from the past in *Wildlife Australia* Summer 2000 pp.33-36



- Holmes, Glenn (2002) Flora and fauna of Limestone Hill, Christmas Island: assessment of proposed mobile telephone base station April 2002
- Holmes, Jenny and Holmes, Glenn (2002) Conservation status of the flora of Christmas Island, Indian Ocean: report to Environment Australia/Parks Australia North, September 2002
- Holttum, R E (1960) *A revised Flora of Malaya: an illustrated systematic account of the Malayan flora including commonly cultivated plants vol.II Ferns of Malaya* Botanic Gardens, Singapore
- Holttum, R E (1988) Studies in the fern genera allied to *Tectaria* Cav. VII> Species of *Tectaria* sect. *Sagenia* (Presl) Holttum in Asia excluding Malesia in *Kew Bulletin* 43:485-6
- Holttum, R E (1991) *Tectaria* group in *Flora Malesiana* ser.II vol.2 pt.1:57-58
- Jones, D L and Clemesha, S C (1981) *Australian ferns and fern allies* Reed, Sydney
- Kay, A (?1994) *Introducing dry rainforests: a guide to the vine thickets and forests of Queensland's central coast and hinterland* Queensland Department of Environment & Heritage, Brisbane
- Mackey, A P (ed.) (nd) *Rubber vine (Cryptostegia grandiflora) in Queensland* Department of Natural Resources and Mines, Brisbane Qld
- Olsen, T (1976) *The magnificent Olsen's caves of Queensland: Nature's masterpiece supreme*
- O'Sullivan, Lyle – letter to Vera Wong, Environment Australia c.1997 [EA File 98/00869]
- QPWS [Queensland Parks & Wildlife Service] (2003) *Mount Etna Caves National Park working draft management plan* March 2003
- Smith, D A (1946) A new fern and some new fern records for North Queensland in *The North Queensland Naturalist* 14(80):4-6
- SPRAT data base – Australian Government Department of the Environment and Heritage [internal] *Tectaria devexa* Species profile April 2003
- Swarbrick, J T (1997) Environmental weeds and exotic plants on Christmas Island, Indian Ocean: a report to Parks Australia
- Vavryn, Dianne (a) – letter to Peter D Bostock, Queensland Herbarium 23 April 2001
- Vavryn, Dianne (b) – letter to Peter D Bostock, Queensland Herbarium 23 July 2001
- Weeds Australia (2003) Weeds of National Significance – [www.weeds.org.au/natsig.htm](http://www.weeds.org.au/natsig.htm)
- Exemption notice - Immigration Reception and Processing Centre April 2002 - <http://www.deh.gov.au/epbc/notices/pubs/immigrationcentreexemptions158.pdf>
- Listed Key Threatening Processes – Environment Australia: [www.ea.gov.au/biodiversity/threatened/ktp/index.html](http://www.ea.gov.au/biodiversity/threatened/ktp/index.html)
- List of CITES Species for the Purposes of subsection 303CA(1) of the *Environment Protection and Biodiversity Conservation Act 1999*, instrument dated 29 November 2001 [www.ea.gov.au/biodiversity/trade-use/lists/instruments/cites.pdf](http://www.ea.gov.au/biodiversity/trade-use/lists/instruments/cites.pdf)
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## PERSONAL COMMUNICATIONS

Augusteyn, Ann	Co-owner, Capricorn Caves Qld
Berrill, Peter	Central Queensland Speleological Society, Rockhampton Qld; member Mount Etna Caves National Park Management Advisory Committee and member of Pacific Lime Rehabilitation Committee
Bostock, Peter	Principal Botanist, Queensland Herbarium, Environmental Protection Agency, Brisbane Qld
Chinnock, Dr Bob	Senior Botanist, South Australian Herbarium, Adelaide SA
Claussen, Jeff	Parks Australia North, Department of the Environment & Heritage, Christmas Island
Dayton, Gene	Senior Lecturer (Geography), Central Queensland University, Rockhampton
Hart, Roger	Manager, Booderee Botanic Gardens, Jervis Bay NSW, Department of the Environment & Heritage; formerly of Christmas Island Rainforest Rehabilitation Program, Parks Australia North
Holmes, Glenn	Glenn Holmes & Associates, Atherton Qld; environmental consultant with flora survey experience on Christmas Island
James, Cameron	Manager, Mount Etna Caves National Park, Queensland Parks & Wildlife Service, Environmental Protection Agency, Rockhampton Qld
Jeffery, Mick	A/g Conservator, Parks Australia North, Department of the Environment & Heritage, Christmas Island
Lee, Dr Linda	Threatened Species Coordinator, Threatened Species & Ecosystems Unit, Queensland Parks & Wildlife Service, Environmental Protection Agency, Brisbane Qld
Marshall, David	Senior Conservation Officer, Planning, Queensland Parks & Wildlife Service Central Region, Rockhampton Qld
Melzer, Dr Rhonda	Principal Conservation Officer, Natural Resource Management, Queensland Parks & Wildlife Service Central Region, Rockhampton Qld
Reddell, Paul	Plant Ecologist, EWL Sciences, Darwin NT; flora survey experience on Christmas Island
Rodgers, Claire	Science and Knowledge Coordinator, Fitzroy Basin Association, Rockhampton Qld
Sewell, Sven	Environment Officer, Indian Ocean Territories
Spate, Andy	Consultant ACT; formerly Karst Investigation Officer, NSW Parks & Wildlife Service
Stone, Dr Roger	Director, Predictive and Precision Systems, Qld Department of Primary Industries, Brisbane
Thomas, Megan	Queensland Herbarium, Environmental Protection Agency, Brisbane Qld
Toop, John	Senior Conservation Officer, Queensland Parks & Wildlife Service, Central Region, Rockhampton Qld
Tranter, Jeff	ERIN, Department of the Environment & Heritage, Canberra; formerly of Parks Australia North, Christmas Island
Vavryn, Dianne	Casual cave tour guide, Queensland Parks & Wildlife Service, Rockhampton Qld; formerly cave guide at Capricorn Caves and Cammoo Caves
White, Chris	Company manager, Pacific Lime (Cement Australia), Rockhampton Qld
Zimmermann, Anja	Plant Ecologist, EWL Sciences, Darwin NT; flora survey experience on Christmas Island

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