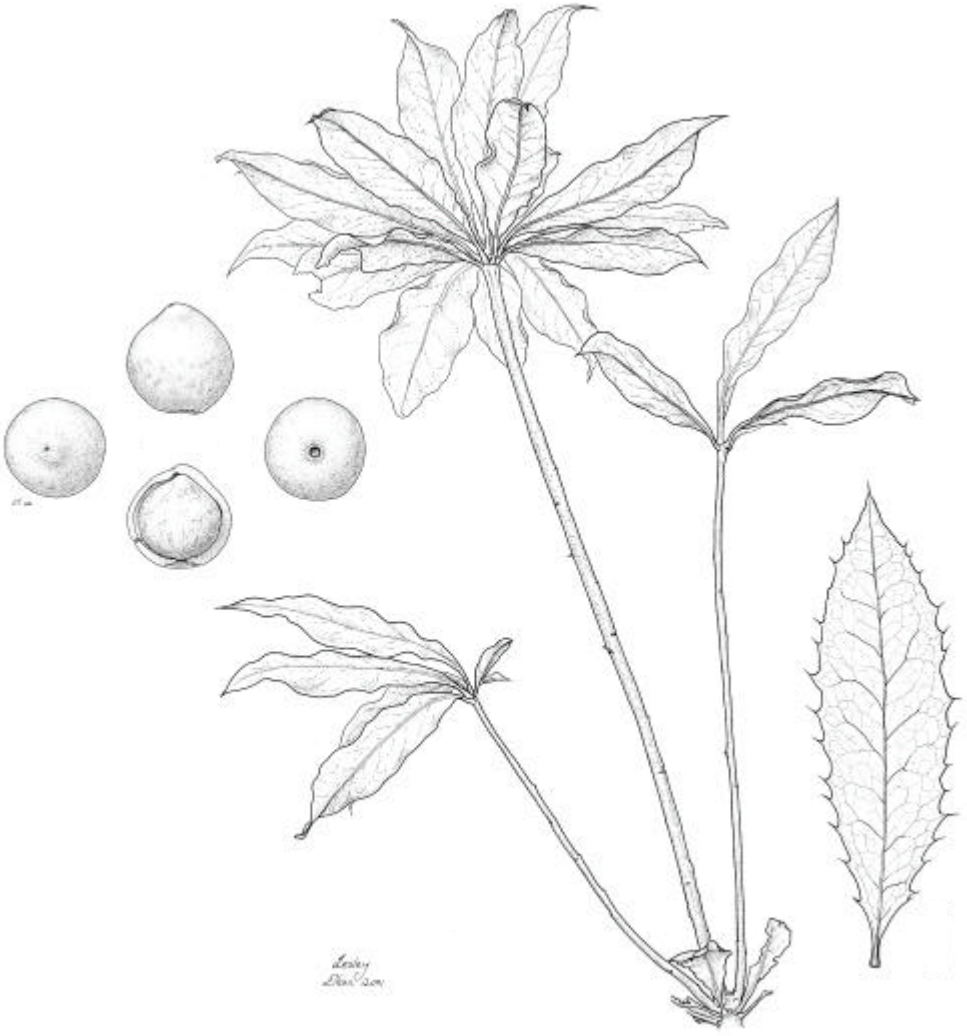
Approved NSW & National

Recovery Plan

Eidothea hardeniana

(Nightcap Oak)

September 2004



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A Commonwealth Government Initiative

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Cover illustration: Adult and juvenile leaves and fruit of *Eidothea hardeniana*

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Recovery Plan for the Nightcap Oak (*Eidothea hardeniana*)

Foreword

The New South Wales Government established a new environment agency on 24 September 2003, the Department of Environment and Conservation (NSW), which incorporates the New South Wales National Parks and Wildlife Service. Responsibility for the preparation of Recovery Plans now rests with this new department.

This document constitutes the New South Wales State and National Recovery Plan for *Eidothea hardeniana* Weston & Kooyman (Nightcap Oak), and as such considers the conservation requirements of the species across its range. It identifies the actions to be taken to ensure the long-term viability of the Nightcap Oak in nature and the parties who will undertake these actions.

The Nightcap Oak is included as Critically Endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999, and is listed as an Endangered species on the NSW *Threatened Species Conservation Act* 1995. The Nightcap Oak is a rainforest tree from the Nightcap Range of north-east New South Wales. It is located only on public land, namely national park estate.

The future recovery actions detailed in this Recovery Plan include: habitat management; survey for further populations; investigations into genetics, pollination biology and life history; monitoring for changes in the population; and *ex-situ* conservation.

It is intended that this Recovery Plan will be implemented over a five year period. Actions will be undertaken by the Department of Environment and Conservation using existing resources and externally sourced funding.

LISA CORBYN

Director-General

BOB DEBUS MP

Minister for the Environment

Acknowledgments

Dianne Brown, Department of Environment and Conservation (DEC), Threatened Species Unit, North East Branch, prepared this plan.

The Nightcap Oak Recovery Team comprised Dianne Brown, Robert Kooyman (consultant botanist), Ken McRay (Department of Primary Industries), Damien Hofmeyer (DEC) and Peter Weston (DEC). The Recovery Team is thanked for input into and assistance with the preparation of this plan.

Robert Kooyman, for survey work and background report on distribution and habitat. Peter Weston for the taxonomic description. Maurizio Rossetto (DEC) and Robert Henry (Southern Cross University) for genetic studies. Peter Bernhardt (University of St Louis), Peter Weston and Robert Kooyman for information on the pollination studies. Anthony Azzopardi, Peter Cuneo and Cathy Offord (DEC), the late Barry Walker (Nimbin) and Alex Floyd (Coffs Harbour Regional Botanic Gardens) for information on propagation. Lesley Elkan (DEC) for provision of the line drawings. Lynn Baker, Andrew McIntyre, and Katrina McKay (DEC) Threatened Species Unit for project support and assistance.

DEC Threatened Species Unit North East Branch funded survey and establishment of monitoring plots.

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1 Introduction

Eidothea hardeniana Weston & Kooyman (Nightcap Oak) occurs only in New South Wales (NSW), and is currently known from one population of about 100 adult plants and about 84 juveniles/seedlings in the Nightcap Range on the far north coast of NSW. The species is a tall rainforest tree in the Proteaceae family and was first discovered in 2000. It has recently been formally described (Weston & Kooyman 2002).

This document constitutes the NSW and National Recovery Plan for the Nightcap Oak and as such considers the requirements of the species across its known range. It identifies the actions to be taken to ensure the long-term viability of the Nightcap Oak in nature and the parties who will undertake these actions. Achieving the objectives of this Recovery Plan is subject to budgetary and other constraints affecting the parties involved. The information in this Recovery Plan is accurate to July 2004.

This plan has been prepared by the Department of Environment and Conservation (DEC) in consultation with the Nightcap Oak Recovery Team.

2 Legislative Context

2.1 Legal Status

The Nightcap Oak is listed as Critically Endangered on the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and Endangered on the NSW *Threatened Species Conservation Act* 1995 (TSC Act).

2.2 Recovery Plan Preparation

The TSC Act provides a framework to protect and encourage the recovery of Threatened Species, Endangered Populations and Endangered Ecological Communities in NSW. Under this legislation the Director-General of the DEC has a responsibility to prepare Recovery Plans for all species, populations and ecological communities listed as Endangered or Vulnerable on the TSC Act schedules. Similarly, the EPBC Act requires the Commonwealth Minister for the Environment and Heritage to ensure the preparation of a Recovery Plan for nationally listed species and communities, or adopt plans prepared by others including those developed by State agencies.

This Recovery Plan was placed on public exhibition from 7 March 2003 to 11 April 2003.

The *Threatened Species Conservation Amendment Act* 2002 states that an approved Recovery Plan must include a summary of advice given by the NSW Scientific Committee with respect to the plan, details of any amendments made to the plan to take account of that advice and a statement of the reasons for any departure from that advice. This summary is provided in Appendix 1.

This Recovery Plan has been prepared to satisfy both the requirements of both the TSC Act and the EPBC Act and, therefore, will be the only Recovery Plan for the species. It is the intention of the Director-General of the DEC to forward this Recovery Plan to the Commonwealth Minister for the Environment and Heritage for adoption, once it has been approved by the NSW Minister for the Environment.

2.3 Recovery Plan Implementation

The TSC Act requires that a public authority must take appropriate measures to implement actions included in a Recovery Plan, and report on implementation of those actions for which they have agreed to be responsible. In addition, the Act specifies that public authorities must not make decisions that are inconsistent with the provisions of the plan. The government agency relevant to this plan is the DEC .

The EPBC Act specifies that a Commonwealth agency must not take any action that contravenes a Recovery Plan.

2.4 Relevant Legislation

The Nightcap Oak occurs only on DEC estate. Relevant legislation includes:

- NSW *National Parks and Wildlife Act* 1974;
- NSW *Environmental Planning and Assessment Act* 1979;
- NSW *Rural Fires and Environmental Assessment Legislation Amendment Act* 2002;
- Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

The most significant implications of the above legislation in relation to the TSC Act are described below and in Section 2.5.

***National Parks and Wildlife Act* 1974 and *Environmental Planning and Assessment Act* 1979**

The *National Parks and Wildlife Act* 1974 (NPW Act) regulates activities within national parks and nature estate reserves and therefore applies to areas

within DEC that contain the Nightcap Oak. This Act also requires that a licence must be obtained to propagate or sell the Nightcap Oak.

The NPW Act and TSC Act are administered by the DEC. These Acts require that any proposal to 'pick' or 'damage the habitat of' a threatened plant species must be approved by the DEC, unless the activity has been granted consent or approval under the *Environmental Planning and Assessment Act* 1979 (EP&A Act) or is conducted with approval under the *Rural Fires Act* 1997. If a proposal is likely to have a significant impact on the Nightcap Oak then a Species Impact Statement (SIS) must be prepared.

***Rural Fires and Environmental Assessment Legislation Amendment Act* 2002**

The NSW *Rural Fires and Environmental Assessment Legislation Amendment Act* 2002 amends the *Rural Fires Act* 1997 and several environmental assessment-related Acts. This Act provides for mapping bush-fire prone lands and the development of a Bush Fire Environmental Assessment Code. This code is aimed at streamlining the assessment process for hazard reduction works. To this end, the Code will include general ameliorative prescriptions and, in some cases, species specific prescriptions. Threatened species and their habitats are one of the items considered in the code.

***Environment Protection and Biodiversity Conservation Act* 1999**

The EPBC Act provides a framework for the protection of Nationally listed Endangered and Vulnerable Species and Endangered Ecological Communities. This includes the preparation of a Recovery Plan and assessment of the impact of activities on the subject species.

2.5 Environmental Assessment

The EP&A Act requires that approval authorities consider known and potential habitat of threatened species, biological and ecological factors and the regional significance of individual populations when exercising a decision-making function under Parts 4 and 5 of the EP&A Act.

The DEC is the public authority with a decision making function regarding the Nightcap Oak. Additional authorities may have responsibilities if the species is located in other areas in the future.

Any activity not requiring development consent under the EP&A Act, and which is likely to have an impact on the Nightcap Oak, requires a licence or a certificate from DEC under the provisions of either the TSC Act or NPW Act.

The EPBC Act regulates actions that may result in a significant impact on nationally listed threatened species. It is an offence to undertake any such actions without obtaining prior approval from the Commonwealth Minister for the Environment and Heritage. As the Nightcap Oak is listed Nationally under the EPBC Act, any person proposing to undertake actions likely to have a significant impact on this species must refer the action to the Commonwealth Minister for consideration. The Minister will then decide whether the action requires EPBC Act approval.

Consultation with indigenous people

Local Aboriginal Land Councils, Elders and other groups representing indigenous people in the areas where the Nightcap Oak occurs have been identified and a copy of the Nightcap Oak Recovery Plan sent to them. Their comments on this plan have been sought and considered in the preparation of this Recovery Plan. It is also the intention of the DEC to consider the role and interests of these indigenous communities in the implementation of the actions identified in this plan.

2.6 Critical Habitat

The TSC Act makes provision for the identification and declaration of Critical Habitat. Under the TSC Act, Critical Habitat may be identified for any Endangered Species, Population or Ecological Community occurring on NSW lands. Once declared, it becomes an offence to damage Critical Habitat (unless the action is exempted under the provisions of the TSC Act) and a SIS is mandatory for all developments and activities proposed within declared Critical Habitat.

Under the EPBC Act, Critical Habitat may be registered for any nationally listed threatened species or ecological community. When adopting a Recovery Plan the Commonwealth Minister for the Environment and Heritage must consider whether to list habitat identified in the Recovery Plan as being critical to the survival of the species or ecological community. Any action that is likely to have a significant impact on a Commonwealth listed species occurring within registered Critical Habitat on non-Commonwealth land is subject to referral and approval under the EPBC Act.

This Recovery Plan identifies those habitat features and the location (sections 3.2 - 3.4) critical to the survival of the Nightcap Oak, as required by the EPBC Act.

To date, Critical Habitat has not been declared for the Nightcap Oak under the TSC Act or the EPBC Act.

2.7 Key Threatening Processes

As of July 2004 there are 22 Key Threatening Processes listed on the TSC Act. Of these, Anthropogenic Climate Change, Clearing of Native Vegetation and Infection of native plants by *Phytophthora cinnamomi* have the potential to impact on the Nightcap Oak. Land Clearance and Dieback Caused by the Root-rot Fungus *Phytophthora cinnamomi* are also listed as Key Threatening Processes on the Commonwealth EPBC Act. Threat Abatement Plans must be prepared for all listed Key Threatening Processes. In addition to these Key Threatening Processes, a range of other processes are recognised as threatening the survival of the species in NSW. These are listed in Section 4.

3 Species Information

3.1 Description and Taxonomy

The Nightcap Oak is in the Proteaceae family. The Proteaceae family contains many well-known Australian genera such as *Banksia, Grevillea, Macadamia* and *Telopea* (Waratah).

Proteaceae is the fifth largest family of the Australian flora in terms of number of species (Harden *et al.* 2000). It is an ancient family of flowering plants that probably originated while the supercontinent of Gondwana was still intact. Gondwana began splitting up over 120 million years ago and the fragments carried a variety of lineages of the Proteaceae (White 1994). The genus *Eidothea* is the only relic of one of those early lineages, surviving in the rainforests of eastern Australia.

The Nightcap Oak was discovered in 2000 by consultant botanist Robert Kooyman during survey work in the Nightcap Range. The genus itself was described as recently as 1995 from a species (*Eidothea zoexylocarya)* discovered on Mt Bartle Frere in north Queensland (Douglas & Hyland 1995). The Mt Bartle Frere species bore a close resemblance to a fossil fruit (*Xylocaryon lockii)* described in 1875 by botanist Baron Ferdinand von Mueller from the Ballarat region in Victoria. The fact that representatives of the *Eidothea* genus have been found at localities as far apart as north Queensland, north-east NSW and Victoria illustrates that rainforest once covered vast areas of eastern Australia.

The following description was provided by Peter Weston of the Botanic Gardens Trust:

> Rainforest trees 15–40 m high, with one main trunk to 70 cm diameter at breast height, but often with up to 40 smaller subsidiary shoots branching from the base. Bark grey, compact. Branchlets glabrous. Leaves narrowly elliptical to oblanceolate or lanceolate, mostly 8–15 cm long, 1.7–5 cm wide, crowded in false whorls of mostly 3–7. Juvenile leaves with toothed margins with 9–20 teeth, each bearing a spine 1–4 mm long. Adult leaves with entire margins. Leaf venation more prominent on the upper leaf surface than the lower when dried. Hairs simple. Inflorescences lateral, in leaf axils or on bare twigs, a shortly stalked, 7–11-flowered head, with a central, bisexual or male flower or flower pair, surrounded by a false whorl of male flowers. Flowers ± actinomorphic, creamy white, lacking nectaries. Male flowers with perianth 8.0–9.6 mm long, glabrous externally; basal tubular part of perianth 2.2–3.3 mm long; staminal filaments free or almost so, thread-like, not supporting the anthers, 3.7–6.5 mm long; anthers narrow-oblong, without terminal appendages, 4.0–5.0 mm long. Bisexual flowers slightly larger than the male flowers; ovary densely covered in ascending hairs; style terete, the tip not modified as a pollen presenter; stigma bilobed. Fruits drupaceous, broad-ovoid to broad-ellipsoidal, 3.5–4.0 cm long, 3.0–3.7 cm diameter, green maturing to dull golden yellow; pyrene (stone) broad-ovoid to broad-ellipsoidal, with a rounded base and sharply pointed tip, with several longitudinal ribs on the inside of the endocarp.
>
> Figure 1 illustrates the adult leaves and flowering shoot of the Nightcap Oak, and Figure 2 illustrates the flower structures.

3.2 Distribution

The Nightcap Oak is known from a very limited area in the Nightcap Range on the upper north coast of NSW, north east of Lismore. The trees are scattered across a few hectares.

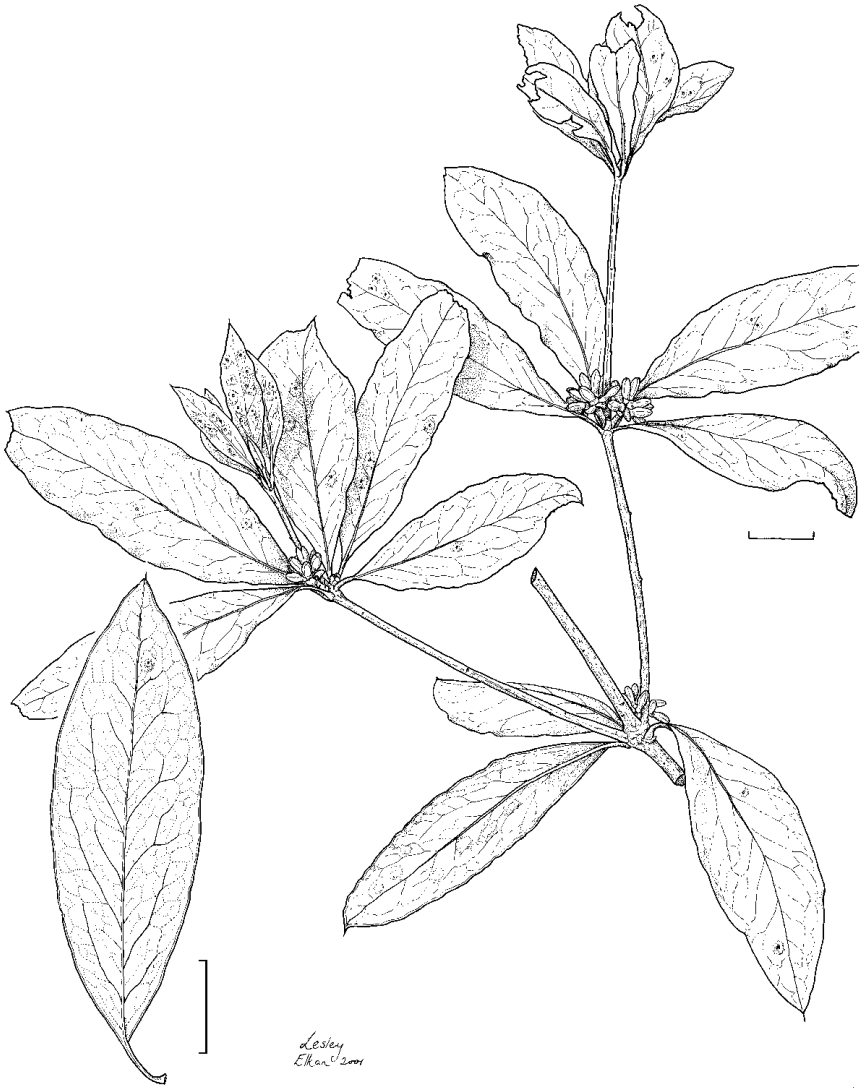

Figure 1. Adult leaves and flowering shoot of the Nightcap Oak. Scale bar = 2cm

3.3 Land Tenure

The Nightcap Oak occurs on DEC estate. It is not known to occur on any other land tenure. Details of locations have not been included to maintain site confidentiality.

3.4 Habitat

The Nightcap Oak grows in simple notophyll/microphyll vine forest (Webb 1959) (warm temperate rainforest) on rhyolite geology.

Vegetation

The rainforest tree *Ceratopetalum apetalum* (Coachwood) is a dominant or co-dominant canopy and sub-canopy species in the Nightcap Oak habitat (Kooyman 2001). Large emergent trees such as *Tristaniopsis collina* (Mountain Water Gum), *Lophostemon confertus* (Brush Box), *Syncarpia glomulifera* (Turpentine), *Callitris macleayana* (Stringybark Pine), and *Araucaria cunninghamii* (Hoop Pine) occasionally occur in these rainforest communities.

Three Floyd (1990) suballiances can be recognised in the Nightcap Oak habitat, namely; 33 (*Ceratopetalum/Schizomeria-Argyrodendron/Sloanea),* 35 *(Ceratopetalum/Schizomeria-Caldcluvia)* and 45 (*Tristaniopsis collina-Ceratopetalum/Schizomeria)* (Kooyman 2001). Forest Type mapping, a classification based on dominant canopy species, is used in most areas of state forest estate (Forestry Commission of NSW 1989). Four forest types (FT), or combinations of forest types, are recognisable in the Nightcap Oak habitat. These are FT 2 (*Sloanea woollsii*), FT 11 (*Tristaniopsis collina/Schizomeria ovata*), FT 13 (*Tristaniopsis collina/Ceratopetalum apetalum*) and FT 53 (*Lophostemon confertus*). Table 1 lists the common

species in the Nightcap Oak habitat and gives a comparison between vegetation classifications.

Threatened and significant species

Seven NSW threatened plant species occur in the Nightcap Oak habitat. These are listed in Table 2.

Plant species listed as rare by Briggs and Leigh (1996) that occur in the Nightcap Oak habitat include *Acacia orites*, *Argophyllum nullumense*, *Austrobuxus swainii*, *Gahnia insignis*, *Helmholtzia glaberrima* and *Pararistolochia laheyana.* Examples of species associated with the Nightcap Oak that also has biogeographical significance includes the rare Dorrigo Plum (*Endiandra introrsa*), a species found only on the Nightcap Range and in the Dorrigo region.

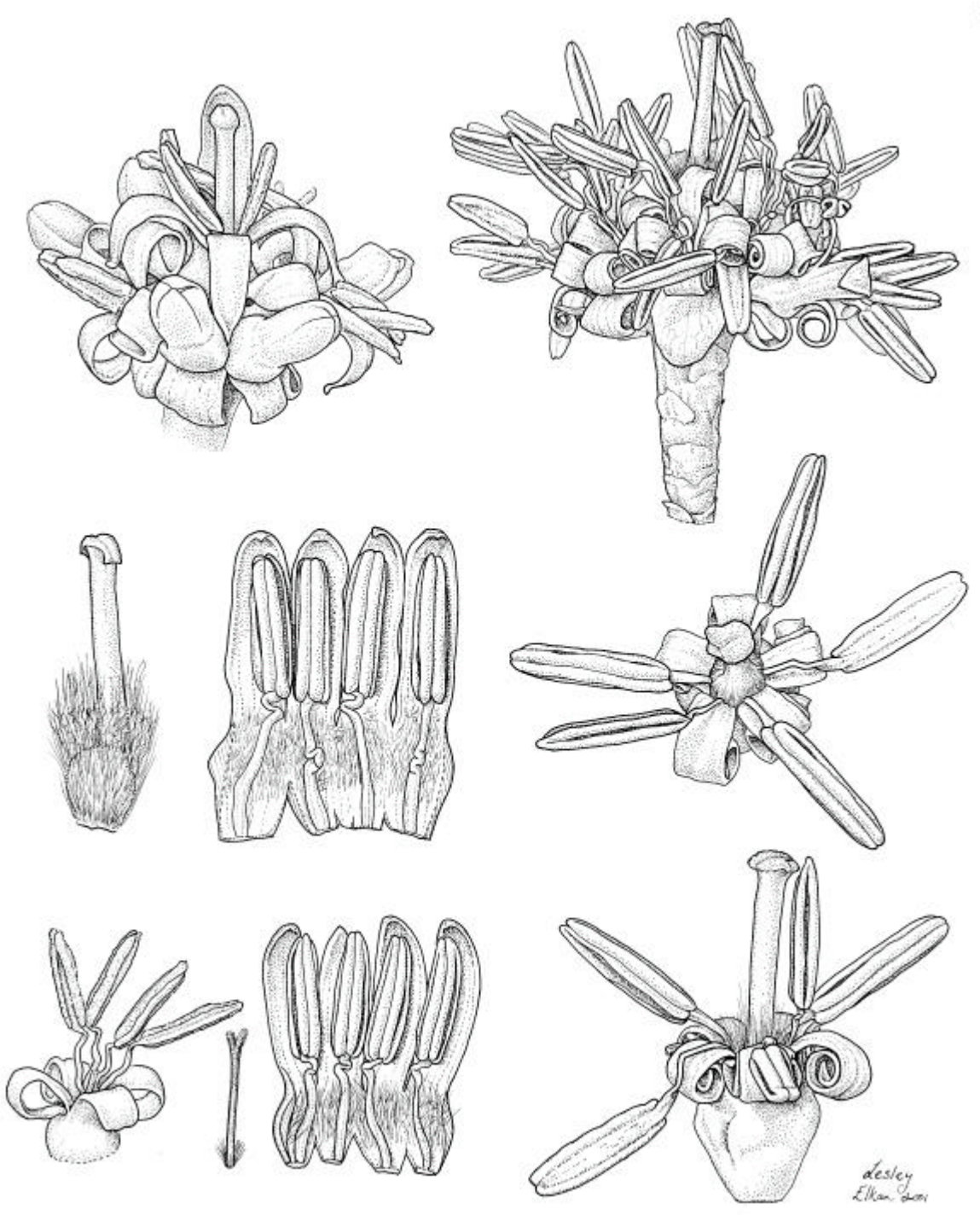

Figure 2. Flower structures of the Nightcap Oak showing male and female flower parts

Table 1. Common species, Floyd sub-alliances, and Forest Types in the Nightcap Oak habitat.

Common species	Floyd suball	SFNSW FT.
Ceratopetalum apetalum, Endiandra introrsa, Sloanea woollsii, Canarium australasicum, Syzygium luehmanii, Schizomeria ovata, Caldcluvia paniculosa, Quintinia sieberi, Randia benthamiana, Triunia youngiana, Cryptocarya meissneriana, Wilkiea huegeliana, Linospadix monostachya, Blechnum cartilagineum, Adiantum formosum, Lomandra longifolia.	33	FT 2/11
Ceratopetalum apetalum, Schizomeria ovata, Caldcluvia paniculosa, Anopterus macleayanus, Endiandra introrsa, Austrobuxus swainii, Triunia youngiana, Helicia ferruginea, Linospadix monostachya, Lomandra longifolia.	35	FT 11
Tristaniopsis collina, Araucaria cunninghamii, Ceratopetalum apetalum, Endiandra introrsa, Schizomeria ovata, Canarium australasicum, Quintinia sieberi, Anopterus macleayanus, Triunia youngiana, Wilkiea huegeliana, Linospadix monostachya, Citriobatus pauciflorus, Blechnum cartilagineum, Lomandra longifolia.	45	FT 13, FT 11/13
Lophostemon confertus, Callitris macleayana, Tristaniopsis collina, Ceratopetalum apetalum, Cinnamomum oliveri, Austrobuxus swainii, Synoum glandulosum, Schizomeria ovata, Cryptocarya meissneriana, Wilkea huegeliana, Triunia youngiana, Lomandra hystrix, Lomandra longifolia.	33 or 35 with *L. confertus*	FT 53/11, & 53

Table 2. Threatened plant species associated with the Nightcap Oak.

Species	Common Name	Status*
Corokia whiteana	Corokia	V
Elaeocarpus sp. 'Rocky Creek'	Minyon Quandong	E
Endiandra hayesii	Rusty Rose Walnut	V
Hibbertia hexandra		E
Hicksbeachia pinnatifolia	Red Bopple Nut	V
Symplocos baeuerlenii	Small-leaved Hazelwood	V
Uromyrtus australis	Peach Myrtle	E

***TSC Act status – E = endangered; V = vulnerable**

Physiography

The Nightcap Range forms part of the southern rim of the erosion caldera of the Mt Warning Shield Volcano. This area is dominated by Nimbin rhyolite, which overtopped the initial basalt flows from the Mt Warning volcano (Adam 1987). The yellow podzolic soils produced from rhyolite have a lower fertility than the basalt-derived soils and support vegetation with a lower species diversity than that of the basalt areas.

The elevation of the Nightcap Range varies from approximately 200 m Australian Height Datum (ahd) to just over 800 m ahd. The Nightcap Oak occurs above 300m ahd.

Climate

The Nightcap Range experiences a subtropical climate with heavy summer-autumn rainfall and a relatively dry winter. Cyclonic activity further to the north is often associated with heavy, intense rainfall events, and infrequent cyclonic winds can cause extensive local destruction.

The Nightcap Range has a very high annual rainfall with an average of over 2500 mm per annum (Graham 2001). Figures for nearby areas have a mean annual rainfall of 1358 mm (Lismore) and 1687mm (Murwillumbah) and a mean temperature range of between 19.1^0C and 29.7^0 C (Lismore) and 19.1^0 C and 29.5^0 C (Murwillumbah) (CSIRO 1996). The climate of the Nightcap Range varies somewhat from these figures due to its higher elevation, resulting in lower temperatures and significantly higher rainfall due to the orographic effect of the range.

3.5 Life History and Ecology

Life cycle

As the Nightcap Oak can grow to be a tall canopy tree, it is presumably a long-lived species. Information to date indicates that the species may flower annually from early November (it has flowered for the past three seasons since discovery), and sets fruit approximately 15–18 months after flowering. Mature fruit have been collected from February to May.

Seed viability

Observations indicate that fruit of the Nightcap Oak takes over one year to develop. The fruit is difficult to detect until it ripens to yellow on the tree.

For seed of the Nightcap Oak to germinate, the woody endocarp must be removed or at least partially removed to allow water to penetrate to the seed. Exposed seeds from freshly matured fruit take up to six months to germinate at about 25^{o} C in glasshouse conditions (Offord and Azzopardi 2002). No germination has been recorded from fruit collected from the ground, which may indicate a short life of seeds, possibly one to three years (Offord pers. comm.). It is presumed that seedlings arise from fruit in which the endocarp is broken down naturally within a relatively short space of time following maturity. Seed biology of this species requires further examination.

Population structure

Comprehensive surveys by Kooyman (2001) indicate that the species has a small population size of approximately 100 mature individuals. Maturity is based on size class and is arbitrarily measured as individuals with a diameter at breast height over bark (dbhob) greater than 10 cm. Of the mature individuals, 20 (12% of whole population) have a dbhob greater than 50 cm. Kooyman (2001) recorded 84 individuals (47% of whole population) with a dbhob of less than 1.5 cm (immature).

Predators and parasites

Known seed predators of the Nightcap Oak include small mammals, probably the Bush Rat *Rattus fuscipes* and possibly a *Melomys* (based on residual tooth marks on inner pericarp remains). These mammals eat the seeds by carefully removing the very bitter outer flesh before chewing through the hard layer to gain access to the edible core of the drupe. Seed predation appears to occur after the fruits have fallen to the ground. It appears that a significant proportion of the seeds are damaged and eaten, although seedlings are present at a number of sites, suggesting that adequate recruitment is occurring despite predation. It is possible that *R. fuscipes* may assist with dispersal by caching fruit.

In north Queensland, *Eidothea zoexylocaryon* seeds are eaten by small mammals, (probably Giant White-tailed Rats *Uromys caudimaculatus)*, with hollowed fruit of various sizes often found on the ground around the tree (Harden *et al.* 2000). These rats eat the nuts while the fruits are still on the trees.

Leaf suckers such as pit-galling psyllids, and leaf miners have a minor impact on the leaves of the Nightcap Oak. This minor impact does not rule out the possibility of periodic irruptions.

Pollinators

In Australia, field observations indicate that members of the Proteaceae are visited by a wide range of pollinators including birds, mammals, and insects (Maynard 1995). The flowers of the Nightcap Oak lack nectar glands and pollen is the only edible reward for visiting insects. This finding narrows the range of prospective pollinators (Bernhardt 1996).

Preliminary field investigations conducted in November 2001 and 2003 (Weston, Kooyman and Bernhardt, unpublished data) found that the most abundant pollen feeders on flowers of the Nightcap Oak were various species of beetles, both diurnal (primarily *Diphucephala*:Scarabidae and an unidentified genus of Chrysomelidae) and nocturnal (unidentified genus of *Alleculinae*:Tenebrionidae and an unidentified genus of Chrysomelidae). Less common pollen feeders were nocturnal katydids (*Zaprochilus*:Orthoptera) and diurnal hover flies (*Melangyna*:Syrphidae). Some of these species have already been found to carry small quantities of Nightcap Oak pollen, and the others are presently the subject of active investigation.

The morphology, colour and scent of inflorescences and flowers of the Nightcap Oak is consistent with insect pollination, a prediction that is tentatively confirmed by the observations described above. However, available data are too meagre to draw conclusions as to whether any of the observed visitors are effective pollinators, or that those observed to date are the predominant insect visitors. Another potentially limiting factor is whether the breeding system of the Nightcap Oak is self-compatible (accepts its own pollen to form healthy seeds) or self-incompatible (must be cross-pollinated with another tree to form healthy seeds). Self-incompatible species are more vulnerable to inbreeding depression than are self-compatible species (Frankham *et al.* 2002). Preliminary genetic data (Rossetto, unpublished data; section 5.4) strongly suggest that the Nightcap Oak is

predominantly outcrossing (section 5.4). However, observations of the behaviour of insect visitors (Weston, Kooyman and Bernhardt, unpublished data) suggest that most pollen transfers between anthers and stigmas occur on the same inflorescence. This suggests that Nightcap Oak is likely to be self-incompatible.

Studying the reproductive biology of large rainforest trees like *Eidothea* is difficult because the flowers of wild plants are relatively inaccessible. Only one tree of the Nightcap Oak has reproductively mature shoots that can be reached from ground level and this tree has been the sole subject of all pollinator observations so far. The canopies of other trees could be reached using various techniques, however such techniques may injure individual trees. The breeding system could be characterised with crossing experiments conducted on cultivated plants propagated from reproductively mature shoots gathered from the canopies of adult trees. It is possible to strike cuttings from reproductively mature shoots but it is not known how long it takes for such cuttings to flower and set fruit.

Disturbance

There is no information available on the response of the Nightcap Oak to disturbance. As the species occurs in mature phase rainforest it is likely to be adversely impacted by changes that alter or impact upon this habitat type.

3.6 Ability of Species to Recover

It is not known whether the Nightcap Oak has declined in recent times. It is not known whether the current population size is adequate to maintain the species in the long term. As the Nightcap Oak is a long-lived tree, changes in the habitat may take some time to show an impact on the species as a whole.

4 Threats and Management Issues

4.1 Current Threats

Lack of knowledge

As the Nightcap Oak has only recently become known to science, there is little information available about the species' biology and ecology. Basic information such as habitat requirements is needed in order to adequately manage the species.

Small population size

Small population size makes the Nightcap Oak vulnerable to inbreeding depression (Ellstrand & Elam 1993) and stochastic events.

Fire

There is no information on the response of the Nightcap Oak to fire. As the species occurs in rainforest, it is presumed that fire is not needed for germination and reproduction. As fire would change the habitat conditions of the site, it is likely that fire would adversely impact upon the Nightcap Oak.

Weeds

Exotic plant species are not currently considered to be a threat in the habitat of the Nightcap Oak.

Tourism and site visitation

Commercial and recreational activities such as bushwalking, mountain biking and other outdoor activities are becoming increasingly popular in the Nightcap Range area. These activities may have an impact on the Nightcap Oak from direct impacts such as trampling and potential indirect impacts such as the introduction of pathogens or weed propagules.

Visitation and potential collection by enthusiasts may also constitute a significant threat to the species through those impacts listed above as well as a potential reduction in the recruitment of the species by the removal of propagules.

Breeding system

A potentially limiting factor is the breeding system of the Nightcap Oak. It is not known whether the Nightcap Oak is self-compatible or self-incompatible (section 3.5). Self-incompatibility requiring obligate cross-pollination between plants is common in other members of the Proteaceae including some species of *Persoonia* (Krauss 1994), *Telopea* (Whelan & Goldingay 1989) and *Banksia* (Goldingay *et al. 1991*) and this could present special problems for a reduced population of trees like the Nightcap Oak.

Natural rates of fecundity drop when parents cross with offspring or siblings exchange pollen (Richards 1986).

If the Nightcap Oak is pollinated by beetles, katydids and hover flies, natural rates of pollen flow between individual trees will be limited as these insects do not show the long-range foraging patterns associated with organisms such as large-bodied bees, sphinx moths, honeyeaters or flying foxes (Bernhardt pers comm).

If the Nightcap Oak is pollinated by only one, or a small number of insect species, then conservation of these species must also be ensured in managing the Nightcap Oak.

5 Previous Recovery Actions

5.1 Surveys and monitoring

Extensive targeted surveys of potential habitat were undertaken in 2001 (Kooyman 2001). These surveys indicate that the Nightcap Oak is restricted to a limited area.

A large number of systematic surveys have also been undertaken on public land in north-east NSW (Brown *et al*. 2000, State Forests of NSW 1995, NPWS 1994; 1995; 1999a; 1999b). None of these surveys detected the Nightcap Oak. This reinforces the view that the species has a limited distribution.

5.2 Memorandum of Understanding

A Memorandum of Understanding (MOU) between the former National Parks and Wildlife Service (NPWS) and the former Royal Botanic Gardens, regarding the Nightcap Oak was drafted. With these two agencies now part of the one Department, DEC, it is likely that a Service Agreement between the two divisions will supersede the MOU.

5.3 Management plans

There are three management plans relevant to the Nightcap Oak. Issues related to the management of the Nightcap Oak in these plans are outlined below.

Parks and Reserves of the Tweed Caldera Draft Plan of Management

This plan states that actions in the Plan of Management will be superseded by any specific actions in a Recovery Plan for a species.

Nightcap National Park Fire Management Plan (in prep)

No prescribed burning is planned for Nightcap National Park. However, with the addition of substantial areas of eucalypt forest from State Forest to Service Estate, there is the possibility that the Fire Management Plan will propose some strategic burning for asset and property protection, as well as to protect sensitive vegetation types.

Pest Management Plan for Nightcap National Park

No areas of the Nightcap Oak habitat are priority areas for treatment in the Pest Management Plan (NSW NPWS 2001).

5.4 Genetic studies

A comprehensive analysis of genetic variation in the Nightcap Oak including all known specimens and using specifically developed DNA markers (microsatellites), is being carried out by the BGT in Sydney after having been initiated at Southern Cross University at Lismore. Preliminary results based on three microsatellite loci (positions of a gene) suggest that allelic diversity and heterozygosity are surprisingly high for such a restricted species. There are no apparent signs of inbreeding across generations, with the levels of gene diversity within seedlings corresponding to those found in adult plants. This suggests that the Nightcap Oak is a preferential outcrosser (ie. breeding occurs as a result of mating between two unrelated / distinct individuals), and completion of the genetic study should confirm this. Outcrossing can be a perilous mechanism for a threatened species, as the loss of even a relatively small amount of diversity could significantly diminish its reproductive potential. The completion of in-depth DNA-based studies will provide more information on the recent evolutionary history of this species, and the possible effect of recent environmental changes.

5.5 *Ex-situ* conservation

Seeds and cuttings of the Nightcap Oak have been propagated at the Royal Botanic Gardens Mt Annan (RBGMA) (Offord and Azzopardi 2002). In addition, seed has been propagated at the North Coast Regional Botanic Gardens (NCRBG) at Coffs Harbour, and by Mr Barry Walker, Nimbin.

Seed research

Seed germination success has varied from 0% to 71%, while germination periods varied from four to five months. Conversely, cuttings have proved to be far less successful where only one of ten cuttings has struck. Both the RBGMA and the NCRBG have the Nightcap Oak specimens as part of the living collection.

As indicated in Section 3.5 of this plan, it is anticipated that the seed viability period for this (and similar) species is likely to be short. It would, however, be of research value to test this assumption on seed storage behaviour for this

species under a range of storage conditions at the BGT seedbank, when adequate seed is available.

6 Proposed Recovery Objectives, Actions and Performance Criteria for the Nightcap Oak

The overall objective of this Recovery Plan is to protect known populations of the Nightcap Oak from decline by human-induced impacts, and to ensure that wild populations of the Nightcap Oak remain viable in the long-term.

Specific objectives of the Recovery Plan for the Nightcap Oak are listed below. For each of these objectives a number of recovery actions have been developed, each with a justification and performance criterion.

Specific Objective 1: Habitat Management

Recovery Action 1.1. Fire management

The DEC recommends that management aim to exclude fire from the Nightcap Oak habitat. The DEC will ensure that no new fire trails are constructed, or closed fire trails reopened, in the Nightcap Oak habitat. Fire Management Plan – strategic placing of fire trails to protect species in the event of wildfire.

Justification: Fire is not likely to be necessary to promote regeneration of the Nightcap Oak and may have adverse impacts on the species as it occurs in rainforest habitat.

Performance Criterion: Fire is excluded from the Nightcap Oak habitat. No fire trails are constructed or reopened in the Nightcap Oak habitat. Fire Management Plan has mechanisms to protect the Nightcap Oak in wildfire event.

Recovery Action 1.2. Tourism

The DEC will not permit commercial tourism activities to be conducted in the Nightcap Oak habitat, outside existing roads or tracks.

Justification: The Nightcap Range area is subject to increasing recreational activity, particularly by commercial operators visiting with groups of various sizes. Commercial tourism has the potential to adversely impact on the Nightcap Oak and its habitat. This impact may be by physical damage to habitat or individual Nightcap Oak plants or by introduction of disease, pests and weeds.

Performance Criterion: No commercial tourism activities are conducted in the Nightcap Oak habitat outside existing roads or tracks.

Recovery Action 1.3. Site visitation and location confidentiality

The DEC will coordinate the development of a site access strategy. This strategy will detail conditions of access to the Nightcap Oak sites and the maintenance of the confidentiality of the locations of the Nightcap Oak. Access is to be limited to essential research and management purposes. The strategy will also investigate the production of film footage of the Nightcap Oak and its habitat to provide to commercial film operators who would otherwise want to access the sites.

Justification: There has been significant media and public interest in the Nightcap Oak since its discovery in 2000, which has led to increased visitation for reasons ranging from research to film making. Unrestricted access has the potential to adversely impact the Nightcap Oak habitat or individuals by physical damage or by introduction of disease, pests and weeds. In addition, illegal collection of plants or plant parts by enthusiasts may have adverse impacts upon the species. It is therefore necessary to both limit access to the Nightcap Oak and to maintain confidentiality about the location of the Nightcap Oak.

Performance Criterion: A site access strategy is developed. Film footage is produced.

Recovery Action 1.4. Weed management

Management will aim to maintain the current weed-free status of the Nightcap Oak habitat. If weeds are identified in the Nightcap Oak, the DEC will treat the area as a priority using appropriate techniques.

Justification: Weeds are not present in any known sites containing the Nightcap Oak. Weeds have the potential to outcompete the Nightcap Oak seedlings and adversely modify the Nightcap Oak habitat.

Performance Criterion: The Nightcap Oak habitat remains free of weeds that may adversely impact upon the viability of the species.

Recovery Action 1.5. Environmental assessment

Standard survey and environmental assessment guidelines for the Nightcap Oak will be developed and distributed to all relevant consent authorities.

Justification: A standard minimum survey effort should be undertaken when determining if the Nightcap Oak is present in or near an area of potential development. Presence of the species should require implementation of effective mitigation measures to reduce the impact of proposed development.

Performance Criterion: Standard survey and environmental assessment guidelines are developed and distributed.

Recovery Action 1.6. Investigation of listing of Critical Habitat

An assessment of the need to declare Critical Habitat for the Nightcap Oak under the TSC Act will be investigated in order to determine if it would produce any demonstrable benefits to the species.

Justification: A declaration of Critical Habitat under the TSC Act may deliver significant conservation benefits for the species.

Performance Criterion: Listing of Critical Habitat is investigated and pursued if appropriate.

Specific Objective 2: Research

Recovery Action 2.1. Survey

Targeted surveys for the Nightcap Oak in suitable habitat will be carried out. As extensive targeted surveys have already been undertaken, additional survey should be done opportunistically during any resource inventory work that is undertaken.

Justification: Additional targeted survey will assist with establishing whether any further individuals or populations of the Nightcap Oak exist.

Performance Criterion: Additional targeted survey is carried out during resource inventory work.

Recovery Action 2.2. Monitoring

The Nightcap Oak has been known for only three years, therefore little is known of the species' population dynamics and demography. While floristic, environmental and ecological data have been collected from a range of sites (Kooyman, 2001) critical questions remain:

- Is the population stable, increasing, or in decline?
- What is the 'turn over' rate for larger stems, smaller stems and seedlings?
- What is the 'survivorship' of seedlings?
- Does the species flower and fruit every year?
- Do fruit crops vary substantially between years?
- How important is the clonal reproductive strategy for the maintenance of the population?

A population monitoring program will be developed to study population dynamics, seedling recruitment, seedling survivorship, flowering and fruiting, habitat attributes, and edaphic, biophysical, and climatic factors.

It is recommended that broad area (whole of population) population structure monitoring be undertaken on a regular (annual to bi-annual) basis to detect any variations in population dynamics and the species' response to any disturbance events. In addition to this, demographic studies based on yearly monitoring of permanently marked individuals at a number of locations (three areas minimum) will be developed. Reproductive success of the population will be monitored to ensure that the population remains viable. Tree health will be monitored on a regular basis.

Justification: Population monitoring is essential to understand whether the population is stable, in decline or expanding and to determine the viability of the Nightcap Oak in the wild.

Performance Criterion: A population monitoring program is developed and undertaken on a regular basis.

Recovery Action 2.3. Genetics

Investigate the amount and distribution of genetic variation within the Nightcap Oak using microsatellite analysis.

Justification: By obtaining direct measures of gene flow (ie. through the genetic investigation of parental and seed material) it will be possible to elucidate the breeding system and population dynamics within this species. Simple experimentation can also be designed to assess the correlation between genetic diversity and seedling fitness. All understanding of current levels of genetic diversity will provide important information on the long-term viability of the Nightcap Oak. It is essential to comprehend what the limiting factors (if any) to its breeding success are, and how gene flow contributes to the maintenance of current levels of diversity.

Performance Criterion: Information on genetic diversity and gene flow from the entire species, as well as data on a representative number of ex-situ germinated seedlings is obtained.

Recovery Action 2.4 Pollination biology and breeding system

Studies into the pollination biology and breeding system of the Nightcap Oak will be carried out to determine the reproductive biology of the Nightcap Oak.

Justification: In order to manage populations of the Nightcap Oak in the wild, it is important to have some knowledge of its reproductive biology, particularly given that pollination and self-

compatibility are potentially limiting factors in the species' ability to reproduce.

Performance criterion: Pollinator(s) of the Nightcap Oak determined and the breeding system is characterised to improve knowledge of its reproductive biology.

Specific Objective 3: *Ex-situ* conservation

Recovery Action 3.1. Ex-situ *conservation*

Ex situ plants of the Nightcap Oak will be established in appropriate locations (e.g. regional and national botanic gardens or universities). *Ex-situ* conservation should aim to sample the variation within the population by propagating plants from a range of parent trees. At a minimum, ten trees should be established as part of the general garden display.

It is unlikely that establishment of a seed bank is appropriate given the probable short-viability of the seed, which is typical of large-fruited Proteaceae.

Justification: As the population numbers of the Nightcap Oak are very low in the wild, it is appropriate that *ex situ* plants are established at suitable institutions to act as an insurance against any catastrophic disturbance to wild plants. In addition, due to the taxonomic and natural history interest of this species, it is appropriate for plants to be established as part of the living display collection in suitable botanic gardens as an educational resource.

Performance Criterion: *Ex situ* plants are established as appropriate.

Recovery Action 3.2 Seed collection

Seed collection will need to be undertaken for the *ex-situ* conservation program. Seed needs to be collected from a range of plants to sample any variation that may be present in the population.

Justification: Seed collection from across the population must be undertaken to allow the establishment of plants for a representative *ex-situ* collection.

Performance Criterion: Seed is collected from a range of the Nightcap Oak plants.

7 Implementation

Table 3 identifies the relevant government agencies responsible for outlines the implementation of recovery actions specified in this plan for the period of five years from publication. The DEC is the sole responsible party.

8 Social and Economic Consequences

8.1 Intrinsic ecological value

The ecological function of the Nightcap Oak is not known.

8.2 Scientific and taxonomic value

As the tree is new to science, it holds considerable scientific interest. The genus contains only two species, one in north Queensland and this species. The genus *Eidothea* is a phylogenetically isolated member of the Proteaceae that may hold valuable information on the evolution and biogeography of the Australian flora and the contraction of rainforests.

8.3 Biodiversity benefits

The Nightcap Range has a major concentration of rare and restricted species. Many threatened and significant flora and fauna species are known to occur in the habitat of the Nightcap Oak. Threatened flora recorded in the vicinity of the Nightcap Oak are listed in Table 2. Many species of threatened fauna have been recorded in the Nightcap Range including the Marbled Frogmouth *Podargus ocellatus*, Alberts Lyrebird *Menura alberti*, Spotted-tailed Quoll *Dasyurus maculatus*, Powerful Owl *Ninox strenua*, Masked Owl *Tyto novaehollandiae*, Sooty Owl *Tyto tenebricosa*, Red-legged Pademelon *Thylogale stigmatica*, Parma Wallaby *Macropus parma*, Stephens Banded Snake *Hoplocephalus stephensii*, the Pouched Frog *Assa darlingtonii*, the Barred Frogs *Mixophyes fleayi* and *M. iteratus*, and many others. Protection of the Nightcap Oak habitat will therefore also protect habitat for these species.

Parts of Nightcap National Park are included on the World Heritage list as part of the Central Eastern Rainforest Reserves (Australia) (Adam 1987; DASET 1992; CERRA 2000). One of the reasons that this series of reserves is considered of outstanding universal value is the concentration of relic plant species (such as the Nightcap Oak), which are considered to have origins in the rainforests of Gondwana. Protection of the Nightcap Oak habitat will assist with the conservation of the values of the World Heritage Area.

8.4 Commercial and pharmaceutical value

There are no known commercial or pharmaceutical values of the Nightcap Oak.

8.5 Social benefits

The preparation of a Recovery Plan for the Nightcap Oak will provide an information base for future management and research of this species. Research into the phylogeny of the species may lead to important discoveries on the evolution of Australian flora and climate change, which may in turn have a broader benefit to society.

Increased community awareness of threatened species such as the Nightcap Oak will increase support for the conservation of such species and, as a result, for the protection of biodiversity.

8.6 Economic consequences

The total cost of implementing the recovery actions will be $67,520 over the five year period covered by this plan. Existing resources within the DEC will fund $20,520 of this cost over the five year period. The balance of the costs ($47,000) are unsecured. Implementation of actions against unsecured funds will be subject to budgetary and other constraints.

9 Preparation Details

This Recovery Plan was prepared by Dianne Brown of the DEC Threatened Species Unit, North East Branch, with assistance from the Nightcap Oak recovery team.

10 Review Date

Any major changes to this Recovery Plan will require the revised plan to be placed on public exhibition in NSW and re-approval by the NSW Minister for the Environment. The DEC, the Commonwealth Department of Environment and Heritage or other Recovery Team members should be contacted if it is believed any change to the Recovery Plan or recovery program should be considered.

A major review of this Recovery Plan will occur within five years of the date of its publication.

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12 Abbreviations Used in this Document

ahd	Australian Height Datum
dbhob	diameter at breast height over bark
BGT	Botanic Gardens Trust
DEC	Department of Environment and Conservation (NSW)
EP&A Act	NSW *Environmental Planning and Assessment Act* 1979
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999
ESD	Ecologically Sustainable Development
FT	Forest type
MOU	Memorandum of Understanding
NCRBG	North Coast Regional Botanic Gardens
NPW Act	NSW *National Parks and Wildlife Act* 1974
NSW	New South Wales
NVC Act	NSW *Native Vegetation Conservation Act* 1997
P&R Act	*Plantations and Reafforestation Act* 1999
RBGMA	Royal Botanic Gardens Mt Annan
SIS	Species Impact Statement
TSC Act	NSW *Threatened Species Conservation Act* 1995

Table 3. Estimated costs of implementing the actions identified in the Recovery Plan.

Action no	Action Title	*Priority	Cost Estimate ($'s/year)					Total Cost ($	Responsible Party/Funding sources	#In-kind	^Cash
			Year 1	Year 2	Year 3	Year 4	Year 5				
1	**Habitat management**										
1.1	Fire management	1							DEC		
1.2	Tourism	1	1000					1000	DEC	1000	
1.3	Site visitation and location confidentiality	1	7000					7000	DEC		7000
1.4	Weed management	1	500	500	500	500	500	2500	DEC	2500	
1.5	Environmental assessment	1	1000					1000	DEC	1000	
1.6	Critical habitat	3	1000					1000	DEC	1000	
2	**Research**										
2.1	Survey	2	500	500	500	500	500	2500	DEC	2500	
2.2	Monitoring	1	5000	5000	5000	5000	5000	25000	DEC		25000
2.3	Genetics	3	15000					15000	DEC		15000
2.4	Pollination biology and breeding system	2	5000					5000	DEC	5000	
3	**Ex-situ conservation**	1									
3.1	Maintenance of living collection	1	5720	200	200	200	200	6520	DEC	6520	
3.2	Seed collection	1	1000					1000	DEC	1000	
	Annual cost of the Nightcap Oak Recovery Program		**42720**	**6200**	**6200**	**6200**	**6200**	**67520**		**20520**	**47000**
Total											**67520**

* Priority ratings are: 1 - action critical to meeting plan objectives; 2 - action contributing to meeting plan objectives; 3 - desirable but not essential action

#'In-Kind' Funds represent salary component of permanent staff and current resources

^'Cash' Funds represent the salary component for temporary staff and other costs such as the purchasing of survey and laboratory equipment

Appendix 1 Summary of Advice from the NSW Scientific Committee

Submission	Comment	Amendments made to Recovery Plan
NSW Scientific Committee	Should State Forests be a relevant agency?	Species no longer occurs on State Forest – all land has been transferred to National Park estate.
	Within the brief time the species has been known, no leaf suckers etc have been observed to cause serious problems – this does not rule out the possibility of periodic irruptions.	Text added.
	Collection by enthusiasts would not only be a threat but would be illegal.	Noted – wording changed from "inappropriate" to illegal.
	Is there anything more known about the population dynamics and breeding system of the other *Eidothea* species (*E. zoexylocarya)* in Queensland that could be useful in understanding the biology of *E. hardeniana.*	All relevant available information on the Queensland *Eidothea* was included in the plan.

Department of
Environment and
Conservation (NSW)