IVG FOREST CONSERVATION REPORT 9A

Report to Professor Jonathan West, Chair of the Independent Verification Group
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Summary

Task (i): The documentation provided in support of the HCV forests is a compendium of reviews, reserve proposals and coupe-level case studies which make a collective argument for the protection of particular native forests based on their assessed conservation values. The documents vary in their detail and degree of persuasion but are generally of a high standard, with cogent arguments supported at least in part by modern conservation theory and practice. However, some documentation is rather dated and overlooks newly available evidence and conservation insights.

Task (ii): I have identified a number of critical gaps in available conservation knowledge that could impact the potential values of identified HCV forest areas. The documentation does not always provide a comprehensive account of authoritative information on the conservation values of the nominated areas and makes only limited use of information and data such as that available in the Tasmanian Natural Values Atlas. Nevertheless, in most cases new information reinforces the biodiversity values previously collated. Many of the HCV areas contribute valuable elevation gradients supporting altitudinal movement of species.

Task (iii): It is difficult to comprehensively address the impact of current and past off reserve forest management on Tasmanian biodiversity. This is largely due to the paucity of follow-up studies to examine the fate of species and communities subject to this mode of management. While general conservation theory underpins most recent silvicultural planning and practices, time frames are too short to be certain of the efficacy of outcomes. A considerable contribution comes from private land acquired to meet RFA targets for forest types, with the expectation that these will act as surrogates

for a diverse range of other biota. This assumption is largely untested in Tasmania and not fully supported based on studies elsewhere in the world. Consequently the implications of off reserve management for the level of reservation needed to provide adequate biodiversity conservation outcomes are not clear. The conservation outcomes mediated through the Forest Practices Code as administered by the Forest Practices Authority are mixed and sometimes controversial. This is effectively a facilitatory and self-regulatory system with some inherent conflicts of interest, general adherence to minimalist (legislated) outcomes and with a limited range of auditing. In some instances of truly independent audit in the service of external tribunals or courts, this system has been found to be wanting. These experiences have undermined public confidence in the capacity of the native forest industry to deliver good conservation outcomes. The Forest Conservation Fund ($17.5 million) which wound up in 2009 achieved well under half its old growth forest area target. Consequently, considerable areas of high conservation value old growth forest are at risk.

In summary, I conclude that there are major shortfalls in the area of native forest needed for adequate biodiversity outcomes. This applies both to the quantum of forest, its configuration and landscape context and its representation across IBRA bioregions. North eastern Tasmania, the Western Tiers and parts of southern Tasmania seem to be rich in biodiversity assets important for resilience and need better protection. In particular I would highlight the opportunity to conserve long elevational gradients supporting natural environments from low to high altitude and offering security to species which need to adjust their ranges under climate change.
Off reserve management in Tasmania is poorly coordinated, opportunistic, beset with on-going compromises and under resourced in terms of management funds and research needed to make good decisions. Although excellent work is done by a cohort of Tasmanian conservation biologists their individual focus has tended to be narrowly into their specialisations and their additive conclusions and advice are diluted in the competing demands made upon the native forest estate. New research is uncovering extraordinary biodiversity riches in Tasmania, including at the genetic level. The latter is yielding new insights into the history of the biota and equally offering guidance for conservation planning for the future..

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INTRODUCTION

The Australian and Tasmanian Governments entered into the *Tasmanian Forests Intergovernmental Agreement* (IGA) in August 2011 in response to the community-led Tasmanian Forests Statement of Principles (SoP).
The IGA anticipates that an Independent Verification Group be established to provide advice to the Prime Minister and Tasmanian Premier on a number of matters including stakeholder claims relating to conservation values, areas and boundaries of potential reserves from within the ENGO-nominated 572,000 hectares of High Conservation Value native forest (Clauses 20 and 28).

Task (i): Provide expert assessment of and report on the documentation provided by ENGO's in support of the proposed 572,000 hectare addition to the Reserve System of the area of Tasmanian forest identified by ENGO's as being of High Conservation Value (HCV) and referred to in the Tasmanian Forests Intergovernmental Agreement.

Task (ii): As part of the assessment, provide expert advice on whether there are critical gaps in conservation knowledge that could impact the identified area of HCV forest, particularly in terms of
(a) whether the documentation provides a comprehensive account of published authoritative information on the conservation values of the nominated HCV areas and
(b) if there are significant additional published or otherwise available, data or information concerning the conservation values of Tasmania's native forests.

Task (iii): Provide expert advice on the impact of current and past off reserve forest management on biodiversity and the implications of off reserve management for the level of reservation needed to provide adequate biodiversity conservation outcomes.

METHODS

Task (i)

Provide expert assessment of and report on the documentation provided by ENGO's in support of the proposed 572,000 hectare addition to the Reserve System of the area of Tasmanian forest identified by ENGO's as being of High Conservation Value (HCV) and referred to in the Tasmanian Forests Intergovernmental Agreement.

The key document for assessment is entitled: *Tasmania's Native Forests: Places for Protection*. A backgrounder on the ENGO identified high conservation value reserve areas dated June 2011. The document and supporting evidence were read carefully and assessed against a set of criteria which addressed the veracity of the claims made in the documentation.

Task (ii)

As part of the assessment, provide expert advice on whether there are critical gaps in conservation knowledge that could impact the identified area of HCV forest, particularly in terms of
(a) whether the documentation provides a comprehensive account of published authoritative information on the conservation values of the nominated HCV areas and
(b) if there are significant additional published or otherwise available, data or information concerning the conservation values of Tasmania's native forests.

I conducted a literature review of recent developments in our understanding of the Tasmanian forest biota in order to identify critical gaps in conservation knowledge that could impact the identified area of HCV forest. From this exercise I make a judgement whether the documentation provides a comprehensive account of published authoritative information on the conservation values of the nominated HCV areas.

In addition, I explored (i) the elevational range of habitat which would be delivered by each of the HCV forest areas and (ii) the availability of distribution data, including published maps, for a cross section of forest dependent biota which would be relevant to assessing the conservation value of Tasmania's native forests.

Task (iii)

Provide expert advice on the impact of current and past off reserve forest management on biodiversity and the implications of off reserve management for the level of reservation needed to provide adequate biodiversity conservation outcomes.

For this task I firstly summarised the range of instruments and incentives in place to encourage better conservation outcomes in forested habitats in Tasmania. These include a variety of government and private initiatives. Secondly, I examined the efficacy of conservation outcomes delivered by compliance with the Forest Practices Code 2000 which covers production forests in Tasmania. I then examine some of the major shortcomings of the system, drawing on recent documentation and events, and draw conclusions.

RESULTS

Task (i)

Provide expert assessment of and report on the documentation provided by ENGO's in support of the proposed 572,000 hectare addition to the Reserve System of the area of Tasmanian forest identified by ENGO's as being of High Conservation Value (HCV) and referred to in the Tasmanian Forests Intergovernmental Agreement.

The ENGO documentation is a collation of reviews, brochures and other documents in support of the conservation values of the proposed additions to the reserve system. These draw upon a wide range of sources, including published scientific papers, government reports, previous park proposals including evidence from the Community Forest Agreement 2005 and previously unpublished material.

Review of Chapter 4 - Conservation Benefits of the ENGO Reserve Areas

This chapter benchmarks the ENGO areas against a set of social and conservation criteria.

4.1. The Change in Forest Type Reservation of the ENGO Reserves

Overall the ENGO reserve area requires one third of the net production forest area (222,000 ha out of 676,900 ha).

4.2 Regrowth and Plantation

The conservation value attached to regrowth and, especially, plantation forest is contentious. However, legacy old growth values usually persist in natural regrowth following wildfires (e.g. moist large logs and standing hollow-bearing stags) compared to few such values in post logging regrowth. Silvicultural regeneration can contribute by enabling better reserve design through the provision of connectivity via corridors and reduction in deleterious edge effects for example. In time, higher conservation values should also accrue to regrowth forests as hydrological values are restored and populations of important species recover through dispersal. Only 2% of the ENGO HCV area is plantation and it is intended that this will be harvested before eventual restoration to native forest. A considerable literature on ecological restoration exists to inform management of this process.

4.3. Tasmania Together Goals for Tasmania's Reserve Estate

Tasmania Together (TT) is an integrated social, environmental and economic blueprint containing 24 goals, supported by numerous indicative benchmarks, to achieve a shared vision of Tasmania by 2020. It was released in 2001 following a two and a half year period of public consultation. Two thirds of Tasmanians supported a TT benchmark to phase out old growth logging in HCV forests by 2003.

I find the following both claims supported on the evidence, viz. that (i) the ENGO claim will increase old growth reservation by about 8% and (ii) will create an additional 5.5 % of state reserves bringing the total protected land to over 50% and therefore meeting the 2020 target (i.e. indicator - 11.4.1).

4.4. An Indicative Desktop Analysis of High Conservation Values across the State Forest Estate.

This is arguably the most contentious aspect of Chapter 4, largely due to the semi-subjective nature of the methodology employed and the incomplete knowledge of the occurrence of threatened species and other conservation assets. Context issues also arise since some values will be affected by the nature of neighbouring land uses. However, the need for forest area selection to satisfy multiple conservation criteria can be met by using scoring systems which combine different values. This approach, common in economics, has been used by conservation planners in the past (Williams 1998, Ferrier & Wintle 2008). The subjectivity in weighting of values associated with the approach is an inherent limitation of the method but it has the advantage of capturing the input of a range of expert knowledge. Alternatives in area selection such as complementarity methods also suffer limitations such as requiring reasonably complete knowledge of the species in each candidate area, or well supported surrogates *in lieu*. Nevertheless, I believe this exercise employs a credible balance between subjective and objective criteria relevant to ranking the conservation merit of the land in question.

5. A Comprehensive, Adequate and Representative Forest Reserve Network in Tasmania: The ENGO proposed forest reserve system explained.

5.1. Background

5.2. Historical context

5.3. A comprehensive, adequate, representative forest reserve design for Tasmania.

5.4. ENGO reserve design

4.5 [sic!] Conservation values criteria for reserve proposal areas

6. Appendixes

6.1. Table of conservation values in forest areas within the ENGO Reserve Proposal.

6.2. Documents in Support of Extending the Boundary of the TWWHA – 1989 to 2008

6.3. Maps

6.4. ENGO and community group reserve proposals for ENGO identified high conservation reserve area proposals.

The following 17 items constitute the majority of detailed evidence provided in support of the proposal, to which I annotate a short commentary:

1. Law, Geoff. 2009. *Western Tasmania - A Place of Outstanding Universal Value*. Proposed extensions to the Tasmanian Wilderness World Heritage Area. 36 pp.

   This document comprehensively reiterates the case for World Heritage Status for the Tasmanian Wilderness WHA and argues for improving the integrity and completeness of the area in order to better protect its outstanding universal values.

   It is the only document in the set to explicitly highlight the threats posed by the recent malicious introduction of foxes to Tasmania as both a predator and competitor for dens as well as the hazards associated with foxes using roads as dispersal routes (Meek and Saunders 2000).

2. Hitchcock, Peter. 2008. *Tasmanian Wilderness World Heritage Site - A Review and Evaluation of Critical Forest Issues.* OC Consulting. 180 pp. (including appendices).

   This document makes a comprehensive case for adding the tall forest areas which fringe the margins of the current TWWHA. A particular strength of the Hitchcock report is the careful calibration of documented values for these candidate HCV areas against the objective World Heritage criteria.

3. Pullinger, Michael (editor) 2004. *A proposal for a Tarkine National Park – protecting Australia's largest temperate rainforest.* Tarkine National Coalition Inc., Burnie, Tasmania. 113 pp.

   This document is the most comprehensive case available for the conservation values of the north western forests. Although somewhat dated now, its key findings remain pertinent. Noteworthy is the rare opportunity to conserve a large expanse of forest developed on high fertility substrates (basalt). Most such forest elsewhere in Tasmania has been historically cleared for agriculture or plantations. Forests on nutrient rich sites may harbour special values such as enhanced species richness and resilience to disturbance through high local productivity.

4. Anonymous. n.d. *Ben Lomond National Park Proposal*. 24 pp.

   This proposal makes a compelling case for improving the conservation value of the Ben Lomond massif through the addition of adjacent forested habitats which will conserve the integrity of outstanding environmental gradients which surround the high plateau.

5. Fitzgerald, Nick & Dudley, Todd. 2007. *Constable Creek – Loila Tier Reserve – a new protected area for north east Tasmania*. North East Bioregional Network. 20 pp.

   This document makes an excellent case for the conservation of a valuable area in the north east where conservation outcomes are presently limited.

6. West Wellington Protection Group. 2010. *West Wellington High Conservation Value submission*. 10 pp.

This document assembles evidence in support of the conservation of natural assets in the West Wellington range. Due to its proximity to Hobart and the closer settlement on its fringes, the area is under growing pressure from human-related impacts, including recreation.

7. North East Bioregional Network . 2007. *Linking landscapes – new reserves for north east Tasmania*. 22 pp.

This document is predicated on a relatively new conservation concept – that of linking landscapes to leverage the benefits of connectivity. Its careful assessment of suitable land packages and their configuration makes an excellent case for consideration. The NEBN draws on the expertise of local naturalists and landowners with a high level of familiarity and understanding of local conservation assets.

8. Nicklason, L., Millen, T. & Ball, J. 2007. *North east Highlands National Park Proposal*. 20 pp.

9. Anon. n.d. St Marys Protected Landscape [map only]. 1pp. North East Bioregional Network.

This map presents a scenario which delivers excellent conservation outcomes through incorporating good regional representation of forest types, an excellent coverage of environmental gradients (notably elevational range) and protection of east coast "cloud forest" environments which are otherwise very poorly conserved in Tasmania. In addition, proposed extensions on public land deliver connectivity from near the coast (Scamander conservation area) to north west of the Nicholas range via the German Town Forest reserve.

10. Anon. 2009 *Wielangta WildCountry Conservation Plan*. 12 pp.

This plan addresses 41,098 hectares of eastern Tasmania situated over a hotspot of conservation values, including important swift parrot breeding habitat, a variety of narrow range endemic species and a likely climate refugium. Using MARXAN as an analysis tool it makes a significant case for the addition of new reserves on public land which complement existing reserves. In addition it identifies more than 100 conservation assets (Appendix 1) incorporating vegetation types, geological substrates and landscape position.

11. Fitzgerald, N. 2009. *The Bay of Fires – A new national Park for Northeast Tasmania*. Bay of Fires Coastal Preservation lobby and the North East Bioregional Network. 33 pp.

A compilation of evidence in support of a new conservation area in NE Tasmania which would make a valuable contribution to the representation of forest types in the bioregion.

12. Fitzgerald, N. 2006. *Special values of the Upper Florentine - flora, vegetation, giant trees, geomorphology, archaeology.* 8 pp.

13. Fitzgerald, N. 2007a. *Special values report for Larsen creek coupe GC104A.* 16 pp. North East Bioregional Network

14. Fitzgerald, N. 2007b. *Special values report for Ransom River coupe GC148A, near Goshen.* 18 pp.

15. Fitzgerald, N. 2007c. *Special values report for coupe GL208A.* 8 pp.
16. Fitzgerald, N. 2007d. *Special values report for coupe GL208C.* 8 pp.
17. Fitzgerald, N. 2007e. *Special values report for Siamese Ridge coupe UR020D, near Pyengana.* 20 pp.
Items 12 to 17 document special values for a number of coupe-sized areas (typically 50-100 hectares in extent). These items are exemplars of careful independent evaluation of ecological assets and highlight the importance of quite small areas as repositories of threatened species as well as their excellent condition through freedom from unnatural disturbance including weed invasion.

FORESTIER AND TASMAN PENINSULAS including extensions to Tasman National Park (based on Tooker, n.d.)

A newly available reference is the *Tasman National Park and Reserves Management Plan* 2011 which offers a more comprehensive accounting of local conservation assets. The narrow, almost linear configuration of the existing Tasman National Park which hugs the coastline of the combined peninsulas, falls short of good conservation principles. Although many of the catchments are small there are few relatively unimpacted catchments on the peninsulas.
Despite their modest area, the Peninsulas are a hotspot of diversity for endemic fauna and flora as well as outliers of remnant rainforest ecosystems. Areas near MacGregor Peak on the Forestier Peninsula and Tatnells Hill on the Tasman Peninsula have been identified as areas indicative of high flora species richness with 14 eucalypt species present within $10km^2$.
http://www.parks.tas.gov.au/file.aspx?id=7040
Unfortunately, half the flora is susceptible to *Phytophthora cinnamomi* and enlarging the area of reservation will help buffer populations against losses to pathogens.
The Peninsulas' important function as a refuge from past climatic stress is likely related to a benign maritime climate from its proximity to the ocean, relatively high rainfall, and complex topography including elevated peaks offering small scale refuges and various environmental gradients. To exploit these opportunities species must be able to move across the landscape facilitated by good connectivity and large contiguous areas of natural habitat.

Forestier Peninsula (FID 17)
Similarly the presently conserved area is configured as a very narrow coastal band and includes only the eastern facing slopes and cliff face. The proposed extension will contribute more high ground, some exceeding 500m, and the cloud forest at High Yellow Bluff in addition to preserving the scenic attributes of this region. Some steep elevational gradients are also captured in this block.

The extension will improve water catchment values on the Peninsula and help protect the rare slender tree fern (*Cyathea cunninghamii*) at nearby Walters Opening. The rare and highly localised Burgundy Snail *Helicarion rubicundus* is virtually restricted to the forests of the Forestier Peninsula where E*. regnans, E. obliqua* and *E. globulus* are dominant (Taylor 1991).
Furthermore, FID 18 contributes a greater contiguous area that takes in a trend to drier forest communities associated with a westerly aspect thus sampling a greater range of the Peninsula's habitats important for local endemics.
This block also contains forest necessary to meet the RFA JANIS criteria including RFA identified oldgrowth. It is important habitat for the threatened Tasmanian Devil.

Forests south and east of Murdunna have been heavily impacted by intensive commercial forestry since the 1970s and forest structure has been simplified over very large areas of Forestier Peninsula. This block is a rare opportunity to capture a cross section of the original spectrum of native forests and their fauna.

Taranna Component (FID 14)
The National Park in this region is also too narrow and protects the only easterly cliff face and adjacent vegetation.
Important cloud forest in the vicinity of Tatnell's Hill is currently poorly reserved and likely to be rich in endemic invertebrates.
Much of this area is skyline and will maintain the scenic attributes of a major tourist destination.
The proposed Taranna extension will widen the park, reducing edge effects relative to area, and take in the upper catchment for easterly-flowing streams through the Park. By enlarging the area of protected catchment it will enhance the quality of the freshwater entering the Fortescue Bay Marine Reserve and its associated kelp forest ecosystem.

Mt Fortescue Component (FID 7)
Park in this area is narrow strip with easterly aspect. Extension (FID 8) will take in more of the westerly aspect as well as rare cloud forest habitat in the upper reaches. Catchment values will be protected with high water quality maintained in the stream entering Fortescue Bay.
The skyline view near Mt Fortescue will be enhanced for the proposed "Three Capes Walking Track"

Mt Spaulding Component (FID 10)
This area contributes high quality forested habitat and intact upper catchment values. The forested upper slopes exceed 250 m elevation, high enough to harvest additional water from cloud stripping. It adds considerable area of extent to the Mt Spaulding forests which presently configure as a small peninsula on the current boundaries of the Tasman National Park.

The proposed extension is in the immediate region of the beginning of the proposed Three Capes Walking Track.

East of Nubeena Component (FID 12)
This 820 ha block contributes a upper slopes which exceed 500 m elevation and likely to qualify as cloud forest and somewhat isolated from others. It is an important forested stepping stone between the eastern and western parts of the Peninsula.

FID 9
Is a small (31.5 ha) elevated block of native forest, mostly above 300m, is strategically located among clearfells, cleared land and early regrowth forest. Its location close to FID 13 will contribute to the collective conservation value of the ensemble through adding habitat area and elevational gradient.

Appendix 2 CONNECTIVITY AND TALL EUCALYPT FORESTS OF SOUTHERN TASMANIA (p.174).

In relation to the 3 related species of tall eucalypts, the claim is made in the ENGO documentation that "ecologically the forests have a shared animal biota". While broadly true, this statement overlooks the presence of subtle differences reflecting variation in resources, forest age (Hingston 2010) and landscape position (MacDonald 2001).
Birds illustrate some of this difference. In the absence of treecreepers in Tasmania (Keast 1970), the deciduous bark of *E. regnans* is regularly probed for insects by honeyeaters. Bark is the major foraging substrate for endemic strong-billed honeyeaters (*Melithreptus validirostris*) and their distribution may reflect its availability. In contrast, the persistent bark of *E. obliqua* provides fewer feeding opportunities for these birds. Loose and hanging bark is a major winter foraging substrate for birds in *Eucalyptus regnans* forests in Victoria also (Loyn 1985a, b).
In another point of difference, tree hollows in the lower trunk are less common in *E. regnans* compared to *E. obliqua* and *E. delegatensis* because the latter species are more fire tolerant and older trees often exhibit cavities caused by fire erosion.
The spread of age cohorts in these forests also differs with fewer cohorts typical in stands dominated by *E. regnans* (Turner 2009). This could be expected to affect the profile of large phytophagous insects such as *Abantiades* (Hepialidae) which prefer trees of a particular age class (Kile 1979) or stem diameter which influences large borers such as *Aenetus* (Hepialidae) larvae. In turn the latter attract specialised predators such as Yellow-tailed Black Cockatoos *Calyptorhynchus funereus* which have the physical capacity to extract insect prey deeply embedded in tree stems.

Task (ii)

As part of the assessment, provide expert advice on whether there are critical gaps in conservation knowledge that could impact the identified area of HCV forest, particularly in terms of (a) whether the documentation provides a comprehensive account of published authoritative information on the conservation values of the nominated HCV areas and (b) if there are significant additional published or otherwise available, data or information concerning the conservation values of Tasmania's native forests.

(a) *Does the ENGO documentation provides a comprehensive account of published authoritative information on the conservation values of the nominated HCV areas?*

In my judgement, the quality of the review of published information on the nominated HCV areas is uneven and sometimes under documented, as discussed later. Some of the case studies in the documentation are long-established ones which are relatively well known but would be enhanced by better or updated quantitative data. However, while data-driven conservation planning is necessary for sound planning, available data is inadequate for most Tasmanian forest biota. Consequently better documented taxa will tend to drive conservation outcomes with the expectation that they will serve as proxies for less well known species.

Taken together, there is general conformity in the ENGO reports with established and emerging conservation theory and practice (Pressey *et al.* 2007). Three key principles of conservation planning are addressed: comprehensiveness, adequacy and representativeness (CAR). These were originally established in the context of the regional forest agreements in the 1990s.

Comprehensiveness refers to the inclusion of the full range of species, processes and ecosystems occupying a region. A comprehensive conservation plan should therefore avoid conservation action that is biased towards certain bioregions as is currently evident in Tasmania (McQuillan *et al.* 2009). Further examples include the design principle of *replication* at landscape scales in order to deliver adequacy in the reserve system. Given the frequency of unpredictable events such as fire and drought in the Tasmanian environment, such replication serves an important role as insurance against regional loss of populations and habitats. Adequacy can also be addressed by conserving processes which support the persistence of biodiversity such as connectivity. A particular challenge around adequacy in catchment conservation planning involves the connected nature of freshwater systems

Representativeness attempts to account for the full range of biodiversity represented within regions chosen for comprehensiveness. Surrogates that serve as proxy measures for wider biodiversity values may be necessary in the short to medium term.

(b) *Are there are significant additional published or otherwise available, data or information concerning the conservation values of Tasmania's native forests?*

I find here is a considerable amount of newly available data relevant to the conservation assets and values of Tasmanian forests which has not been drawn upon in the ENGO documentation.
Equally, there are important functional groups of forest dwelling biota for which no, or only limited, useful data is available. Progress in being made in some groups (e.g. the Fungimap initiative) but objective assessment at spatial scales appropriate for conservation management is lacking for the foreseeable future. Consequently a strong case can be made for a precautionary approach to conservation planning in these forests.
Those conservation assets which will contribute to long term resilience to environmental change should be paid particular attention. For example, corridors which incorporate an uninterrupted sequence of natural habitat stretching from lowland to highland forests are particularly valuable because they assist the migration of species as climates change (Killeen & Solórzano 2008).

The exemplars of tall wet forest we see today in Tasmania are largely the stochastic outcome of fire-driven regeneration cycles. Extensive areas of land are therefore needed in order to conserve a representative range of the forests resulting from the various successional trajectories which give rise to them.
The oft-repeated claim that the clearfell-burn-sow (CBS) silvicultural regime recapitulates natural regeneration in Tasmanian forests is a foundation tenet of commercial tall forest management (Attiwill 1994). However, it obscures the fact that total stand replacement by an even-aged cohort of new trees is but one of a number of fire-driven outcomes in the life history of tall wet forest. It is now apparent that most tall wet forests dominated by ash-group eucalypts are multi-aged (Hickey *et al.* 1999; Turner 2009), rather than even aged cohorts of trees recruited from a single stand-replacing disturbance event such as wildfire (Gilbert 1959). Consequently extensive areas of native forest need to be protected in order to accommodate this spectrum of natural outcomes which underpins so much structural diversity.
The possibility exists that the processes of ongoing forest fragmentation, biomass removal, changes in fire intervals and the ingress of pest species may conspire, via feedbacks, to produce "landscape traps" or regime shifts in native forests which may be very difficult to reverse (Lindenmayer *et al.* 2011). Under this scenario, entire landscapes might be shifted into a state in which major functional

and ecological attributes are compromised. However, this hypothesis is controversial (Ferguson & Cheney 2011).

Furthermore, there is no analogous process in nature which "instantaneously" removes the majority of the standing biomass including important structures such as hollow trees and slowly decaying logs. This ecological reality is only slowly being acknowledged by the forest industry (Baker & Read 2011) yet the consequences for native forest management would seem quite profound.

Comprehensive information is available on the identity of fauna using tree hollows in Tasmanian forests (Koch *et al.* 2008) together with tested survey methodologies (Koch *et al.* 2008; Koch and Baker 2011) and information concerning the influence of forest type on hollow dynamics (Koch *et al.* 2008).

GAPS

While a very substantial case for the status of potentially HCV forests can be made on the information addressed in the documentation I find there are a number of gaps in the data and arguments pertinent to good decision making. These relate to both the neglect of published or otherwise available information and insufficient data regarding important taxa, communities and ecological functions. In the 6 months since the documentation was completed, various studies have been published in the formal literature and I have incorporated some of their key findings in this review.

This information can be conveniently considered under the groupings of "conservation assets" and "conservation threats".

1. CONSERVATION ASSETS

1.1 Genetic diversity

Genetic diversity is a fundamental component of forest ecosystems and explicitly featured in standard definitions of biodiversity. Unfortunately, this asset has been largely unmeasured or ignored in assessment and planning outcomes until very recently (Laikre *et al*. 2010). Despite the challenges posed in its documentation, interpretation and management, there is no compelling reason why genetic diversity should not be more widely considered in conservation planning for Tasmanian forests. Its geographical structure has long been appreciated; indeed it has been forestry practice for some decades to collect and resow into harvested coupes the local provenance seed of commercially useful eucalypts. This practice has helped preserve local biotypes of these trees *in situ*. Conservation imperatives should consider both the quantum of genetic diversity contained within species and the geographical distribution of genetic variation manifest as discrete populations and clines. The effects of deep historical processes on population genetic structure are today increasingly overlain by the effects of contemporary habitat modification so that much variation has already

been depleted or otherwise altered. Increasingly, the evolutionary future of many species and populations will be compromised as a result as more limited genetic potential (Mace & Purvis 2008). The conservation importance of genetic diversity within species is well illustrated by current research into management around the Devil Facial Tumour disease (Jones and McCallum 2011). Genetic understanding of Tasmanian devil populations is a major line of enquiry in its conservation (Miller *et al.* 2011) due to the limited genetic diversity of the species and the hope that genetic based resistance to the disease may be discovered.
The effects of climate change at the most fundamental level of biodiversity—intraspecific genetic diversity—are little studied, but cryptic genetic losses have been recently modelled in aquatic invertebrates adapted to cold water (Balint *et al.* 2011).

1.1.1 **Plants**

The configuration of geographic structure in plant genetic diversity has important implications for conservation planning. Genetic research is revealing the phylogeography of important Tasmanian trees including canopy eucalypts and rainforest species. Evidence for past bottlenecks in distribution is emerging which suggests an important role for components of the physical landscape as both refugia and as facilitators for connectivity between populations.
In addition, reticulate evolution via hybridization is apparent in Tasmanian eucalypts (Jackson *et al.* 1999) resulting in geographically complex associations of taxa closely adapted to the prevailing environmental conditions. However, the integrity of native Tasmanian eucalypts is now under pressure via genetic introgression from plantations of exotic eucalypts (Barbour *et al.* 2005) and changes in pollinator profiles due to increasing rarity of some vectors. Despite their conservation importance, the documentation of pollen vectors in Tasmania remains in its infancy. Indeed, the first pollination ecology study on *Eucalyptus regnans*, the world's tallest angiosperm, was published only recently (Griffin *et al.* 2009). Elsewhere in the world, the integrity and restoration of pollinator communities are high conservation priorities (Williams 2011).
The large and growing importance of Australian eucalypts as plantation trees in other countries places a premium on the commercial value of local genetic diversity conserved within the historical range of these species. Plant resistance to pests and frost tolerance are assets particularly sought after.

1.1.1.1 Myrtle beech *Nothofagus cunninghamii*

The cool temperate rainforests of Australia were much reduced in range during the cold and dry glacial periods. It is now apparent that keystone wet forest trees such as myrtle beech *Nothofagus cunninghamii*, survived the arid cycles of the Pleistocene in multiple refuges around the state (Worth 2009) and underwent only local range expansions at the end of the Last Glacial. In particular, the north eastern populations are highly distinct genetically from those elsewhere in Tasmania.

1.1.1.2 Sassafras *Atherosperma moschatum*

This wind-dispersed rainforest tree is widely co-extensive with *Nothofagus cunninghamii* but is less cold-tolerant (Macqueen, Goldizen *et al*. 2009). A chloroplast phylogeographic study by (Worth *et al.* 2011) shows sassafras is geographically structured with an inferred ancestral haplotype restricted to Tasmania (Fig. 1). Last glacial refugia for *A. moschatum* are likely to have occurred in at least one location in western Tasmania and in Victoria and within at least two locations in the Great Dividing Range of New South Wales. The nucleotide diversity of sassafras appears to be amongst the lowest recorded for any tree species. Its narrower climatic niche during glacials is thought to have resulted in past bottlenecks having impacted the chloroplast diversity of *A. moschatum*

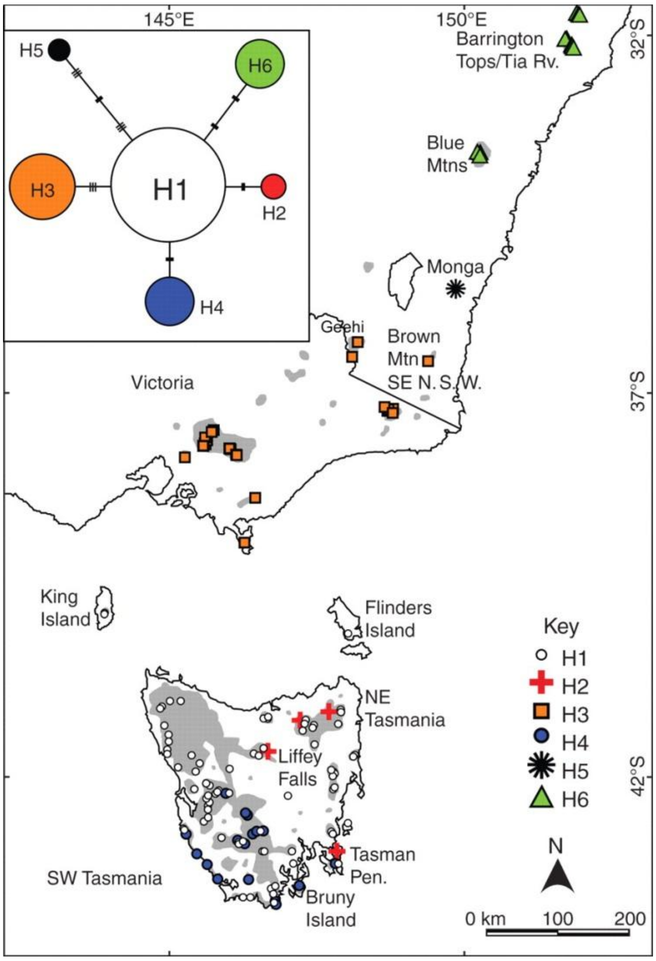


Figure ii-1. The distribution of the six haplotypes observed in *A. moschatum* (H1–H6). Grey areas indicate the natural distribution of the species.

The inset shows the median-joining network of the six haplotypes observed across the range of *Atherosperma moschatum*. The area of the circles in the haplotype network is proportional to the frequency of each

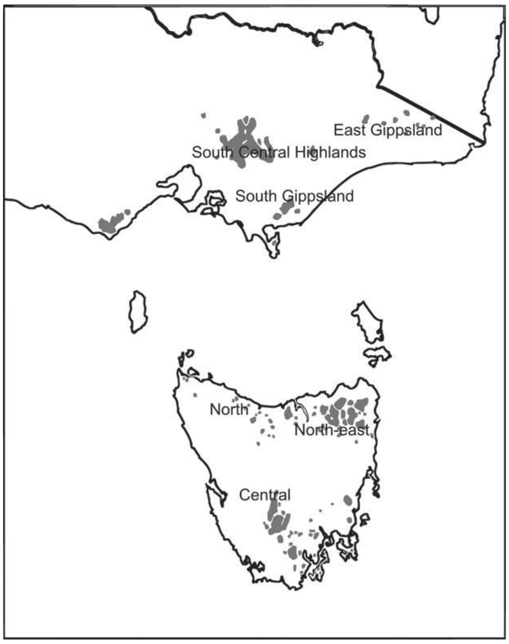


Figure ii-2. Current natural range of *Eucalyptus regnans* (indicated by grey shading) in south-eastern Australia and Tasmania and the location of the 10 geographic regions used in the analyses (Otway Ranges, Central Highlands, south Central Highlands, South Gippsland, East Gippsland, northern Tasmania, northeastern Tasmania, eastern Tasmania, south-eastern haplotype. Lengths of lines connecting each haplotype are proportional to the number of character differences between them. Single nucleotide polymorphisms (SNPs) are indicated by solid bars and simple sequence repeats (SSRs) are indicated by three stacked lines. From Worth *et al.* 2011.

Tasmania and central Tasmania) From Nevill *et al.* 2010.

1.1.1.3 Bluegum *Eucalyptus globulus*

The genetic structure within bluegum and its current distribution (Dutkowski and Potts 1999; Freeman *et al.* 2001) coincide with hypothesised glacial refugia; it is likely the species is still expanding its Holocene range from seed dispersal.

There is also significant genetic variation in plant resistance to herbivores amongst races and localities (O'Reilly-Wapstra *et al.* 2002). Differential levels of mammal browsing on bluegum are thought to be due to variation in levels of plant secondary metabolites.

1.1.1.4 Stringybark *Eucalyptus obliqua*

Genetic variation in *Eucalyptus obliqua,* which dominates much of the commercially important wet sclerophyll forest, has been recently studied by Bloomfield *et al.* (2011). Although within population diversity for nuclear microsatellites was high (average H(E)=0.80) and inbreeding coefficients low (average F=0.02), the degree of differentiation between populations was notably low (F(ST)=0.015); variation in quantitative traits is thus apparently maintained by natural selection. Pollen-mediated gene flow is likely to be the main agent countering selection along local environmental gradients, suggesting an important role for its pollinating agents, thought to be mostly insects.

1.1.1.5 Swamp Gum *Eucalyptus regnans*

The genetic relationships between populations suggest that, despite the rather narrow ecological tolerances of *E. regnans* and the stressful environmental conditions during the Last Glacial Maximum it was able to persist locally or contracted to multiple near-coastal refugia (Fig. 2), thereby maintaining a diverse genetic structure (Nevill et al 2010).

1.1.1.6 Blackwood *Acacia melanoxylon*

Blackwood is a high-quality appearance-grade timber species native to eastern Australia. Wide variation in its survival, growth and form, influence its progressive domestication and commercial development. Bradbury *et al*. (2010) found significant genetic variation in survival, growth and form were found among trees sourced from various provenances in Tasmania and mainland Australia. This variation was partly explained by broad scale adaptive differences across the wide geographic distribution of blackwood. Tasmanian seedlots from low altitudes grew better than those from high altitudes, while those from north-east Tasmania had significantly better growth rates than seedlots from the south-east. Significant genetic differences in growth form were found between Tasmanian seedlots. The increasing value of this species would therefore argue for the conservation of a wide cross section of this genetic variation.

1.1.2 **Animals**

Although the terrestrial mammal fauna of Tasmania is modest in its diversity, its isolation since the beginning of the Holocene has facilitated the emergence of unique genetic races in many species. Genetic data is helping to resolve some previous taxonomic uncertainties regarding relationships among species and populations; equally some new data is creating new uncertainties and challenges for conservation manegement. For example, the contribution of genetic data to improved phylogenetic resolution is manifest in the discovery of cryptic species in short-range endemic terrestrial crayfish, some of which occupy forests and the recognition of the ancient centipede *Craterostigmus tasmanianus* as a species separate to New Zealand examples and therefore endemic to the state (Vélez *et al.* 2011). Tasmania has a newly recognised (Parnaby 2009) endemic microbat *Nyctophilus sherrini* (Tasmanian long-eared bat) in part due to genetic evidence.

1.1.2.1 Tasmanian pademelon *Thylogale billardierii*

Pademelons show evidence of weak phylogeographical structuring of haplotypes and evidence for a divergent clade implying the mid-Pleistocene isolation of a far northwestern population. On genetic evidence contemporary Tasmanian populations can be divided into eastern and western regions, consistent with a former barrier such as greater aridity in the lowland Midlands during glacial periods, and with a contemporary barrier resulting from recent habitat modification in that region (Macqueen, Goldizen *et al.* 2009). The maintenance of this genetic diversity is important as it preserves within the population the historical signal of previous climate change, giving insights into the capacity of the species to cope with change in the future.

1.1.2.2 Snow skinks *Niveoscincus* spp.

Climate models suggest that ectotherms, such as reptiles, will be strongly affected by climate change. Tasmanian snow skinks (*Niveoscincus* spp.) are a remarkable insular diversification involving three clades and possibly resulting from the interplay between Pleistocene climate events and landscape refugia (Melville & Swain 2000). Some species display major variation in a range of life history traits as a result of the interaction between local climate and elevation. These lizards are valuable models for studying the influence of climate on population demography (Hare & Cree 2010), including the effects of increased cloud cover (Cadby *et al.* 2010). This is well studied in the viviparous spotted snow skink (*Niveoscincus ocellatus*) which occupies an altitudinal and climatic gradient spanning 1,200 m from sea level to the highlands (Cadby *et al.* 2010). Sex determination in lowland populations is mediated by maternal basking opportunity, whereas highland populations are not similarly sensitive to thermal conditions. Climate also affects female age at maturity (Wapstra *et al.* 2001).

1.1.2.3 Giant Tasmanian freshwater crayfish *Astacopsis gouldi*

This iconic animal, the world's largest freshwater invertebrate, was formerly widespread across river drainages in northern Tasmania. A narrow distribution, pollution and over-harvesting has led to the rapid decline of populations and its subsequent total loss from some drainages (Walsh & Doran 2010). Mitochondral DNA reveals a lineage from north-eastern Tasmania which is genetically divergent from the remaining populations in north-western Tasmania (Sinclair 2011). North western populations were found to be genetically homogeneous with <1% sequence divergence and included haplotypes which spanned the Tamar River, an otherwise significant faunal barrier. This finding is concordant with a hypothesis of more interconnected drainages associated with lower sea levels in the past. The cryptic lineage from north-east Tasmania may therefore be of extremely high conservation value. Conservation efforts for *A. gouldi*, combining habitat restoration with *in situ* management of wild populations and some population augmentation into once occupied rivers, will also have a positive impact for conservation of freshwater ecosystems in northern Tasmania (Sinclair 2011). There are also two colour morphs of *A. gouldi* - a blue morph, mostly found in the Arthur River catchment rarely exceeds 2kg in weight, while the more widespread brown/black morph can attain 6kg+ (T. Walsh, pers. com. 2011).

1.1.2.4 Other freshwater crayfish *Parastacidae*

Recent molecular analysis reinforces the importance of Tasmania's freshwater crayfish fauna of 34 species (Richardson *et al.* 2006) as an outstanding example of evolution in a Gondwanan group. The radiation of Australian crayfish throughout the Cretaceous and into the Recent has established a highly biodiverse group such that south-eastern Australia is one of the most globally significant regions for crayfish, second only to the Appalachian Mountains of the south-eastern United States. Similar data on coastal parastacid crayfish is also revealing the configuration of ancient drainages associated with past sealevels (Schultz *et al.* 2008) which can help clarify areas needed for the long term persistence of a species.

Two endemic Tasmanian genera, *Spinastacoides* and *Ombrastacoides,* form a clade with New Zealand and Malagasy crayfish (both monophyletic) which is a sister group to all South American parastacid crayfish (Toon *et al.* 2010). Divergence of crayfish among southern landmasses is estimated to have occurred around the Late Jurassic to Early Cretaceous (109–178 Ma). The early divergence time between New Zealand *Paranephrops* and the Tasmanian *Ombrastacoides* and

Spinastacoides (~ 136 Ma, 109–160 Ma) suggests that speciation among these crayfish pre-dates the rifting of New Zealand and Australia (~ 80 Ma.) (Toon, Perez-Losada *et al.* 2010).

1.1.2.5 Butterflies *Papilionoidea*

In some Tasmanian butterflies, regional phenotypic diversity has resulted in numerous subspecies being recognised. This diversity is thought to relate to a combination of historical isolation and adaptation to contemporary local or regional climates. In at least one species, such variation has been shown to be clinal in relation to environmental gradients (McQuillan and Ek 1997).
Several forest butterflies show strong phenotypic clines possibly reflecting adaptation to local and regional climates. Noteworthy in this regard are Macleays' Swallowtail *Graphium macleanum*, the Tasmanian Brown *Argyninna tasmanica* and the endemic Leprea Brown *Nesoxenica leprea*. These species are associated with wet forests and wet forest ecotones but their conservation needs require more thorough assessment. A recent review of butterfly phylogeny asserts that swallowtail butterflies are an ancient group with Cretaceous origins (Heikkila *et al.* 2011). This is consistent with Macleay's Swallowtail feeding as a larva upon Monimiaceae, an ancient plant family.

Recommendation: That a comprehensive sample of both continuously and vicariantly distributed populations of species be protected for both their intrinsic values, evolutionary potential and as exemplars of adaptation to climate change.

1.1.3 **Plant-animal associations**

Plant-animal associations involve key ecological interactions which deliver essential functions such as pollination, seed dispersal and litter recycling. However, our broader understanding of these patterns is still in its infancy. As detailed below, these associations are prone to invasion by exotic pest species and already we may not be able to learn about some natural associations in their absence.
The organisation of invertebrate communities on key foodplants also appears to have strong regional characteristics. On *Nothofagus cunninghamii*, the phytophagous insect fauna is distinctive at the regional level (Keble Williams 2011) which may correlate with patterns seen in chloroplast diversity at a similar scale (Worth et al 2009). Thus the consequences of regional genetic diversity within foundation species may reverberate through trophic levels.

(Barbour *et al.* 2009) recently reported significant population-level variation in biodiversity associated with bluegum leaf litter (i.e. in community richness, abundance, composition and beta diversity among 27 invertebrate orders). In addition, considerable population-level differences were evident in soil characteristics based on linseed germination and growth responses. Thus, intraspecific genetic variation in canopy trees may impact on communities and ecosystems with important implications for in situ community conservation and, biodiversity management. These community-level effects of tree genetics are expected to extend to higher trophic levels because of the extensive use of tree trunks as foraging zones by birds and marsupials. Thus, potential biodiversity benefits that may be gained through the conservation of intraspecific genetic variation within broadly distributed tree species. (Barbour *et al.*, 2009b) found substantial genetically based variation within bluegum in the quantity and type of decorticating bark. In the community of macroarthropods associated with this bark, significant variation in composition existed among trees of different races, and there was a two-fold difference in species richness (7-14 species) and abundance (22-55 individuals) among races. This community variation was tightly linked with genetically based variation in bark, with most variation (60%) in community composition driven by bark characteristics.

Recommendation: That a comprehensive sample of the genetic diversity of native trees and animals be captured in the permanent conservation estate in order to maximise the diversity of associated herbivores and detritivores. This will help maximise the potential of these species to adapt to future environmental change and act as a repository of commercially valuable genes for plantation eucalypts.

2. THREATS TO CONSERVATION ASSETS

2.1 Impact of invasive species, mutualists and social predators

A variety of non-native species introduced to Tasmania have now established large and growing populations in native forest areas. As they integrate themselves into local foodwebs competition with native species for resources is expected to put additional pressure on ecosystems. This presents a major challenge to conservation managers charged with maintaining the ecological integrity of these forests. The following four examples are illustrative of the management challenges ahead.

2.1.1 Honeybees *Apis mellifera*

Feral honeybees are well established in Tasmania and may monopolise floral sources in forested areas with poorly understood ecological consequences. Elsewhere in the southern hemisphere temperate zone invasive nectarivores have been shown to erode native pollination networks (Aizen *et al.* 2008). In Tasmanian rainforest, honeybees locally deplete both nectar and pollen resources of the endemic leatherwood tree *Eucryphia lucida* (Mallick and Driessen 2009). Exotic bees also rob nectar from bird-pollinated flowers such as the endemic *Prionotes cerinthoides* without apparently effecting pollination (Mallick and Driessen 2009; Johnson *et al.* 2010). However, the extent of honeybee impacts on *Eucalyptus* pollination remain equivocal (Horskins and Turner 1999; Hingston

et al. 2004) but outcomes can include an increase in geitogamy (Bacles *et al.* 2009) and novel pollen flows at landscape levels, both with implications for evolutionary potential in the tree species.
The introgression of genes from exotic eucalypts or populations into the gene pools of native trees is a detrimental consequence of the expansion of tree plantations. Insect-mediated pollen dispersal from exotic *Eucalyptus nitens* plantations into native *E. ovata* forest in Tasmania was documented by (Barbour, Potts *et al.* 2005) although native pollinators are mostly implicated as agents in the transfer. Most hybridisation occurred within 200 metres of exotic plantations but was detected out to a distance of 1.6 kilometres, the geographical limit of the study. It might therefore be regarded as an edge effect which could be somewhat ameliorated by attention to patch configuration.
In South Australia, the presence of honeybees in national parks was shown to reduce the carrying capacity of meliphagid honeyeaters, presumably due to competition for food resources (Paton 1996).

2.1.2 Bumblebees *Bombus terrestris*

Bumblebees of European origin established (probably via New Zealand) as a feral pest in Tasmania in the early 1990s and despite its highly inbred population (Schmid-Hempel *et al.* 2007), rapidly spread over the island (Hingston and McQuillan 1998). This highly polylectic social bee has been observed to take nectar from more than 100 species of native plants. There is a reasonable fear that a number of sleeper weeds pre-adapted to bumblebees, formerly limited by low seedset, may become more invasive as a consequence of its introduction (McFadyen and Lloyd 2006). In addition, bumblebee colonies establish nests in pre-existing holes in the ground including small mammal retreats. Some wet forest weeds such as rhododendron, gorse, broom and foxglove may be candidates for enhanced levels of viable seedset due to the activities of this pest (Dafni *et al.* 2010).

2.1.3 European wasps *Vespula germanica, V. vulgaris*

European social wasps can monopolise carbohydrate resources in forests to the detriment of native species (Beggs 2001) and are implicated in the restructuring of insect communities (Beggs & Rees 1999) and decline of native birds in temperate forests in New Zealand (Elliott *et al.* 2010). The recent establishment of a second species in Tasmanian tall forests is a potential ecological catastrophe (Matthews *et al.* 2000). Effective control of these invasive predators and amelioration of their effects is unlikely in the short to medium term (Beggs *et al.* 2011). Therefore land area offsets may be required to compensate for their ecological impacts as they compete with insectivorous birds for prey and native pollinators for access to nectar and pollen. Their exploitation of pre-existing cavities, usually in the ground, puts them in conflict with a variety of native vertebrates for living space.

2.1.4 Lyrebirds *Menura novaehollandiae*

Following their deliberate introduction to Tasmania in the 1930s-40s (Sharland 1944) lyrebirds are still spreading through the wet forests of Tasmania (MacDonald 2001) where their intensive foraging activity in the topsoil and litter layer may affect forest structure and nutrient dynamics (Ashton and Bassett 1997) and potentially interfere with native ground foraging birds such as the Bassian thrush *Zoothera lunulata* (Tanner 2000). Given the public endearment surrounding the lyrebird, it is unlikely that an extermination programme involving lethal methods would be approved.

3 Refugia

If biodiversity conservation is to be truly long term, planning in relation to present distribution patterns is not likely to be sufficient. There is also a need to reserve the places that are most critical for the survival of biodiversity in the extremes of climatic variability that have occurred in the past, and are likely to occur again in the future (Kirkpatrick & Fowler 1998).

The complex topography of Tasmania, along with its marked environmental gradients, has generated a diversity of both local and landscape scale refugia which has facilitated the long term survival of many species (Kirkpatrick & Fowler 1998). Essl *et al.* (2011) argue that concentrating conservation efforts on known Pleistocene refugia has merit as a first step towards a strategy for protecting regional endemics of at least among less mobile species.

The critical refugia for conservation planning are those that occur at the extremes of the climatic fluctuations that have characterized the last few million years. Knowledge of the location of such refugia in Tasmania is now beginning to emerge (Kirkpatrick & Fowler 1998). Reconstruction of the genetic history of the Tasmanian pademelon *Thylogale billardierii* point to the importance of the north western sector of the island as a refuge during the mid Pleistocene (Macqueen *et al.* 2009). The low elevation central Midlands region at the time was semi-arid and a likely barrier between pademelon populations in the east and west of the state and there is genetic evidence of at least one glacial refuge in eastern Tasmania from which the species recolonised Flinders Island.

Earlier arguments that reservation should largely cover the main Last Glacial refugia (e.g. rainforest, Mendel & Kirkpatrick 2002) need modification in the light of the discovery of complex phylogeographic structure in important rainforest trees revealing a Pleistocene history involving retreat to multiple refugia followed by cycles of expansions. In addition, more immediate and future climate challenges will probably include warm and dry conditions rather than cold and dry regimes typical of the ice ages. Under such scenarios, refugia are likely to be different in location and configuration and necessary to confer protection from hazards such as fire and high evapotranspiration.

Physical refugia from dryness and fire are highly variable in scale and can be scattered across landscapes and regions. Microrefugia support locally favourable climates amidst unfavourable regional climates. Typically, interaction between regional advective influences and local terrain defines these sites (Dobrowski 2011). Tasmanian examples include cloud forests on near-coast uplands; deep valleys; south and south-east facing slopes which confer shading and lower evapotranspiration; areas of ground water supplementation; riparian habitats, wetlands and mossbeds which help store and redistribute moisture. The accumulation of important old-forest habitat features such as coarse woody debris is correlated with available moisture even at small scales. Sphagnum moss beds can be locally extensive in Tasmania and are a special habitat highly sensitive to environmental conditions and local hydrology (Whinam *et al.* 2001). Outstanding examples, such as Bird Plain south of Hartz Peak, create fire-proof habitat which has favoured the development of giant examples of *Richea pandanifolia*.

4 Parapatric and other speciation boundaries

Many Tasmanian clades show mosaic distributions among related species, involving phenomena such as parapatric boundaries, or narrow zones of geographic overlap, or sympatric contact zones. Parapatric boundaries occur where the biogeographic distribution of two species abut without obvious physical barriers between them, but do not overlap. Recent mapping has revealed the existence of a number of such boundaries which are of conservation interest in Tasmania.
Some of these boundaries are intuitive, such as wide valleys (e.g. the Mersey valley) or substantial rivers (e.g. the Tamar and Derwent rivers) but some others appear to not coincide with any obvious physical barriers and may be less spatially constant over time.

Examples of parapatric boundaries are documented in the following forest-dwelling taxa in Tasmania:

4.1 *Velvetworms*

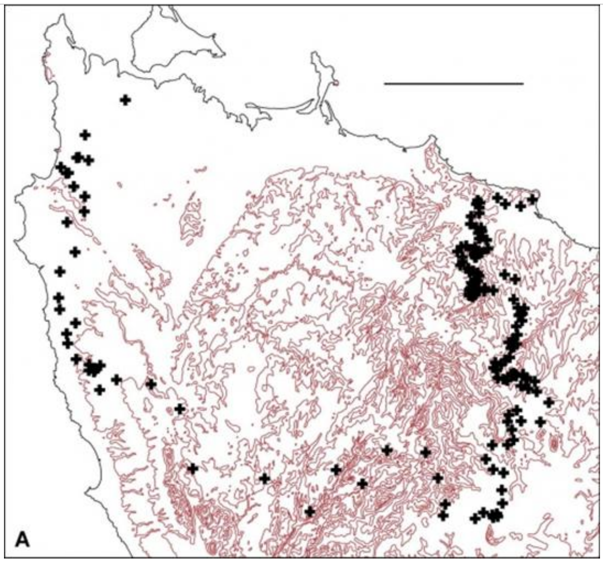
Onychophorans have high conservation value due to their status as a phylum of “living fossils” with connections to the Cambrian explosion of terrestrial lifeforms (New 1995). Discoveries since the 1980s show that Tasmanian forests are rich in endemic taxa including the genus *Tasmanipatus* which displays a parapatric boundary in species’ distributions in NE forests (Mesibov 1990). If sufficient log habitat is left on the ground there is evidence that some onychophorans can survive at least the first cycle of forest logging (Mesibov 1990) but the depletion of suitable woody debris and microclimates in subsequent harvest cycles is likely to be problematic. Habitat loss is recognised as the major threat to velvetworm taxa worldwide (IUCN).

4.2 *Millipedes*

In eucalypt forest in NW Tasmania, the well mapped parapatric boundary between the dalodesmid millipedes *Tasmaniosoma compitale* and *T. hickmanorum* is about 230 km long but only ~ 100 m wide (Mesibov 2011). It spans 0-700 m elevation, crosses most of the river catchments in northwest

Tasmania and several major geological boundaries, and one margin runs parallel to a steep rainfall gradient (Fig. 3), suggesting no influence of any obvious environmental features.

Figure ii-3. Parapatric boundary in NW Tasmanian between the dalodesmid millipedes *Tasmaniosoma compitale* and *T. hickmanorum* (from Mesibov 2011).



4.3 *Stag beetles*

Tasmania has at least 25 endemic species of flightless stag beetles (Coleoptera: Lucanidae) including 3 species in an endemic genus *Hoplogonus,* all thought to be of Gondwanan origin (Moore 1978). This is one of the most biodiverse stag beetle faunas in the world and a degree of beta diversity is evident across forested landscapes. Several Tasmanian species are in decline and five taxa already feature on threatened species schedules. S

tag beetles breed in decaying wood or deep litter and are characteristic of old growth forests although not all species are exclusive to them. Some occur at very low population densities, such as *Lissotes latidens* (Meggs and Munks 2003) whereas others such as *Hoplogonus simsoni* are extremely restricted in range (*ca* 265 km^2) but can be locally common (Meggs *et al.* 2004). *H. simsoni* is managed under a Species Management Plan (SMP) on State forest. A few stag beetles, including *Lissotes rudis*, can recolonise disturbed areas if sufficient dead wood is available on the ground for breeding (Bashford 1990). Mapping of known distributions suggests the existence of various parapatric boundaries and a possible role for ice-age refugia in the vicinity of Blue Tier; new species continue to be discovered (e.g. Bartolozzi 2003), suggesting insufficient survey for this group.

4.4 *Freshwater crayfish*

In most documented cases, the ranges of closely related species are also geographically close and exceptions to this trend may represent older clades, some members of which have suffered range contractions (Richardson *et al.* 2006). The stability or persistence of these boundaries remains uncertain, but the evolutionary trajectory of the group has clearly played out over large geographical scales.

5 Critical habitat

Critical habitat is that area of land comprising the habitat of a highly threatened species, population or ecological community that is essential to its survival. In the absence of a formal declaration of critical habitat, it is appropriate to conserve larger areas of useable habitat in order to deliver a satisfactory carrying capacity for threatened species at landscape levels. Declaration of critical habitat can be an important tool in the management of rare and threatened species, although its efficacy remains contentious in some cases (Hoekstra 2002). The identification of critical habitats for threatened species was a recommended action in Tasmania's recent Nature Conservation Strategy (DPIW 2006). The following three species are apex, or near-apex predators, in Tasmania and their loss from landscapes will have serious repercussions through the ecosystem.

5.1 Tasmanian devil *Sarcophilus harrisii*

Uncertainties attach to the question whether the endangered but wide-ranging Tasmanian devil should have critical habitat defined as an aid to its survival. A typical home range across a two to four week period is estimated to be 13 km^2, ranging from 4-27 km^2, and can incorporate otherwise degraded habitat such as farmland (Pemberton 1990). Nevertheless, essential resources such as denning sites and access to prey are unevenly distributed and it should be possible to rank habitat quality accordingly. It is commonly claimed that because devils are wide-ranging animals that it is inappropriate to declare critical habitat for them under state and federal threatened species acts. However, devils generally rely on pre-existing structures for denning sites such as old wombat burrows, caves, or large hollow logs and these can be a scarce resource, especially in human modified landscapes. Owen & Pemberton (2005) note that "Habitat interference affects animals by altering the refuges where they breed, raise young and rest. For the devil this could be critical…. favoured dens … may have existed for centuries. Destroying them through, for example, land clearance, disrupts population stability". As far as I am aware, no special effort is made to identify and protect devil den sites in Forest Practice Plans. In my view, secure denning sites for Tasmanian devils are a relatively scarce resource and should be declared critical habitat in order to protect them.

5.2 Spotted-tail quoll *Dasyurus maculatus maculatus*

On mainland Australia spotted-tail quoll populations have been devastated by land clearing and invasive predators such as foxes and dingos. They are listed in the *EPBC Act* as endangered on mainland Australia and vulnerable in Tasmania while the *Tasmanian Threatened Species Protection*

Act lists the species as rare. Insufficient research on the impact of logging on the species constitutes a significant knowledge gap preventing its effective conservation management. In Tasmania, Jones & Rose (1996) estimated that half of the habitat within this forest dependent species core distribution has been cleared, with approximately half of the remaining habitat having been subjected to logging practices in the previous two decades. A loss of structural diversity, including a reduced abundance of hollow logs and roots used as shelter and maternal den sites by spotted-tailed quolls and their prey, and lowered prey population densities, along with fragmentation of formerly contiguous habitat, are hypothesised to result in population decline (Long and Nelson 2008). The National Recovery Plan for spotted tail quolls explicitly identifies "habitat loss, modification and fragmentation and timber harvesting" as a major threat to the species and that "given the threatened status of the Spotted-tailed Quoll, all habitats within its current distribution that are known to be occupied are considered important" (Long and Nelson 2008).

It would seem prudent to declare old growth forest with a high degree of structural complexity to be critical habitat for this important but declining mesopredator in Tasmania.

5.3 Tasmanian Masked Owl *Tyto novaehollandiae castanops*

Listed as Vulnerable under the *EPBC Act* since 2010, this endemic bird is the world's largest barn owl, with females achieving a wingspan of almost 130 cm. An example of island gigantism, it is a top nocturnal predator and may occupy a similar niche to the Powerful Owl *Ninox strenua* of mainland Australia. Although the diversity of arboreal marsupials is depauperate in Tasmania, densities of these mammals are locally high and attractive to predators. Small population size and habitat loss threaten the Tasmanian Masked Owl and individuals have home ranges which may exceed 1000 hectares in area (Bell *et al.* 1997). Between 1996 and 2009, ca 142 000 hectares of native forest in Tasmania was converted to monoculture plantation or agriculture (FPA, 2009). This has resulted in the loss of nesting habitat (large tree hollows) and the degradation and alteration of foraging habitat for the Tasmanian Masked Owl (DPIPWE, 2009).

In the absence of critical habitat being defined for this functionally important and globally unusual subspecies, a wide geographical cross section of old growth forests rich in potential nesting sites and prey should be recommended in order to support as many occupied home ranges as possible.

6 Resilience

Resilience was identified by a recent review as a key objective of management of natural areas for resistance against damaging levels of environmental change (Heller and Zavaleta 2009). Resilience strategies attempt to bolster a system's ability to absorb rapid change in particular.

The spread and establishment of exotic species represents a particular challenge for ecosysetems under stress. Native forests in good ecological condition are relatively resilient to invasion and occupation by pests and diseases but less so when degraded. While forest invasions may develop comparatively slowly under natural disturbance regimes, anthropogenic processes can be expected to accelerate the rate of invasion (Martin *et al.* 2009).

A related concept, biotic resistance, is a well documented phenomenon which describes the ability of resident species in a community to reduce the invasion success of exotic species (Levine *et al.* 2004). As a consequence, newly established exotic plants may escape their coevolved herbivores only to be preferentially consumed by the native generalist herbivores in their new ranges, suggesting that native herbivores may provide biotic resistance to plant invasions (Parker & Hay 2005, Morrison & Hay 2011). In the face of predation by foxes and feral cats the intrinsic resistance to extinction of declining critical weight range mammals such as bettongs, peramelid bandicoots, and quolls is, in part, connected to their local population size (Purvis *et al.* 2000). Offsets in the form of larger reserves supporting larger populations may be necessary at regional scales to improve the demographic resilience of these animals.

Resilience in the biota against predicted climate change in Tasmania must also be planned for. Many species are shifting their ranges under the influence of global warming at faster than expected rates. In a recent global review across a number of animal groups, Chen *et al.* 2011 found ranges changing upslope at a median rate of 11.0 metres per decade, and to higher latitudes at a median rate of 16.9 kilometres per decade. The duration of wet, dry and windy spells is an important stressor of ecosystems and the capacity of species and communities to resist and respond to predicted changes in these events needs consideration. Hot and dry windy days in Tasmania increased almost four-fold in the ten-year period from 1996–2006. The Forest Fire Danger Index identifies a trend in the last decade in particular to greater seasonal severity, with more seasons having greater numbers of significant fire weather days, while the spring quarter has seen an abrupt increase in the number of severe fire weather events over the same period (Fox-Hughes 2008). This variability intersects with fire risk and behaviour which could lead to irreversible changes in local ecosystems. The complex topography of Tasmania in itself is an important contributor to resilience through the creation of long term and multi-scaled refugia in terms of benign microclimates and connectivity along “sea to mountain” corridors.

A transect study on Mount Weld spanning 70m-1300m is targeting invertebrates in particular with the intention of clarifying species turnover along the habitat gradient (Doran *et al.* 2003, Grove 2004). Initiatives such as this will give important insight into the fate of montane species especially. Tasmania now has the most detailed climate futures scenarios of any state (at a regional scale ~10 km) and these will form an important tool for conservation planning (Grose *et al.* 2010). For example, inferred changes to rainfall, cloud cover and extreme events for the north-east coastal region include:

• cloud cover is projected to increase slightly in summer and decrease slightly in winter
• rainfall is projected to increase in autumn and summer
• solar radiation is projected to decrease.

These changes are consistent with projected and measured increases in the mean sea surface temperatures off the east coast of Tasmania associated with the southern extension of the East Australian Current.

• Extreme rainfall events are projected to increase in the north-eastern coastal region. These increases in Average Recurrence Intervals (ARIs), in an area where rainfall is already the most variable and intense, are likely to have impacts on runoff and erosion, particularly in areas in which vegetation cover has been removed. Extensive areas of the north eastern forests occupy erodible soils on coarse-grained granites.

Recommend: A number of conservation assets which confer and support resilience, as well as special conservation values should be protected, including:

6.1 **Cloud forests of eastern Tasmania.**

Mountains within about 8km of the coast in eastern Tasmania (figs 4-7) regularly receive supplementary summer moisture from cloud condensation associated with onshore easterly weather systems from the Tasman Sea which deliver about a third of high rainfall events in summer (Barras & Simmons 2008). These conditions help create special microclimates near the ground supportive of many rare and unusual species which have a poor tolerance of drought. Until it was largely destroyed by the 1967 bushfires, a montane rainforest reliant on supplementary moisture existed beneath the dolerite cliffs (“organ-pipes”) on Mt Wellington. The eastern reaches of the Nicholas Range, including the upper parts of South Sister, support deep, summer-moist, organic soils and broad-leaved understorey shrubs which resisted burning in the extensive east coast fires of 2006 (PB McQuillan pers. obs. 2009). It is likely that uplands in the vicinity of the Blue Tier and Mt Elephant also qualify as cloud forests as described by Hamilton (1995). Both locations are thought to have been important refuges for rainforest in the past (Kirkpatrick & Fowler 1998) and are important as feeders of groundwater into upper catchments..

A higher level of summer moisture is known to be associated with the presence of greater plant diversity in south eastern Australian in the last two million years (Sniderman 2011) and reliably moist microclimates sustained over millenia are probably responsible for the persistence of high concentrations of litter-dwelling endemics such as velvetworms, millipedes and stag beetles in the north east of Tasmania. Cloud forests are also valuable carbon repositories but are readily damaged by fire intruding from drier adjacent habitats (Roman-Cuesta *et al.* 2011).

The north east quadrant is one of the most poorly studied regions of Tasmania for the purpose of biodiversity assessment. Yet, when considered at the community level, the regional combinations of co-occurring species highlight the importance of the north east as a globally unique bioregion. For example, beetle communities occurring on *Dicksonia* treeferns are notably different in the NE than elsewhere in the state (Fountain-Jones *et al.*, 2012). Similarly, the profile of millipede communities in NE Tasmania is unique to the bioregion and includes local hotspots of endemicity and diversity, and examples of short range endemism (Mesibov 2006); similar patterns are seen in velvetworms including unusual phenomena such as parapatric boundaries which separate species' distributions. Cryptic lineages in freshwater crayfish also highlight the novelty of the NE domain (Sinclair 2011). It is noteworthy that various taxa display independent responses to the environment, with Cranston & Trueman (1997) reporting almost no overlap in the species diversity patterns of eleven groups of invertebrates surveyed in NE Tasmania.

The north east is prone to extreme rainfall events every few years, especially in the vicinity of Gray and St Marys Pass (Mesibov 2001). Native forest cover therefore plays an important role in stabilising soils against erosion and reducing land slippage. Steeper slopes in this part of the state, especially, should remain under continuous forest cover in order to preserve soil and protect assets.

Recommend: that a representative cross section of near-coast montane forests, especially in eastern Tasmania, be included in the HCV set to conserve their unique species and communities.

Coastal highlands likely to receive supplemental summer moisture from easterly weather systems are scattered as an archipelago along eastern Tasmania and are indicated in Figures 4-7. I have conservatively proposed 500m as a minimum elevation although it is likely that lower elevations will also sequester additional summer moisture from easterly weather systems.

Figures ii-4 to ii-7. Areas likely to be suitable for supporting cloud forests in eastern Tasmania. Areas above 500m elevation and within 8 km of the coast are outlined in red.

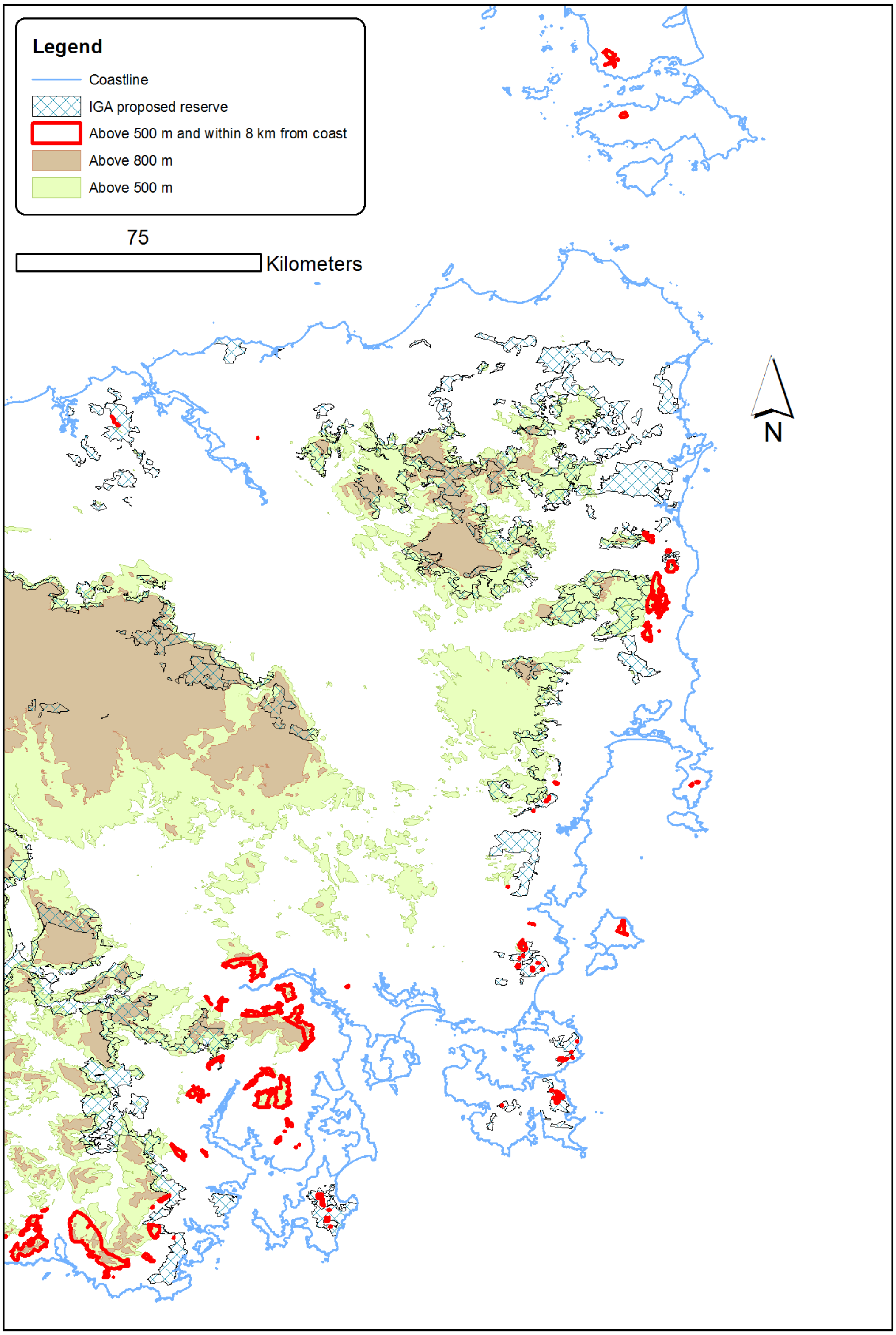


Figure ii-4. Areas likely to be suitable for supporting cloud forests in the eastern half of Tasmania. Areas above 500m elevation and within 8 km of the coast are outlined in red.

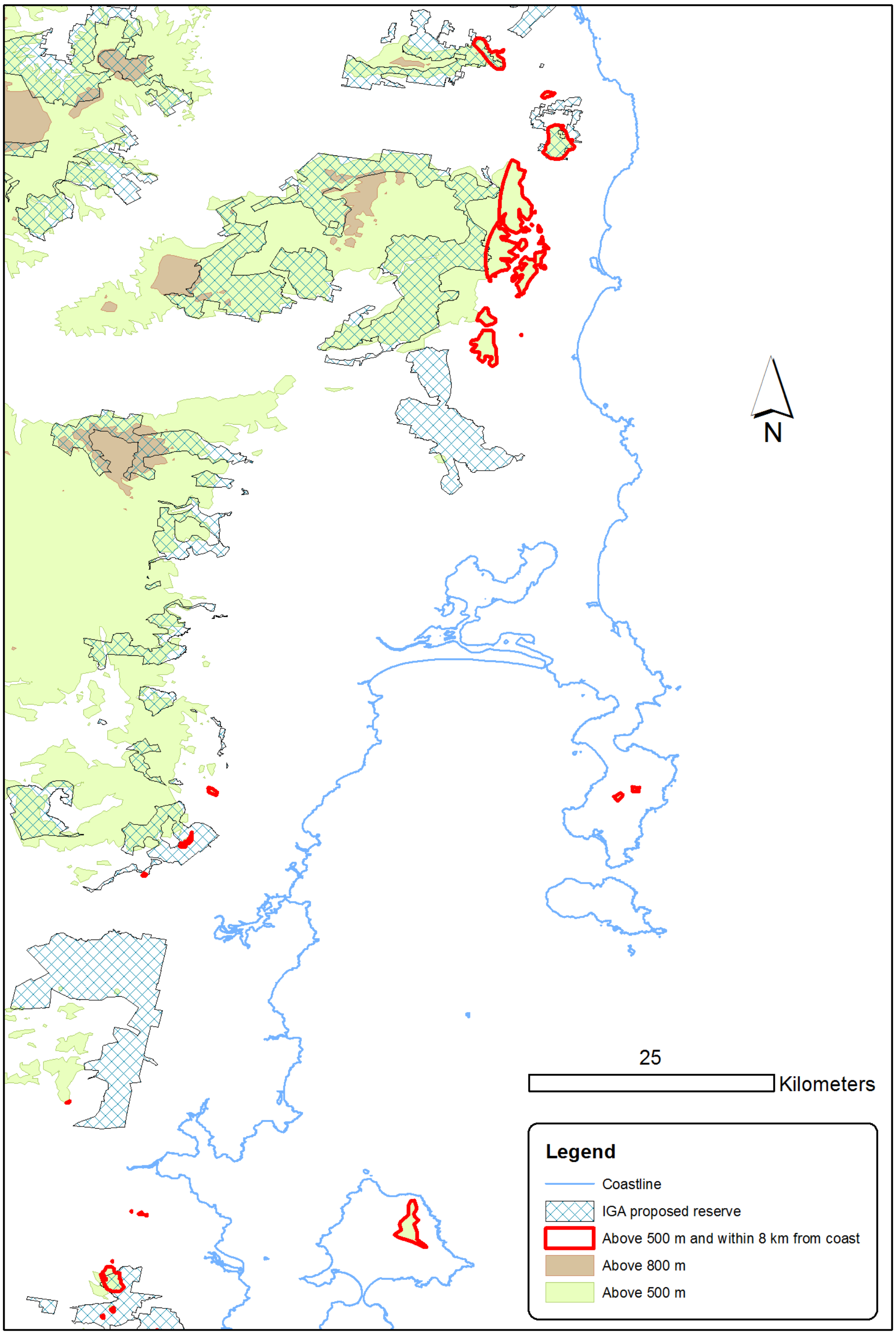


Figure ii-5. Areas likely to be suitable for supporting cloud forests in mid eastern Tasmania. Areas above 500m elevation and within 8 km of the coast are outlined in red.

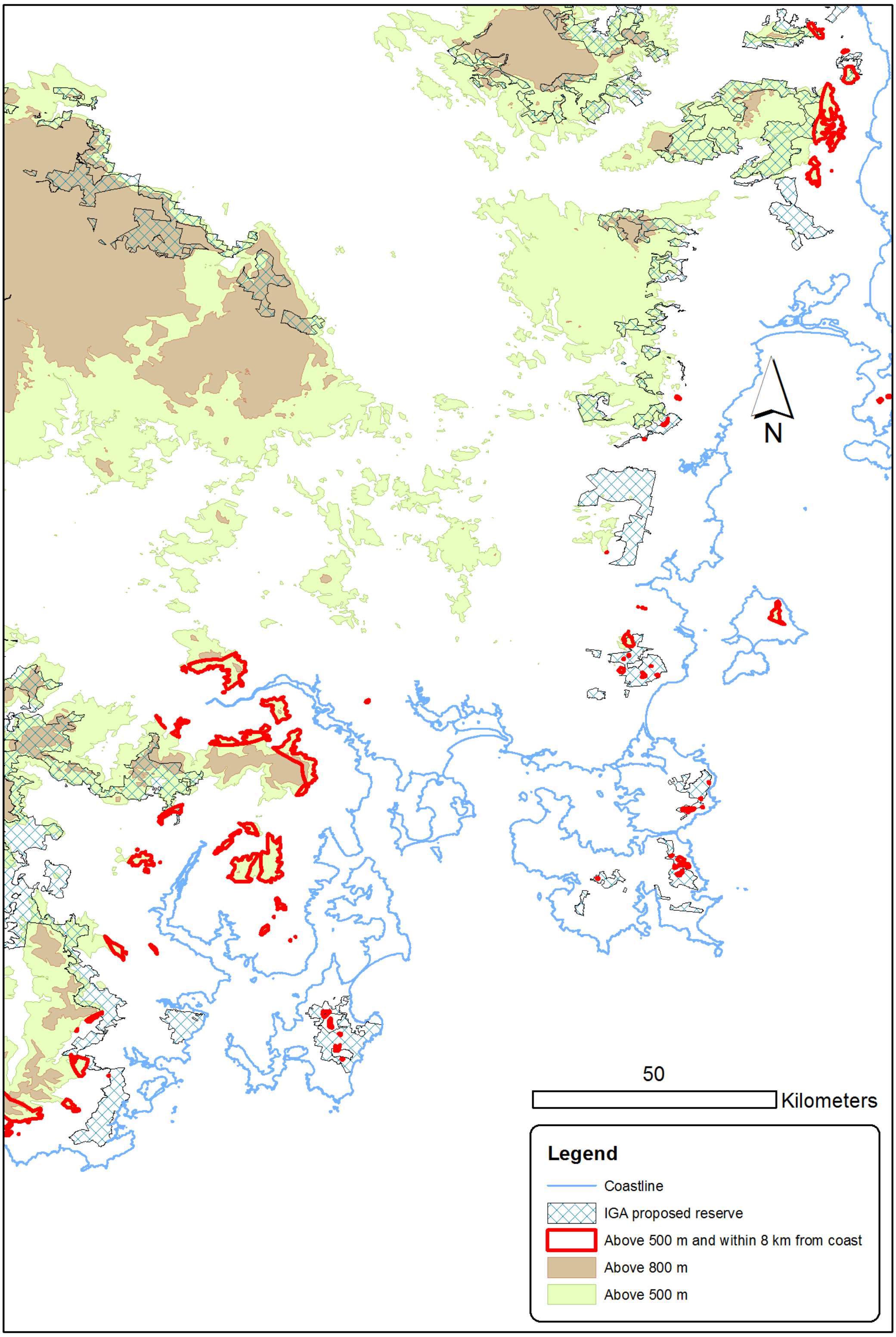


Figure ii-6. Areas likely to be suitable for supporting cloud forests in south eastern Tasmania. Areas above 500m elevation and within 8 km of the coast are outlined in red.

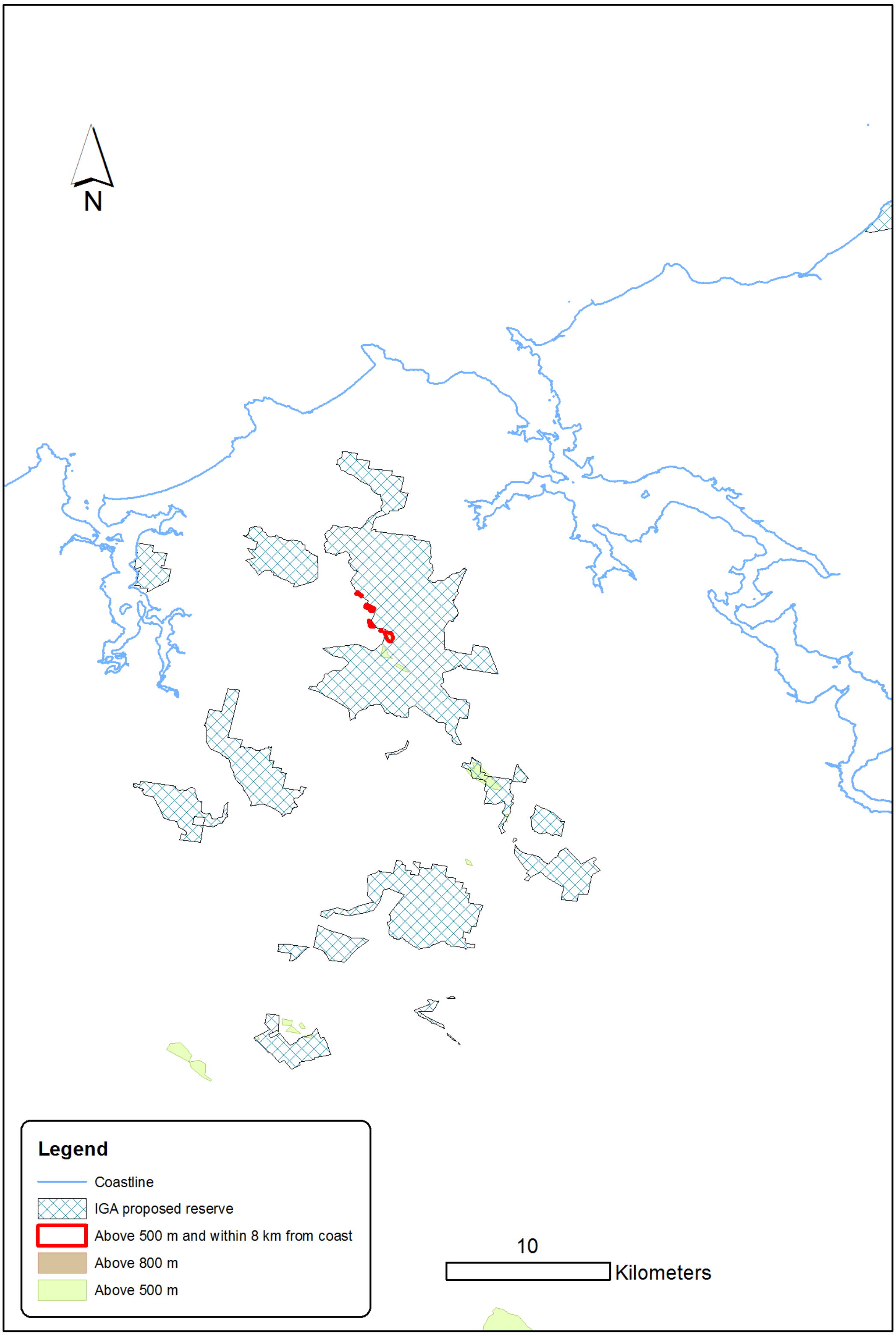


Figure ii-7. Areas likely to be suitable for supporting cloud forests in south eastern Tasmania. Areas above 500m elevation and within 8 km of the coast are outlined in red.

6.2 **Forests with inherently high levels of resilience against fire**

Landscape level resilience against fire should be preserved where possible. Australian forests with high levels of canopy cover such as rainforest and some mixed forests are up to 3 °C cooler in summer (Shoo *et al.* 2011), reducing their flammability. Topographic refuges in eastern Australia which support damp forests are important reservoirs of endemic species which prefer cooler, less fire-prone conditions. As much rainforest and mixed forest should be conserved as possible for their landscape fire suppression values. This facility would be especially useful against the boundaries of the World Heritage Area and other reserves as a buffer against the ingress of wildfires. Differences in solar radiation between north and south facing slopes are at a maximum in mid latitudes (Holland & Steyn 1995) and this effect is readily seen in eucalypt forest in Tasmania (Kirkpatrick & Nunez 1980). The unusually high levels of carbon storage in Tasmania's tall wet forests is due in large part to the slow decay rates of woody debris which in turn is promoted by cool, damp conditions at ground level (Keith *et al.* 2009).

Natural environments in good condition are more resilient to invasion by exotic species and hence offer an important service of both environmental and commercial value to humans (Thompson *et al.* 2009).

Weeds are especially invasive on high fertility sites (Prober & Wiehl 2011) and for this reason native forests on basalt soils should be maintained in as undisturbed condition as possible.

Recommend: that good representation be achieved for HCV forests situated in topographic refuges such as cooler, damper south and south-east facing aspects.

6.3 **Forests which span a large range of elevation**

Extensive elevational gradients and corridors of vegetation connecting populations and maintaining pathways from sealevel to the mountains, are an essential buffer against the impacts of both natural and human-enhanced climate change on native species. These should be regionally replicated where possible in order to offer multiple pathways for retreat or expansion. The present distribution of many species and communities in present-day Tasmania is best explained by such migration in the past (e.g. Huon pine *Lagarostrobus franklinii* (Clark & Carbone 2008).

The elevation range of the proposed IGA forest extensions is shown in Fig. 8. Block area is a poor predictor of elevational range (Fig. 9) and all blocks which offer an elevation range of 400 or more metres would make a worthwhile contribution to conservation values around resilience. Those blocks which abut existing reserves may contribute an even greater collective elevational gradient which further enhances their value.

Candidate HCV forest blocks are ranked by elevation range in Appendix 1.

Recommend: good replicated representation of HCV forests which serve to connect populations over elevational gradients.

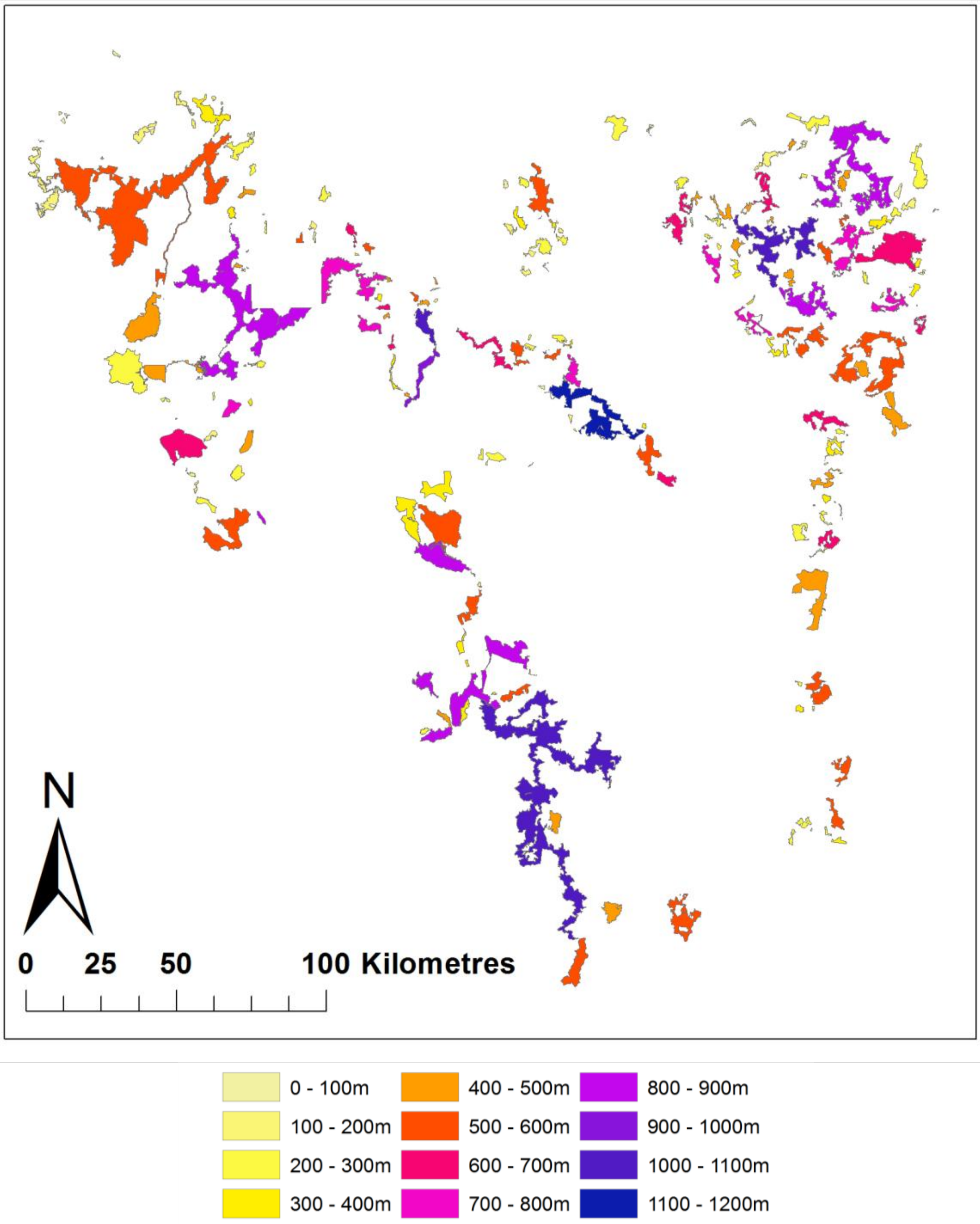


Figure ii-8. Elevation range of the proposed IGA forest extensions

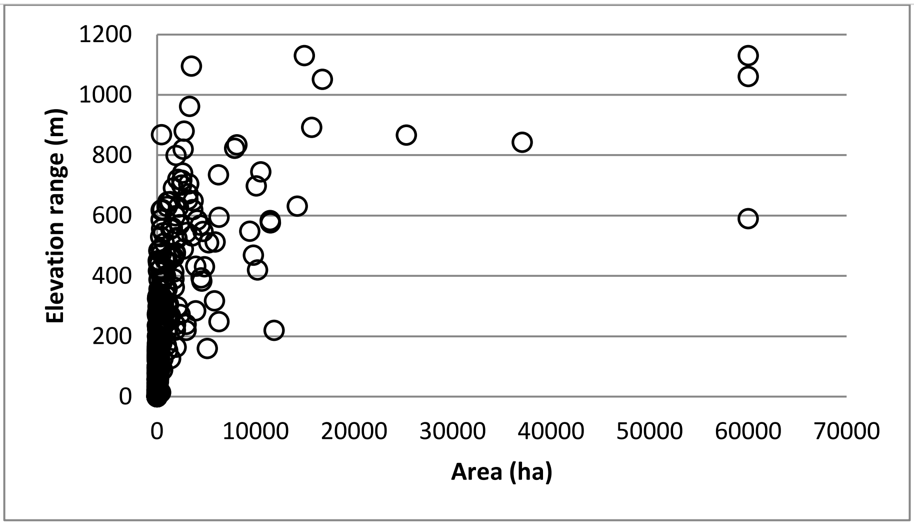


Figure ii-9. Relationship between area of HCV forest blocks and their elevation range.

6.4 Forests on fertile substrates

Forests on high fertility sites (such basalt derived soils) which were over cleared in the past for agriculture and plantations should be better represented in the conservation estate; productivity (i.e. carbon storage potential), and often biodiversity, are positively related to site fertility (Carroll *et al.* 2011). Higher species richness at a site also generally predicts higher productivity (Schmid 2002) and carnivorous marsupials in Victorian forests are more common on productive sites (van der Ree *et al.* 2001). Conversely, the selective clearing of woodlands on fertile sites is implicated in the decline of native birds since less productive sites yield less food (Watson 2011).
Downslope areas accumulate nutrients and soil from upslope. Consequently forests on benches or valley bottoms reflect these conditions in more nutritious foliage. Forests on higher nutrient sites are known to support higher densities of mammals for example (Kanowski *et al.* 2001). Under Tasmanian conditions, high productivity sites should deliver mean annual growth increments in trees of >20m^3/ha/yr (Laffan & Neilsen 1997).

Recommend: that some emphasis be given to downslope HCV forests in order to capture adequate representation of native forests on fertile, deep-soil sites.

6.5 Forests with complex age structure and high levels of moist litter and woody debris

Despite early claims to the contrary, many tall eucalypt forests in Tasmania are multi-aged, indicating that some individuals have survived multiple fire events (Turner *et al.* 2009) and there is little doubt that many large logs also survive fires intact (Grove *et al.* 2009). Although even-aged stands occur in nature, they are probably uncommon, but their existence has been used to argue that stand-replacement after CBS (clearfell-burn-sow) silviculture mimics nature and is therefore ecologically benign.

In some south-eastern Australian forests, broad vegetation units can be useful predictors of vascular plant, fern, bryophyte and lichen diversity (Pharo & Beattie 2001). However, particular floristic elements are not necessarily good surrogates for invertebrate diversity in general (Moritz *et al.* 2001). High levels of moist woody debris and leaf litter under complex well shaded forests create ideal conditions for numerous small life-forms such as mites, beetles, bryophytes and fungi.

Recommend: that not too much emphasis be placed upon using broad forest types as surrogates for all biodiversity and that adequate regional representation of special habitats be sought.

6.6 **Forests which preserve evidence of both long-past and recent evolutionary processes within Tasmania**.

An unusually species-rich and highly endemic soil and litter fauna in Tasmanian forests is only now being revealed (e.g. Niedbala & Colloff 1997, Colloff 2009). Small animals such as these play important roles in nutrient cycling and soil conditioning. In the last decade, significant new diversity of ants, earthworms, beetles, pauropods and millipedes has come to light (Blakemore 2000; Mesibov 2006, 2009, 2010; Scheller 2009). Earthworm communities in Tasmania are remarkably rich by global standards (>200 native species) and regionally endemic (Blakemore 2000). These may represent an unrealised agroecological resource useful in the future (Blakemore & Paoletti 2006); however native earthworm responses to landscape and vegetation changes need much more study.

We now know that keystone trees such as myrtle beech *Nothofagus cunninghamii*, survived the arid cycles of the Pleistocene in multiple refuges around the state (Worth *et al.* 2009). In particular, the north eastern populations are genetically distinct from other populations elsewhere in Tasmania, reinforcing the biogeographical distinctiveness of this region.

Recommend: that representative forests be conserved statewide in order to capture the full extent of local speciation in diverse groups of functionally important small animals and the structured genetic diversity of native biota.

Ecologists remain uncertain about the causes and consequences of local variation in biodiversity, biomass productivity and depletion of nutrient resources (Gross & Cardinale 2007) and this uncertainty complicates judgement regarding the “best subset” of sites needed for the most desirable conservation outcomes. Nevertheless, a number of well supported ecological principles can be used for guidance, along with the results of recent discoveries which point to a number of special biodiversity values in Tasmanian forests that are not well represented in the existing conservation estate.

6.7 **Old forests**

It now appears that the lifespan of some *Eucalyptus* is a century older than previously thought (Wood *et al.* 2010). These forests not only have the potential to store vast amounts of carbon, but can also maintain these high carbon densities for a long period of time. Wood et al 2010 conclude that *E. regnans* has a longevity that may exceed 500 years, in excess of the widely held view that the longevity of *E. regnans* is around 350–450 years (Wells and Hickey, 1999).

7 IBRA representation

The fact that Tasmania qualifies for nine IBRA ver.6.1 bioregions within its physically modest area (68,000 km^2) attests to the rich biological endowment of the island. However, the scoping of the Tasmanian Regional Forest Agreement was not in conformity with the IBRA configuration; rather, the state's 9 bioregions were conflated to a single state-wide region to facilitate RFA planning. This historical decision partly underlies the unbalanced regional impact of woodchip and timber harvesting on native forests. Since 1996, the area of remaining *Eucalyptus regnans* forest has been reduced significantly, due to conversion to plantations. The total decrease in the Ben Lomond bioregion was 9,114 ha (33% of 2002 RFA area) and 880 ha (33%) in the Woolnorth bioregion in the period 1996–2008 (Tasmanian Planning Commission 2009). These are unsustainable rates of loss of irreplaceable tall forest in a bioregion with poor representation of its ecosystems in national Parks.

8 Gaps in documentation and understanding of key ecological interactions.

In recent years the importance of maintaining and conserving ecological interactions has become a key motivation in sustainable ecosystem management. Significant advances have been made in species inventory for a range of eucalypt forests and outlines of foodwebs and interactions are beginning to emerge.

However, our understanding of pollination ecology in Tasmanian forest ecosystems is rudimentary for most species including canopy eucalypts, although some recent progress is apparent for bluegum (Hingston and Potts 1998) for which the endangered swift parrot is an important pollen dispersal agent. Despite evidence of a diverse native bee fauna in forest (e.g. Hingston 1998, 1999), little can be said about the conservation status and needs of native pollinators.

8.1 Ectomycorrhizal (EMF) and other fungi

Community level knowledge of an entire biotic kingdom within Tasmania, the fungi, is only just emerging, but recent inventories of macrofungi alone point to outstanding biodiversity in tall forest habitats (G. Gates, pers.comm. 2011). It is noteworthy that these numbers exceed those recorded in the temperate forests of south western China, regarded as one of the world's richest domains for macrofungal diversity (Zhang *et al.* 2010); equally it highlights the poor state of documentation of Tasmania's biodiversity and demonstrates that, for many important groups, we are still in the "discovery" phase.

Fungi are crucial to many ecosystem functions and have great ecological and economic value. Many forest trees have evolved mutualisms with ectomycorrhizal (ECM) fungi that facilitate their phosphorus nutrition. Mycorrhizal fungi depend on photosynthetically fixed carbon produced by their associated trees and forest resilience, recovery, vigour, and composition are intricately tied to EMF diversity (Amaranthus 1998).

Recent surveys have documented 360 named species of macrofungi (305 spp of Basidiomycota and 55 spp of Ascomycota) present in Tasmanian forests (mainly wet sclerophyll) (Ratkowsky & Gates 2005). In a benchmark study, Gates et al (2011a) found 331 ECM species in a limited area of tall *Eucalyptus obliqua* forest in southern Tasmania. The family Cortinariaceae (mainly *Cortinarius*) dominated the communities and covariation of plant and fungal communities was evident in the woody perennial plant community and their fungal assemblages. In a further study, Gates et al (2011 b) showed that litter in these tall forests also supports a rich and diverse mycota, with 146 macrofungal species found fruiting in or on litter in a 1 ha area of native forest encompassing a range of fire histories. Regenerating forest after fire (including CBS harvest) is dominated by opportunistic, mainly saprotrophic fungi and has few symbiotic basidiomycetous ectomycorrhizal species that are abundant in the soils of nearby mature forests (Ratkowsky & Gates 2009).

The macrofungi of lowland wet *Eucalyptus obliqua* forest are responsive to forest succession. In a local community of 307 species of macrofungi 248 species were observed in mature forest (>70 yr since wildfire) and 131 in 2 or 3 year old regeneration (Gates *et al.* 2005). The large proportion of single records would suggest that many more undetected species may be present. The number of species that were observed exclusively in the mature forest (176 spp.) was three times the number observed exclusively in the regeneration (59 spp.). Most species known to be mycorrhizal were confined to the mature forest, suggesting that such species may take many years to establish, or reach maturity, following major disturbance. Most macrofungi were associated with either soil or wood, highlighting the importance of these substrates.

Tasmanian and Victorian wet forests, in which *Laccaria* and *Cortinarius* fungi are among the most abundant ECM taxa, offer a contrast to northern hemisphere temperate forests (Tedersoo, 2007).

This suggests that these austral lineages may have different ecological roles and importance compared with Holarctic ecosystems.

Other important mycota in Tasmanian forests include specialised wood rot fungi which condition the interiors of logs to the advantage of a highly diverse insect fauna (Yee *et al.* 2006; Wardlaw *et al.* 2009) .

The incursion of phytophthora root fungus into eucalypt forests is known to deplete the diversity and abundance of macrofungi and the important mycorrhizal community in particular (Anderson et al 2010). Since ECM fungi are considered to be highly dependent on host plants for energy this is unsurprising.

9 The large area needs of landscape scale species

A number of important vertebrates are adapted to exploit resources at unusually large geographical scales, reflecting dispersion patterns in their mates, food, shelter or other requirements. This behaviour has consequences for conservation planning in terms of their habitat area, its configuration and the permeability of the intervening landscape.

9.1 *Swift parrot* Lathamus discolor

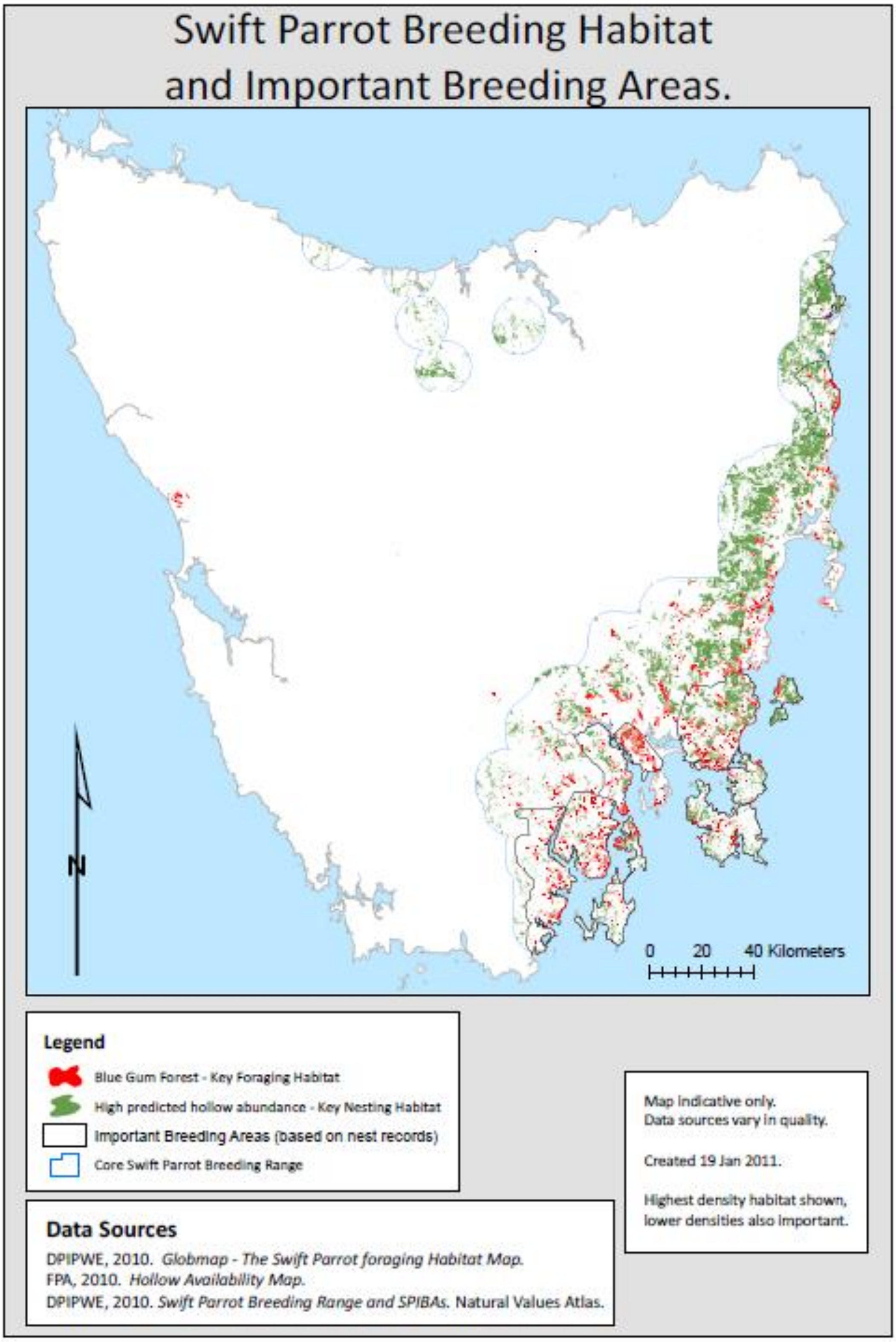
The endangered Swift Parrot *Lathamus discolor* population is declining because of habitat loss and modification (Garnett & Crowley 2000; Swift Parrot Recovery Team 2001). Based on survey data of the breeding population in Tasmania (Figs 10, 11), the estimated number of breeding pairs declined by ca 29% over the eight-year period between the 1987/88 and 1995/96 breeding seasons. Furthermore, reporting rates have declined in recent years, and sightings of large flocks are now rare (Department of Sustainability, Environment, Water, Population and Communities 2012). The spatial and inter-annual variability in the flowering of Tasmanian bluegum is likely to be a key driver in the biology and behaviour of the endangered swift parrot. Its gregarious nature, rapid flight and sustained levels of large scale movement are behaviours consistent with adaptation to a key food resource which is unpredictable in space and time. In the spring of 2011 for example, bluegum flowers in SE Tasmania are scarce compared to recent years and the birds are highly reliant on *Eucalyptus ovata* flowers (pers. observ.).

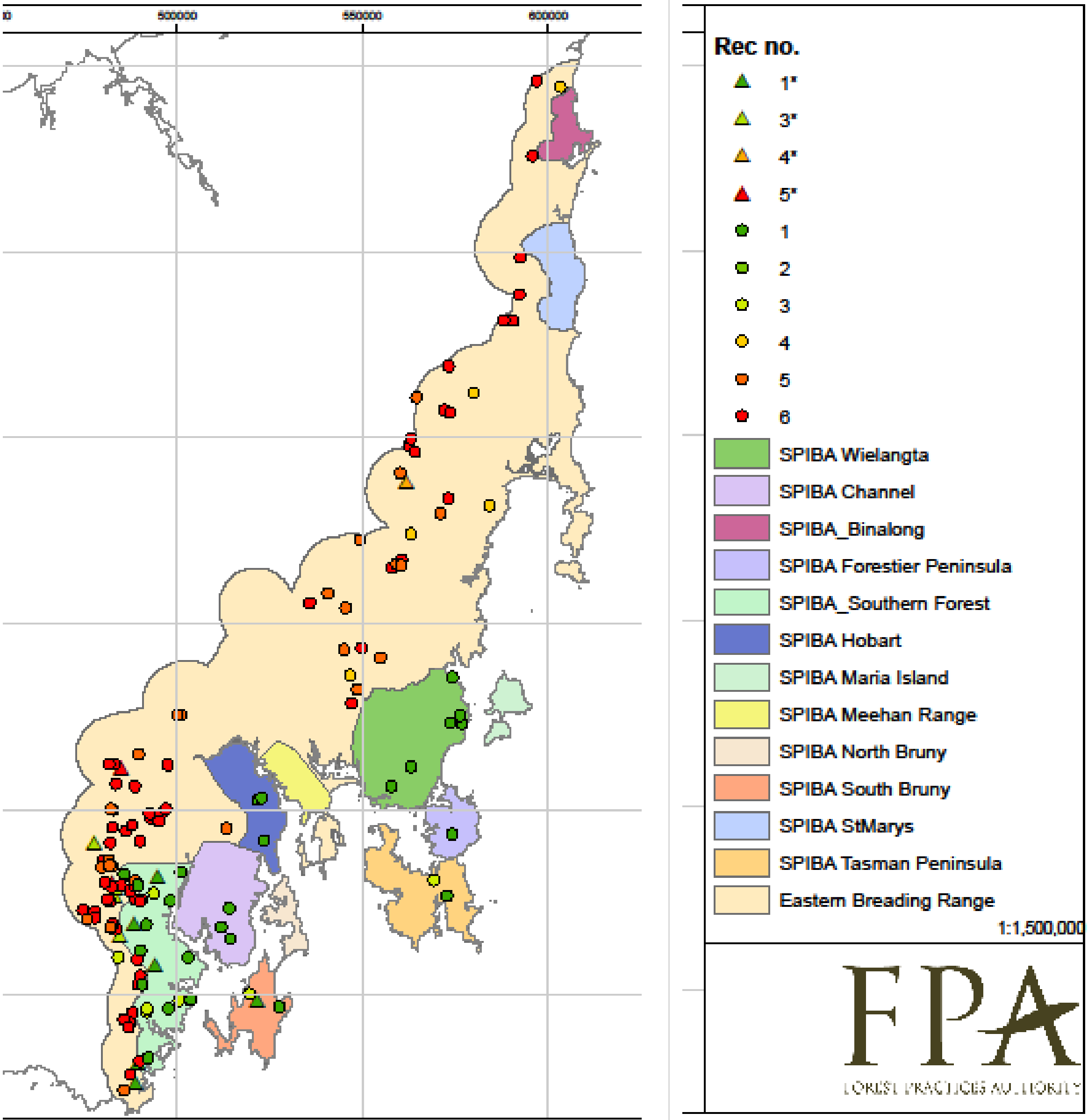
Wet forests have been recently shown to provide an important foraging and nesting resource for swift parrots in some years. The southern region and an associated flowering event were of particular importance to the species in 2007–08 (Webb 2008).

The swift parrot is a key pollinator of several *Symphyomyrtus* eucalypts especially Tasmanian bluegum (Hingston, Potts *et al.* 2004) and this association has been suggested as a possible source of the pattern observed in chemical phenotypes *of E. globulus* (Wallis *et al.* 2011).

Swift Parrots prefer to forage in larger bluegum trees perhaps because both flowering frequency and flowering intensity increases with tree size (Brereton *et al.* 2004). Clearing has eliminated over 50% of the pre-European grassy bluegum forest in Tasmania and much of the remainder is highly fragmented. Even isolated trees of large stature can be an important food resource for the Swift Parrot (Brereton, Mallick *et al.* 2004).
Collisions with vehicles, fences, windows and other structures keep pressure on the population. The proliferation of windfarms in south eastern Australia may be an emerging threat to the species, depending on their location.

Management of swift parrot habitat outside of existing reserves is problematic because it is migratory species with a wide range and unpredictable habitat use. In an attempt to reduce uncertainty to the forest industry, a newly developed Habitat Planning Guideline for species focuses conservation management on Swift Parrot Important Breeding Areas (SPIBAs, Figs 10, 11) and provides guidelines for retention of current foraging and nesting habitat based on the context of the surrounding landscape (Chuter & Munks 2011). The planning guideline was developed by the Forest Practices Authority and DPIPWE, via agreed procedures, in response to a need by industry for a more strategic approach to species management in wood production areas (Forest Practices Authority & DPIPWE 2010, Chuter & Munks 2011).


Swift Parrot Breeding Habitat
and Important Breeding Areas.
N
0 20 40 Kilometers
Legend
Blue Gum Forest - Key Foraging Habitat
High predicted hollow abundance - Key Nesting Habitat
Important Breeding Areas (based on nest records)
Core Swift Parrot Breeding Range
Map indicative only.
Data sources vary in quality.
Created 19 Jan 2011.
Highest density habitat shown, lower densities also important.
Data Sources
DPIPWE, 2010. Globmap - The Swift Parrot foraging Habitat Map.
FPA, 2010. Hollow Availability Map.
DPIPWE, 2010. Swift Parrot Breeding Range and SPIBAs. Natural Values Atlas.



Figures ii-10, ii-11. Location of notification for FPPs which have had recommendations from the swift parrot decision tree applied (colour coded by Important Breeding Areas SPIBA). Circles are locations from the previous version of the swift parrot decision tree; triangles are from the current version of the swift parrot decision tree. Adapted from: Public comment on the *Swift Parrot Interim Planning Guideline* (SPIPG) 2011.

http://www.fpa.tas.gov.au/__data/assets/pdf_file/0005/68054/Swift_Parrot_Interim_Planning_Guideline_public_comments_and_response_table.pdf

9.2 *Wedge tailed eagle* Aquila audax fleayi

The endangered Tasmanian subspecies of the wedge-tailed eagle *Aquila audax fleayi* has been shown in recent modelling to be sensitive to a range of human disturbances including plantation establishment and native forest harvesting (Bekessy, Wintle *et al.* 2009). A predicted decline over the next 160 years (~ 65%) will most likely be driven by loss of current and potential future nest sites associated with harvesting activities, exacerbated by unnatural mortality in the wider landscape. Interventions that minimise unnatural mortality, reduce nest disturbance, and retain breeding habitat and nest sites may improve its prospects in the north east. Bekessy *et al* (2009) conclude that if nest disturbance and unnatural mortality continue at the modelled rates, the eagle appears to face a high risk of declining substantially in the region.

Wiersma *et al.* (2009) found that a relatively small proportion (26%) of Tasmanian wedge-tailed eagles were successful in producing young. Over half of the nests examined (56%) showed no recent signs of use, while the remaining 18% of sites showed signs of activity but no successful breeding (Tasmanian Planning Commission 2009).

9.3 *Tasmanian Devil* Sarcophilus harrisii

Home ranges for devils are extensive, but can overlap considerably. A typical home range across a two to four week period was estimated by Pemberton (1990) to be 13 km², ranging from 4-27 km².

9.4 *Spotted tail Quoll* Dasyurus maculatus

The nationally threatened spotted-tailed quoll is solitary, except when mating, and occupies very large home ranges during and after the breeding season. The mean size of the home range of male spotted-tailed quolls (minimum convex polygon (MCP) 1755.4 ha, kernel 3761.7 ha) was significantly larger than that of females (MCP 495.9 ha, kernel 1113.0 ha). Adult female spotted-tailed quolls defend their home range from other females throughout the year whereas the more mobile males are not territorial.

The spatial organization of the spotted-tailed quoll differs from that of the eastern quoll *Dasyurus viverrinus* and the Tasmanian devil *Sarcophilus harrisii* but clearly the conservation of these species requires management across their range. Large dasyurids live at low densities and require a lot of habitat area and consequently their conservation needs to be addressed at local, landscape and regional scales (Jones 2011). These behaviours limit their capacity ability to adapt to the degradation of their home ranges (Nelson *et al* 2010).

Landscape scale movement has been important to the long term survival these species in the past – and is therefore likely to be important in the future. This observation focusses attention on the permeability of landscapes and their role as either bridges of barriers to movement among plant and animal populations.

9.5 *Bats*

The eight species of microbats present in Tasmania are an important component of local forest mammal diversity but amongst the least studied. Although bat species respond differently to forest management, recent work by Law & Law (2011) suggests that logging impacts on bat activity in Tasmanian forests may be considerably greater than previously believed. Tasmanian bats prefer to roost diurnally in large diameter trees (Taylor & Savva 1988), but it is not known whether bats continue to roost in patches of old forest retained within clearfell zones (Law & Law 2011).

The newly recognised endemic Tasmanian Greater Long-eared Bat *Nyctophilus sherrini* belongs to a genus of highly manoeuvrable bats with short, broad wings (low aspect ratio) and high frequency calls (O'Neill and Taylor 1986). Such bats are more active in old growth forest and least active in the centre of logged coupes (Law 2011). The western margin of the range of this species approximates the tall forests fringing the eastern boundary of the WHA and the species is largely absent from the south west moorlands (Reardon *et al.* 2008). Forest clearance for plantations, agriculture, and commercial logging are major threats to at least the roost sites of this species (Reardon *et al.* 2008).

10 High carbon storage in wet forests

Tall wet forests ecosystems in cool temperate climates store extraordinary amounts of carbon due in part to the benign climate which promotes high growth rates but only modest decay rates in the non-living biomass (Keith *et al.* 2010, Wood *et al*. 2010). A recent study estimates the mass of carbon in standing trees on 1.5 million ha of State forest in Tasmania at 163 Tg C, with 139 Tg in eucalypt forest. The highest carbon densities were found in the tallest, highest crown cover, mature, wet eucalypt forests, although these are limited in extent and therefore contribute only 1.3 Tg C (Moroni *et al.* 2010). A great deal of additional carbon is stored in fallen trees and coarse woody debris which is a key component of forest ecosystems, ultimately supporting perhaps the majority of forest dependent species in Tasmania (Grove 2009).

11 The emerging use of invertebrates in defining areas of global conservation significance.

The Tasmania fauna incorporates an extraordinary heritage of invertebrate animals, estimated to number 46,500 species (McQuillan et al 2009). Evidence collated two decades ago for the World Heritage evaluation of western Tasmania showcased an irreplaceable fauna involving ancient Pangean and Gondwanan taxa, island endemism, speciation bursts, insular gigantism, rare cave fauna and other globally outstanding phenomena.

Investigations since that time have continued to add further examples of globally significant conservation value. These include the most ancient living dragonfly (*Hemiphlebia mirabilis*) (Lak *et al.* 2009) recently discovered to occur in NE Tasmania; the world's largest member of the cabbage moth family (*Proditrix nielseni* Plutellidae) in montane forests (McQuillan 2003); a mandibulate moth *Tasmantrix tasmaniensis* belonging to a primitive group which predates the rise of the angiosperms (Gibbs 2010); an outstanding representation of ancient spiders (Rix 2005, Lopardo & Hormiga 2008, Rix & Harvey 2010); newly discovered species of endemic Gondwanan stag beetles (Bartolozzi 2003), and an extraordinary array of endemic terrestrial flatworms (Sluys 1999) and millipedes (Mesibov 2010). Many appear to be restricted to consistently humid microhabitats, and the greatest diversity of species exists in temperate rainforests and tall wet forests where moss, thick leaf litter and rotting logs offer refuge and well buffered microclimates.

Invertebrates have special utility in defining areas of high conservation value due to their intimate microhabitat requirements and close functional relationships with other species (New 2009). However, the limited information available regarding the ecology and distribution of most species is a serious limitation to comprehensive conservation planning. Vertebrates or vascular plants are rarely useful surrogates for identifying significant areas for invertebrate conservation in temperate latitudes and invertebrate groups can even show poor congruence amongst themselves (Fattorini *et al.* 2011). In temperate eucalypt forest in Western Australia it was demonstrated that whereas vascular plants, mammals and frogs have different centres of endemism within an area, centres of endemism for millipedes encompass all of these plus other areas (Moir *et al.* 2009).

Mountainous areas in Australia are notably rich in invertebrate biodiversity, including ancient taxa, but montane biota is especially vulnerable to rapid climate change (e.g. Wilson *et al.* 2007). Within Tasmania, several eucalypt dependent moth genera incorporate largely allopatric species pairs which differentiate into a widespread lowland and a more restricted highland form (e.g. *Plesanemma*, *Paralaea*). The influence of topography on species richness is apparent even in areas of modest relief. Millipede diversity and endemism are positively associated with differences in elevation in south western Australia for example. A species turnover boundary was positively associated with annual rainfall, broadly located in the transition zone of 300-600 mm (Moir, Brennan *et al.* 2009).

Our relative lack of knowledge on the endemism patterns of invertebrates also hampers their ready incorporation into conservation planning. Nevertheless Tasmania is emerging as a global biodiversity hotspot for forest invertebrates (e.g. (Sluys 1999; Mesibov 2010)) and this knowledge should eventually assist the recognition of essential conservation areas.

Task (iii)

"Provide expert advice on the impact of current and past off reserve forest management on biodiversity and the implications of off reserve management for the level of reservation needed to provide adequate biodiversity conservation outcomes."

Off reserve management of biodiversity has a chequered history in Tasmania, with a variety of instruments and incentives in play at various times. But there is no doubt that for some native species it is essential for their long term survival (Munks *et al.* 2004). Various rare and threatened species have ranges which have now contracted to off reserve areas while some wide ranging animals use landscapes at scales which require consideration across all landscape tenures (e.g. large dasyurid mammals, raptors). Most remaining populations of the endemic Ptunarra brown butterfly (*Oreixenica ptunarra*), dependent on native *Poa* grassy woodlands and grasslands, are present on private land, much of which is in production for wool and meat (New 2010).

About 30% of Tasmania's forests occur on privately owned land and a large proportion of native species and habitat types which are poorly reserved on public land occur there. Private Land Conservation Program initiatives co-ordinated by the Tasmanian Government include the Protected Areas on Private Land Program (PAPL) and Land for Wildlife. As at 2011, private protected areas in Tasmania number over 550 involving approximately 66,000 hectares.

http://www.dpiw.tas.gov.au/inter.nsf/Attachments/DRAR-8A84Z3/$FILE/PAPL%20Focal%20Landscape%20Flyer.pdf

1. Tasmania's Nature Conservation Strategy 2002-2006

Tasmania's *Nature Conservation Strategy* 2002-2006 made numerous recommendations which sought to improve natural resource management by encouraging private land managers to undertake modern property management planning. Such planning addresses the conservation of native vegetation, protection of threatened species, sustainable land management practices, prevention and control of weeds and pests and use of poisons such as 1080. The Strategy was also informed by pre-existing initiatives such as *Tasmania Together*, the State of Environment Report and the Natural Resource Management. It was produced by the State Biodiversity Committee, a broadly based group of experts established in 2000 and issued following public consultation.
The Government response highlighted 17 recommendations that are supported as a high priority. However, alignment with the strategy has been slow to emerge in some areas.

Management of those native species deemed pests to forestry and agriculture continues to impact the biota in various ways. The more controversial lethal options operate under precarious social licences and public disquiet has been effective in restricting or partially banning some prevailing management activities. The use of monosodium fluoroacetate (1080) to control browsing native herbivores on farmland and plantations is controlled under a Code of Practice and has been recently phased out on public land (except for fox control).

2. Threatened Native Vegetation Communities

In contrast to most other Australian jurisdictions, threatened biological communities are not considered by Tasmania's *Threatened Species Protection Act* 1995. Instead, an initial list of threatened communities under Schedule 3A of the *Nature Conservation Act* 2002 has been established through a scientific assessment process against criteria for "rare" (a total range of less than 1,000 hectares), "vulnerable"(70% of original area cleared) and "endangered" (90% of original area cleared). Table 1 summarises the threatened forest subset of native vegetation communities in Tasmania.
http://www.dpiw.tas.gov.au/inter-nsf/WebPages/SSKA-8PJ8L9?open

Although the JANIS report recommended that the CAR forest reserves be preferentially selected from public land, it was clear that some occurrences on private land would be needed to meet the formal reservation targets for some forest types. Indeed, with nearly 30 per cent of Tasmania's forests on private property it has been argued that the greatest proportion of poorly reserved and threatened elements of forest biodiversity now occur on private land (Kirkpatrick 1998). Important examples of declining vegetation communities such as native grassy woodlands are presently outside the formal reserve system.

Land clearing in Tasmania is regulated under the *Forest Practices Act* 1985 and *Forest Practices Regulations* 2007. A certified forest practices plan is required to authorise clearing of forest or threatened non-forest native vegetation unless an exemption is provided. However, small scale clearing, up to one hectare annually, is permitted without a permit. There are no controls under the Forest Practices Act on clearing non-forest vegetation that is not threatened. This has facilitated considerable losses of native vegetation in recent years as irrigation and cropping has expanded. Non-forest vegetation is more fragmented than forest vegetation largely due to agriculture and settlements (Tasmanian Planning Commission 2009).

Table iii-1. Threatened forest subset of native vegetation communities in Tasmania (as listed in the *Nature Conservation Act* 2002)

	Threatened forest communities
1	*Allocasuarina littoralis* forest (Bull oak forest)
2	Pencil pine / Deciduous beech short rainforest
3	Pencil pine open woodland
4	Pencil pine rainforest
5	King Billy pine / Deciduous beech short rainforest
6	King Billy pine rainforest
7	*Banksia serrata* (saw-tooth banksia) woodland
8	*Callitris romboidea* (Oyster Bay Pine) forest
9	*Eucalyptus amygdalina* (black peppermint) forest and woodland on sandstone
10	*Eucalyptus amygdalina* (black peppermint) inland forest & woodland Cainozoic deposits
11	*Eucalyptus brookeriana* (Brookers gum) wet forest
12	*Eucalyptus globulus* (blue gum) dry forest and woodland
13	*Eucalyptus globulus* (blue gum) King Island forest
14	*Eucalyptus morrisbyi* (Morrisbys gum) forest and woodland
15	*Eucalyptus ovata* (black gum) forest and woodland
16	*Eucalyptus risdonii* (Risdon peppermint) forest and woodland
17	*Eucalyptus tenuiramis* (silver peppermint) forest and woodland on sediments
18	*Eucalyptus viminalis – E. globulus* (white gum – blue gum) coastal forest and woodland
19	*Eucalyptus viminalis* (white gum) Furneaux forest and woodland
20	*Eucalyptus viminalis* (white gum) wet forest
21	*Melaleuca ericifolia* (coast paperbark) swamp forest
22	*Notelaea – Pomaderris – Beyeria* forest (Native olive – dogwood – pinkwood forest)
23	Subalpine *Leptospermum nitidum* (shining tea-tree) woodland

3. Permanent Forest Estate Policy 2011

http://www.dier.tas.gov.au/__data/assets/pdf_file/0003/68052/Revised_PNFEP_Sept_2011post_Cabinet_amendment_.pdf

This policy reiterates the commitment to maintain the statewide level of native forest cover above 95 per cent of the 1996 CRA native forest area, managed on a sustainable basis both within formal reserves and within multiple-use forests across public and private land. Whereas reporting on the Permanent Native Forest Estate is at the resolution of IBRA bioregions, initial conservation planning was ignored at this level when Tasmania, uniquely, was conflated into a single region for the RFA planning purposes.

The conversion of native forest on public land to plantations ceased in 2010 and the phase out of broad scale clearing and conversion of native forest on private land is mooted by 2015. The policy is given effect through the Forest Practices Authority's consideration of applications for Forest Practices Plans under the *Forest Practices Act* 1985.

Table iii-2. Native forest losses in Tasmania until 2010-11 (minor losses resulting from dam works permits issued under the *Water Management Act* 1999 (11.5 ha in 2010–11) are included).

Bioregion and state totals at 1 July 2011	1996 RFA area (ha) (2002 dataset)	2010–11 decrease (ha)	Total decrease 1996–2011 (ha)	% total decrease from 1996 RFA Area (2002 dataset)	Area remaining before threshold is reached (ha)
Woolnorth	375 839	1 326	41 652	11.1%	
Ben Lomond	500 654	256	44 252	8.8%	
Midlands	244 853	53	8 263	3.4%	
Freycinet	444 127	118	11 443	2.6%	
Central Highlands	572 175	428	25 769	4.5%	
West & Southwest	776 052	17	5626.	0.7%	
D'Entrecasteaux	261 593	168	13 605	5.2%	
Furneaux	30 405	0	63	0.2%	
State total	**3 205 698**	**2 369**	**150 677**	**4.7**	**9 608**

4. Conservation initiatives on private land

Private land contributes to the management of some rare vegetation types, habitats and priority species. The following conservation initiatives on private land in Tasmania make a contribution to the forest reserve system:

4.1. Bush Heritage Australia

Bush Heritage Australia (formerly the Australian Bush Heritage Fund) is a non-profit organisation founded in Tasmania by the conservationist Bob Brown in 1990 to protect threatened species and preserve biodiversity. It purchases private land of high conservation value to manage as wildlife reserves in perpetuity. By 2011 the organisation was helping to conserve 67 threatened vegetation communities and more than 236 threatened plant and animal species nationwide.

BHA now largely focusses on 5 key anchor regions in Australia, among them the grasslands of the Tasmanian Midlands one of the least conserved ecosystems in the state.

BHA currently owns 6 properties in Tasmania, totalling 472 hectares (Table 3). It makes an important contribution to the conservation of the endemic South Esk Pine as well as a number of threatened forest and other communities.

Table iii-3. Bush Heritage Australia properties in Tasmania 2011. Adapted from source: http://www.bushheritage.org.au/our_reserves/state_tasmania (11.i.2012)

BHA Reserve	Area (ha)	Vegetation communities represented
Liffey Valley Reserves n=4	275	White gum wet forest (endangered) Myrtle beech–sassafras rainforest Stringybark dry forest Stringybark forest with broad-leaf shrubs Lowland grassy sedgeland
Friendly Beaches Reserve	190	Black gum forest and woodland (endangered) Silver peppermint forest and woodland (vulnerable) Coastal heathland Black peppermint coastal forest and woodland
South Esk Pine Reserve	7	Black gum–South Esk pine forest (vulnerable) Coastal black peppermint forest
Total area	472	

Summary: While these reserves are a worthwhile local contribution, they are small in extent and recent emphasis of BHA procurement is now outside Tasmania.

4.2. Tasmanian Land Conservancy

Beginning in 2001 the TLC has been involved in the conservation of over two per cent of private lands in Tasmania containing many of the state's most precious wildlife species and habitats (TLC Annual Report 2010).

Initiated in 2010, the *New Leaf project* was endowed by philanthropists who provided almost $20 million in funding through gifts and loans. This project protects almost 28,000 ha of native forests, grasslands and wetlands purchased from Gunns Limited following their decision to move exclusively to plantation based resources. Some areas are remote and remain untouched while other forested areas have been harvested but will be restored progressively. One purchase, Skullbone Plains, contains rare conservation assets including sphagnum moss beds, native fish and cider gum eucalypts.

However, while the conservation value of candidate areas can be measured and ranked, the accrual of these conservation assets is largely opportunistic.

http://www.tct.org.au/campaigns/private_land_biodiversity.htm

4.3. The Protected Areas on Private Land Program (PAPL)

PAPL is a multi-way initiative between the National Reserve System Program, the Tasmanian Department of Primary Industries, Parks, Water and Environment, the Tasmanian Farmers and Graziers Association and the Tasmanian Land Conservancy.

It contributes to the CAR Reserve System by promoting and facilitating voluntary conservation covenants between the Tasmanian Government and landowners with important natural values on their properties. Natural values of particular interest include under-reserved vegetation communities, freshwater values, threatened species and geo-conservation assets. It targets natural areas >10 hectares in size that are in good condition and ideally linked to other areas of native bush. The viability of some of the smaller patches is open to question; for example, a threshold of around 30 hectares in open forest fragments is necessary to disadvantage the aggressive Noisy Miner whose presence strongly discourages many other bird species (MacDonald and Kirkpatrick 2003).
The total area protected under the PAPL initiative in 2011 was 4,300 ha in IUCN Category IV but the proportion of this area under forest is unclear.
http://www.dpiw.tas.gov.au/inter.nsf/WebPages/DRAR-7T8VB6?open
http://www.environment.gov.au/parks/nrs/getting-involved/case-studies/tas-private-land.html

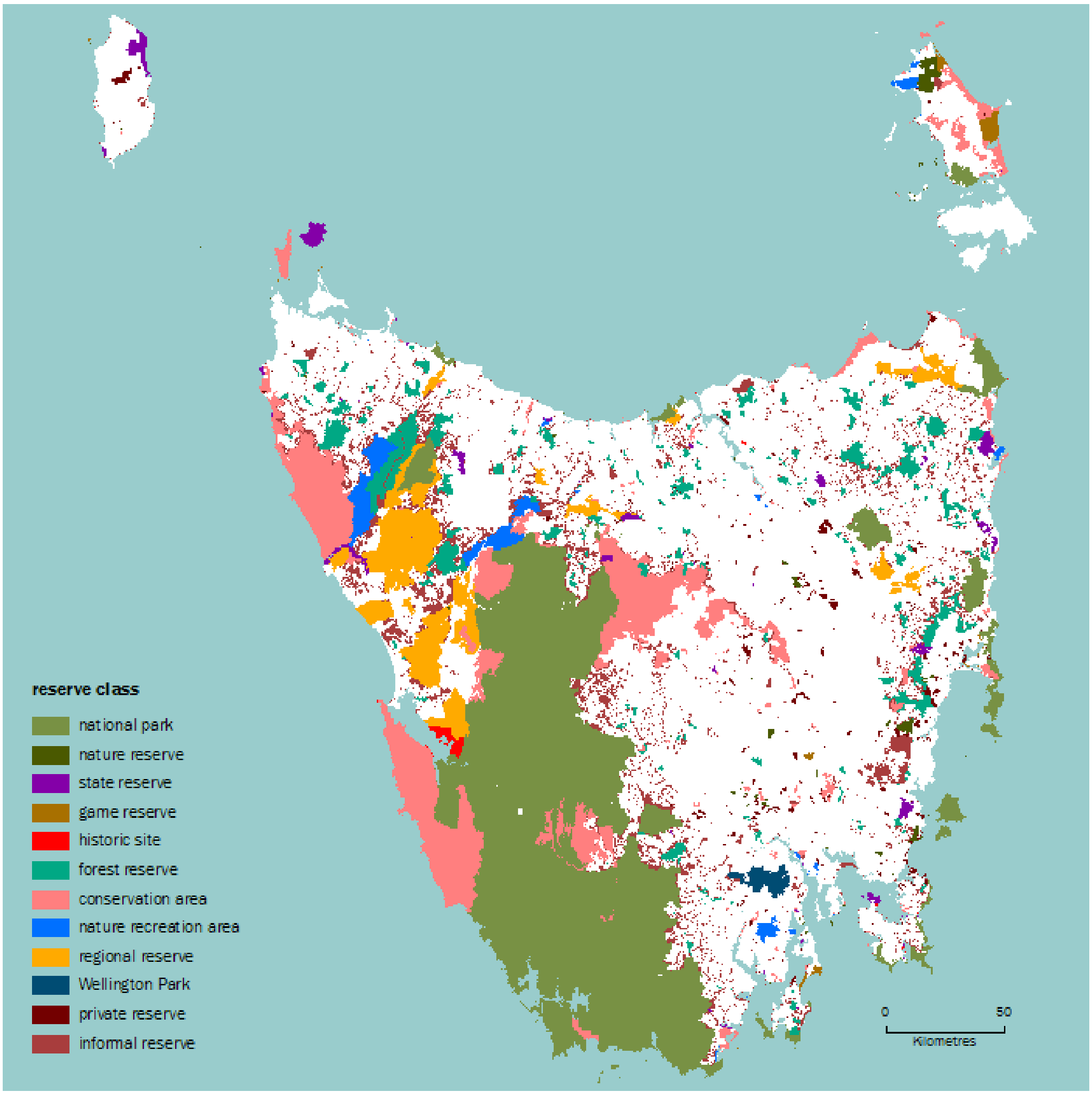
Summary: a relatively minor contribution to forest conservation at this point in time but is useful in filling in some regional gaps.

4.4. Land for Wildlife
The Land for Wildlife scheme (LFW) established in Tasmania since 1998, offers encouragement and support to private property owners seeking to integrate land management with nature conservation on their land. The scheme generally seeks areas exceeding two hectares in size. Participation in this scheme is voluntary, free, and non-binding.
As of March 2011, there were *ca* 780 LFW agreements in Tasmania covering 54,184 hectares.
http://www.dpiw.tas.gov.au/internnsf/WebPages/DRAR-7T8VRQ?open
http://www.dpiw.tas.gov.au/inter.nsf/Attachments/DRAR-8A84Z3/$FILE/PAPL%20Focal%20Landscape%20Flyer.pdf

Summary: an especially important contribution for the conservation of wide ranging species but the long term viability of smaller LFW areas is uncertain.

5. Informal reserves (those not guaranteed by Parliament)
The large number of informal reserves in Tasmania is testament to both the large quantum of conservation values dispersed across the island, and the shortcomings of the formal reserve system in capturing them. The distribution of these informal reserves is noteworthy for their high concentration on the fringes of the World Heritage Area and within and adjacent to production forest area in the east of the state in particular (Fig. 12).

Figure iii-12. Distribution of reserves by reserve class. The plethora of tiny informal reserves against the eastern boundary of the World heritage Area is especially obvious.
http://soer.justice.tas.gov.au/2009/image/908/index.php



6. Crown Land Assessment and Classification (CLAC) Project

The CLAC Project (2004- 2006) reviewed the tenure of Public Reserves and unallocated Crown land, involving some 7000 properties across Tasmania.
Recommendations included reservation as Public Reserves under the *Crown Lands Act* 1976 and reservation under the *Nature Conservation Act* 2002. In total, the area of land recommended to reserve under the *Nature Conservation Act 2002* is approximately 78,000 hectares.

There are eight different reserve classes under the Act: Conservation Areas, Nature Recreation Areas, Regional Reserves, Game Reserves, Historic Sites, State Reserves, National Parks and Nature Reserves. These vary considerably in their accommodation of activities such as mining, hunting and commercial businesses.

CLAC reserves proclaimed under the *Nature Conservation Act* 2002 in 2011 are listed at http://www.dpiw.tas.gov.au/inter,nsf/Attachments/LBUN-8KK87U/$FILE/CLAC%20reserves%20proclaimed%20in%202011.pdf

The necessary steps to create reserves under the *Nature Conservation Act* 2002 commence once Cabinet approval to reserve is received. Cabinet has now endorsed reservation in all twenty-nine municipalities. However, Cabinet has deferred implementation of the recommendations to create these reserves, pending resolution of funding issues.

8 Culling of native mammals

On private land and in public forests, large numbers of Tasmanian marsupials are culled each year under permit (Table 4). A credible argument is that populations of some species are locally high due to the extensive interface of bushland and farms in Tasmania, offering an ideal combination of shelter and food; in drought years competition for herbage between livestock and native animals can becomes unsustainable. The loss of the thylacine as the top terrestrial predator may also be implicated in the boom-bust population cycles of some marsupials seen in recent decades. Most concern attaches to the Forester Kangaroo *Macropus giganteus tasmaniensis*, an endemic subspecies and the largest native marsupial in Tasmania (up to 60 kg). Its area of occurrence has declined by 90% since European settlement and the total population is thought to number *ca* 26,000. The Forester Kangaroo is not listed as threatened under any legislation though it is classified as 'protected native wildlife' under the *Tasmanian Nature Conservation Act* 2002. http://www.environment.gov.au/biodiversity/threatened/species/forester-kangaroo.html .

This culling has unknown consequences on the local function of Tasmanian ecosystems. However, common marsupials are ecologically influential, in part due to their preferential feeding behaviour (McArthur & Turner 1997), and important conservation assets such as “marsupial lawns” would be at risk in their absence (Roberts *et al.* 2011). In addition, larger marsupials support a range of native dung beetles *Onthophagus* spp. and even the refractive dung of brushtail possums is eaten by specialised moth larvae (genus *Telanepsia*) (Common & Horak 1994).

Table iii-4. Native Tasmanian mammals culled under crop protection permits 2000-2007. Source: SoE 2009. * wallabies plus pademelons

Year	Wallabies*	Brushtail Possum	Forester Kangaroo	Tasmanian Devil	Wombat
2000-01	724,491	258,524	444	20	528
2001-02	824,336	204,004	716	20	231
2002-03	777,016	218,338	772		230
2003-04	743,686	204,530	1,355		235
2004-05	994,232	264,004	2,239		134
2005-06	1,074,904	295,887	3,237		336
2006-07	1,364,970	287,383	3,987		554

9. The contribution of production native forests to conservation

There is little question that production native forests are rich in native species but it is difficult to be certain of the contribution of these forests make to biodiversity conservation in the future following multiple cycles of harvesting. Apart from the obvious challenge of documenting effects across a sufficiently wide spectrum of taxa, few studies follow effects beyond a single cycle of harvesting. However, it seems reasonable to assume that any legacies of old growth features will be progressively depleted in subsequent harvest cycles. This will be to the detriment of many important native species dependent on complex forest structure.
Another issue is that effects on biodiversity are context dependent. Dispersed harvested coupes surrounded by intact native forest are likely to recruit biota more quickly and completely than coupes surrounded by farmland or degraded forests. A few chronosequence studies undertaken in Tasmania have attempted to shed light on this question in the form of space for time studies, however, many uncertainties remain in the longer term fate of forest dependent species.

Native silviculture as practiced in Tasmania unavoidably creates ecological disturbances, most obviously at the harvest unit scale. Disturbance associated with production degrades surface soils and facilitates the incursion of pests. The extensive roading network promotes erosion and sediment run-off and facilitates more ignition points in remote areas. The high levels of residual slash help sustain fires initiated by lightening.

The Forest Practices Code describes a number of provisions which Forest Practices personnel can draw upon to help reduce the impact of forest harvesting on important species and habitat.
At the coupe level (up to 100ha), these include:

Special Management Zones (SMZs)

In wood production forest, Special Management Zones recognise particular conservation values through particular restrictions on machinery for example.

Special Timbers Zones

Leaving patches of unburnt forest or using very long rotations (>100 years) is designed to ensure the continued presence of special timber trees such as myrtle and sassafras sought after by furniture makers and craftspeople (Forestry Tasmania 2010).

Some provisions in the current Forest Practices Code focus at the landscape level:

Wildlife habitat strips (WHS)

The Regional Forest Agreement presaged an intensification of clearfelling and, on productive sites, the conversion to plantations of exotic species which triggered renewed concerns on impacts on native fauna and flora.

The commercial practice of concentrating plantation establishment in local 'nodes', has promoted major fragmentation of native forest remaining in the neighbourhood which is largely confined to linear strips. A prescription for wildlife habitat strips up to 100 metres wide for conservation purposes was introduced in 1987 (and prescribed in the FPC 2000) but only a few attempts have been made to test their short term efficacy in Tasmania. For birds in a dry sclerophyll forest, MacDonald *et al.* (2005) found that these provisions did not maintain an avifauna equivalent to that of extensive native forest 10 years after logging, citing significant reductions in bird abundance and species richness in wildlife habitat strips and streamside reserves that did not occur in the control sites. A study of ground beetles in wetter forest by Grove & Yaxley (2005) reported species composition in habitat strips to be intermediate between that in plantations and continuous native forest. Some edge adapted beetles were favoured at the expense of interior species and highlighted a need for additional formal reserves, large enough to cater for forest interior species and arranged at a scale appropriate to the rate of species turnover among ground beetle assemblages. The edge effects such as drying are likely to impact fungivorous beetles in particular. In addition predatory species such as carabid species seem to be at particular risk of local extinction from fragmentation in eucalypt forests (Davies *et al.* 2000).

The ideal width of habitat strips remains controversial, with edge effects reported for various microclimatic measures ranging from 10m (Westphalen 2003) to 100m (Dignan & Bren 2003).

Biodiversity spines

Biodiversity spines involve networks of production forests or contiguous coupes to be managed with greater sensitivity to flora and fauna values. By linking reserves, their purpose is to impose a pattern that will facilitate dispersal of species and a source of individuals for recolonization of disturbed patches in a forested landscape. Typically rotations in the spines are extended beyond 80 years. Burgman *et al.* (2005) explored the utility of this planning tool to arrest the decline of Simson's stag beetle (*Hoplogonus simsoni*) a threatened local endemic in north east Tasmania. For a rare north western forest snail, *Tasmaphena lamproides*, a PVA study by Taylor *et al.* (2003) showed that a biodiversity spine would make a positive contribution to the persistence of the species in a plantation intensive landscape.

Streamside reserves

Whereas in many overseas jurisdictions streamside reserves are calibrated in meaningful ecological units such as multiples of potential tree height (e.g. Richardson *et al.* 2012), in Tasmania such prescriptions are legislated in relatively arbitrary distances. Consequently, the recruitment of logs to the CWD pool is compromised as they will commonly fall outside the boundaries of the reserve. Edge effects, including desiccation and windthrow, are likely to penetrate the majority of the smaller streamside reserves further degrading their longer term utility.

Use of offsets

These are used to compensate for the loss of significant biodiversity values within forest practices plans. They are determined on a case by case basis and in accordance with a set of general principles for biodiversity offsets issues by DPIPWE.

The Tasmanian Regional Forest Agreement (Commonwealth of Australia and State of Tasmania 1997) established a number of initiatives designed for conservation outcomes. These included the recognition of:

9.1 *RFA Priority Species*

The conservation of RFA priority species and their habitats occurs primarily through the CAR reserve system and by prescriptive management in off-reserve areas (Chuter & Munks 2011). The formal reserves, informal reserves and private reserves which make up the CAR system play the major role in landscape scale habitat maintenance for RFA priority species in Tasmania.

The original list of RFA priority species was drawn from a list of candidate taxa solicited from biologists in the 1990s; however the process of final selection was not transparent and many submitted forest species were not listed. However, some of these reappear in the revised priority species list prepared by the Tasmanian and Australian Governments for the 2007 ten year review of the Tasmanian RFA (Appendix 1.2.b.1 from the Sustainability Indicators for Tasmanian Forests 2001-2006). The updated list also includes forest-dwelling additions to 2007 of the *Threatened Species Protection* Act 1995. (http://www.dpipwe.tas.gov.au/inter.nsf/WebPages/LJEM-7VH9NV?open)

The conservation of RFA priority species and their habitats is managed through a legislative and policy framework which includes the Tasmanian forest practices system which endeavours to conserve biodiversity in the wood production forest environment (Chuter & Munks 2011).
In particular, the *Forest Practices Act* 1985 provides that the Forest Practices Code shall prescribe the manner in which forest practices are conducted so as to provide reasonable protection to the environment.

Following harvest, state forests are no longer converted to plantations (since the end of 2006) and Gunns, the largest private forest company, has recently ceased this practice also.

9.2 *The importance of coarse woody debris CWD and its dynamics*
Dead wood or coarse woody debris (CWD) is an important habitat, nutrient store and structural component in forest ecosystems (Yee *et al.* 2001). Tasmanian tall forests are characterised by very high levels of CWD, among the highest of any forests globally and slow rates of log decay (Grove et al 2009). As decomposition progresses, attributes in CWD volume, size class spectrum and decay status change over time and in response to disturbance. Recent research emphasises its importance for biodiversity and as a carbon store. Short rotation lengths between harvest cycles through its effect on CWD dynamics will impact negatively on dependent biodiversity. Fuelwood harvesting in native forests may also increase the impacts of CBS on biodiversity and on threatened species.
http://oldforests.com.au/pages/Posters/Stamm_Grove_woody_debri.pdf

Invertebrate communities are highly responsive to forest management and species richness of saproxylic beetles, a highly biodiverse group, is positively related to the amount of CWD in the vicinity (Grove 2009). It is noteworthy that various CWD dependent beetles in Tasmania have close relatives in European temperate forests that are now locally extinct or at high risk of extinction due to human-mediated changes in the forest landscape (Grove & Meggs 2003). In Fennoscandia, these beetles now make up the largest group of threatened forest animals. This should serve as a warning to forest managers that CWD dynamics need careful management.

Assemblages of macrofungi in tall wet forest are also sensitive to the type of woody substrate as well as vascular plant species (Gates *et al.* 2011c), while various polypore species in particular were indicative of biodiverse old growth *E. obliqua* forest. Polypores support many temperate forest beetles which use them as feeding and aggregation sites (Epps & Arnold 2010). The retention of dead wood of all sizes, species and decay stages is key to maintaining saproxylic fungal diversity.

Regeneration burns following clearfelling deplete the CWD values of harvested forest and also increase the threat to values in nearby forest, including reserved forest.

Recommendation: Given its importance for species diversity, the natural spectrum of forest structure should be maintained and replicated across landscapes at bioregional levels. In some places, especially NE Tasmania, age structure in native forests has been strongly simplified as a result of CBS harvesting methods.

9.3 *Aggregated retention*

The partial clearance of forest coupes, or variable retention silviculture, is presently being promoted as a better conservation outcome than broad-acre clearfelling and as an example of adaptive management to higher public expectations of better land management (Baker and Read 2011). Patches or islands of 0.6–2.6 ha were typically retained in the study of Stephens *et al.* (2012). However, the evidence that this can make a long term contribution to conservation is so far equivocal and the importance of islands within aggregated retention as stepping stones for small mammal dispersal in the medium to long-term is as yet unknown (Stephens *et al.* 2012).
In relation to macrofungi, Gates & Ratkowsky (2009) found that retained aggregates had lower species richness than an unharvested control coupe suggesting an effect from factors such as the initial site preparation, opening up of the canopy, and proximity of the surrounding harvested areas, which tend to suppress the full development of the mycota in the aggregates. Nevertheless, unharvested aggregates can be important reservoirs of ectomycorrhizal fungal diversity.

Short term effects (1-3 years post regeneration fire) on rodents were examined by Stephens *et al.* (2012) who reported that the cover-dependent swamp rat (*Rattus lutreolus velutinus*) was most abundant in unlogged forest, intermediate in aggregated retention and lowest in clearfells. In contrast, the habitat generalist, long-tailed mouse (*Pseudomys higginsi*) was unresponsive to overstorey cover. It was also noted that reduced vegetation cover in islands due to edge effects from post-harvest burns (McElwee and Baker, 2009) and increased windthrow may increase predation risk for small ground mammals. The relatively long distances between islands and contiguous forest (102 ± 35 m) coupled with the lack of dense vegetation in the harvested matrices may prevent dispersal of swamp rats, and in the absence of immigration populations surviving within islands may be at risk of inbreeding depression.

Long term effects on the forest bird fauna are also not clear due to the absence of sufficiently long term experiments. However, early responses of birds to clearfelling and some modified harvest methods in wet eucalypt forest have been recently documented. In a community of 44 bird species, LeFort & Grove (2009) (Lefort and Grove 2009) found most birds had strong associations with either mature forest or young regeneration post-harvest, with relatively few generalists apparent. Harvesting induced major change in bird composition irrespective of the silvicultural system applied. Among a variety of silviculture systems trialled, aggregated retention offered some promise of sustaining mature forest bird assemblages at the coupe-level. However, birds typical of mature forest varied in their tolerance and the authors concluded that no system is completely resilient to the effects of tree harvesting.

A special problem accrues in Tasmania as a consequence of the legislated commitment to industry of a predetermined annual volume of higher grade product negotiated under the Regional Forest Agreement 1997. Consequently, any resource set aside in retained patches within harvested coupes must be replaced with timber sourced from intact forest which may not otherwise have been disturbed. Arguably, the conservation outcomes could even be worse under this scenario.

Recommendation: The conservation argument for aggregated retention remains contentious at his point. A perverse outcome could be the need to harvest extra areas of old growth forest in order to meet legislated or contracted commercial commitments.

Given the incomplete knowledge of the forest biodiversity and the uncertain longer term outcomes arising from current forestry practices, adaptive management approaches will continue to play an important role.

Clearly, great skill is needed to plan and conduct successful regeneration burns around retained aggregates. Although “slow-burning” prescriptions are under trial (Baker and Read 2011), Neyland et al (2009) demonstrated that the highest *E. obliqua* seedling densities and fastest early seedling growth rates occur on seedbeds burnt the hottest. For well managed burns, edge effects on the vascular flora generally did not exceed 10 metres into the adjacent unburnt forest (Neyland and Jarman 2011). While the persistence of retained aggregates may be threatened by the imperative to maximise the heat yield from the regeneration burn, some unintended partial incineration of aggregates may add structural diversity to the production landscape that favours certain species (Baker and Read 2011).

9.4 *Other Management Options*

(i) Forestry Tasmania has entered into a number of Public Authority Management Agreements (PAMA) with various public authorities which provide for the management of threatened species or threatening processes (*Threatened Species Protection Act 1995* sect. 31 Public authority management agreements). PAMAs typically attempt to allow for wood harvesting while making concessions to the species in question. e.g. for the management of the rare Forth River peppermint *(Eucalyptus radiata)*, which is restricted to a few river systems in northern Tasmania, and for Simson's stag beetle in north eastern Tasmania.

(ii) Collaboration between State agencies has led to reservation of most populations on public and private land. e.g. the endangered *Tetratheca gunnii* (shy pinkbells), is restricted to serpentinite rocks in a localised part of northeast Tasmania. This collaboration seeks to manage the pathogen *Phytophthora cinnamomi* and deliver the particular fire regimes the species needs to regenerate.

9.5 *Tasmanian Forest Conservation Fund* (FCF)

The Forest Conservation Fund to protect forested land on private property emerged from the 2005 Supplementary Regional Forest Agreement (Tasmanian Community Forest Agreement). It replaced the PFRP (Private Forest Reserve Program, initiated by the RFA in 1997. Market-based incentives were used to target old growth and under reserved forest communities on private land.

The headline target of the FCF was to protect up to 45 600 hectares of forested private land, including a minimum of 25 000 hectares of old growth forest and up to 2 400 hectares to protect karst values in the Mole Creek area (Clause 21 of the Supplementary Regional Forest Agreement 2005).

The FCF supported private landowners to manage and conserve forest on their land using voluntary conservation arrangements, secured through agreements with landowners; the development of conservation management plans with the landholder, and the provision of ongoing advice and assistance to manage protected areas.

Outcomes of the FCF: The FCF concluded in June 2009 having secured ca 28 000 hectares of forest including ca 11 000 hectares of old growth forest and involving 150 landowners (Tables 5, 6) at a cost of $17.5 million. However, less than half the old growth area target and less than one quarter of the Mole Creek Karst target was achieved.

Minor extensions may be achieved from the Revolving Fund of the FCF which has been extended until 2014, to allow further properties to be purchased, covenanted then sold to conservation-minded individuals who commit to their ongoing management.

http://www.environment.gov.au/land/forestpolicy/fcf/index.html

Table iii-5. Outcomes of the Forest Conservation Fund to 2009. Source: Marsden Jacob Associates (Financial & Economic Consultants): Analysis of FCF data

Achievements against headline targets (end 2009) Forest type	*Target (ha)*	*Secured (ha)*	*% of target*	*Outstanding (ha)*
Total	45,000	28,900	63	16,700
Old growth	25,000	11,000	44	14,000
Mole Creek - Karst	2,400	540	22	1,860

Table iii-6. Comparison between outcomes of the Forest Conservation Fund (FCF) compared to the Private Forest Reserves Program (PFRP). Source: Marsden Jacob Associates (Financial & Economic Consultants): Analysis of FCF data
http://www.environment.gov.au/land/publications/forestpolicy/pubs/fcf-performance.pdf

Program	*Funding ($)*	*Area secured (ha)*	*Cost $/ha*	*Old growth (ha)*	*Duration of program*
FCF	$54.4m	28,900	$1,378	11,000	2006-2009
PFRP	$30m	43,140	$695	6,108	1997-2006

9.6 Shortcomings of the Tasmanian Forest Practices System for biodiversity conservation

9.6.1 Insufficient focus at larger scales

The Tasmanian Forest Practices System has traditionally focussed conservation management for flora and fauna values on the coupe (harvest unit) level through measures such as targeted species reserves and maintenance of representative habitat (Chuter & Munks 2011). However, a recent review of the biodiversity provisions of the Forest Practices Code (Biodiversity Review Panel, 2008) identified gaps and shortcomings in delivering conservation outcomes across multiple scales. It recommended that the system increase its capacity to manage biodiversity conservation strategically and at a range of spatial scales, notably the landscape level.

Such initiatives can be guided by the five principles outlined by Lindenmayer and Franklin (2002) which help maintain habitat across multiple spatial scales: Maintenance of (i) connectivity, (ii) landscape heterogeneity, (iii) stand structural complexity, and (iv) aquatic ecosystem integrity, along with (v) adoption of “risk spreading”.

9.6.2 Protection of class 4 streams

Improved protection for freshwater environments was a priority action identified by the Tasmanian Nature Conservation Strategy and called for the establishment of freshwater CAR reserves and complete integrated catchment planning for natural resource management.

Small headwater streams (Class 4 streams with catchments <50 hectares) are an important part of hydrological networks and can be important habitats for some aquatic taxa but have been historically poorly managed (Bunce *et al.* 2001). Headwater streams are distinctive in that they collectively extensive and are closely connected with adjacent terrestrial processes (Barmuta et al 2009) including groundwater exchanges. However, groundwater dependent systems are poorly studied and difficult to manage. Many class 4 streams in Tasmania are non-perennial and extended droughts create stress in their biota. Degradation risks from disturbance associated with roading and clearcutting are enhanced by slope and soil erodibility. Under the Forest Practices Code a risk assessment approach is taken and encourages the use of 10m wide machinery exclusion zones (MEZ) where appropriate (FPA 2011). However, on steep slopes high-lead cable logging is used and this apparatus is not classified as machinery by the Code; consequently logs can be dragged through riparian vegetation and may destroy valuable stands of leatherwood (*Eucryphia lucida*) as reported in coupe WE008E (ABC 2005). The conservation of remaining leatherwood stands remains an important issue for the local honey industry (Tasmanian Beekeepers Association 2011).

Threatened species such as the Giant Freshwater Crayfish may breed in Class 4 streams if perennial flow is maintained by supplementary water from underground (Davies *et al*. 2005). Headwaters are also important habitat for hydrobiid snails, e.g. the species-rich *Beddomeia*, many of which have very restricted distributions across the upper streams of catchments that drain into Bass Strait (Ponder and Colgan 2002). Burrowing crayfish also have complex distributions across headwaters, with adjacent catchments supporting different species (Hansen and Richardson 2006).

The maintenance of native forest cover in headwaters has an important role in protecting soils and ameliorating runoff effects An increase in the magnitudes of the 24 hr and 48 hr duration precipitation events across Tasmania by the end of the 21st century is predicted, with the largest increases in the average recurrence intervals modelled to occur in the north‐east (up to 90%) where the most variable and intense precipitation already occurs.

9.6.3 Independent tests of the Forest Practices System have lowered public confidence

Since annual auditing of compliance with the Code is conducted "in-house" by the Forest Practices Authority, third-party independent insights into the efficacy of the Forest Practices System for conservation are rare. However, the proceedings of two recent court cases examining the effects of forestry practices on threatened species are illuminating.

Case (i) (F. Giles, J. Weston & T. Dudley v Break O Day Council & T. Denney TAS RMPAT No. J115/200).

A landmark decision by Tasmania's Resource Management and Planning Appeal Tribunal highlighted serious deficiencies in the preparation of the Forest Practices Plan (Hall 2001). Inexplicably, the private forest owner failed to have his forest declared a Private Timber Reserve and consequently his change of landuse to a plantation was open to challenge by neighbours under the local council planning scheme (F. Giles, J. Weston & T. Dudley v Break O Day Council & T. Denney TAS RMPAT No. J115/200).

The forest practices plan for the operation, prepared by an experienced and accredited forest practices officer, was shown to be seriously deficient in that it:

● contained no prescriptions for the listed velvet worms predicted to occur in the area and subsequently found by independent biologists.

● the flora survey failed to identify a stand of the rare species *Eucalyptus brookeriana*, an RFA priority species, and consequently no allowance was made in the FPP.

● large bluegums on the site were not recognised as a key habitat resource for swift parrot.

● as the plan was drafted in reference to the Forest Practices Code rather than the council Planning Scheme there was a disparity between the watercourse buffer zones required under the Scheme (30 metres) and the 10 metre buffer zones proposed in the plan and allowed by the Code.

It was successfully argued in a 3 day hearing that the planned forestry activities would unacceptably compromise the conservation values of the coupe.

The decision in this case provides a clear demonstration of the discrepancy between environmental outcomes allowed under the two systems. The fact that the proponents can overcome the decision by having the coupe declared a Private Timber Reserve highlights the special status afforded to the forestry industry by law (Hall 2001).

The Forest Practices System is not part of the Resource Management and Planning Scheme and therefore not subject to the RMPS integrated planning and sustainable development objectives. The Forest Practices System's own objectives emphasise self-regulation and resource security and serve to facilitate maximising the availability of native forests for commercial use.

Case (ii). Robert Brown v Forestry Tasmania, Commonwealth of Australia and State of Tasmania Federal Court of Australia 2006/1729.

http://www.austlii.edu.au/au/cases/cth/federal_ct/2006/1729.html

An application in the Federal Court by Senator Brown under s 475 of the *Environment Protection and Biodiversity Conservation Act* 1999 concerned alleged contraventions of s 18(3) of the EPBC Act by Forestry Tasmania. It was alleged that Forestry Tasmania's current and proposed forestry operations in the Wielangta State forest east of Hobart have had, or will have, a significant impact on three threatened species: the Tasmanian wedge-tailed eagle, the swift parrot and the broad-toothed stag beetle *Lissotes latidens*. As such, the operations would be prohibited in the absence of approval by the relevant Commonwealth Minister.

After 33 sitting days, the Court found that forestry operations were likely to have a significant impact on all three species, having regard to their endangered status and all other threats to them. Tellingly, the Court found that Forestry Tasmania did not have an exemption from relevant provisions of the EPBC Act by virtue of exemption provisions in s38 of that Act and s6(4) of the *Regional Forest Agreements Act* 2002. This is because the Court formed the view that the relevant forestry operations will be, and have been, carried out otherwise than in accordance with the RFA.

Shortly after this ruling the Tasmanian Government and the Australian Federal Government responded by changing the text of the Tasmanian Regional Forest Agreement which makes further legal appeals pointless. The new clauses make it clear that the word 'protection' in the RFA relates only to whether the two respective governments *deem* a species to be protected rather than the meaning of the word being based on actual evidence of an outcome.

It is my opinion that both these findings have severely undermined public confidence in the efficacy of the self-regulatory system administered by the Forest Practices Authority.

9.6.4 Other insights and issues

(i) At a public hearing of the Senate *Rural and Regional Affairs and Transport References Committee* inquiring into forestry matters, Tasmania's former senior Forest Practices auditor Mr Bill Manning made widely reported claims of malpractice. The most serious of these allegations concerning his personal and professional experience with the FPB were the basis of an ABC *Four Corners* programme in February 2004.

Attempts by the committee of inquiry invited the CEO and the chair of the FPB also to give evidence to the committee. The committee was frustrated in its inquiry by the decision by the Deputy Premier of Tasmania and Minister for Economic Development, Energy and Resources, the Hon. Paul Lennon, to not make available the CEO and chairman of the FPB available to the committee.

The Hansard record of proceedings is at:
http://parlinfo.aph.gov.au/parlInfo/download/committees/commsen/6992/toc_pdf/2920-2.pdf

(ii) In Western Australia the Forest Products Commission, responsible for managing the harvesting, regrowing and sale of timber from native forests, seeks community involvement through consultation on the annual timber harvest plans and before harvesting operations begin in an area. There is also a program of Community Forest Inspections following harvesting. These inspections emerged from WA Government's 2001 *Protecting our old-growth forests* policy to improve public involvement in, and understanding of, forest management. Although not intended as an audit of operating standards, non-compliance with operational standards may be identified as a result of community inspections. The outcomes are provided to all participants and matters of concern are followed up, or reported on, by staff of the Department or the Forest Products Commission.
In Tasmania, although the Forest Practices Authority solicits public input into reporting violations of the Forest Practices Code; in reality, a twenty dollar fee per copy of a Forest Practices Plan, trespass laws and a propensity to lock off active harvest areas act as effective deterrents to meaningful public engagement.

At a state level, there is ongoing incremental loss of conservation values in existing reserves, mainly driven by economic interests. In recent years, examples include:
• a reservoir built within Freycinet National Park to service a new hotel development, flooding formerly protected habitat.
• scouring of riparian rainforests along the Gordon River in the WTWHA due to water release from the Gordon Power Station which has increased with the establishment of Basslink as part of the interstate electricity market (Locher 2001).
• a major walking track and permanent accommodation is soon to be built in the Tasman National Park, an area with high species endemism and landscape resilience values.

Area offsets may be required in compensation and expanses of uncommitted forest worthy of conservation will be needed to meet this demand.

10. Insights from the jarrah production forests of Western Australia.
Since 1985, revised silvicultural objectives in south western Australia have necessitated monitoring of responses by forest fauna to silvicultural treatments (harvesting and post-harvest burning). The Forestcheck programme, initiated in 2002, monitors these biodiversity impacts in jarrah (Eucalyptus marginata) forest ecosystems for the purpose of adaptive management. Jarrah forest is mapped into eight broad ecosystems that occur across a wide range of climatic variables, soil types and topography. In Forestcheck, a selection of biota is systematically sampled, including cryptograms, macro-invertebrates, frogs, reptiles, terrestrial mammals and birds.
The most extreme logging treatment (gap release) involves removal of most of the overstorey from patches up to 10 ha, followed by a regeneration fire. A shelterwood/selective-cut regime was of

intermediate impact and the comparison reference forests had not been harvested for at least 40 years, if ever. Regeneration age (time since harvest and post-harvest fire) of gap release grids ranged in age from 3 to 16 years, while time since fire in reference treatments ranged from 2 to 28 years. However, comparisons with Tasmanian tall forests require caution because jarrah is a much more open and xerophytic ecosystem and fewer species of birds and other biota are fully forest dependent (Abbott *et al.* 200x).

Results from the first 5-year sampling cycle show that responses to treatments vary with biotic groups and are summarised below:

Terrestrial vertebrates

Although forests cover only 5% of Australia's landmass, they support almost half of the terrestrial vertebrates, including 77%, 53% and 33% of all mammal, frog and reptile species, and 75% of these are endemic forest animals (Lamb & Smyth 2003).

The most abundant terrestrial mammals in jarrah forests were *Trichosurus vulpecula* and *Bettongia penicillata* but neither showed a strong response to silvicultural treatment (Wayne *et al.* 2011). The fraction of terrestrial vertebrates species apparently unaffected by harvesting in these forests was much higher than reported by comparable studies in eastern Australia. However, exotic rodents were more abundant in harvested sites which also apparently lacked native rodents.

Silvicultural treatment and the intensity of timber harvesting had relatively minor effects on overall terrestrial vertebrate richness, abundance and community structure compared to fox control on those species subject to fox predation, and differences attributable to ecosystem/year effects (Wayne *et al.* 2011). Similarly, species richness and total abundance of terrestrial vertebrates were unresponsive to live tree basal area after timber harvesting. Associations between these vertebrates and silvicultural treatment were nonetheless evident. The significantly different community structure between shelterwood samples and the external reference forest was largely reflected in the former having higher mean species richness, two reptiles being more abundant, and greater overall vertebrate abundance. Within the limits of the data, no species were negatively associated with silvicultural treatment compared with the reference forest.

Wayne et al (2011) conclude that it is likely that the current silvicultural treatments in the jarrah forest have been within the tolerance thresholds to disturbance for many of the terrestrial vertebrates as suggested for other taxa in these forests (e.g. Abbott *et al.* 2011).

Birds

Only limited changes in the bird fauna of jarrah forests were detected over a five year period. Species accumulated in samples at similar rates in gap release, shelterwood /selective cut, and reference forests. The number of species represented as singletons was greatest on the never harvested (8), coupe buffer (7) and gap release (6) grids.

Abbott *et al.* (2011) found little evidence of any substantial effect of silvicultural treatments on community structure or on individual bird species. Community structure was, however, significantly associated with forest ecosystem/year of sampling. The basal area of live trees was not correlated with bird species richness or abundance.

These results suggest that most bird species in jarrah forest have a high threshold level of tolerance to disturbance. It is likely that the rapid regeneration of dominant tree species after harvesting and burning, the patchiness of treatments at the landscape scale, the high degree of connectivity of harvested and burnt forests with forests not recently harvested or burnt, and the retention of habitat trees in the most heavily harvested (gap release) forests all conduce to dampen local-scale impacts and conserve the avifauna in relation to the home range and normal movements of its constituent bird species (Abbott *et al.* 2011).

Macro-invertebrates

The species richness of macro-invertebrates in jarrah forest declined with degree of silvicultural disturbance, being highest in reference forest (1783 morphospecies), intermediate in forest subject to shelterwood/selective cut treatment (1652 spp.) and lowest in forest subject to gap release (1527 spp.) (Farr et al 2011). Silviculturally treated grids had a more homogenous species composition. Although species composition did not change significantly with regeneration age there were few replicates in each age category, including 1–4 y after post-harvest fire, the time when changes in species composition are likely to be greatest (Van Heurck & Abbott 2003).

Cryptogams

Strong regional influences, reflecting different forest ecosystem types, were observed in the composition of cryptogamic communities (Cranfield *et al.* 2011). Silvicultural treatments affected the species richness of lichens, which decreased with intensity of harvest, and the composition of the total cryptogam community. Total cryptogam species richness was lowest in silviculturally treated grids 1–4 years after treatment, but 10 or more years after treatment it was similar to that in reference grids prescribed-burnt at least 10 years previously. Some cryptogams associated with mature trees, survived on retained habitat trees within the most intensive harvest treatment. Half of the 318 spp. of cryptogams recorded used coarse woody debris as a substrate. CWD in jarrah forests is affected by both timber harvesting and fire, but the specific requirements of saproxylic cryptogams in this ecosystem remains little known (Cranfield *et al.* 2011).

Forest management proceeds within the context of incomplete and imperfect information and continued application of the precautionary principle and active adaptive management will remain necessary to minimise effects on the biota.

Comparisons elsewhere

In Tasmania, clearfelling in native forests is allowed in coupes up to 100 ha, (50 ha if ≥50% of the coupe is on slopes ≥ 20°). This is amongst the clearfelled forest block sizes permitted in the world (McDermott *et al*. 2007).

In a global comparison of forest practices, McDermott et al. (2010) note that, by international standards, many of the environmental directions contained in the Tasmanian Forest Practices Code are "voluntary" since discretion is afforded to non-governmental Forest Practice Officers. The authors draw attention to the widespread use of the word "should" (defined as indicating a desirable practice for which Forest Practice Officers can make exceptions if "acceptable environmental outcomes are achieved (Forest Practices Board 2000)." By way of example, the policy for wildlife habitat strips states, "As a guide, strips of uncut forest 100 metres in width, based on streamside reserves but including links up slopes and across ridges to connect with watercourses in adjoining catchments, should be provided every 3-5 km (Forest Practices Board 2000)."

CONCLUSION

In summary, I conclude that there are major shortfalls in the area of native forest needed for adequate biodiversity outcomes. This applies both to the quantum of forest, its configuration and landscape context and its representation across IBRA bioregions. North eastern Tasmania, the Western Tiers and parts of southern Tasmania seem to be rich in biodiversity assets important for resilience and need better protection. In particular I would highlight the opportunity to conserve long elevational gradients supporting natural environments from low to high altitude and offering security to species which need to adjust their ranges under climate change.

Off reserve management in Tasmania is poorly coordinated, opportunistic, beset with on-going compromises and under resourced in terms of management funds and research needed to make good decisions. Although excellent work is done by a cohort of Tasmanian conservation biologists their individual focus has tended to be narrowly into their specialisations and their additive conclusions and advice are diluted in the competing demands made upon the native forest estate. New research is uncovering extraordinary biodiversity riches in Tasmania, including at the genetic level. The latter is yielding new insights into the history of the biota and equally offering guidance for conservation planning for the future.

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Appendix 1. IGA HCV forest areas (reserve ID) ranked by range in elevation. Calculations performed on IGA_RSFINAL1 and 25x25m DEM layer.

RANK	RESERVE ID	IBRA	RANGE (m)	SD (m)	AREA (ha)
1	97	Tasmanian Central Highlands, Tasmanian Northern Slopes, Tasmanian Northern Midlands	1130.1	219.0	14955.1
2	136	Tasmanian Central Highlands,	1095.3	246.4	3490.9
3	25	Tasmanian Southern Ranges	1060.9	232.7	60020.1
4	208	Ben Lomond	1051.5	162.7	16785.4
5	112	Tasmanian Northern Slopes, Tasmanian Central Highlands	961.8	197.5	3304.9
6	33	Tasmanian Southern Ranges	892.4	233.3	15699.6
7	30	Tasmanian West	880.0	160.0	2753.0
8	50	Tasmanian West	868.1	175.8	454.2
9	258	Ben Lomond, Flinders	866.8	187.3	25312.2
10	198	Tasmanian Central Highlands, Tasmanian West, Tasmanian Northern Slopes	843.0	173.8	37073.8
11	44	Tasmanian Southern Ranges	834.5	133.5	8107.3
12	156	Ben Lomond	823.1	184.3	7879.3
13	19	Tasmanian Southern Ranges, Tasmanian West	820.1	153.8	2653.1
14	88	Tasmanian Central Highlands	799.4	178.7	1928.8
15	176	Tasmanian Northern Slopes, Tasmanian Central Highlands	745.0	145.1	10531.8
16	106	Tasmanian Central Highlands, Tasmanian Northern Slopes	741.2	184.5	2595.8
17	197	Ben Lomond	735.2	137.5	6238.6
18	130	Tasmanian Central Highlands, Tasmanian Northern Slopes	720.4	159.1	2104.9

19	181	Ben Lomond	717.2	169.3	2516.5
20	150	Ben Lomond	705.4	130.8	3219.3
21	137	Ben Lomond	701.2	143.1	2496.2
22	81	Tasmanian West	698.5	73.6	10074.8
23	65	Tasmanian Central Highlands, Tasmanian Northern Midlands	691.7	146.9	1661.4
24	236	Ben Lomond	672.3	184.7	3156.4
25	212	Ben Lomond	652.5	116.1	3134.4
26	87	Tasmanian South East	648.8	151.7	3665.3
27	225	Ben Lomond	646.6	140.4	1322.9
28	129	Ben Lomond	645.8	146.5	1094.9
29	193	Ben Lomond, Flinders	631.4	109.7	14235.9
30	196	Tasmanian Northern Slopes	630.3	149.8	1031.9
31	45	Tasmanian South East	628.3	143.7	2177.3
32	140	Tasmanian Northern Slopes	620.3	170.0	538.0
33	125	Tasmanian Central Highlands, Tasmanian Northern Slopes	619.9	118.2	3624.8
34	122	Tasmanian Central Highlands, Tasmanian Northern Slopes	618.3	169.4	417.3
35	26	Tasmanian Southern Ranges	599.7	135.8	1859.9
36	5	Tasmanian Southern Ranges	594.6	126.7	6290.3
37	252	King, Tasmanian Northern Slopes, Tasmanian West	590.0	93.9	60015.4
38	191	Tasmanian Northern Slopes	586.8	125.1	410.9
39	78	Tasmanian Central Highlands, Tasmanian Northern Midlands	585.4	122.4	4076.4
40	54	Tasmanian Southern Ranges	583.6	119.4	11484.3
41	123	Ben Lomond, Tasmanian South East, Tasmanian Northern Midlands	576.1	101.1	11508.5
42	17	Tasmanian South East	570.0	143.0	2281.9
43	29	Tasmanian South East	568.5	109.1	4392.8

44	184	Ben Lomond	560.1	134.1	1554.8
45	209	Ben Lomond	556.5	126.9	460.1
46	126	Ben Lomond	555.5	145.5	1399.7
47	52	Tasmanian West	548.3	101.9	9411.9
48	113	Ben Lomond, Tasmanian Northern Midlands	547.6	89.3	4671.1
49	35	Tasmanian Southern Ranges	544.1	117.1	3003.9
50	183	Tasmanian Northern Slopes	543.1	96.1	640.2
51	127	Ben Lomond, Tasmanian Northern Midlands	532.7	117.3	3560.4
52	148	Tasmanian Central Highlands	530.3	116.3	367.4
53	115	Tasmanian Northern Slopes, Tasmanian Central Highlands	527.5	118.6	1988.9
54	14	Tasmanian South East	523.7	109.6	2029.3
55	239	Tasmanian Northern Slopes	512.7	105.2	5895.4
56	2	Tasmanian Southern Ranges	510.0	55.8	5235.4
57	110	Tasmanian Northern Slopes, Tasmanian Central Highlands	508.9	100.2	733.4
58	3	Tasmanian Southern Ranges	489.2	117.7	2669.6
59	250	Ben Lomond	489.0	107.2	411.1
60	159	Tasmanian Northern Slopes	483.9	119.9	179.4
61	68	Tasmanian South East	477.3	74.8	1867.3
62	226	Ben Lomond	474.1	110.1	444.9
63	13	Tasmanian Southern Ranges	473.1	103.8	1858.1
64	237	Ben Lomond	470.5	78.8	1458.3
65	39	Tasmanian South East	469.0	83.2	9782.7
66	103	Ben Lomond	462.4	76.8	1700.8
67	224	Ben Lomond	460.6	93.7	1356.8
68	20	Tasmanian Southern Ranges, Tasmanian West	455.3	95.9	785.1
69	158	Tasmanian Central Highlands	450.9	109.9	120.6
70	187	Ben Lomond	450.6	101.9	934.9

71	171	Tasmanian Central Highlands	450.0	99.6	257.5
72	166	Ben Lomond	444.6	106.7	1083.9
73	91	Tasmanian Northern Slopes	442.5	116.7	152.4
74	132	Tasmanian Northern Slopes	439.0	112.6	229.6
75	102	Tasmanian West	432.5	58.5	3931.3
76	93	Tasmanian South East	430.7	72.9	4814.8
77	141	Tasmanian Central Highlands, Tasmanian Northern Slopes	425.3	97.2	407.1
78	221	Ben Lomond	423.6	76.3	353.5
79	149	Tasmanian West	420.0	82.5	10201.2
80	205	Ben Lomond	417.1	85.3	140.4
81	80	Tasmanian Central Highlands, Tasmanian West	413.4	51.4	1707.4
82	227	Tasmanian Northern Slopes	400.4	106.4	859.3
83	107	Tasmanian Central Highlands	395.6	86.9	766.6
84	66	Tasmanian Southern Ranges, Tasmanian Central Highlands	393.8	101.7	4472.4
85	219	Tasmanian Northern Slopes	391.9	101.8	710.0
86	76	Tasmanian South East	390.2	83.0	1721.6
87	7	Tasmanian South East	389.7	71.2	493.4
88	116	Tasmanian Northern Slopes	388.4	68.9	199.8
89	268	King, Tasmanian Northern Slopes	383.1	54.8	4544.9
90	60	Tasmanian South East	379.1	65.9	506.2
91	207	Ben Lomond, Flinders	362.8	86.7	1753.1
92	173	Ben Lomond	357.8	71.4	847.9
93	23	Tasmanian Southern Ranges	357.3	94.3	1025.3
94	89	Tasmanian Central Highlands	356.5	72.8	201.3
95	145	Ben Lomond	339.2	70.6	162.9
96	34	Tasmanian Southern Ranges	333.9	61.5	915.3
97	22	Tasmanian South East	332.4	84.6	443.5

98	32	Tasmanian Southern Ranges	331.2	82.0	142.9
99	42	Tasmanian South East	330.8	83.4	68.1
100	84	Tasmanian Central Highlands, Tasmanian Northern Midlands	330.0	68.1	173.4
101	117	Ben Lomond	326.9	78.6	580.8
102	202	Ben Lomond	325.0	68.4	49.0
103	146	Tasmanian Northern Slopes	323.2	92.6	300.3
104	58	Tasmanian Southern Ranges, Tasmanian Central Highlands	317.8	56.8	5831.8
105	203	Tasmanian Northern Slopes	314.9	79.0	296.6
106	174	Flinders	308.9	71.8	380.9
107	154	Flinders, Ben Lomond	306.2	50.0	655.0
108	218	Tasmanian Northern Slopes	306.0	58.5	1166.3
109	119	Ben Lomond	302.6	70.2	1028.6
110	147	Ben Lomond	299.1	79.7	100.0
111	163	Ben Lomond	296.8	44.1	426.3
112	238	Tasmanian Northern Slopes	295.3	63.6	518.2
113	200	Tasmanian Northern Slopes	292.0	89.8	193.1
114	189	Ben Lomond	290.7	70.0	188.8
115	124	Ben Lomond	286.9	66.6	130.7
116	121	Tasmanian Northern Slopes	285.1	57.8	93.8
117	245	Flinders, Ben Lomond	284.7	42.4	3921.5
118	182	Ben Lomond	284.7	63.9	172.8
119	114	Tasmanian Northern Slopes	284.0	78.8	427.2
120	234	Tasmanian Northern Slopes	281.3	56.0	719.3
121	90	Tasmanian West	280.3	64.1	216.6
122	12	Tasmanian South East	278.7	59.4	809.5
123	82	Tasmanian South East	275.8	70.8	334.2
124	213	Ben Lomond	275.1	76.6	36.3
125	51	Tasmanian South East	272.8	46.3	437.2

126	249	Tasmanian Northern Slopes	272.7	46.4	2342.1
127	216	Ben Lomond	269.1	49.4	44.8
128	69	Tasmanian West	268.1	50.0	1367.4
129	233	Ben Lomond	267.7	63.4	1003.1
130	74	Tasmanian Central Highlands	263.1	54.0	1253.9
131	188	Tasmanian Northern Slopes	256.4	46.6	590.1
132	59	Tasmanian West	251.8	62.1	1147.2
133	18	Tasmanian West	250.0	51.0	385.1
134	211	Ben Lomond	246.8	57.4	557.5
135	120	Tasmanian Northern Slopes	243.6	35.7	734.1
136	264	Ben Lomond	239.8	42.9	2952.0
137	46	Tasmanian South East	238.3	43.7	1877.5
138	222	Ben Lomond	236.3	59.7	30.1
139	217	Ben Lomond, Flinders	231.1	51.9	604.4
140	10	Tasmanian South East	230.0	45.9	221.2
141	178	Tasmanian Northern Slopes	224.0	65.0	63.8
142	235	Ben Lomond	223.3	51.5	223.8
143	186	Tasmanian Northern Slopes	220.7	43.2	1864.6
144	111	Tasmanian West	220.0	41.0	11884.6
145	262	Flinders	220.0	36.0	2949.2
146	27	Tasmanian South East	219.9	54.6	184.3
147	104	Tasmanian West	216.6	42.2	455.6
148	229	Tasmanian Northern Slopes	215.6	41.1	971.8
149	8	Tasmanian South East	214.3	53.0	404.4
150	75	Tasmanian Central Highlands	213.6	42.0	364.4
151	21	Tasmanian South East	204.1	43.0	73.9
152	24	Tasmanian Southern Ranges	202.7	44.9	74.4
153	53	Tasmanian South East	200.5	54.5	39.3
154	40	Tasmanian South East	199.9	42.2	59.9

155	79	Tasmanian West	198.3	43.2	612.5
156	41	Tasmanian South East	194.8	38.1	88.8
157	167	Tasmanian Central Highlands	185.7	40.1	70.7
158	240	Ben Lomond, Flinders	178.6	47.9	264.6
159	169	Tasmanian Northern Slopes	177.9	28.7	490.4
160	47	Tasmanian South East	176.5	34.5	34.9
161	92	Tasmanian West	176.2	52.1	138.0
162	194	Tasmanian Northern Slopes	173.5	42.4	187.8
163	223	Ben Lomond	170.1	24.7	952.6
164	43	Tasmanian Southern Ranges	170.0	21.0	177.3
165	38	Tasmanian Southern Ranges	164.8	44.4	21.8
166	257	King	164.3	21.6	1939.0
167	64	Tasmanian West	160.0	42.3	209.9
168	244	King, Tasmanian West	160.0	37.3	5101.7
169	9	Tasmanian South East	155.4	25.5	30.5
170	142	Tasmanian Northern Slopes	153.5	29.9	90.6
171	269	King	153.4	30.1	1081.5
172	56	Tasmanian South East	152.3	37.4	20.6
173	175	Flinders	150.9	35.5	68.3
174	37	Tasmanian Southern Ranges	144.3	38.4	113.7
175	71	Tasmanian Central Highlands	142.2	38.2	21.2
176	242	Ben Lomond	139.8	33.4	89.4
177	62	Tasmanian West	139.8	38.0	110.6
178	201	Tasmanian Northern Slopes	137.2	35.4	41.6
179	247	Ben Lomond	132.5	21.2	265.2
180	16	Tasmanian Southern Ranges	132.0	29.9	11.9
181	185	Ben Lomond	131.6	31.6	25.9
182	11	Tasmanian Southern Ranges	131.1	30.0	49.5
183	49	Tasmanian South East	130.4	16.8	26.7

184	28	Tasmanian Southern Ranges	129.5	30.8	12.4
185	195	Tasmanian Northern Slopes	126.5	16.3	604.7
186	243	Ben Lomond, Flinders	126.4	27.9	1378.6
187	83	Tasmanian Central Highlands	120.9	29.5	47.8
188	210	Tasmanian Northern Slopes	120.7	25.2	16.7
189	61	Tasmanian West	119.2	27.3	132.8
190	204	Ben Lomond	118.7	28.1	139.6
191	177	Tasmanian Northern Slopes	118.2	21.8	72.7
192	164	Flinders	117.5	18.8	138.8
193	259	King, Tasmanian Northern Slopes	113.6	23.8	273.0
194	86	Tasmanian Central Highlands	112.2	27.0	165.8
195	267	King	110.4	18.3	136.9
196	180	Tasmanian Northern Slopes	106.7	16.2	298.1
197	99	Tasmanian West	101.0	27.4	22.9
198	199	Tasmanian Northern Slopes	100.4	19.7	400.8
199	206	Tasmanian Northern Slopes	99.8	24.3	15.8
200	232	Flinders	99.6	22.9	325.3
201	152	Tasmanian Northern Slopes	99.3	17.2	21.1
202	101	Tasmanian West	98.9	22.5	91.5
203	220	Ben Lomond	97.1	27.3	20.4
204	153	Flinders	96.5	24.8	5.3
205	31	Tasmanian Southern Ranges	93.5	20.7	71.1
206	151	Tasmanian Central Highlands, Tasmanian Northern Slopes	90.5	13.9	84.0
207	77	Tasmanian South East	90.3	22.8	14.1
208	254	Tasmanian Northern Slopes	90.2	23.6	283.3
209	231	Ben Lomond	88.8	19.4	568.4
210	73	Tasmanian Central Highlands	88.4	21.9	53.0
211	192	Tasmanian Northern Slopes	86.0	23.2	221.2

212	108	Tasmanian Northern Slopes	84.1	20.8	33.4
213	70	Tasmanian South East	83.8	18.0	47.8
214	155	Tasmanian Northern Slopes	81.9	17.8	21.1
215	36	Tasmanian Southern Ranges	78.7	17.5	5.3
216	241	King	77.4	20.0	42.8
217	138	Ben Lomond	77.0	19.0	7.8
218	160	Tasmanian Northern Slopes	74.2	19.1	25.3
219	266	King	62.9	21.6	35.4
220	256	Flinders	60.0	16.4	158.3
221	190	Tasmanian Northern Slopes	58.2	15.8	2.6
222	94	Tasmanian Central Highlands, Tasmanian Northern Slopes	57.9	13.7	3.1
223	6	Tasmanian Southern Ranges	57.2	15.2	1.3
224	215	Flinders	51.3	12.4	38.0
225	95	Tasmanian Central Highlands	49.8	9.8	142.3
226	4	Tasmanian Southern Ranges	48.3	13.5	5.8
227	55	Tasmanian South East	46.5	12.5	20.4
228	118	Ben Lomond	46.3	11.7	49.6
229	263	King	44.2	10.2	88.8
230	72	Tasmanian South East	43.8	12.9	0.9
231	63	Tasmanian South East	37.4	8.6	9.6
232	214	Flinders	36.3	9.4	4.3
233	255	Flinders	35.9	9.0	38.9
234	170	Tasmanian Northern Slopes	35.6	10.7	55.4
235	67	Tasmanian West	33.0	8.7	7.4
236	246	King	31.7	9.5	12.0
237	57	Tasmanian South East	30.5	6.8	6.2
238	100	Tasmanian West	30.0	6.9	8.7
239	261	King	30.0	6.5	129.5

240	162	Ben Lomond	29.7	6.7	66.5
241	85	Tasmanian West	29.1	5.6	14.6
242	168	Tasmanian Central Highlands	26.0	6.7	6.1
243	139	Tasmanian Central Highlands	23.5	7.5	5.4
244	143	Tasmanian West	23.0	8.6	0.6
245	128	Ben Lomond	22.7	7.6	10.8
246	228	Ben Lomond	20.6	4.3	2.2
247	179	Tasmanian Central Highlands	20.3	4.9	22.3
248	265	King	20.0	3.3	84.6
249	1	Tasmanian Southern Ranges	18.1	4.7	12.3
250	109	Tasmanian Northern Slopes	16.5	4.6	0.8
251	260	Flinders	14.2	0.5	363.3
252	48	Tasmanian South East	13.5	3.2	2.1
253	105	Tasmanian West	13.0	3.7	60.8
254	96	Tasmanian West	11.1	3.1	14.0
255	98	Tasmanian West	11.0	4.2	1.2
256	270	King	10.0	3.0	222.3
257	230	Ben Lomond	6.7	2.2	0.4
258	248	King	6.2	1.7	1.8
259	131	Tasmanian Central Highlands	5.2	1.4	1.7
260	144	Tasmanian Northern Slopes	3.6	1.0	2.5
261	165	Tasmanian Northern Slopes	2.7	0.7	2.4
262	253	Flinders	1.9	0.6	1.6
263	172	Tasmanian Northern Slopes	1.4	0.3	2.9
264	135	Tasmanian Central Highlands	0.6	0.2	0.6
265	133	Tasmanian Central Highlands	0.5	0.2	0.3
266	161	Tasmanian Northern Slopes	0.3	0.1	0.1
267	134	Tasmanian Central Highlands	0.3	0.1	0.1
268	15	Tasmanian Southern Ranges	0.0	0.0	0.0

269	157	Tasmanian Northern Slopes	0.0	0.0	0.1
270	251	Flinders	0.0	0.0	1.8