6. Biodiversity of Plants

Issues and relevance to ESFM

Regeneration of a forest after harvesting according to ESFM demands that ecological integrity is maintained though the re-establishment of a suite of plant species characteristic of the early successional stage of the forest type.

State of knowledge

There have been a number of studies of understorey composition after clear-felling and harvesting in wet eucalypt forests. As far as we are aware, there are no records of extinction of any plant species as a result of timber harvesting in the wetter forests of Victoria and Tasmania.

Most studies have found little change in the composition of vascular plants (herbaceous plants, shrubs, trees): most of the species that were present prior to logging were present in the regenerating forest within the first few years. For example, Hickey (1994) found that most of the vascular species common in old-growth mixed forest (eucalypt forest with a rainforest understorey) in Tasmania were present in regenerating forest, whether this regeneration was due to logging or to wildfire. The frequency of most species was similar in regeneration after logging or wildfire, but differed markedly from that in old-growth forests, as is to be expected where early successional vegetation is compared with later successional vegetation.

In the wetter forests of Victoria and Tasmania, however, the evidence (Mueck, 1992; Mueck and Peacock, 1992; Ough and Ross, 1992; Hickey 1994; Mueck *et al.* 1996; Ough 2001) points to a decrease after past logging practices in cryptogamic plants – tree-ferns, ground ferns, and epiphytic plants (ferns, mosses). Both Ough (2001) and Hickey (1994) found more sedges in regeneration after logging than in regeneration after bushfire, and Ough (2001) also found an increase in silver wattle in areas that had been logged. At least part of this change is due to the intensity of harvesting and extraction techniques, and the extent to which top-soil is disturbed thereby destroying root-stocks from which a number of species regenerate by re-sprouting.

In a range of forests in East Gippsland, Victoria, the average time following logging for species richness to resemble that of the old-growth 'controls' is 20-30 years (Mueck and Peacock, 1992). Hickey (1994) concluded that rotation length may be more critical for the perpetuation of species frequencies than regeneration treatment. Peacock and Duncan (1994) suggest that at least 60 years is required for the understorey epiphytes of regenerated mixed forest to become similar in species frequency to that of the mature mixed forest.

Where there is evidence for botanical change after past logging activities, an important question is: how can logging methods be managed so that botanical change is minimized? In the wet, mountain ash forests of Victoria, Ough and Murphy (1999) showed that one of the key solutions is to minimize soil disturbance. They introduced the concept of understorey islands in *E. regnans* forests; understorey islands are defined areas within which no machinery can operate and into which no trees can be felled. They are designed to provide habitats where species that regenerate by re-sprouting and other species characteristic of older-growth forests (e.g. tree-ferns) are protected. They can be to some extent protected from the regeneration fire by ensuring that they are clear from logging slash.

Will energy-wood harvesting in addition to current harvesting create adequate regeneration of understorey species?

Energy-wood harvesting presumably will not necessitate a change in felling and extraction techniques. It will involve an increased removal of timber from 'downers' and from log landings, especially over the first 24 years. There is no *a priori* reason why energy-wood harvesting will result in any change in the regeneration of vascular plants if soil disturbance during extraction continues to be managed so that soil disturbance is minimized. However, downers provide a regeneration niche and habitat for a number of non-vascular plants, and their frequency is therefore likely to decrease if large numbers of downers are removed.

Will energy-wood harvesting affect rotation length with consequences for floristic composition?

Our understanding is that harvesting energy-wood for will not necessitate any change in the rotation length used in current harvesting operations for sawlogs and pulpwood. On those coupes and in those years where energy-wood harvesting is particularly intense, a longer rotation for recovery should be considered.

Options to overcome perceived deficiencies

1. Undisturbed patches have been incorporated in the silvicultural systems trial at the Warra LTER site. On-going monitoring will define their usefulness. Elsewhere in this report, we have commented on the possibility of incorporating the retention of both habitat trees and significant coarse woody debris within the 'island' concept. This effectively increases retention of relatively undisturbed habitat.

2. All of the studies of understorey composition following clear-felling and burning are of necessity retrospective. There are two issues here:

- They lack an experimental control. Most studies have used old-growth forest as the reference. What happens after disturbance - whether by logging or by wildfire - depends on the intensity, frequency (time since previous disturbance) and timing (season) of the disturbance and on the succeeding weather conditions. The most appropriate reference for comparing recovery after disturbance by clear-felling and burning is therefore the forest which is recovering after the disturbance of a stand-replacing bushfire at about the same time, all other variables being equal.
- They assess the effects of past rather than current harvesting techniques.

3. We have previously commented that we know of no plant species that has become extinct as a result of past logging in wet eucalypt forests. We know that most plant species are present in the early years after regeneration of a logged forest, and that plant composition is more or less fully restored after (say) 60 years. That is, the understorey is not irreversibly changed in composition after clearfelling and burning.

For the energy-wood catchment of Southwood, about 50% of the forest is managed as State forest for timber production. After the first rotation of (say) 90 years, 33%

of this State forest will have an understorey composition more or less characteristic of the unlogged forest (it will be >60 years old). That is, 67% of the Southwood forest will have a more or less mature understorey, and 33% of the forest will have understoreys in earlier successional stages.

We conclude that this management meets two principles of EFSM, namely:

- *Intergenerational equity*: The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations; and

- *Conservation of biological diversity and ecological integrity*.

Summary and Recommendations

Regeneration of a forest after harvesting according to ESFM principles demands that ecological integrity is maintained though the re-establishment of a suite of plant species characteristic of the early successional stage of the forest type. There has been good research in the wetter forests of Tasmania and Victoria to provide the basis for future management, but the number of published papers on occurrence and frequency of plants, particularly non-vascular plants, is small. The key points coming from this research are (i) that soil disturbance that uproots those species that regenerate from root-stocks must be avoided; (ii) soil compaction will not favour species characteristic of wetter forests; (iii) at least 60 years is required for the understorey epiphytes of regenerated mixed forest to become similar in species frequency to that of the mature mixed forest.

Recommendation 8. *Extraction techniques should continue to be planned so that topsoil is maintained intact wherever possible, thereby ensuring that regeneration of understorey species both from seed and from root-stocks is maximized.*

Recommendation 9. *The value of undisturbed patches that maintain some proportion of a coupe in a relatively undisturbed state, for maintaining plant diversity should continue to be evaluated. This Recommendation is in consort with Recommendations 6 and 14.*

Recommendation 10. *Studies of change in plant species composition and frequency after current and proposed logging regimes should continue.*

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7. Role of Coarse Woody Debris in the Conservation of Biodiversity

Issues and relevance to ESFM

Coarse woody debris and biodiversity

Coarse woody debris in Tasmanian forests, as in other parts of the world, supports an extensive biodiversity composed of fungi, lichens, bryophytes, many invertebrates and some vertebrates (reptiles, devils, quolls; possums and birds when the tree is still standing). Of the animals, invertebrates dominate, and among these beetles are the most significant group. The saproxylic fauna[1] includes groups that feed directly on dead wood, fungus feeders, and predatory species that are dependent on them. Saproxylic animals are likely to form a very significant part of the forest community; 20-50% of the beetle fauna in forests may be saproxylic (Grove 2002a).

The saproxylic and log-dependent fauna includes species with a range of dispersal capacities, from actively flying birds or insects and large mammals with a dispersal range of kilometres, through to those insects that fly only rarely and over perhaps 100s of metres, to the flightless insects and non-insect groups with a range of only 10s of metres. The former species are least likely to be affected by the removal of fuelwood in a wet eucalypt ecosystem managed under CBS, provided it includes an adequate reserve system. The latter are much more vulnerable since they must eventually disperse from their natal CWD unit as it decays, but they have a limited range. Streamside and scattered reserves may not be sufficient to conserve this component of the fauna, as suggested by modelling of the habitat of the Mt Mangana Stag Beetle (Grove *et al.* 2002). Biodiversity spines are one way of dealing with this issue.

The dispersal capacity of saproxylic species and the size of logs that they require are the key variables in managing the log-dependent biodiversity in the wood production forest matrix. While neither can be quantified in any detail in Tasmanian forests, when they are cross-classified it is clear that it is species which require large logs and yet have narrow dispersal capability that are the most vulnerable.

		Dispersal	
		Wide	**Narrow**
Log Size	Small	*OK*	*OK*
	Large	*OK*	*At risk*

This fauna is vulnerable to extractive forestry, as indicated by the large number of red-listed saproxylic species in the European fauna. In Sweden, for example, of 739 red-listed forest invertebrates, old living trees are critical for 33%, logs for 28% and snags for 35% (Berg *et al.* 1994). This reflects the long history of forestry in Western Europe, but highlights the potential for biodiversity loss in the relatively young forestry

[1] Saproxylic animals are "dependent, during some part of their life cycle, upon the dead or dying wood of moribund or dead trees (standing or fallen), or upon wood-inhabiting fungi, or upon the presence of other saproxylics" (Speight 1989).

landscape of Australia. Forest practices that increase the removal of CWD from the forest, such as fuelwood harvesting, increase the risk to this fauna.

The maintenance of this significant component of forest biodiversity is clearly part of sustainable forest management, as established by the Australian government under the National Forest Policy Statement (1992).

Biodiversity conservation at landscape and coupe levels

However effective the Tasmanian Forest Practices Code (2000) is, the impact of forestry operations is inevitably high at the coupe scale. The CBS regime that is used in the wet eucalypt forest of Tasmania reduces biodiversity markedly soon after a regeneration burn. Although substantial recolonisation may occur before the next harvesting cycle, it will be limited to those species that have the capacity and/or time to colonise, and those that can find suitable habitat within the regrowth. The CBS regime is successful for regenerating wet eucalypt forest but differs from wildfire in several other respects. After wildfire in the natural forest not only would there be a very long period available for recolonisation, but there is also a large amount of CWD remaining from fallen trees in the previous forest, and a continuing recruitment of CWD as dead stags fall. The very existence of the CWD-dependent species under discussion implies that they are evolutionarily adapted to survive intense fires, but this does not necessarily adapt them to the production forestry landscape.

As discussed above, species with medium to wide dispersal ranges, or those with low dispersal ranges that can survive in small sized CWD will persist in the production forest matrix. But those with short dispersal ranges requiring large logs are most at risk.

The response of forest planners and managers to this problem has been to establish a system of reserves within the industrial forest matrix that provide sufficient undisturbed (or less frequently disturbed) habitat to provide reservoirs for those species capable of recolonising coupes, and refuges for those than cannot. This still leaves the question of whether the reserve system is extensive enough, permanent enough and appropriately distributed to conserve the more slowly dispersing species in the long term. The reserve system depends to a considerable extent on habitat strips (streamside reserves, wildlife corridors etc.), but the geometry of these areas (large perimeter to area ratio) means that their fauna is more vulnerable to stochastic effects causing local disappearance of the species, and the chance of recolonisation is much reduced.

Size structure of coarse woody debris

Undisturbed native forest contains a large amount of CWD in a range of sizes up to large logs of a metre or more in diameter. Ecological and physical first principles (island biogeography, habitat heterogeneity and surface area/volume effects) suggest that large logs are likely to support a greater biodiversity than small ones. Unless precautions are taken, extractive forestry will inevitably lead to a decline in the upper range of log sizes, as well as a decrease in the overall amount of CWD. This is a general problem for CBS regimes, and could be exacerbated if fuelwood removal is imposed on the system.

If the CWD biota is to be conserved in the wood production forest landscape, not only will the amount of CWD available be important, but its size distribution will also be crucial.

In natural forest, CWD is created through the death of trees or parts of them (i.e. large branch loss). Trees may die through fire or of old age, but may remain as standing dead stags for many years before falling. In production forest under CBS, much woody material arrives on the forest floor as logging slash and debris, usually still green and without the standing dead phase of CWD. Furthermore, logging slash is generally not randomly distributed across the landscape, but concentrated around landings. Research is required to compare the biota and decay trajectories of naturally fallen CWD with that of green logging slash (or trees fallen to provide CWD habitat) in wood production forests.

Establishment of Plantations

Conversion of native forest to plantations greatly reduces local biodiversity. Plantations are regarded as a crop rather than regenerated forest, and accordingly little or no attempt is made to conserve biodiversity within plantations. Measures to minimise defoliation both by insects and mammalian grazers aim to reduce biodiversity, as in other agricultural endeavours.

Conversion to plantation produces the same conservation problems as CBS native forestry, but they are exacerbated by the greatly restricted habitats within plantations, as compared to regenerated forest. Existing CWD is bulldozed into windrows and often burnt in the conversion of native forest to plantations, or under a fuelwood regime much might be harvested. In addition, because plantations are managed on a shorter rotation than native regeneration, there is even less time for CWD to accumulate.

State of knowledge

Coarse woody debris and biodiversity

Grove *et al.* (2002) provide a comprehensive review of the biodiversity conservation issues associated with CWD in forests worldwide, and in Australia. The vulnerability of the saproxylic fauna is well recognised in the European and Finnish and Scandinavian and North American literature, but much less has been done to document it in Australian forests. Some work has been done on the availability of commercially over mature "habitat" trees for hole-dwelling vertebrates (eg Gibbons & Lindenmayer 1996), and on the effect of forest management history on the saproxylic beetle fauna in Queensland forest (Grove 2002b). Although some studies are in progress in Tasmanian forests (Bashford *et al.* 2001, Yee *et al.* 2001), there are few published data on which to base an analysis. Mesibov & Ruhberg (1991) highlighted the importance of fallen logs in the conservation of two threatened velvet worms, and Michaels & Bornemissza (1999) discuss the effect of clearfall harvesting on stag beetles. Several reports have addressed the effect of harvesting on the decaying log habitat, with particular reference to a threatened stag beetle (Meggs 1996, 1999, Meggs & Taylor 1999).

Biodiversity conservation at landscape and coupe levels

Saproxylic species may be able to pass several generations in one unit of CWD, but eventually the unit will decay away, so the species have evolved strategies to disperse. Saproxylic species show a range of mobility, from those that fly readily from unit to unit to those that fly rarely or are incapable of flight. The balance of dispersal strategies might be expected to change from situations where the supply of CWD is reliable and species are generally sedentary, to situations where the CWD amounts fluctuate unreliably and species are generally dispersive. In Tasmania's wet forests the natural dynamics of CWD are largely unknown, but decay rates are likely to be slow (favouring sedentary species) while the supply of CWD, through wildfire, is likely to be sporadic (favouring dispersers). (Grove *et al.* 2002); Bashford (1990) reported a range of dispersal abilities in beetles colonising plantations in northern Tasmania.

Overseas studies (reviewed by Grove *et al.* 2002) have shown that the diversity of saproxylic species is positively correlated with the abundance of CWD at scales ranging from hectares to tens of hectares.

Size structure of coarse woody debris

Overseas studies (reviewed by Grove *et al.* 2002) have demonstrated positive relationships between log diameter and species incidence, richness and abundance.

An ARC Linkage program between the University of Tasmania, Forestry Tasmania and Gunns Ltd. (Yee *et al.* 2001) is examining the relationship between log size and the diversity of fungi and invertebrates (especially beetles) at the Warra LTER site. Preliminary results agree with overseas findings that larger diameter logs (>100 cm diameter, as compared to 30-60 cm diameter) support a more diverse biota. This study complements a long-term study established by Forestry Tasmania at the Warra LTER site to examine invertebrate succession in logs (Bashford *et al.* 2001). These studies are likely to confirm the general relationship between log diameter and species richness. However, they will not immediately supply information detailed enough to set precise prescriptions, for example, for the size of CWD that should be left on coupes, or to determine whether there are threshold log diameters required by particular saproxylic species.

Establishment of Plantations

Various studies have highlighted the restricted biodiversity in plantations. The structural simplicity of plantations, herbicide and pesticide use and the short rotation time are likely to favour only a very restricted biota, particularly dispersive species. However, some evidence suggests that some non-dispersive species can persist, at least through the conversion process. The abundance of native snails, millipedes, carabid beetles and velvet worms were compared in 6 – 46 year old plantations in northwest Tasmania and equivalent native forest over 50 years old (Bonham 1999). Velvet worms, millipedes and carabid beetles were no less abundant in plantations, while native snails were about 30% less successful in plantations. The slowly dispersing snails and velvet worms presumably survived in, and dispersed from, windrows. It remains uncertain whether these species will persist beyond the first harvest, and the chance of them surviving a fuelwood harvest before plantation establishment is probably low.

Current approach and its adequacy for ESFM

Coarse woody debris and biodiversity

To date there has been little deliberate effort in Tasmanian forest practices to conserve the saproxylic fauna. Conservation of forest invertebrates in general has been dealt with through the establishment of reserves, such as streamside reserves, wildlife habitat clumps, biodiversity corridors and wildlife habitat strips and off-reserve mechanisms such as management by prescription. The Tasmanian Forest Practices Code (2000) dictates how some of these reserves should be established, but makes no direct mention of CWD and its associated fauna. However, some members of the saproxylic fauna are already recognised as threatened under the Tasmanian *Threatened Species Protection Act* (1995) and other priority species were recognised in the RFA. Such species are automatically flagged in the preparation of Forest Practices Plans under the Forest Practices Code. Prescriptions for handling these species are found in the Threatened Fauna Adviser, an expert system available to Forest Practice Officers. Table 4 lists the species that are dependent on logs and that are included in the Threatened Fauna Adviser, and summarises the prescriptions that the Threatened Fauna Advisor provides.

The Forest Practices Code, with its associated manuals and tools, provides a good basis for the management of Tasmania's commercial forests at the coupe level, and the approach taken with threatened species has been formally recognised by the government agency administering the *Threatened Species Protection Act* (1995). To some extent the threatened species found in CWD act as surrogates for other saproxylic fauna, but the special treatment that their presence ensures will only be given in geographical areas where the threatened species are known to occur. However, there is every reason to suppose that there are other species having a short range, and requiring large logs are present that may not have the same ranges as the species listed in the TSP Act.

The prescriptions in the FP Code and the Threatened Fauna Adviser deal only with the conservation of the existing dead wood habitat, without explicitly addressing the continuity of supply of CWD. Some of the new silvicultural treatments being trialled in the Warra LTER site (Hickey *et al.* 2001) aim to improve the continuity of CWD at the coupe level. It remains to be seen how effective they will be, and whether these treatments can be applied operationally taking into account safety, silvicultural and economic considerations.

Biodiversity conservation at landscape and coupe levels

The Forest Practices system does not address the conservation of biodiversity on the ground <u>within</u> coupes to any great extent beyond threatened species management. Rather it deals with maintaining ecological processes, for example through soil conservation. In drier eucalypt forest, the Code recommends the establishment of wildlife habitat clumps that include habitat trees within coupes. In the wet eucalypt forest, however, the intensity of regeneration burns precludes the retention of wildlife habitat clumps, and the Code recommends leaving untouched areas at the edges of coupes that are less likely to burn.

Table 4 Species likely to be dependent on CWD that are listed in the Forest Practices Board's Threatened Fauna Advisor, and the recommendations made to conserve them in wood production forests.

Common Name	Scientific Name	Dependence on CWD	Recommendations
Blind Velvet Worm	*Tasmanipatus anophthalmus*	High	Minimize disturbance to rotting logs: infrequent, low intensity burns; increase size and number of wildlife habitat clumps
Giant Velvet Worm	*Tasmanipatus barretti*	High	No high intensity or frequent burns; no conversion to plantations within wildlife priority area; increase size & number of wildlife habitat clumps to capture suitable habitat
North West Velvet Worm	*Ooperipatellus cryptus*	High	During conversion to plantations retain network of formal & informal reserves; avoid high intensity burns
Broad-toothed Stag Beetle	*Lissotes latidens*	Medium	Focus wildlife habitat clumps at edge of coupes which preserve logs to ensure no burn; special measures to ensure habitat retention; increase width of streamside reserves; prohibit post-clearing firewood collection
Mt. Mangana Stag Beetle	*Lissotes menalcas*	High	Focus wildlife habitat clumps which preserve logs at edge of coupes to ensure no burn; special measures to ensure habitat retention
Burgundy Snail	*Helicarion rubicundus*	Low	Retain continuous network of native forest; coupes to be <50ha, dispersed; adjacent regrowth to be >5m in height
Keeled Snail	*Tasmaphena lamproides*	Medium	Conservation management plan to ensure retention of network of native forest throughout range
NE Forest Snail	*Anoglypta launcestonensis*	Medium	No clear felling; no high intensity burns

The Code gives mandatory instructions for streamside reserves that provide a significant part of the network of biodiversity reserves.

The landscape planning that seeks to conserve biodiversity on State forest is carried out through Forestry Tasmania's MDC and EMS processes. Forestry Tasmania's strategic planning takes biodiversity conservation into account at a regional level through the CAR reserve system, along with retention of informal reserves. In the wood production forest, Special Management Zones recognise particular conservation values, and the placement of coupes, and establishment of wildlife habitat strips aim to conserve biodiversity at a landscape level.

Size structure of coarse woody debris

The Forest Practices Code makes no direct recommendations about maintaining the supply of large fallen logs over future harvesting cycles. Wildlife habitat clumps and the reserve network have the potential to supply such logs, but under the present regime these islands and corridors will become increasingly isolated for the saproxylic fauna that have low dispersal capacity.

The experimental silvicultural trials at the Warra LTER site have the potential to ensure a supply of larger logs from retained trees. It remains to be seen how well these retained trees will survive, and how the supply of CWD can be maintained in future regeneration cycles.

Establishment of Plantations

The general principles at the start of Forest Practices Code's section on establishing and maintaining forests include the aim of maintaining biodiversity, but the Code's recommendations for plantation establishment only deal with this through the retention (or re-establishment) of native vegetation in streamside reserves.

Options for addressing perceived weaknesses

In general, options can be classified as those involving **dispersal** of the impact of CBS silviculture and fuelwood harvesting across the total forest landscape (i.e. harvested coupes + informal reserves + formal reserves), and those involving **retention** of habitat at a local (coupe) level.

The objective should be to **manage the existing CWD habitat** and to **ensure the recruitment of CWD in the long term** (i.e. beyond the next 100 years).

Options include:

(i) Total reliance on reserves to conserve biodiversity

This is a no-action option that relies on the current reserve system and those that would continue to be established under the planning schemes and FP Code to conserve the biodiversity associated with CWD. It is a non-precautionary approach and places at risk that component of the biota that requires large CWD and that has a low capacity for dispersal.

(ii) Retention of trees to recruit CWD

Habitat islands, including large trees, can be retained in coupes if it is possible to control the intensity of regeneration burns. Aggregated retention may be a safer option for forest workers than dispersed retention.

Lengthening rotation times is another option to allow the development of large regrowth trees (>1 m) which could be left to supply the next generation of CWD. This implies rotation times of >100 years.

(iii) Modify coupe size and geometry

Increasing the perimeter to area ratio of coupes, either by making them long and thin, or by including "peninsulas" of the surrounding forest will reduce the dispersal distances between CWD-rich areas. This option presents the same fire management problems as the retention of habitat islands.

(iv) Control the intensity of CWD removal from harvested areas

The material on the coupe after tree harvest will comprise a mix of pre-existing downers, stags pushed over during harvest and logging slash; and this material will exist in arrange of sizes. It would be possible to control the amount of large diameter CWD, especially downers and pushed over stags, that was removed from the coupe.

(v) Manage the proportion of coupes harvested for fuelwood

Coupes might be classified as non-fuelwood, while others would be harvested intensively. Coupes to be converted to plantations might be harvested intensively, since CWD in plantations is likely to be pushed into windrows and burnt.

(vi) Classify coupes and manage them differently depending on their biodiversity value

As an extension to the previous option, coupes could be classified at the landscape level and different prescriptions for fuelwood removal applied, depending on the biodiversity value of the coupe. This value might be assessed in landscape terms, for example the proximity of the coupe to larger reserved areas, or in terms of the coupe's potential to produce large CWD in the future. Such a classification could be stratified over forest productivity classes in order to ensure the representation of CWD-dependent biota from all forest types.

Summary and Recommendations

Managing the biodiversity associated with CWD in a CBS plus fuelwood system

Little is known about the dynamics and habitat/biodiversity role of CWD in Tasmania's wet forests. It is likely that management actions at both the logging unit (coupe) and landscape scales are required to minimize advance effects of harvesting in the short- to medium-term. In general, measures can be classified as those involving **dispersal** of the impact of CBS and fuelwood harvesting across the total forest landscape (i.e. coupes + informal reserves + formal reserves), and those involving **retention** of habitat at a local (coupe) level. Because of the spatial and temporal vulnerability of the slow-dispersing species that require large loss (as exemplified by the Mt Mangana Stag Beetle), management at the landscape level will be essential, and prescriptions at the coupe level should be nested within the landscape approach. The data to allow specific quantitative recommendations about the amount, size structure and distribution of CWD across the landscape are not yet available, so a precautionary approach to the maintenance of this habitat should be adopted at this time.

The broad objectives should be to **manage the existing CWD habitat** and to **ensure the recruitment of CWD in the long term**, i.e. beyond the next 100 years.

Dispersal Recommendations

Recommendation 11. *The dynamics of CWD be modelled at the landscape level to establish how the stock and size structure vary over time across forest types, productivity classes and geographical locations. This information should be used to reduce or avoid fuelwood harvest, and/or increase rotation length beyond 80-100 years in selected areas so as to create zones (nodes) of forest rich in large diameter CWD that are linked throughout the harvested forests.*

Retention Recommendations

Recommendation 12. *Guidelines for retention of CWD be developed that give priority to large (> 1m diameter) decayed logs (existing habitat) and* *defective green sections of harvested trees (which during decay will create a new suite of habitat). The guidelines should specify a minimum quantity (volume/ha) for retention that could be varied according to characteristics (e.g. landscape position) of the harvest unit. Where sufficient material of >1m diameter exists, the harvest of other fuelwood could be high. Coupes to be converted to plantations should be subjected to intensive fuelwood harvest.*

Recommendation 13. *Silvicultural techniques be further developed for aggregated habitat retention on logging coupes.*

Landscape planning for CWD habitat

The Forest Practices Code has been a successful means of regulating forestry activities, largely at the operational (coupe level) scale. The Forest Practices Board which is independent of Forestry Tasmania, was designed to be self-regulatory, and the Board and Advisory Council develops and administers the Code, which applies to all forest tenures. The Board has the potential to be able to incorporate the review of landscape requirements for the conservation of the CWD habitat across the entire commercial forest estate into its responsibilities.

Recommendation 14. *The Forest Practices Board consider developing guidelines for planning the management of CWD at landscape scales, and a role in the review and approval of such plans.*

Research on management of CWD

There are large information gaps that need to be filled before CWD biodiversity can be confidently managed in forest subjected to CBS silviculture and fuelwood harvest. Some key objectives are listed below, with priorities.

- Establish the breakdown rates of natural CWD, logging slash and live trees that might be felled green to provide CWD habitat. (High)
- Establish the dispersal capacities of representative saproxylic, or log-dependent, species in a range of taxonomic classes. (High)
- Establish the proportion of the saproxylic, or log-dependent, biota that falls into the at-risk class of slow dispersers that require large logs, and their geographical ranges. (Medium)
- Compare the biotas and successional stages of natural CWD with those of logging slash and trees felled and left to provide CWD habitats. (Medium).

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