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**Re: Supplementary information to my evidence on the science of logging impacts**

Dear Senate Committee,

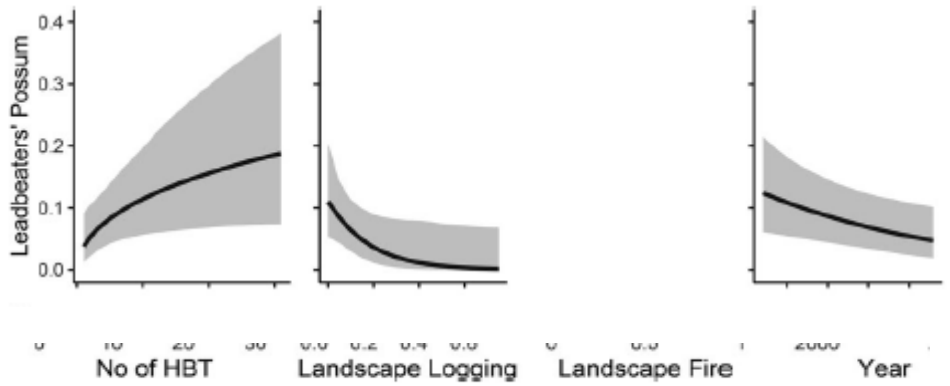
I am writing in regard to my expert evidence presented to Senate Committee on the 19 April 2021. I wish to present further information that is relevant to the inquiry. It is claimed by some forest industry advocates such as the CFMMEU that the science on key aspects of forest logging impacts is not "settled". I strongly disagree with this contention – as outlined by the rigorous peer-reviewed scientific evidence summarized below.

In addition, Senator McKenzie claimed that the native forest logging industry was currently sustainable – which it is demonstrably not. At the end of this letter, I outline why the industry is currently not sustainable –neither ecologically nor economically sustainable.

## LOGGING IMPACTS ON LEADBEATER'S POSSUM

Levels of site occupancy by Leadbeater's Possum have declined by 50% since 1997 (Lindenmayer et al., 2020). The species is strongly associated with the abundance of hollow-bearing trees (see following section on logging effects on these critical keystone structures in forests). The decline is associated with the amount of logging in the surrounding landscape (Figure 1). **Notably, this science is not contested.**

**Figure 1. Long-term changes in occurrence in Leadbeater's Possum in relation to key variables – hollow trees, levels of logging and year (from Lindenmayer et al. 2020).**



A series of major studies led by scientists from the Victorian Government and the University of Melbourne have shown that the current reserve system for Leadbeater's Possum is inadequate (Todd et al., 2020, Taylor et al., 2017). In addition, the top 10% priority areas for 70 threatened forest-dependent species in Victoria are in areas subject to logging under the Timber Release Plan (Taylor and Lindenmayer 2019) (Figure 2).

**Figure 2. Relationships between the conservation value of forests under different tenure (from Taylor and Lindenmayer 2019).**

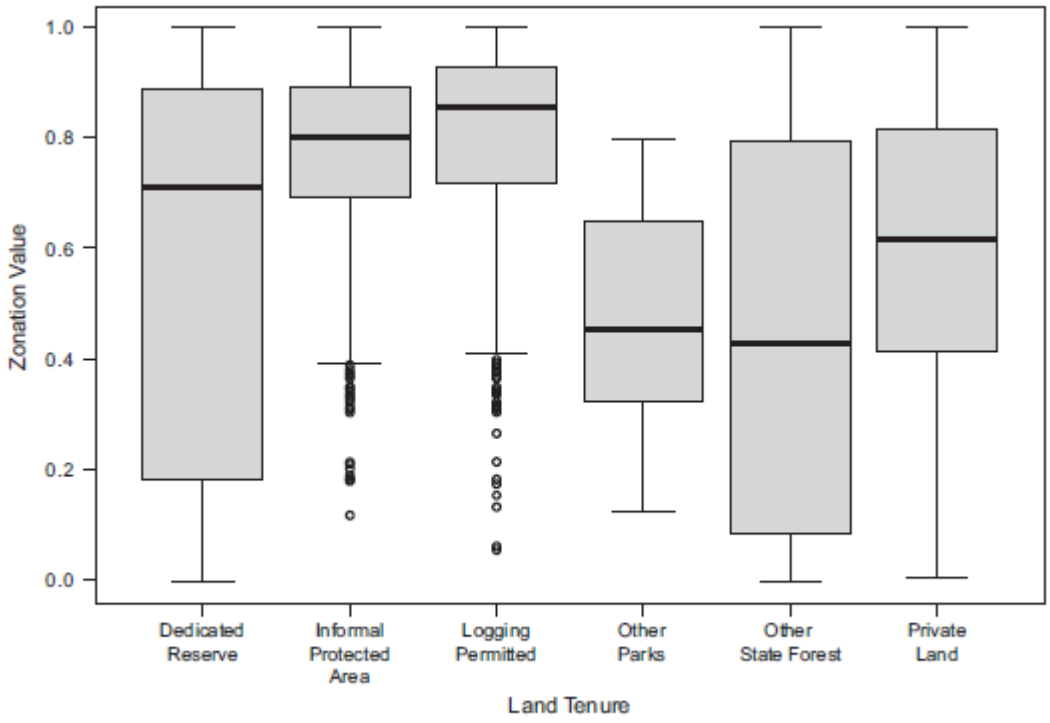
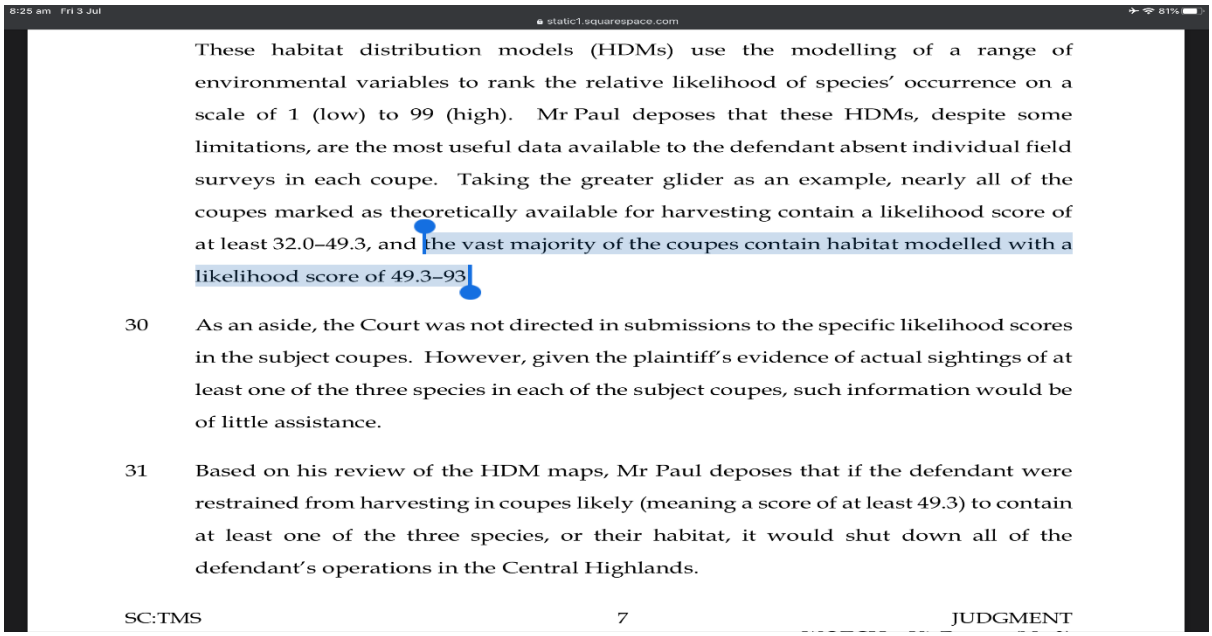



**Fig. 7.** Equal weight Zonation scores for selected land tenure across Victoria.

As part of Victorian Supreme Court testimony: Friends of Leadbeatter's Possum vs VicForests, Mr Paul for VicForests contended that stopping VicForests from logging endangered species habitat (ie, obeying the law) will send it broke (see Figure 3 below). **Therefore, the science on the impact of logging on biodiversity is not contested – including by VicForests.**

**Figure 3. Testimony from VicForests about the need to log threatened species habitat.**



These habitat distribution models (HDMs) use the modelling of a range of environmental variables to rank the relative likelihood of species' occurrence on a scale of 1 (low) to 99 (high). Mr Paul deposes that these HDMs, despite some limitations, are the most useful data available to the defendant absent individual field surveys in each coupe. Taking the greater glider as an example, nearly all of the coupes marked as theoretically available for harvesting contain a likelihood score of at least 32.0–49.3, and the vast majority of the coupes contain habitat modelled with a likelihood score of 49.3–93.

30 As an aside, the Court was not directed in submissions to the specific likelihood scores in the subject coupes. However, given the plaintiff's evidence of actual sightings of at least one of the three species in each of the subject coupes, such information would be of little assistance.

31 Based on his review of the HDM maps, Mr Paul deposes that if the defendant were restrained from harvesting in coupes likely (meaning a score of at least 49.3) to contain at least one of the three species, or their habitat, it would shut down all of the defendant's operations in the Central Highlands.

SC:TMS 7 JUDGMENT

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## LOGGING IMPACTS ON LARGE OLD TREES

A series of major studies over the past 30 has quantified the decline in populations of large old hollow-bearing trees (which are critical nest and den sites for diverse assemblages of cavity-dependent species). Populations of these trees are significantly lower on sites that have a history of logging (Lindenmayer et al., 2016). In addition, rates of tree fall are faster with increasing amounts of logging in the surrounding landscape (Figure 4, Lindenmayer et al. 2018). **The key findings of these empirical studies have never been contested**.

**Figure 4. Relationship between the extent of logging in the landscape and the risk of tree fall (from Lindenmayer et al., 2018).**

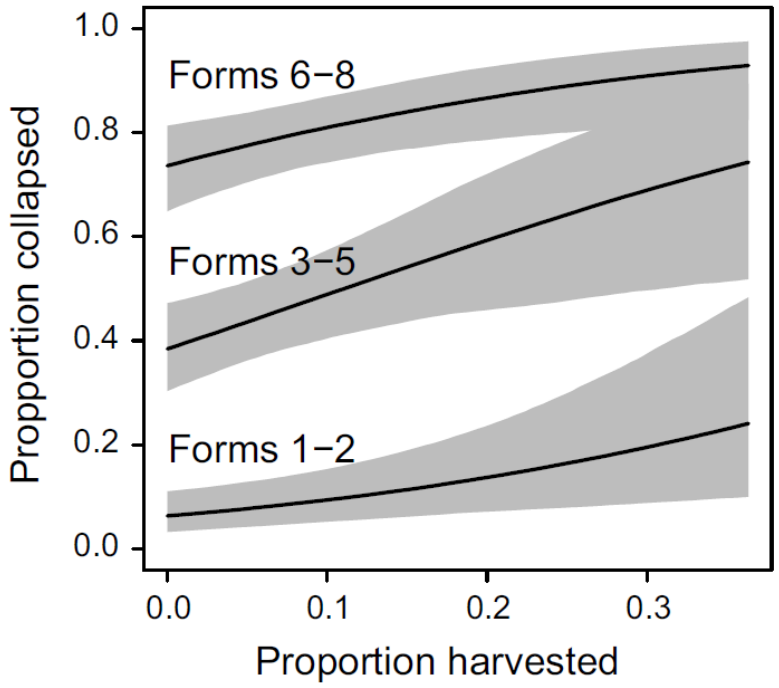



**Fig 2. Relationships between the probability of collapse of hollow-bearing trees between 1997 and 2015 and the amount of logging in the surrounding landscape.** The three components of the relationship show patterns for trees in forms 1 and 2 (category 1), forms 3–5 (category 2) and forms 6–8 (category 3). The amount of fire is held at the mean level in the landscape.

https://doi.org/10.1371/journal.pone.0193132.g002

## LOGGING ON STEEP SLOPES

Our most recent peer-reviewed scientific article showed that VicForests has been illegally logging forests on steep slopes since 2004 (Taylor and Lindenmayer 2021). The Office of the Conservation Regulator likewise found that this was true (in written correspondence and in phone discussions with Dr Taylor and myself) – even though they did not examine logging coupes dating from before two years previously. Notably, reports from the Victorian Government's own auditor (Jacobs) (https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0019/443800/Report-on-the-2017-18-Forest-Audit-Program.pdf ) also found evidence of logging on steep terrain and therefore slope breaches of the Code of Practice. VicForests CEO stated publicly that they were allowed to log on slopes above 30 degrees (https://www.vicforests.com.au/static/uploads/files/191120-vicforests-strongly-rejects-allegations-about-harvesting-on-slopes-final-wftppyfrofcx.pdf), However, the Office of the Conservation Regulator stated that this was false and that logging on steep slopes was unacceptable to the regulator. **Therefore, evidence of Code of Practice breaches are not contested** (other than by the guilty party which is Vicforests).

## LOGGING IMPACTS LEADING TO SUBSEQUENT ELEVATED FIRE SEVERITY

**The key conclusion from a suite of empirical studies is that logging elevates forest flammability and leads to elevated risk of high severity wildfire (Taylor et al., 2014, 2020, Dunn and Zald 2017, Tirribilli et al., 2017). The studies that claim there is no relationship have either failed to look for it at all (IFA Press Release quoting Tolhurst and McCarthy 2016) or failed to properly analyse data (and overlooked an effect that was actually there all along) (Attiwill et al., 2014 – see below).**

A series of studies have shown that logged and regeneration forests are likely to burn at higher severity fire in the event of a conflagration (Taylor et al., 2014, 2020, Dunn and Zald 2017, Tirribilli et al., 2017). This is underpinned by a relationship between the probability of crown fire and stand age. The relationship is non-linear in which forests 0-7 years after logging have a low probability of burning at high severity. Forests at 7-36 years of age have a steeply increased risk of burning at high severity (Figure 5). Old growth forests burn at the lowest severity. This highly significant non-linear relationship was quantified in Taylor et al., (2014). A more recent study of a different data in the wet ash forests of the Central Highlands of Victoria found a similar stand-age forest flammability relationship (Taylor et al., 2020) (see Figure 6).

**Figure 5. Probability of canopy consumption in relation to stand age (from p. 363 of Taylor et al. 2014).**

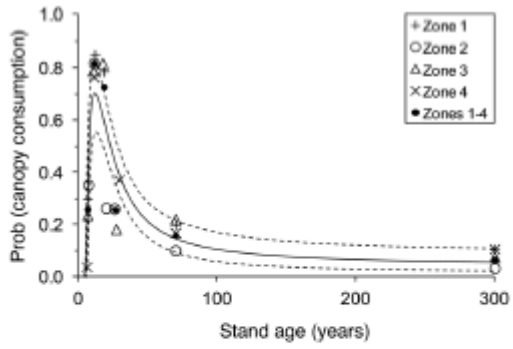
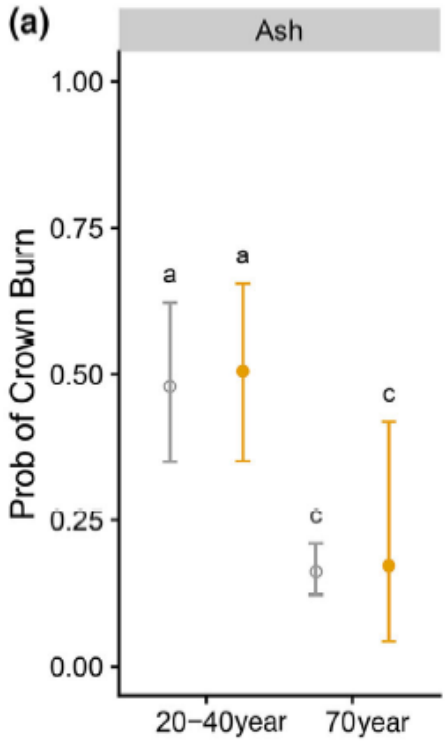



**Figure 7** Probability of canopy consumption versus stand age based on data from the Kilmore East and Murrindindi Fires during the periods before and after the wind change on 7 February 2009. These time periods are indicated by the different zones. The points are average ages and proportion of forest experiencing canopy consumption for each of six age classes, and for each of the four zones (Figure 2), and for all four zones combined. Only data with 15 or more data points are shown to reduce noise arising from small sample sizes. The solid line is the mean of the posterior prediction of the probit regression model fitted to a stratified sample of the data, and the dashed lines are 95% credible intervals.

**Figure 6. Probability of Crown Burn and stand age during the 2009 fires (from Taylor et al., 2020).**




The paper by Attiwill et al. (2014) claimed there was no relationship between logging and fire severity. However, Attiwill et al. (2014) did not subject their data to any robust statistical analysis. Moreover, and contrary to that paper's claim that logging does not increase fire risk, the paper actually presents data in which the risk of fire declines with forest age, consistent with the wider body of work. Indeed, Attiwill *et al (2014)* wrote:

*"…there was an apparent increase in the severity of crown fire with time since logging or bushfire up to about age 30 years (Figure 4) …"*

Together with other fire ecologists, we have reproduced Figure 4 from Attiwill *et al* as Figure 7 and 8 below, and annotated the columns representing crown fire incidence with their values measured from the graph. The claim of the authors can be seen from the graph, where the incidence of crown fire in 2009 (black columns) increased from 22% in young forests that had been logged or burnt in the preceding 10 years, to 40% in those forests that had been logged or burnt between 10 and 30 years previously.

**Figure 7. Fitted line to data from Attiwill et al. (2014).**

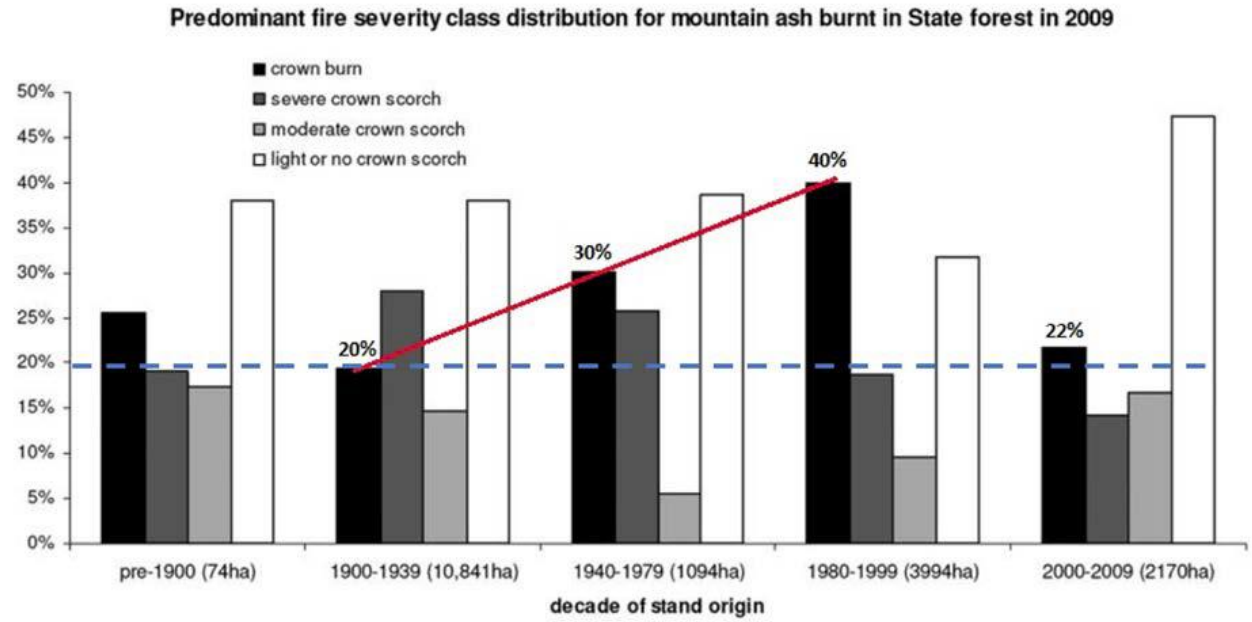
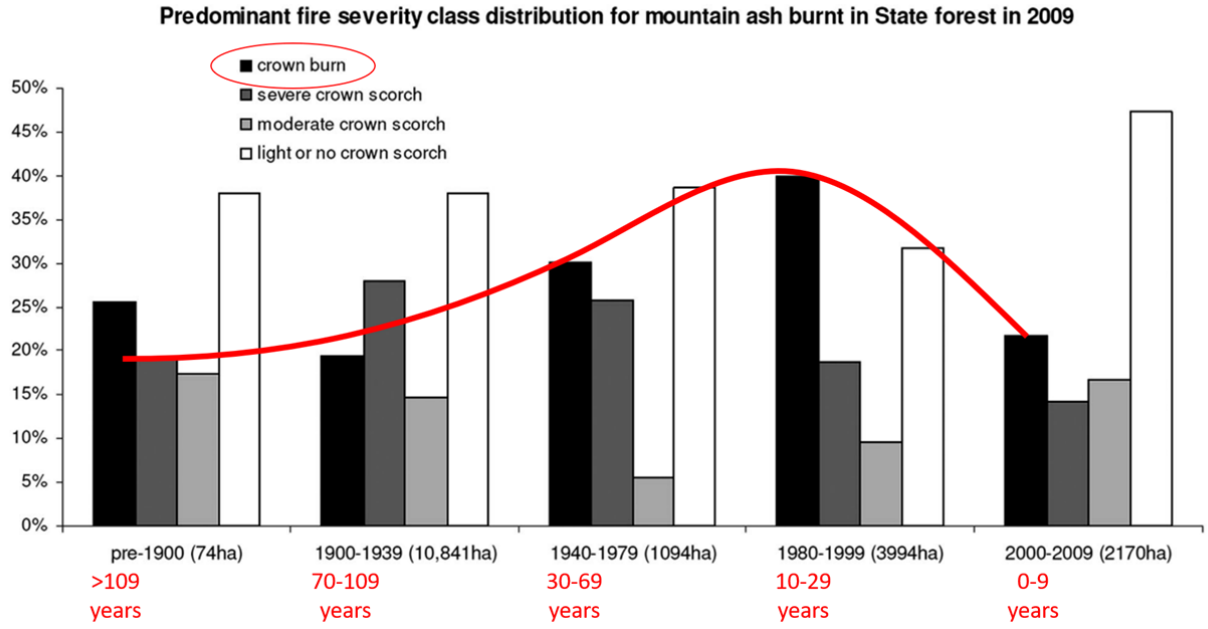



**Figure 4** Fire severity classes over the predominant age-class range of burnt mountain ash (*Eucalyptus regnans*) in State forest; the Kilmore East and Murrindindi fires, 7 February 2009. (Data from Department of Sustainability and Environment, 2009.)

When a proper curve-fitting approach is employed, the pattern in the data provided by Attiwill et al. (2014) is very similar to that reported in the wider peer reviewed scientific literature, with flammability highest at intermediate ages (Taylor et al., 2014, 2020, Dunn and Zald 2017, Tirribilli et al., 2017).

**Figure 8. Fitted curve to data from Attiwill et al. (2014).**



The paper by Tolhurst and McCarthy (2016) examined patterns of fire behaviour in Victoria. That paper was then cited in a media release by Tolhurst and Vanclay on behalf of the Institute of Foresters of Australia - which claimed there was no relationship between logging and fire (https://www.forestry.org.au/documents/ifa/OpEd_Tolhurst_Vanclay_DoesTimberHarvesting_ForDistribution.pdf) However, timber harvesting was **NOT** one of the covariates analysed in the work by Tolhurst and McCarthy (2016) (as indicated in the Table 3 of the paper by Tolhurst and McCarthy 2016 – and produced below).

**Table 1. Variables analysed in the paper by Tolhurst amd McCarthy (2016) – note the absence of logging as a variable in the analysis.**

Table 3. Explanatory variables used in this study.

| Explanatory variable | Description |
|---|---|
| FDIdb | Forest Fire Danger Index (McArthur 1967) on the day the area burned. The FFDI was taken from Hunters Hill automatic weather station (AWS) (36°12′S, 147°33′E) for areas in the North-east region, and the FFDI of Gelantipy AWS (37°12′S, 148°16′E) for areas in the Gippsland region. These weather stations were considered broadly representative of the area burnt. |
| FDIwt | Forest Fire Danger Index weighted for the proportion of area burnt on the first day and subsequent days. The FFDI of 'subsequent days' was taken to be the average of the following two days. |
| Fire Age | The number of years since the area was last burnt. Where there was no previous record of fire, 1970 or 33 years was taken as the time last burnt. |
| Fire Size | The area of each fire area studied measured in units of hectares. |
| Aspect NW and Aspect SE | The proportion of the fire areas on either northerly and westerly aspects or southerly and easterly aspects respectively. The rationale was that aspect affects canopy density, vegetation type, fuel moisture, exposure to wind and fuel hazard levels. Northerly and westerly slopes are driest and are exposed to hot dry winds associated with severe fire weather. |
| Mean Elevn | Calculated as the average of the highest and lowest elevations across the fire area. |
| HEDMS | High-Elevation Dry Mixed Species broad vegetation type typified by mountain gum (*E. dalrympleana*) and snow gum (*E. pauciflora*) forests. The Overall Fuel Hazard levels (McCarthy *et al.* 1999) in this vegetation type is generally High to Very High. |
| LEDMS | Low-Elevation Dry Mixed Species forest covered most of the rest of the area and was characterised by a mixture of stringybark, peppermint and gum eucalypts with a generally higher overall fuel hazard level (Very High to Extreme). |

In 2002, we completed a meta-review of the studies exploring relationships between logging and flammability. **The overwhelming body of evidence is for a relationship between flammability and stand age in a non-linear pattern as shown in the above figures (Figure 5-8) see https://www.bushfirefacts.org/.**

## LOGGING IMPACTS ON FOREST SOILS

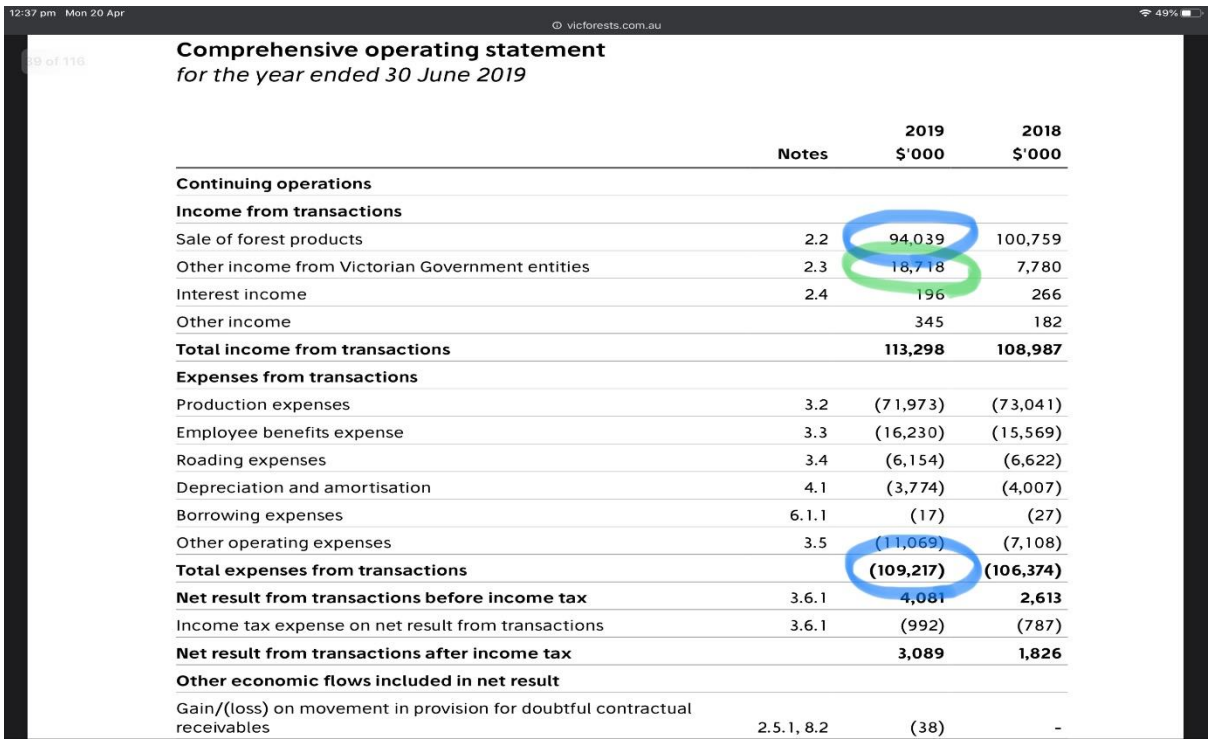
A major study was conducted on the effects of fire and logging on forest soils (Bowd et al., 2019). That study has shown unequivocally there are effects on soil nutrients and soil composition that last at least 80 years. **The key findings of this empirical study are not contested**.

## ISSUES OF ECOLOGICALLY SUSTAINABLE FOREST MANAGEMENT

Senator McKenzie claimed that the native forest logging industry is currently sustainable – which it is demonstrably not. The concept of Ecologically Sustainable Forest Management has been extensively discussed in the peer-reviewed scientific literature – and many books written on the topic (e.g. Lindenmayer and Franklin, 2002, 2003).

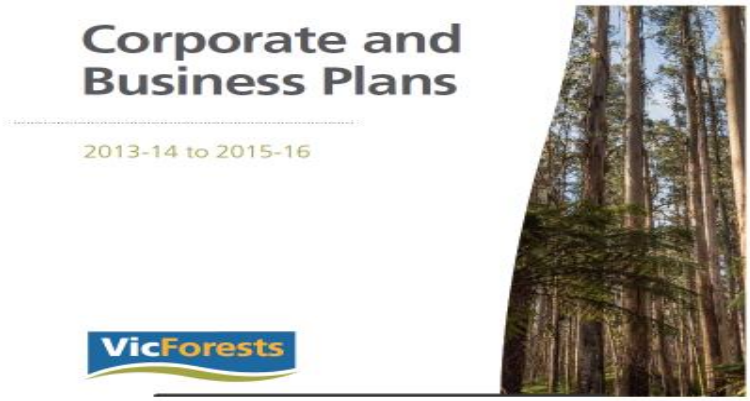
An extensive series of analyses shows that the native forest logging industry in Victoria is NOT sustainable. This conclusion is reached for the following major reasons.

- Logging is concentrated in areas of High Conservation Value for Victoria's 70 threatened forest-dependent species. Logging is one of the key factors contributing to the decline in site occupancy of key species such as Leadbeater's Possum.
- Logging is heavily fragmenting native forests, which has negative impacts on a range of threatened forest-dependent species (Taylor and Lindenmayer 2020).
- Logging is changing a key natural process in forests – namely fire regimes, leading to elevated fire severity.
- Logging is changing the natural process of collapse of large old trees – which are a critical denning and nesting resource for an array of cavity-dependent threatened species.
- Logging is having major effects on the condition and nutrient status of forest soils, with effects lasting for up to 80 years (and potentially longer).
- Logging is taking place illegally, including on steep slopes and in dedcaited harvesting exclusion zones.
- There is no longer certainty of resource because of the impacts of past overcutting and recurrent wildfire. That is, there is a very high risk forest (~ 80%) will be destroyed by fire before trees reach sawlog age (~ 80 years). The industry cannot therefore be considered to be sawlog driven – indeed, ABARES data shows that 87% of all native forest logged goes into the pulp and woodchip stream.
- The native forest logging industry is demonstrably uneconomic. VicForests losses have quadrupled from $5m to $20m per annum over the past 4 years. The costs of logging operations far exceed the sale of forest products (see COS below).



**Comprehensive operating statement**
*for the year ended 30 June 2019*

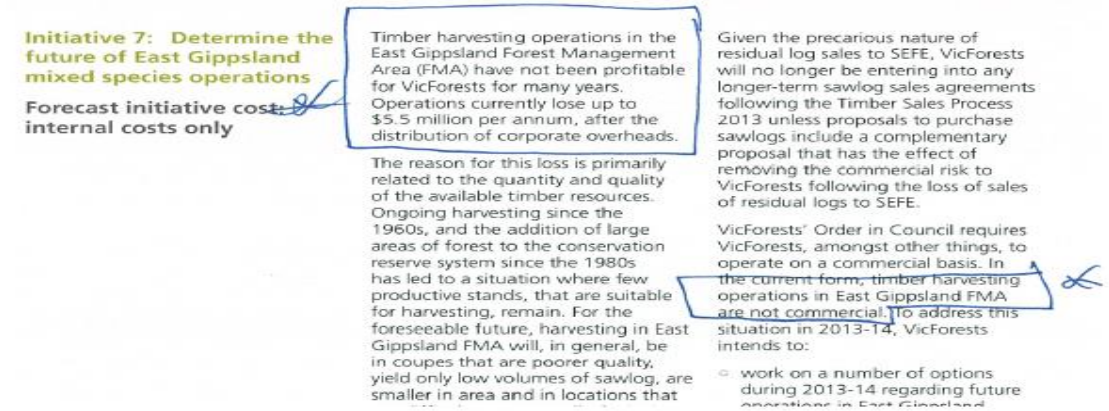
| | Notes | 2019 $'000 | 2018 $'000 |
|---|---|---|---|
| **Continuing operations** | | | |
| **Income from transactions** | | | |
| Sale of forest products | 2.2 | 94,039 | 100,759 |
| Other income from Victorian Government entities | 2.3 | 18,718 | 7,780 |
| Interest income | 2.4 | 196 | 266 |
| Other income | | 345 | 182 |
| **Total income from transactions** | | **113,298** | **108,987** |
| **Expenses from transactions** | | | |
| Production expenses | 3.2 | (71,973) | (73,041) |
| Employee benefits expense | 3.3 | (16,230) | (15,569) |
| Roading expenses | 3.4 | (6,154) | (6,622) |
| Depreciation and amortisation | 4.1 | (3,774) | (4,007) |
| Borrowing expenses | 6.1.1 | (17) | (27) |
| Other operating expenses | 3.5 | (11,069) | (7,108) |
| **Total expenses from transactions** | | **(109,217)** | **(106,374)** |
| **Net result from transactions before income tax** | 3.6.1 | **4,081** | **2,613** |
| Income tax expense on net result from transactions | 3.6.1 | (992) | (787) |
| **Net result from transactions after income tax** | | **3,089** | **1,826** |
| **Other economic flows included in net result** | | | |
| Gain/(loss) on movement in provision for doubtful contractual receivables | 2.5.1, 8.2 | (38) | - |



# Corporate and Business Plans

2013-14 to 2015-16

VicForests



**Initiative 7: Determine the future of East Gippsland mixed species operations**

**Forecast initiative cost: internal costs only**

Timber harvesting operations in the East Gippsland Forest Management Area (FMA) have not been profitable for VicForests for many years. Operations currently lose up to $5.5 million per annum, after the distribution of corporate overheads.

The reason for this loss is primarily related to the quantity and quality of the available timber resources. Ongoing harvesting since the 1960s, and the addition of large areas of forest to the conservation reserve system since the 1980s has led to a situation where few productive stands, that are suitable for harvesting, remain. For the foreseeable future, harvesting in East Gippsland FMA will, in general, be in coupes that are poorer quality, yield only low volumes of sawlog, are smaller in area and in locations that

Given the precarious nature of residual log sales to SEFE, VicForests will no longer be entering into any longer-term sawlog sales agreements following the Timber Sales Process 2013 unless proposals to purchase sawlogs include a complementary proposal that has the effect of removing the commercial risk to VicForests following the loss of sales of residual logs to SEFE.

VicForests' Order in Council requires VicForests, amongst other things, to operate on a commercial basis. In the current form, timber harvesting operations in East Gippsland FMA are not commercial. To address this situation in 2013-14, VicForests intends to:

- work on a number of options during 2013-14 regarding future

Independent analysis by PWC shows that the cost of a job in the native forest industry is 10 times the cost of a job in plantation forestry (see Table 2 below).

Table 2. Data on the FTE cost of a job in different sectors in Victoria.

**Table 1 Estimated capital investment funds required to obtain one full time equivalent job (FTE)**

| Industry | Level of investment required for one FTE |
|---|---|
| Native forestry | $5,041,000 |
| Forestry | $574,000 |
| Average of all non-forestry industries | $416,000 |
| Non-forestry manufacturing | $272,000 |
| Accommodation and food services | $222,000 |
| Other services | $139,000 |

Source: PwC analysis

From a regional development or employment perspective, the higher level of investment required to create one FTE, suggests that supporting native forestry would be less beneficial than supporting other industries, as it generates lower employment per dollar spent.

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**In summary, the results of an array of rigorous peer-reviewed scientific studies conducted over many years is actually very settled and the findings highlighting an array of detrimental environmental impacts at a range of scales is unequivocal and therefore not contested.**

Yours sincerely

Professor David Lindenmayer FAA, FESA, AO

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