Consultant report to Forestry Tasmania

Forests which provide protection from flooding

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Summary

The most important factors influencing flooding are rainfall and catchment and stream topography. Forest cover may influence small to moderate floods in small catchments (<10 km^2), but usually has little influence in large catchments (>10 km^2) or during severe meteorological events (FAO and CIFOR, 2005).

We sought to identify a threshold at which protection from flooding could be assumed to be diminished by forest harvesting. Small scale catchment experiments show that when 20% or more of a catchment's vegetation is altered, measurable changes in stream flow may occur including increases in peak flow when forest cover is reduced (Bosch and Hewlett, 1982). Because forests are regenerated after harvesting, we selected 5 years as the period that forest cover is diminished after harvesting. This is the period that coincides with maximum increases in water yield (Bosch and Hewlett, 1982) because canopy closure has not yet occurred and evapotranspiration is still lower than for mature forest (Roberts *et al.*, 2011)

We concluded that flood protection could be diminished if more than 20% of the area of a catchment of a defined floodplain was harvested within a 5 year period. This is a conservative approach as, typically, rivers in large catchments are less responsive to changes in vegetation type than rivers in small catchments and it is likely that an area greater than 20% would need to be altered before there is a change in flood protection (Bosch and Hewlett, 1982).

To assess the probability that forest management would decrease protection from flooding, we quantified the area of Forestry Tasmania (FT) Permanent Timber Production Zone (PTPZ) land in the catchments of DPIPWE defined floodplains.

Only one DPIPWE defined floodplain in Tasmania has more than 20% PTPZ in its catchment area – the North Esk River/Tamar Estuary. Assessment of forest age classes, showed that under FT's proposed management regime, no more than 3% of the catchment area will have PTPZ aged less than 5 years at any time. . This means that it is extremely unlikely that forest management will decrease protection from flooding for the North Esk River/Tamar Estuary, or at any other DPIPWE defined floodplain in Tasmania.

Introduction

To obtain Forest Stewardship Council (FSC) Certification for all native forests and eligible plantations under its control, it is Forestry Tasmania's responsibility to demonstrate that High Conservation Values (HCVs) will not be threatened as a result of management activities.

The HCV under consideration in this paper is "Protection from flooding" which is listed as a critical ecosystem service under HCV 4 "Forest areas that provide basis services of nature in critical situations (e.g., watershed protection, erosion control)" (FSC Australia2013, page 14). This paper:

- reviews literature on the levels of harvesting that are generally required to exacerbate flooding,
- lists locations in Tasmania where flooding has the potential to damage infrastructure according to the Department of Primary Industries, Parks, Water and Environment(DPIPWE),
- assesses the area of Permanent Timber Production Zone (PTPZ) Land occurring in the catchments of each of these locations,
- reaches conclusions about the likely effects, if any, of harvesting on flooding at the listed locations based on the proportion of the catchment that is PTPZ,
- provides a detailed study of harvesting levels in the most vulnerable catchment.

The relationship between forest harvesting and flooding

'Contrary to popular belief, forests have only a limited influence on major downstream flooding, especially large-scale events. It is correct that on a local scale forests and forest soils are capable of reducing runoff, generally as the result of enhanced infiltration and storage capacities. But this holds true only for small-scale rainfall events, which are not responsible for severe flooding in downstream areas. During a major rainfall event (like those that result in massive flooding), especially after prolonged periods of preceding rainfall, the forest soil becomes saturated and water no longer filters into the soil but instead runs off along the soil surface.'

(FAO & CIFOR, 2005, page 5)

Flooding is influenced by many factors. These factors include (but are not limited to):

- the intensity, spatial extent and duration of rainfall and how saturated the catchment is before a major rainfall event,
- soil depth and structure, geology, and catchment size and morphology and river morphology,

- the full range of land uses occurring in the catchment including agriculture and urbanisation,
- enhanced drainage as a result of urbanisation, roads, and drains, and
- sediment generation that leads to downstream channel sedimentation (Eisenbies *et al.*, 2007).

There is a widespread public perception that forests provide protection from flooding. The suggested mechanisms for this protection are the increased interception of rainfall on foliage which may reduce the volume of rainfall transmitted to streams, and the increased capacity for water to infiltrate and be held in forest soils which may slow the transmission of water to streams, potentially decreasing peak flood levels. It does not appear that forests are important for flood protection at all locations, with some scientists reporting increases in flooding in response to deforestation (Alila *et al.*, 2009; Bowling *et al.*, 2010; Burton, 1997), and others reporting that there is no measurable difference in flooding following deforestation (Bradshaw *et al.*, 2007; FAO & CIFOR, 2005; Van Dijk, 2009; and Calder, 2006).

There is a general consensus that forests provide flood protection at a local level (<10 km^2) during small to moderate rainfall events (Burton, 1997; Alila *et al.*, 2009). However, there is little evidence to suggest that this protection extends to the regional level during severe meteorological events. Bosch and Hewlett (1982) studied 94 catchment experiments and concluded that the presence or absence of forest did not appreciably influence the magnitude of the largest flow events. During major rainfall events, the amount, intensity and extent of rainfall combined with catchment and river morphology are by far the greatest determinants of the amount of flooding downstream. Forests cannot stop catastrophic large scale floods commonly caused by severe meteorological events (FAO& CIFOR, 2005).

Despite the lack of evidence that forestation prevents flooding at regional levels, intuitively, it seems sensible to maintain forest cover in catchments where flooding can cause significant damage to infrastructure.

In the absence of quantitative information on the flood risk associated with forest harvesting over a small percentage of a large catchments, over an extended period of time (the catchments of interest in Tasmania range in size from 384 to 7890 km^2), we sought to identify a threshold at which forest harvesting might exacerbate flood risk.

Bosch and Hewlett (1982) concluded that at least 20% of a catchment's vegetation needs to be altered to produce a measurable and/or statistically significant change in stream flow. This value was derived from small paired catchment experiments (<10 km^2) where stable land uses such as pasture, mature forest or plantation were converted to a different land use –usually in a single large event such as a fire, harvesting or planting.

The levels of hydrological response to vegetation change seen in small catchment experiments are unlikely to be seen in large catchments. Large catchments usually have a range of land uses and vegetation types, so activity in one part of the catchment may compensate for changes in other parts of the catchment. In a larger catchment, the distances that water must travel to reach the catchment outlet are longer so there is greater opportunity for the water to be intercepted, infiltrated, diverted or stored. Thus the use of a threshold of 20% to signify when deforestation is likely to exacerbate flood risk is a conservative approach as the threshold is actually likely to be higher than this.

Because FT forests and plantations are being harvested and regenerated rather than permanently removed through the process of deforestation, we needed to determine a time after harvesting (and regeneration of forest) at which a harvested area is no longer deemed to be contributing to flood risk. An age of 5 years was selected

. Maximum water yield increases are usually observed in the first 5 years following reduction of forest cover (Bosch and Hewlett, 1982). In addition, in Tasmanian forests, canopy closure is often achieved by age 5; with evapotranspiration reaching similar levels to older forest and plantation at around this age (Roberts *et al.*, 2011).

In order to identify Tasmanian floodplains that could be adversely affected by FT harvesting practices, it was determined that if the area of PTPZ land aged less than 5 years at any one time exceeds 20% of the catchment area of a designated floodplain, that there is then a risk that harvesting practices could increase flooding.

Flood Risk in Tasmania

The Department of Primary Industries Water and Environment (DPIPWE) have identified 12 floodplains in Tasmania where there is significant risk of economic loss or loss of life from flooding. . These are: Derwent River through New Norfolk; Upper reaches of the Tamar River and lower reaches of the North Esk River; Huon River at Huonville and Mountain River; South Esk River through Longford to the Tamar River; Jordan River below Pontville; Mersey River through Latrobe; Bagdad Rivulet, Elizabeth River through Campbell Town; Macquarie River at Ross; Coal River at Richmond; Meander River at Deloraine (http://www.dpipwe.tas.gov.au/inter.nsf/WebPages/RPIO-4YQ6V4?open).

Area of PTPZ in Tasmanian catchments that are vulnerable to flooding

Forestry Tasmania undertook GIS analyses to determine the percentage area of forest and plantations (PTPZ) under the management of FT in the catchments of each of the floodplains listed above (Table 1).

Where the percentage area of PTPZ is less than 20% of the catchment area, it is improbable that FT could harvest enough forest to increase the risk of flooding.

Table 1. Location of DPIPWE floodplains, catchment areas (km^2), and area of catchment in FT PTPZ (%)

Location	Grid coordinate of catchment outlet	Total Catchment Area (km^2)	Catchment Area in PTPZ (%)
Derwent River through New Norfolk	503612, 5235438	789	16.36
Tamar and North Esk Rivers	510729, 5412981	1064	24.47
Huon River at Huonville	503794, 5235438	2462	13.45
Huon River at Mountain River	508916, 5243557		0
South Esk River at Longford	510358, 5396313	7435	12.57
Jordan River below Pontville	521412, 5275951		0
Mersey River at Latrobe	449989, 5434991	1700	18.75
Bagdad Rivulet	521859, 5273434		0
Elizabeth River at Campbell Town	540853, 5357556	405	9.55
Macquarie River at Ross	540533, 5346692	1542	7.57
Coal River at Richmond	536020, 5268644	538	3.20
Meander River at Deloraine	471495, 5402943	384	5.60

Case study – North Esk catchment

The PTPZ exceeds 20% of the North Esk River catchment. Theoretically it would be possible (although unlikely) for FT to harvest 20% or more of the catchment area in a five year period.

There is no relevant information available on the potential impact of forest harvesting on peak flows in the Tamar and North Esk Rivers. Although Peel *et al.* (2002) and Peel *et al.* (2003) modelled the effects of forest harvesting on stream flow in the North Esk Catchment with Macaque, this modelling was undertaken to address concerns that conversion of old growth forest to regrowth forest combined with conversion of grassland to plantation would reduce stream flow. It provides no information on flood risk. TasLUCaS (Brown *et al.*, 2006), a tool to assess the impacts of forestry on run-off from small catchments, could possibly be used to investigate the effect of forest management on flooding in the North Esk catchment, however TasLUCaS was designed for use in small catchments (up to 100 km^2), and use of this tool would require extensive use of rainfall and stream flow data and land use information. This effort is not warranted unless it can be demonstrated that FT is likely to harvest more than 20% of the catchment area in a 5 year period.

In the absence of any reliable and rapidly available calibrated stream flow models to represent the effects of forest harvesting on stream flow for the North Esk River, information on the age class of forests and plantations occurring in the North Esk Catchment was obtained from FT's GIS. This information, combined with the proposed harvesting schedules for PTPZ in the North Esk catchment, was used to determine the percentage area of catchment that would have PTPZ aged less than 5 years for each year from 2013 to 2026 (Table 2).

Some forests and plantations in the North Esk/Tamar catchment are clearfelled – all of their area was deemed to be aged zero in the year of proposed harvesting. Some forests and plantations are partially harvested – 2/3 of their area was deemed to be aged zero in the year of proposed harvesting. The percentage areas of the North Esk Catchment with forest on PTPZ land aged less than 5 years are shown in Table 2 for each year.

The percentage area of the North Esk catchment likely to contain trees aged less than 5 years based on proposed management regimes, averaged 2.3 % between 2013 and 2026. The range was 1.73 to 3.08%.

Table 2. Percentage areas with clearfelling, partial harvesting and a combined estimate of harvested area in previous 5 years in the North Esk Catchment.

Year	% of North Esk catchment with forest/plantation clearfell harvested in last 5 years	% of North Esk catchment with forest/plantation partially harvested in last 5 years	Total % area of harvesting during last 5 years (all of column 2 and 2/3 of column 3)
2013	0.52	1.82	1.73
2014	0.69	1.68	1.81
2015	0.87	2.26	2.38
2016	1.24	2.41	2.85
2017	1.35	2.60	3.08
2018	1.27	2.50	2.94
2019	1.27	2.54	2.96
2020	1.22	1.95	2.52
2021	0.94	1.69	2.07
2022	0.97	1.36	1.88
2023	1.05	1.31	1.93
2024	1.16	1.02	1.85
2025	1.42	0.99	2.08
2026	1.61	0.99	2.27
Average	1.16	1.79	2.31

Conclusions

In a large catchment, a reduction of forest cover across 3% or less of the catchment area is unlikely to create a measurable change in stream flow. It is thus deemed unlikely that the levels of harvesting proposed by FT will contribute in any measurable way to the flood risk experienced by the DPIPWE listed locations.

Use of detailed hydrological tools such as TasLUCaS (Brown *et al.*, 2006) is unnecessary due to the low risk of increased flooding associated with harvesting across such a small percentage of catchment areas.

Acknowledgements

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References

Alila, Y., Kuras, P.K., Schnorbus, M . and Hudson, R. 2009. Forests and floods: a new paradigm sheds light on age-old controversies. Water Resources Research 45.

Bosch, J.M., and Hewlett, J.D. 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. Journal of Hydrology 55, p 3-23.

Bowling, L., Storck, P. and Lettenmaier, D. 2010. Hydrologic effects of logging in western Washington, United States. Water Resources Research 36 (11), p 3223-3240.

Bradshaw, C., Sodhi, N., Peh, K. And Brook, B. 2007. Global evidence that deforestation amplifies flood risk and severity in the developing world. Global Change Biology 13 (11), p2379-2395.

Brown, A.E., Hairsine, P.B. and Freebairn, A. 2006. The development of the Tasmanian Land Use Change and Stream Flow (TasLUCaS) tool. Report to the Tasmanian Natural Resource Management Committees. CSIRO Land and Water Science Report 54/06, July 2006.

Burton, T.A. 1997. Effects of basin-scale timber harvest on water yield and peak streamflow. Journal of the American Water Resources Association 33(6), p1187-1196.

Calder, I.R. 2006. Forest and Floods: Moving to an Evidence-based Approach to Watershed and Integrated Flood Management. Water International 31 (1) p87-99.

DPIPWE http://www.dpipwe.tas.gov.au/inter.nsf/WebPages/RPIO-4YQ6V4?open

Eisenbies, M.H., Aust, W.M., Burger, J.A. and Adams, M.B. 2007. Forest operations, extremem flooding events, and considerations for hydrologic modelling in the Appalachians- A review. Forest Ecology and Management 242, p 77-98.

FAO and CIFOR, 2005. Forests and Floods: Drowning in Fiction or Thriving on Facts? RAP Publication 2005/03, Forest Perspectives 2.

FSC Australia, 2013. High Conservation Valuers (HCVs) evaluation framework. Final 3.4. Responsible forest Management Australia Limited, North Melbourne.

Peel, M., Watson, F. and Vertessy, R. 2003. Modelling Impacts Of Land Use Change On Low Flows In The North Esk River Using The Macaque Model. In MODSIM 2003 - International Congress on Modelling and Simulation, Modelling and Simulation Society of Australia and New Zealand ,July, 2003, Townsville, pp: 849-854.

Peel, M.C., Watson, F.G.R., and Vertessy, R.A. 2002. Modelling of Low Flows in the North Esk River using the Macaque model. Draft report Submitted to Launceston City Council. 55 pp.

Roberts, S., Read, S., MacLarin, M. and Adams, P. 2011. Predicting the water use of *Eucalyptus nitens* plantations in Tasmania using a Forest Estate Model. Forest and Wood Products Australia, Melbourne, Australia. Project No: PNC143-0809.

Van Dijk, A., Van Noordwijk,M., Calder, I., Bruijnzeels, S, Schellekens, J., and Chappell, N. 2009. Forest-flood relation still tenuous – comment on 'Global evidence that deforestation amplifies flood risk and severity in the developing world' by C.J.A. Bradshaw, N.S.Sodi, K.S.-H.Peh and B.W. Brook. Global Change biology 15, p 110-115.