Otago Regional Council

Document Id:

MEMORANDUM

To: **Tom De Pelsemaeker**

From: **Ben Mackey**

Date: **28th February 2024**

Re: **Sediment issues from forestry in Otago**

Name	Role	Date Completed
Dr Sam Thomas	Reviewer 1	28th February 2024

Purpose

This memo presents known information about the sediment issues from plantation forestry in Otago.

Context/Background

The proposed Land and Water Regional Plan is exploring implementing greater control on forestry activities, including measures to better manage issues around sedimentation.

Data and Methods

This memo presents a summary of known literature related to sediment issues from commercial forestry with a focus on the Otago region. Information reviewed was restricted to published scientific papers or technical reports.

Discussion

Sediment issues from forestry

Commercial forestry, which involves the clearance, re/planting and eventual harvest of trees, has a range of recognised environmental risks, a suite of which related to the disturbance of soil and the increased likelihood of erosion and sediment transport (e.g., Wallis and McMahon, 1994).

Commercial forestry can involve substantial land clearance and disturbance associated with the planting and harvesting stages, and requires the establishment of significant roading and harvesting infrastructure, often in steep terrain. Harvesting and replanting activities can leave

areas of exposed or bare earth, and soil in this condition is more susceptible to entrainment and transport by overland flow. Associated activities such as roading, hauling, and the creation of skid or processing sites can disturb the natural hydraulic pathways in a landscape or cause soil compaction. This can cause flow focussing or convergence across exposed ground leading to localised erosion and sediment entrainment and transport to the stream network.

Harvested forests are known to have a period of vulnerability between harvest and the re-establishment of a new forest where the root network of the harvested trees decay, before the roots of the newly planted trees are established (e.g., Phillips et al, 2012). Steep slopes with reduced root strength can be vulnerable to slips or mass movements which can render hillslopes exposed, and potentially transport sediment and tree debris directly to the channel network through landslide and debris flow processes. Vegetation clearance, as is commonly done prior to replanting, leaves extensive bare soil which is vulnerable to rainsplash, sheet or rill erosion.

Of note, these issues have been long recognised (e.g., Croke and Hairsine, 2006), and both industry and regulation (e.g., NPS-PF/CF) have introduced practices to mitigate the effects of forestry on sediment loss over recent years.

Otago context

The environmental effects of forestry-derived sediment are widely recognised, and there has been extensive research documenting sediment issues in New Zealand and overseas (e.g., Croke and Hairsine, 2006). The purpose of this memo is to document forestry related sediment issues within an Otago context.

Otago can be distinguished from other high profile forestry areas in New Zealand because the region has very little commercial forestry in Erosion Susceptibility Classification (ESC) 'Orange' or 'Red' classed land, a national classification which identifies the most erosion-prone land due to a combination of topography and geology. This is in part because Otago does not have the extent of steep, erosion-prone weak marine sedimentary rocks that common across much of the North Island's east coast such as the Gisborne and Hawkes' Bay areas. The required combination of suitable growing climate and proximity to port limits forestry to the ranges of coastal and eastern Otago, which are typically comparatively stable schist-cored ranges. Otago also has historically not been subject to heavy rain from ex tropical cyclones which have hit northern areas, although extreme events are predicted to become more frequent in the future (Macara et al., 2019).

Otago Sediment Studies

We have been unable to find many explicit studies pertaining to forestry-related sediment issues specific to Otago. This could be due to a range of factors such as research attention focussed on more high-profile sediment issues in other areas, research institutes or university researchers not having a large forestry-focussed presence in Otago, or simply that there is not much of a visible issue that warrants investigation.

The most thorough forestry-related investigation in Otago has occurred at the Glendhu forest, where adjacent forested and tussock catchments have been monitored since the 1970's, with an initial focus on the effect of forestry on water yield (Fahey and Payne, 2017).

In the mid 2010's extensive parts of the forested catchment were harvested, and turbidity and suspended sediment was monitored at the catchment outlets to quantify the effects of forest harvest on sediment yield, in comparison to the unharvested tussock catchment (Mager et al., 2019). Sediment yield from the forested catchment approximately doubled during the active harvest phase (17.3 ± 4.5 t km^{-2} a^{-1}), in comparison to the yield measured when the forest was growing (9 ± 2.4 t km^{-2} a^{-1}). The harvested catchment had higher measured sediment yields than the control tussock catchment (approximately 5 times), but turbidity was well within the requirements of the Regional Plan Water. It was noted that stable schist lithology and good harvest management likely contributed to this result.

Mager et al. (2019) also point to another study in Otago by Duncan et al. (2012), and note:

> *"The increased sediment yield associated with forest clearance observed at Glendhu (GH2) is consistent with the yield reported by Duncan (2012) in the Blue Mountains of Otago, where pine plantation forestry yields increased from 9–10 t km-2 a -1 under pine stands to 16 t km-2 a -1 in the two year period of post-harvest."*

Mager et al. (2019) comment that measured sediment yields from harvested forest on Otago schist are low compared to other parts of New Zealand.

Otago Estuary Studies

There have been some recent studies of estuaries at the base of heavily forested catchments that do show degradation due to sediment, and could be considered indirect evidence of the effects of forestry derived sediment.

The Akatore Estuary south of Taieri Mouth was assessed in 2022 as part of the State of the Environment estuary monitoring programme (Roberts et al., 2022). Over three-quarters of the catchment is exotic forestry, putting it among the most highly forested major catchments in Otago. Among the range of parameters quantified, mud extent and sedimentation rate were rated 'fair' to 'poor' indicating that fine sediment is the primary issue in the estuary. This example correlates an estuary with sediment issues to a heavily forested catchment, however there has been no systematic study linking forestry practices to sedimentation in the Akatore estuary.

The Pleasant River catchment (between Waikouaiti River and the Shag River Catchments) is covered by approximately 26% established commercial forestry. The estuary monitoring programme found the estuary to be in poor condition with respect to both nutrients and sediment (Forrest et al., 2022, Roberts et al., 2022). In response to this, the Pleasant River catchment was the focus of a quantitative sediment source tracking study conducted by NIWA (Swales, 2023). Different land uses have a different 'signature', and these proportions can be estimated in sediment deposited in rivers or estuaries.

This study looked at the origin of sediment within the river and estuary and found that in recently deposited terrestrially-sourced sediment in the estuary, topsoil from recently harvested production forestry had a 69 times greater sediment yield (t km^{-2} a^{-1}) than topsoil from pasture/fodder crops, based on their respective proportions of the catchment. In addition, the area downstream of the recently harvested forestry had deposits of 77% with the signature of pine forest harvest. Some context is required in that active forest harvest and pasture/fodder crop land uses have a large difference in contributing area – 1 vs 74 km^2, and

topsoil from each land use contributed about 7.5% of the terrestrially derived (non-marine) sediment deposited in the estuary (approximately 92% of the sediment in the estuary had a marine source). This technique is unable to distinguish subsoil from different land uses however; sediment sourced from deeper slips or road cuttings from either forestry or pastoral land has the same signature.

National examples that have looked at the effects of forestry on sediment

Outside of Otago, there have been numerous studies in other parts of New Zealand looking at the effects of forestry-derived sediment. These include:

- Gibbs and Woodward (2017) CSSI study on sediment sources in the Matai River, Nelson
- Gibbs and Swales (2019) assessed sources of sediment in the Moutere and Waimea catchments.
- Swales et al (2021) rates of sediment deposition and sediment sources within inner Pelorus Sound.

Conclusion

Sediment issues stemming from traditional forestry activity are well recognised in New Zealand and internationally. There is not an extensive body of literature documenting sediment issues from forestry in Otago, but sediment yields from active harvest that have been measured in Otago are typically lower than other parts of New Zealand that have different geology, topography, or climate. The Glendhu Forest study found harvest did increase sediment yield, but this was within acceptable limits. Further evidence comes from the recently established estuary monitoring programme, which has found sediment issues in heavily forested catchments. A sediment source tracking study using quantitative data identified topsoil from forestry harvest as a key terrestrial sediment source in the Pleasant River estuary relative to harvest area.

While there is limited Otago-specific literature relating to sediment issues from forestry, the body of evidence both in New Zealand and Internationally document the link between forestry harvest, roading, land clearance and/or replanting activities, and subsequent sedimentation issues.

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