Report to Otago Regional Council

Overview of Environmental Issues & Management of Forestry in Otago 2021

The overview on environmental forestry is background information as part of the Land and Water Regional Plan for Otago.

Based on Contract Reference-ORC 179. Purchase order to deliver the report PO021059

Introduction

As part of delivering this report it was considered more meaningful to prepare some summary tables (Appendix 1-5) which highlight the general management of forestry practice in Otago. It will include production forestry (e.g., pines, Douglas fir and others) as well as farm forestry plantings and managed native plantings. The basis of the summary is structured around the National Environmental Standards for Plantation Forestry (NES-PF which was invoked in law at 1st May 2018yr).

Definition of Plantation Forestry *(under the NES-FP) means a forest deliberately established for commercial purposes being at least 1 ha of continuous forest cover of forest species (that will be harvested or replanted), includes all associated forestry infrastructure. A forest species capable of reaching 5m in height at maturity.*

Furthermore, as part of this project other forest types and planting options will be included as..
-Small farm forestry woodlots (a range of tree exotic and native species) including shelterbelt trees (belts that are wider than 2-3 rows) and areas of trees that maybe less than 1 ha of continuous forest cover, includes open planting (space planting) eg Poplar and willow poles (see Footnote below) or Eucalyptus varieties, Tasmanian Blackwood trees and other selective species. Includes Riparian planting (both exotic and natives) general native plantings established for productive purposes e.g., Totora, Kauru, and Beech trees (for timber and or carbon sequestration) as some examples.

Otago Forestry Setting-Geological, Erosion and Soils Examples **Table 1**

Geological Rock Primary	**Base Rocks Some eg**	**Cover deposits Examples a guide**	**Erosion (ER) Main Forms eg**	**Based on NZ Soil Classification**
Sedimentary (Sediments laid down)	Mudstone Sandstone Limestone Greywacke	Alluvium Loess Windblown sand Gravels Colluvium	Surface ER Mass movement ER Fluvial ER (eg Under-runners)	Commonly Pallic soils Brown soils Recent soils Gley soils
Metamorphic (Heat and Pressure)	Schist Gneiss	Alluvium Colluvium Loess Gravels	Surface ER Mass Movement ER Fluvial ER	Pallic soils Brown soils others as Recent soils
Volcanic and eruptions	Tephra ?? Mud, Ash	Ash other	Various forms	Small areas in Otago, Granular
Other	Various	Organic Build up after flooding	Accumulation of sediment-silt deposition	Peat soils. (Podzols?) Recent

Footnote: when describing Willows refers to beneficial varieties for erosion control e.g., as tree willows (Salix moutere, Salix tangoio, Salix matsudana or Shrubby willows for riverbank protection e.g., as S. incana, S. glenmark. Not refer to pest plants as S. fragilis (crack willow) or S. cinerea grey willow.

Soil Erosion and Forest Management Activities-a brief Synopsis

Table one provides a basic summary in Otago. This discussion on soil erosion is based on the classification 3rd edition of the Land Use Capability Survey Handbook (LUC). The LUC booklet identifies 4 different Erosion groups which will be referred to below in this report.
The main erosion forms are summarised into Surface, Mass Movement, Fluvial and Deposition.

Surface Erosion

Sheet erosion-very common in forestry operations especially on newly developed tracks, bare ground as skid sites, sloping land where vegetation cleared pre planting. This causes raindrop impact moving soil particles and then overland flow into creeks and floodplains. Refer also to Rilling and Fluvial erosion types.

Wind erosion-In general not a major issue in forest blocks. Mainly an issue in drier environments, in droughts or after a heavy burning of rank vegetation pre planting. Can be prevalent on exposed hill tops and where sand dunes or sandy based soils exist e.g., forest areas as coastal Otago Peninsula, Taieri Mouth, Toko Mouth, Clutha delta and South Otago coast.

Scree erosion-Generally not a major issue in Otago as production forest is normally established below 650m a.s.l. However, protection plantings (e.g., specific species and or native plantings) and soil conservation plantings still play an important role when stabilising scree slopes and sheet wash where fine particles can be carried into rivers as the Shotover, Ben Nevis, Makarora and other localised areas.

The importance of controlling wilding pines in Otago has to be considered however the method of control where wildings are stabilising scree slopes needs close attention (do you use aerial chemical spray, or hand cut or hand poison or just trim the vegetation or use farmed animals to control). Alternatively, the other option on moderate-severe erosion prone scree slopes is to manage and lessen the risk of spreading wildings on the outer boundaries or can be managed primarily for stability. Specific management plans can be undertaken and possibilities of utilising wilding trees for carbon sequestration on specific safe sites.

Mass Movement Erosion

There are various erosion definitions in particular when referring to mass movement erosion e.g., the generic term landslide. Includes a wide range of erosion types where material moves down slope as a more or less coherent mass under the influence of gravity.

Soil Slip- Usually shallow, rapid slides involving soil and regolith e.g., loess normally over 20 degree slopes. The scar surface left can take some time to heal over however by planting pine trees, willows and other hardy tree species will in time as long as moisture levels are adequate then trees will establish and stabilise.

Debris avalanches and Debris flows-similar types of erosion impact. **Debris avalanche** are rapid movements often deep scar down a long slope. Normally over 25 degree slope and often in forested

catchments. For example on the Otago Peninsula, Saddle Hill north face (now replanted in pines), Scroggs Hill and Benger faces near Roxburgh.

Debris flows are like Debris avalanches but generally have greater rainfall impact and are more fluid thus can transport more sediment and vegetation debris into rivers, wetlands and important productive lowlands. Can travel long distances. Native forests in Otago can experience Debris flows in intense flood/rainfall events e.g., Waipori Falls/gorge area and Silverpeaks-Mt Allen forest (pre Wenita Forest establishment in the June 1980 storm event).

Rock Fall-More common on mountainous terrain, maybe caused by earthquakes. Can have minor impact on fine sediment into waterways and water quality. Minimal impact from forested cover.

Earthflow-This is a slow movement of soil and regolith and often hummocky shape and can have broken and open cracks thus leading to more surface water draining into the slip plane and activating downward movement. Often ponds occur and normally found on pastoral land.

Generally don't create much silt/soil into creeks. Planting by using open-space planting (poplars, willows) can be very effective in controlling earthflow. In bush covered land (exotic forestry and healthy native bush) earthflow is not common or may be difficult to locate. Some good examples in Otago are near the Flag Swamp area, Kilmog (beside SH1), Seacliff, near SH8 at Evans Flat & Otokia.

Slump-Generally more deep seated on a rotational movement. Associated with earthflows and common where mudstone parent material exists e.g., Lower Saddle hill (lower slopes), Kilmog, Green Island to Abbotsford. Like Earthflows tend to not contribute major sediment/debris into waterways. However, where the toe of a slump is actively moving into a creek then over time fine mudstone silt will be transported into water ways.

Planting exotic forest will greatly stabilise these areas in particular by drying out the regolith material associated with other dewatering options.

Fluvial Erosion

Fluvial erosion involves the removal of material by channelised running-water. The common forms that impact on forest production and other tree management are of processes by Rilling, Gullying, Tunnel Gullying and Streambank. These 4 forms of erosion can have significant impacts on generation of sediment and vegetative debris thus degrading water quality and stream ecology.

Rill-small closely spaced channels where soil particles and fine debris are transported downslope. The greater the slope angle the worse the issue can become. Normally occurs on loose bare soil surface cover and often in association with sheet erosion in a forest environment. Found on sites where cultivation type machinery is used as pre planting forest preparation. Rilling can occur on new constructed forestry tracks that are not bedded in yet or need gravel veneer laid to stabilise.

Gully-Often occurs due to the regolith material e.g., loess, colluvium on a terrain that is becoming steeper going down hill. Gullies can start as a combination of sheet wash plus rilling as increased rainfall forming into small channels then into larger wider channels. Carrying considerable quantities of debris and silt/gravel and related matters.

Controlling gullying can be advantageous by using engineering design/structures. Sediment traps can help. On severe cases in forest blocks diverting water away safely from the head area of the gully and planting poplars and willows within the gully to minimise future sediment transfer can be beneficial.

Tunnel Gully (or may be known as under-runners or tomos). Can be initiated by ground water penetration via the subsoil (by clay eluviation and scouring due to low strength material) creating a collapse from the surface layer leaving an open hole which can be a safety issue. In time with more rain the tunnel collapses further and considerable fine clay will be transported to streams, ponds and lower land. In severe cases after forest harvesting operations fine flocculated clay can lie on and cover good gravel stream beds.

Using tree species that have effective fibrous root systems such as Poplars, Willows, Shrub willows and trees that sucker like Acacia melanoxylon as well as fast growing Pinus radiata should be considered for stability and minimising siltation downstream for slips, gullying and tunnel gullies.

With Gullying or Tunnel gullying by growing a healthy forest canopy and or diverting water away from the head of each gully can greatly minimise the deposition of fine sediment to waterways.

Deposition- can be discussed as siltation and sedimentation. It is not an erosion process but it is the end product of erosion. It refers to sediment including vegetation that has been eroded (by many forms) transported and subsequently deposited by running water. Can be deposited on low lying stream banks, on terraces, on floodplains and other landforms (depending on the intensity and period that a flood occurred).

Summary of Forestry and related Erosion and Water quality impacts

In Otago mass movement erosion (e.g., debris flows, soil slips and earthflows) can occur at the pre planting preparation phase when clearing vegetation and or earthworks such as roading and quarrying. Once the forest is established mass erosion tends to be less prevalent unless an area is steep with deep seated geology-weak regolith material.

It is not uncommon to find active slips on steep faces where streams or rivers continually undercut the toe of the slip. Downward movement due to gravity and water activation can result in considerable fine debris & silt reaching a river.

The other period where mass movement erosion can be an issue is at the harvest phase. In many of the pre 2000yr forest blocks in some cases minimal roading is carried out (economics of roading costs) until it was time to harvest.

The other issue is when storm events and flood flows occur, mass movement erosion can be observed but generally is an issue due to steep slopes, geology (e.g., Abbotsford mudstone, Caversham sandstone) and impacts from infrastructure or even due to lack of maintenance as on forest roads, lack of cut offs and culverts.

With regards to forestry and earthworks the two main adverse effects are due to firstly accelerated erosion (e.g., collapse of slopes around cuts) and secondly due to excessive sediment discharge to waterways through erosion of water control structures, fill-slope failure and soil disturbance. Earthworks can activate erosion by disturbing high risk areas e.g., toe of a slip, gully heads or old landslide scarps, or by concentrating surface flows into those areas.

In Otago in the case of Surface erosion and Fluvial erosion (e.g., the significant forms as sheet, rilling, gully and tunnel gully) can contribute significantly to waterway siltation and impact greatly to river ecology. Siltation can occur at the general preparation phase of afforestation as well as earthworks operation, quarrying, general maintenance and harvest phase.

It is not uncommon to find that fine silt material can continue to be eroded away in the base of a growing pine forest or Macrocarpa block when active gullies and tunnel gullying occur even when a

complete forest canopy cover exists. This can be identified on NW-NE sector aspects where moderate to deep loess and loess colluvium exist.

The root plate effect of pine trees may only grow down 2m in depth but spread roots more as a surface mass hence the process of clay flocculation means that under runners continue to be active and therefore contribute clay material into lower waterways.

Based on M Harris (pers comm) experience it is considered that if a more detailed scale map was prepared in Otago would highlight the more susceptible sites where deeper loess and colluvium exits. This would more accurately identify and monitor the existing ESC map classification map (NES-PF) classification which may be able to review the severity of erosion (in particular the siltation) e.g., from moderate rating (yellow) up to in some cases to high (orange)?.

Taratua coal measures-gravels and sand material as found near Brighton, Kaitangata, and Boulder Hills mid catchment area of Silverstream will also contribute with fine material into waterways. Issues 20 yrs ago occurred where DCC water intakes had been affected by Taratu gravel-silt in the DCC Silverstream surrounding production forestry harvesting.

Examples of some general areas in Otago where loess -colluvial material exist.
Likely to be under runners, gullying and more active siltation, often on Downlands terrain land. The depth of loess and can vary but as the slope increases over 25deg in general the thickness becomes less. Examples of pockets of loess and colluvium:

-Papakaio front faces to Georgetown.
-Kakanui Valley from Maheno inland to Tokarahi.
-Hampden coastal faces.
-Shag Point Coastal faces.
-Lower hill Northerly faces from Bushey Park and below Puketapu at Palmerston and inland to Morrisons (in particular Dunback-McCormacks Creek catchment area).
-Flag swamp-Tumai area-Waikouaiti.
-Front north faces from Wingatui south to Henley and down to Tokoiti-Moneymore district.
-North Taieri south to Outram Glen area (very deep deposits at Taieri Gorge mouth).
-Pukerangi-Shannon-Sutton area to Clarks Junction e.g., north faces in Deep Stream.
- Waitahuna-Lawrence to Breakneck road to Waitahuna west.
-Raes Junction-Edievale to Heriot north faces and Downlands district Kelso to Waikoikoi.
-Millers Flat both sides of Clutha River (East of Island Block), north face Ettrick to Dumbarton
-Central Otago near lower Earnscleugh Station, Galloway district (very dry for forestry)
-Warm northerly faces Waitepeka to Clinton (south of Hillfoot Road)

Refer to Maps- filed in the Otago Regional Council library for erosion and loess cover under..
"Loess soils & problems of land use on the downlands of the South Island New Zealand Feb 1972" (ORC Library reference Publication no 1117) and..

"Land likely to Suffer Significant Damage by Forestry operations and Vegetation Clearance in Otago August 1993". Ref ORC File RL230, Report No 93/488 & (ORC Library reference Publication no 1939).

Erosion Susceptibility classification (ESC) area and plantation forestry in Otago

Based on the database supplied by Forestry New Zealand at 2017 year and 2018 ESC datasets. This is subject to Crown copyright by Ministry for Primary Industries (Exc DOC Land)... **Table 2**

ESC Group Classification	Total area in Otago (Ha)	Area Exc DOC land (Ha)	Area in Plantation Forestry ha	% total Plantation Forest Otago	Indicative LUC Erosion severity	General
Low (Green)	1,848,435	1,689,977	103,981	5.0%	0, 1?	
Moderate (Yellow)	800,233	628,397	40,750	2.0%	1-2, 0-2	Eg LUC 6e, 4ew
High (orange)	241,875	103,415	230	0.0%	3, 3+	LUC 7e
Very High (Red)	174,238	21,265	0	0.0%	4, 4+	LUC 7e, 8e
Subtotal	3,064,781	2,441054	144,961	7.0%	Na	Na
Other land-not in ESC	126,107	101,415	1077	0.1%	Na ?	Na ?
	3,190,888	**2,542,469**	**146,038**	**7.1%**	---	---

Note 1..*ESC very high category is high altitude -erosion so not suitable for production forestry.*

Note 2*..In Otago in some instances the high or very high ESC class highlights often mass erosion and does not always provide the severity of particle/accelerated erosion by sheet wash, gullies and under runners (Tunnel gullies) where sediment is transported down to waterways.*

Note 3*..Scale of maps & ESC was 1:50,000.*

Note 4.. *Plantation Forest records are about 4 years old.*

Land likely to suffer from significant damage by Forestry Operations in Otago

A report was prepared by Dr Allan Hewitt (1993) for the Otago Regional Council which provided a basic overview of the main limitations affecting any forestry operational activities in particular for commercial forestry in Otago.

The main attributes considered involved:

- Slope especially 21-35 degree (requiring cable hauling) and >35deg with many erosion risks
- Dryness-generally less than 550mm rainfall
- Altitude-generally over 600mm a.s.l and too high for commercial forestry
- Erosion risk-high erosion due to vegetation clearance, roading or harvesting
- Drainage-poor and very poor drainage.

The other attributes and their properties relevant to forestry operations and vegetation clearance include soil depth, riparian effects, hydrological impacts, flooding risk, geology, sedimentation, exposure, landscape impacts, wilding tree risk, soil degradation, loss of natural values and lastly effects of commercial forestry species on soils.

Based on using the existing database using soil maps (map scale ranged from 1:250,000 to 31,680) and NZ Land Resource Inventory (NZLRI) information. The summary data was useful as a baseline.

Summary of the data analysis in the report highlighted (from Hewitt report 1993):

Limitations due to high altitude and erosion	194,144.0ha
Limitations due to erosion only (determine by Rock type)	54,381.0ha)Total erosion
Limitations due to erosion only (determine by soil type)	43,872.0ha) 98,253.0ha
Limitations due to any occurrence of drainage (soil type)	45,138.0ha

Land stability, water quality and Impact of various tree planting regimes.

There has been considerable research in NZ over the past 30-35 years on the role and benefits of tree and shrub species to stabilise and dewater slopes as well as enhancing the water quality and the surrounding ecosystem.

To set the scene on the risks of erosion and sedimentation in Otago a brief synopsis will be outlined in this section.

How trees (Exotic and Native) reduce erosion by:

- Dense canopy effect (may take many years to provide canopy cover) minimise rainfall effect on the soil.
- Canopy effect as rainfall that falls can be removed by evaporation. Can be 25-30% less water yield on a mature forest (Fahey et al.2004).
- Trees reduce excess water in the soil by transpiration in particular on mass erosion sites.
- Tree roots provide mechanical reinforcement of the soil (root tensile strength along with frictional resistance and soil bonding properties influenced by other factors).
- Root grafting between adjacent trees (depend on how close spacing is). Pines commonly graft and strengthen slopes.
- Tree species as Poplars and Willows have very fine root mat and can travel further away towards water. Very useful in forming a dense root mat in gullies and under runners thus trapping large amounts of loessial clay-silt material. Poplar and suitable willow varieties can be open planted and strategically placed on shallow earthflows or within the under runners.

How to reduce and minimise erosion after a clearfell-harvest operation

- The first point is to recognise the "window of vulnerability" after harvest (ie the time for the roots of the new planting to replace the rotting roots from the previous rotation).
  Refer to various research work in NZ on slope stability, tree -root stability & window of vulnerability (approx. 5-8yrs with pines-Otago). (Satchell 2018 but many other reference examples).
- Rotation length for alternative commercially viable species. Otherwise use specialty trees to suit the site.
- Measures that restrict the risk and occurrence from debris flows and sedimentation.
- Undertake Best Environmental Practices (BEP) e.g., using the "Road Engineering Manual"
- Managing slash and silt to minimise risk from blockages and transport of material down stream.
- Provide buffers between productive areas and water courses that act as slash traps.
- Identify areas with high risk of erosion and retire from productive use.
- Replant at higher stocking rate and especially if the tree species is slower growing.
- Use of certain species of trees and timber e.g., on higher risk sites trees that can coppice and or roots sucker or species where root rotting rate occurs at a slower rate e.g., Macrocarpa, Douglas fir or specific varieties of Eucalyptus.

- Correct species and planting density will provide faster canopy cover. Note that often second rotation trees grow faster due to tree litter onsite, greater biological activity in the soil (especially microbes and mycorrizha) and more friable soil with enhanced drainage.
- Consider continuous forest cover regime in certain catchments

Trees provide most of their benefit through the ability of roots to bind the soil. Poplar roots have 2.2 times the tensile strength of radiata pine, and Douglas-fir roots have 1.5 times the tensile strength of radiata pine (Ref: Farm Forestry Newsletter, No 1, November 2001).

The soil holding ability of individual trees, which is root mass times tensile strength, is constant between these species provided the trees are of equal size. The other important point is the number of trees per hectare i.e., the more trees, the more mass of roots, the greater potential for erosion prevention. The slower decay of Douglas fir root systems following harvest becomes an eventual asset.

There is evidence that rather conservatively managed stands of radiata pine on farm sites become effective in preventing about 90% of mass soil erosion once they have reached about 8 years of age and equates to about 30 tonnes of root biomass per ha. This may mean that many radiata pine and Douglas-fir (slower root decay than Radiata) options are running surplus to requirements as far as environmental protection.

Furthermore, over a rotation, and following the initial establishment phase, Douglas fir meets this level of 30 tonnes of radiata pine equivalent root biomass for 91% of the time; radiata exceeds it for 66%; poplar at 100 stems/ha exceeds it for only 23% of the time. However, Poplars at 50 stems/ha never reaches this threshold.

Widely spaced Poplars comment.

Widely spaced poplars are better than nothing, but in many instances may not be as effective in preventing certain forms of erosion as deep seated slumps and large active earthflows.
However, when using Poplar and modern varieties of willows can be very effective in localised erosion prevention e.g., specific microclimate site, stream bank erosion, tunnel gullies and in particular when planting about 100 trees per ha, rather than 20-50 stems /ha.
(This research work was carried out at Patoka NW of Napier as part of the MAF Sustainable Farming Fund- Newsletter No 1, 2001yr).

Forestry and Water quality

Retaining intact riparian management zones during harvest as well as maintaining low light levels and temperature. Can help filter out sediment & any nitrate. (Ref Water Quality, Scion August 2017).

Planted forest produce high water quality for a large component of the forestry cycle, providing a valuable community service to downstream users. To realise the maximum benefit, the forest sector operates under the RMA and the NES-PF regulations plus a range of invaluable working manuals e.g., the NZ Roading Manual, NZ Environmental Code of Practice for Plantation Forestry and sometimes associated with Forest Stewardship Council (FSC).

Improved water quality is delivered downstream from forest cover due to less soil erosion, less streambank erosion, less surface runoff and less nutrients. (Quinn 2005). Plantation forest cover also reduces nutrient levels in both groundwater and surface runoff when compared with pastoral land

use. Furthermore, pine plantations export much less nutrient than pasture because of the uptake and retention of nutrients by trees, along with their low fertiliser requirements.

Fahey and Rowe (1992) have highlighted the impacts of changes in vegetation (e.g., clearance of vegetation or afforestation) on catchment hydrology has been well highlighted.

Furthermore, there is some valuable research findings from the monitoring results from the Glendhu Forest (Rayonier Matariki Forests near Lawrence). In the late 1970s a paired catchment (310 ha) was planted in pines (67% that catchment) while the adjoining catchment (218ha) was left in tussock and some scrub. In 2014 harvesting began on the pine tree catchment and was completed about 2018 then replanted. The paired catchment results provide some invaluable data on changes in water yield and sedimentation from the large V-Notched weirs.

Forestry and Soil Quality

Soil Quality is a measure of soil health and includes the soils biological, chemical and physical condition. Planted exotic forests soil data shows they meet the soil health targets for soil acidity, fertility, organic reserves and physical status. (Ref: Planted Forest Soils, Scion August 2017).

Radiata pine have been shown to improve soil quality e.g., rotation on clay heavy soils or on gravels or coastal dunes as they increase the organic matter and litter layer. Soils are sensitive to forest management. Nutrient supply from one rotation to the next especially when harvest the trees.

The impact of harvest activities on soil fertility depends on the size of the initial soil nutrient pool, vulnerability to soil disturbance and the numbers of harvesting events over time. In general sites at risk is where there is low nutrient pools.

Avoid compaction by machines as they can have a negative affect on the soils ability to hold supply of water and to function as a rooting medium. In Otago the fine textured soils and wet soils tend to be the main issue. Improve the compaction situation by ripping the sites which will increase aeration, improve rooting depth and better drainage.

Forestry and Nutrient balance.

Several international studies have shown productivity of second or subsequent rotations of plantation forest to be similar or higher than that of first rotation crops. Few comparable inter-rotational studies have been undertaken in NZ to date.

Stone and Will (1965) found evidence of chronic nitrogen deficiency in second-rotation radiata pine, as opposed to first-rotation crops, in the Nelson District but could not offer no convincing explanation for the difference. The type of geology in the Nelson district and pines on Moutere gravels can show nutrient deficiencies (various management issues suggested).

In summary there is a dearth of evidence that second-rotation crops of radiata pine in NZ show reduced yields in the absence of poor management practices. However, where good management practices are carried out such as windrowing slash and not disturbing the soil, ripping, discing, weed control and fertiliser applications have demonstrated marked yields.

Leaching losses under forestry are considerably lower than other pastoral farming systems. Calder (1993) listed values from a range of tree species and countries. Nitrogen was generally below 2kg/kg/ha/yr. Losses of nutrients have been calculated following harvest and also compared to pastoral losses. As long as the current practice continues of removing only stem wood (plus or minus bark) at harvest, nutrient losses at harvest will be minimised (carbon, hydrogen and oxygen are not

considered nutrients). There has been an ongoing discussion re growing pines and other tree crops increasing the acidification of the soil. It is well recognised in pastoral farming where lime applications are required.

Will and Ballard (1976) commented that evidence in NZ would indicate that in the case of pines do no irreversible harm.

Pines undeniably alter properties of the soil surface, by lowering pH and earthworm numbers, by mineralising certain nutrients and making other less available, or by tying up some nutrients in vegetation.

It is suggested that the long-term limiting nutrient factor in production forestry is probably potassium (Maclaren P. 1996).

The most common deficiencies in production forestry in Otago are for Nitrogen, Phosphorus and trace element B (Boron). Potassium, Calcium, Magnesium and copper less frequently seen and Zinc, sulphur, manganese and Iron are very rare. Magnesium noted as yellowing in the mid crown area in pine trees.

Summary

This report has only presented a brief overview and set the scene on the issues with afforestation and related types of other forestry land use including exotic and native plantings in Otago. The summarized appendices (Nos 1-5) outline some of the main key issues along with current recommended Best Environmental Practices (BEP) for forest management. A brief snapshot synopsis is included on the National Environmental Standards for Plantation Forestry (NES-PF) and link to some Otago Regional Council rules and policies.

Further work may be required to highlight specific management issues and framework for the ORC when formulating policy objectives and regulations as part of the development of the Land and Water Regional Plan for Otago.

Report Prepared by: **Dated 8th October 2021.**

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Appendices

Appendix 1 Otago Regional Council- Forestry Issues, Best Environmental Practice & Mitigation.

Appendix 2 Examples of Forestry Production and Farm Forestry Best Environmental Practice

Appendix 3 Thresholds Summary on General Forest Activities-aligned to NES-PF for Otago

Appendix 4 Forestry Assessment of Environmental Values and Issues Matrix for Otago

Appendix 5 Forestry Assessment- Ranking of Six Environmental Issues for Otago

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NZ Planted Forests Environmental Facts series.
Refer to NZ Forest Owners website www.nzfoa.org.nz
Examples -"Water Quality" Scion- August 2017

-"Planted Forest Soils" Scion- August 2017

Refer to additional Supplementary notes & information to be provided later from the report author.

Activity-General	Issue-General description (causative)	Effects and Impact on the Environment	Best Environmental Practice (BEP) and Mitigation Management	General Matters
SEC 1.. GENERAL INTRODUCTION	***Definition of Plantation Forestry*** *(under the NES-FP) means a forest deliberately established for commercial purposes being at least 1 ha of continuous forest cover of forest species (that will be harvested or replanted), includes all associated forestry infrastructure. A forest species capable of reaching 5m in height at maturity.* Other forest areas include.. -Small farm forestry woodlots (a range of tree species) as shelterbelt trees (especially belts that are wider than 2-3 rows) and areas of trees that maybe less than 1 ha of continuous forest cover. Includes open planting of e.g., Poplar & willow poles or other selective species as Eucalyptus or may include Riparian sites with exotic & native tree spp.	As below	Refer to Appendix 1 and 4 for a summary table of BEP in Otago region Trees specifically planted to stabilise eroding slopes or as in the case of tunnel gullies/ gullies on loess covered hill land planting poplar and selective willow trees (as poles or rooted seedlings with individual protective covers) therefore enabling stock to graze within the paddock. Reduction in fine loessial material downslope and into waterways. See below	In general the Appendice focus is on exotic tree plantings in Otago. However larger sized areas being planted in natives may warrant environmental BEP when establishing natives e.g., on unstable slopes or streambanks or sensitive areas. Exotic and native species could be established for carbon sequestration use.
SEC 2.. AFFORESTATION In general this is the planting and growing of plantation Forestry trees.	Not so much related to the planting of trees but the location and effects.	• Soil slip/gully/sheet erosion (due to weight of trees/steep slope/soils-Geology • Offsite sediment into waterway/ponds and estuaries	• Harvest Plan-check out ESC risk • Permitted consent or not ? • Wilding removal or long term options for control • Not planting within a Significant Natural Areas (SNA) or Outstanding Natural	Wilding tree risk calculator and Wildings remove, or spray, limit species planted.

		• Water Quality-ecosystem • Flood debris and silt deposition on prime land e.g., horticulture (lower catchment areas) • Landscape/amenity (e.g., shading, modify ONF and SNA) • Potential for Wildings • Fire Hazard (Timber fuel loading)	Features (ONF) or Visual Amenity Landscape (VAL) & other Landscape features. • Set backs in place-see Rules • Animal & Plant Pest Management Rules/advice • Replant in other species (new conifers-e.g., no coning/seeding) • Riparian buffer strip • No burning in specific areas • Water quality monitoring programme-note trends over the forest growth cycle.	Are the trees for production or carbon or multi use?? Consider best species for the use of the site and the productive or non productive objective.
SEC 3.. PRUNING AND THINNING…… + Silviculture aspects	May include need for tracks to carry out the operation (slope, geology, soils, other vegetative cover)..refer to earthworks and other. Various forest Managers carry out different regimes e.g., 2 pruning lifts and 1 thinning or just 1 thinning. May depend also if carbon forestry objective is prime outcome of the trees and forest block.	• Generally limited adverse environmental effects. • Deposition of slash in WW or near water bodies-impact on water flow, quality and aquatic life. • Slash issues can be carried away in flood periods (can form problem dams) and into coastal areas/estuaries. • Impact on bridges, culverts etc	• Plan in advance • Generally a *permitted activity* for pruning & thinning to waste [Reg 20 (1)].. SLASH must not be deposited in a water body, into Coastal water • Construct tracks early on, oversow-regrass batters, proper water tables and other infrastructure. • Carry out the in drier months • If production thinning planned is best not on steep slopes (e.g., Douglas fir timber). • Pruning/thinning trees use experienced silviculture contractors-slash placed well	If trees are planted in correct areas/zones i.e., setbacks and away from WW should be less issues now. Pruning/thinning early means smaller branches and less green waste. Refer to Earthworks Sec 4 on this table.

			away from WW and infrastructure etc.	
SEC 4.. EARTHWORKS Disturbance of land by the movement, deposition or removal of earth, rock & includes construction of roads, tracks, landings, river crossing approaches, cut and fill & upgrade of existing earth works and other	In general not including Sec No 6 & 8. Minimum earthworks is suggested and depends on what year the forest rotation cycle is at eg new harvest roads maybe be only constructed 1 year in advance of clear felling mature trees. In particular slopes over 25 degrees or to the extreme slopes over 35 degrees. Side cutting of 2-3m and greater. Deposition of 500 cubic m of spoil/fill and greater volumes. Is it road-track maintenance or new Roading. Skid Sites, processing sites See also nos Sec 7, 8 and 9 of this report..	• Accelerated erosion due to slope instability and bare soil- regolith exposure. • Collapse of slopes & sedimentation into WW, deposition downstream onto prime farm and, horticultural lands/wetlands • Bare subsoil exposed • Encouraging plant pests ingression. • Water quality and instream damage on biota, impact on healthy vertebrates and invertebrates. • Issues with poor design water tables, no cut offs on soft fill • Gullies can occur on deep deposits of local loess material and Taratu gravel/sands. • General rubbish and contaminants from machinery use (eg oil containers, grease	• Refer to and use the ESC Map and FSI Map.!! Also WTRC. • Is *Resource Consent* required ? • If Earthworks involve more than 500m3 of soil disturbance in any 3 months period Council must be given written notice of location AND require a *Forestry Earthworks Management Plan* [Reg 27]. • Refer to [Regs 20-Regs 31] • Sediment mitigation with practical management plan, setbacks, sediment and storm water control measures. • Road design and engineering structures & construction • Care when using spoil and fill material that it is not scoured after heavy rain. • Use *Corduroy road* stabilisation where fill material/spoil maybe soft, unstable- erosion prone. • Proper design water tables with suitable grades, cut offs (esp on skidder tracks), berms, culverts and where practical divert water into sediment control structures.	***5 key factors to consider when carrying out earthworks i.e:*** *-location* *-timing* *-stabilisation* *-appropriate erosion & sediment controls* *-Maintenance* Check- ESC is it in a red or orange zone & slope over 25 deg, amount of deposition (500m3). Sediment from Earthworks must be managed to ensure that after reasonable mixing it does not cause a change in colour or clarity, or water is unsuitable for farm animals and has no significant adverse effect on aquatic life.

		cartridges, diesel spills).	• Oversow and topdress bare slopes • Use new Drone technology for oversowing on difficult terrain or sensitive areas. • Ensure rubbish is collected and waste oil is stored-removed off site and spillage is contained.	Consider using technologies as drones for seeding batters/earthworks Sediment control measures see Appendix 2
SEC 5.. RIVER CROSSINGS (Riv Cr) These are defined in NES-PF as a structure that is required for the operation of a plantation forest & provide for vehicle or machinery to cross over a water body & includes an apron and other structures and materials to complete a river crossing.	River Crossings are regulated activity under Regs 5(1)(d) of the NES-PF. Regional Council functions apply under Sec 30 of the RMA. Does not include a storm water culvert or a culvert under a forestry road or forestry track. River crossings require good design, installation and on-going maintenance to minimise adverse environment effects. Note size of waterway and depth, flood history/morphology and hydrological records.	River Crossings required for access but in general the adverse effects include: • Sedimentation of suspended material and bed material in construction & use of • Restricting or preventing fish passage • Activating or increasing bed erosion • Ingressing plant pest growth (eg broom, gorse, honeysuckle, Crack willow weed etc) on edges of crossing or near abutments • Old flood debris build up-near culverts & bridge abutments & cause further scouring/flooding	• Existing river crossings need to meet performance standards [Reg 39-42] when they are upgraded, replaced or removed. • Types of RC where Permitted Activity apply for eg Existing RC, Single culvert, Battery Culvert, Drift deck, Ford, Single Span bridge, Temporary river crossing and single Span bridge (Refer to specific Regulations). • Refer to the ESC Map and FSI map for details on erosion vulnerability and fish species ecology for the location. • Must provide for upstream and downstream fish passage in most cases (some exceptions). • Surface water to be diverted away from abutments • Notice must be given to Regional Council for construction or removal of Riv Cr.	Can be issues to determine whether a Resource Consent is required. Refer to (figure 9) flow chart NES-PF Regs Document. Records of flood history and old photos can be invaluable.

		• Ongoing erosion, sedimentation and damming-loss of integrity of structures, safety issues.	• Riv Cr must not be constructed in a wetland larger than 0.25ha, and other matters such as a SNA, within an outstanding freshwater body and others [Reg 43] • No contaminants be discharged into water & other matters [44] • Engineering design, construction to protect the infrastructure and enhance flood way management. • Stabilise stream bank by planting or engineering structures. Planting riparian zones on either side of RC. • Ongoing control of plant pests that can impact on the RC.	
SEC 6.. FOREST QUARRYING Means the extraction of rock, sand, or gravel for the formation of forestry roads and construction of other plantation forest infrastructure, inc	Does not include earthworks, mechanical land preparation, or gravel extraction from the bed of a river, lake, or other water body.	Forest quarrying can have similar adverse effects to earthworks (See Sec 5 above) especially in relation to soil/slope stability, sedimentation on water quality. Other effects include: • Landscape changes and vista-visibility • Amenity values (noise and impacts on bird life).	• **A Quarry Erosion and Sediment Management plan** is required where the volume of material extracted exceeds 200m3 in a calendar year (refer to REGS). • Check Permitted Activity uses. • Setbacks for river, wetland and lake larger than 0.25ha • Overburden must be placed safely and not to cause slope failure-erosion. Must be stabilised within 6 months	Monitor water quality downstream-take samples if required to note trends. Be aware of any Environmental considerations if quarrying on non-forested land (e.g., neighbouring land).

landings, river crossing approaches, abutments and tracks. Also includes extraction of alluvial gravels outside the bed of a river and stockpiling at the quarry site.		• Human health-dust/noise. • Overburden material e.g., loess, colluvial material. Earthflow and gully erosion prone land. Where is over burden placed eg possibility sediment in nearby river. • Location near to 'SNA", or a "ONF" or a significant wetland Or e.g., DOC land.	• No topsoil stripped to be removed from property. • Relandscape, regrass and or establish shrubby-tree vegetation. • Sediment and stormwater control mitigation-BEP action. • Sediment control measures may require silt detention structures/other means. • Dust management control • Traffic management control • Check aquifer regulations depending on location	
SEC 7.. HARVESTING Normally includes clearfelling (whole stand of trees) but also production thinning and low intensity harvest (maybe a sensitive area of land, unstable or amenity values).	Harvesting is defined in the NES-PF as felling trees, extracting trees, thinning tree stems and production thinning, then processing trees into logs, or loading logs onto trucks (other transport options) for delivery to processing plants. Does not include milling/processing of timber or clearance of vegetation not plantation forest trees. Harvesting can be ground based or by aerial methods (cable techniques) on steep slopes, unstable slopes.	Harvesting can have a range of environmental effects depending on the intensity of use, site activity, climatic influence, type of felling and others. Common effects include: • Slash from harvest entering water, damming or diverting flows-build up of sediment • Slash impacting on infrastructure (abutments, culverts, bridges etc) • Tracks and skidder tracks runoff and sediment discharge	• In relation to the NES-PF criteria a **Harvest Plan** is required on all ESC Zones. Refer to [REGS 66]. • Check which activities are Permitted. • Consider low intensity harvesting in orange/red zones (eg only use aerial cable hauling or helicopter use). • *Where located in orange or red zone* must be accompanied by Earthworks plan (see Sec 4). • A considerable number of BEP controls closely can be used as for *Earthwork* (See Sec 4). • Sediment from harvesting does not give a conspicuous change	In some cases monitoring of rivers (sensitive catchments, special aquatic life), commence water sampling before harvest, in the harvest and post harvest to note trends & for future management plans e.g., buffer zones, species to plant, & setbacks. Note the hydrology records of the forest area & the area

	Harvesting in this report also includes areas not defined under NES-PF as.. ..Small farm forestry woodlots (a range of tree species) including shelterbelt trees (especially belts that are wider than 2-3 rows). -Areas of trees that maybe less than 1 ha of continuous forest cover.	• General soil disturbance from machinery movement e.g., skidders hauling logs, Forwarder use • Soil erosion post harvest period-tree root decay and loss of vegetative cover. • Damage to and loss of riparian vegetation • Damage to stream banks when removing fallen logs in and near streams. • Soil compaction on tracks, skid sites-processing sites.	in water colour or visual clarity or does not make fresh water unsuitable for farm animals or no significant effect on aquatic life. [Reg 65] • Disturbed soil must be stabilised or contained. Use of diversion/dams or temporary fabric-geotextile structures (silt traps). • Tracks need cutoffs, water tables and on unstable slopes consider flumes (can be temporary). • Fell trees away from water body/riparian zone • Rivers wider than 3m full suspension of logs must apply • Setback Rules 5m, 10m and 30m [See REGS 68]. • Slash to place on stable ground and be also managed if in piles that they do not collapse (e.g., near landing sites) • Be aware where slash is placed so not to be in a flood zone. • Create Slash no-go zones • Steep unstable slopes use skyline machines/cable hauling or high tech remote Controlled Tree Harvesters.	within a subcatchment or larger catchment when proposing to harvest a large area. In strategic water short catchments consider harvesting smaller Coup areas or the timing of the year e.g., in spring.? Another option in water short catchments is to thin out tree spacing wider (so no closed canopy so rain falls directly onto the ground). Look at replanting different tree species that have a longer rotation e.g., Macrocarpa, Douglas fir and Redwood. Note in some cases temporary bridges (e.g., from recent felled trees) can be

			• Use LIDAR technology to assess sensitive/unstable land pre harvest…assist planning. • Rubber tyred machines & cable hauling to minimise soil compaction	used to transport logs safely over a WW where NO Resource Consent is required-however at the completion of harvesting the site that bridge must be removed and site returned to natural.
SEC 8.. MECHANICAL LAND PREPARATION	Mechanical Land Preparation is a regulated activity under Regulation 5 (1)(f) of the NES-PF. Is defined as using machinery to prepare land for replanting trees, including root raking, discing, ripping, roller crushing, clearing slash, and mounding the soil/subsoil into raised areas. However, it does not include creating alternating drains/mounds. Also includes: -mechanical cultivation (Rip/mound) -spot cultivation -mechanical raking, mulching, -windrowing & discing to clear slash and prepare site for planting -roller crushing of weeds /woody debris ready for planting. -Other options.	• Sediment discharge to waterways causing effects on freshwater quality and aquatic ecosystems • Storm events initiating Rill/sheet/gully erosion • Sediment created by using blade on dozer and removing all vegetation-bare exposed soil. • Using a standard dozer blade, pushing down hill soil into gullies, windrows Into WW. • Placing slash and soil into piles or lying up and down slope • Impacts on indigenous	• Check to see if Resource Consent is required [Reg 74]. • Check to see the ESC and zone colour of site area in particular land over 25 degrees slope • Check to see Indigenous Vegetation rules. • Mechanical land preparation must be carried out on the contour (e.g., into windrows) where possible unless it is deemed unsafe (e.g., for roller crushing, downhill ripping) • Use correct designed Root Rake attachments on Excavators • No downhill ripping on land with gully or tunnel gullying erosion ESC risk as severe or greater. • An alternative option to root raking scrub/weeds is to apply herbicide aerially	In general, the stabilisation of bare exposed areas must be carried out as soon as practicable after the completion of the mechanical land preparation. Using herbicides and selective chemicals the requirement for a *Growsafe Certificate and or a Certified Handler and Spraying Contractors approval*. Compacted skid sites and temporary tracks may be ripped prior to planting-best on slopes less than 10 degrees and on the

		Fauna/flora from using mechanical means • Activating unstable slopes, removing toe slopes (e.g., new track) and stream banks disturbance • Soil-subsoil compaction	• In sensitive areas use larger capacity Drones for spraying. • Sediment from mechanical land preparation must not cause a conspicuous change in colour or visual clarity, and not causing fresh water unsuitable for consumption of farm animals and must not cause adverse effects on aquatic life. • Note Setback rules depending on site/location • Control and mitigation options to minimise silt/debris into waterways refer to Earthworks Sec 4 & App 2 (this report).	contour (not downhill).
SEC 9.. REPLANTING	Replanting under the NES-PF is defined as the planting and growing of plantation forestry trees on land less that five (5) years after plantation forestry harvesting has occurred. NOTE- if the 5 yr period is exceeded the activity is no longer replanting but is instead treated as Afforestation (see Sec 2). The second rotation of trees may have a more optimal soil and organic matter layer available (from first	• The potential environmental effects of replanting are similar to AFFORESTATION (Sec 2) but generally less impact. • Forest infrastructure is in place and should be well maintained hence less likelihood of major silt, debris transport to WW. • However major storm events can occur. • Wilding tree spread can be an issue	• Check on permitted activity and conditions required • Check on rules over distance of Setbacks in particular must not occur in any area closer than the stump line to an adjacent Significant Natural Area (SNA). • Replanting must not occur in any area closer than the stump line to an adjacent: -perennial river -wetland or lake or Coastal marine area or SNA. • Note Setback conditions of 5m, 10m and 30m different conditions & settings [Reg78].	Consider animal pest control where rabbit/hares/possums are destroying new forest exotic and native seedlings as well as feral animals as deer, goats, pigs. Replanting sensitive areas or difficult locations/terrain or unstable sites then it is recommended using Drones to over sow bare area with appropriate seed,

	rotation) resulting in better growth rates and less risk for ground erosion.	• Smoke pollution from burning of windrows and scrub cover (See section 2 and 8).	• Wilding Tree Risk Calculator-Condition to assess the 6 class Calculator to see the impact that various tree species may have on the local environment and neighbouring land before replanting. Score must not exceed more than 12-action is required. Refer to [REG 79] • Wilding conifers established in wetlands and SNA must be eradicated (see conditions). • Refer also to ORC Regional Pest Management Plan. • Using Drones on specific land.	fertiliser or alternatively suitable exotic native tree seeds to survive. Consider planting conifers as Pinus attenuata or P Radiata x P attenuata (closed cones-often sterile) -less spread. Growing at Wenita Forest at Mahinerangi
SEC 10.. OTHER GENERAL MATTERS Other Provisions -fish spawning -Noise & vibration -Dust -smoke/pollution -Indigenous bird nesting -Fuel storage and refuelling.	Section 7 NES-PF Manual p116 **Guidance of general Provisions and Requirements.** Regulation 97 provides specific conditions to manage the effects of plantation forestry activities **on Fish Spawning.** In particular discharges of sediment, disturbance of the bed or a river or lake or of a wetland, and diversions of water in terms of the effects on fish spawning. **The Fish Spawning Indicator groups** fish species and their spawning periods into 2 sensitive classes as:	**Note general impacts on:** -Fish spawning timing & disturbance of the bed of river or lake or a wetland -Noise and vibration -Dust -Smoke/pollution -Indigenous bird nesting -Fuel storage and refuelling	• Need to refer to the ***Fish Spawning Indicator calculator***. If it is complied with [REG 97(3) and (4) then it is a permitted activity. In particular must comply with: - Pruning and thin to waste [REG 19(2) &20 -Earthworks [REG 24-33] -River Crossings [37-46] -Forest Quarrying [var REG] -Harvesting [var REGS] -Mechanical land prep [REG 73(2) and 74] -Slash Traps[REGS 83(2), 84-91]. • Monitor special areas to assess fish population trends &	**Check if a Forest Management Plan exists.??** **Is the Forest area registered under the FSC Accreditation scheme.** This should highlight important ecological inventory such as important flora and fauna e.g., fish, birdlife. What management plans exist for e.g.,

Consider Historical and heritage management.	**Group A-**Salmonids or species with a conservation status of threatened or at risk and **Group B**-Species with a higher sensitivity to disturbance. Other matters to consider in forest management including small woodlots to large forest estates. **Forest Protection-** Various management systems and protocols in relation to.. -Forest Fire and management -Plant pest and animal pest -Monitoring forest health & disease -Security and trespass issues (e.g., hunting -Infrastructure monitoring e.g., bridges, Flood silt build up blockages.		species- use scientist to carry out field trials/monitoring. • Special ecological monitoring where important birds are nesting e.g., Harriet Hawks and native Falcons, Owls and the like-may need to defer harvesting a forest coup or establish a new site. • Refer to the ORC Regional Air Plan and [REGS} • Indigenous bird nesting REGS to be followed where the birds are known-also train staff to monitor/observe and record. • Fuel must not be stored, machinery must not be refuelled and oil not changed in any location where fuel can enter water-[REG 104]	endangered or vulnerable birds and fish. *Refer to Forest Owners Association Rare Species website.* *Check to see no QE2 Covenants adjoining!* *Check to see no DOC reserves and the like adjoining or down stream.!!*

NOTES and Glossary

- **<u>The summary table (Appendix one</u>**) above generally highlights a range of activities with common forestry management and the growing of trees. The framework used and the general activities are based on the NES-PF categories but is not inclusive. Other types of planting e.g., soil conservation, and flood control, wide shelter belts, riparian planting, carbon planting (exotic or native) as some examples Manuka etc.
- **National Environmental Standards for Plantation Forestry (NES-PF). May 2018.**
  Under the NES-PF there are 3 Risk Assessment tools (which can initiate threshold levels) as follows:
  (1) Erosion Susceptibility Classification (ESC) where 4 categories of risk assessment i.e., Low (green), Mod (yellow), High (orange) & very high (Red).
  (2) Fish Spawning Indicator and (FSI Map)
  (3) Wilding Tree Risk Calculator (WTRC).

<u>Refer to Appendix 3 which highlights</u> some of the threshold levels that are triggered when assessing a new site or operational forestry work.

- **Where SNA** means “Significant Natural Areas” & **ONF** means “Outstanding Natural Features” & **VAL** “Visual Amenity Landscape” (Page 38 NES-PF).
- WW is waterways and River Crossings (see Riv Cr)
- Where [Reg No] refers to examples of regulations under the NES-PF legislation.
- Where FSC is the Forest Stewardship Council. Is an international non-profit organisation to promote responsible forestry. http;//info.fsc.org.

Examples of Forestry Production & Farm Forestry BEP and Mitigation **APPENDIX TWO**

Specific issues	Best Environmental Practice (BEP) and Mitigation options	General comments
Sediment, Storm water and Water runoff Control measures.	Not a complete list: -**Silt Fences** -to intercept sediment laden run-off and filter out larger material. Using filter fabric using different height and stabilised with uprights-is a short-term solution until site settles down, revegetates -**Sediment traps** (help settle out heavier sediment laden water-best near roads best to use for mobile sediment). -Often **called Slash Traps-**defined as a structure set in a river, or the bed or a river, or on land to trap slash mobilised by water see [REG 5(1)(1). Common use after harvest -**Soak holes** (best in sandy soils/material-water can drain away, soak in). -**Sediment retention ponds**-larger that silt traps -care on site/soils/geology -Water table drains. Aim to direct water away from causing erosion to cut offs & culverts. -**Flood Detention dams** can also act as sediment traps/collect larger material. -**Sump holes** at direct invert area of the culvert (or in some cases flumes. A small hole where water draining from a water table can deposit heavier silt to be captured in these sumps. Need cleaning out each year. **-Flumes**. Help protect fill areas and steep batters from erosion, conveying water from culverts to safe zones. Water can be directly into slash or silt traps -**Mulch** and similar vegetative material e.g., straw, bark, other woody material to minimise rill and sheet erosion. Maybe a quick fix in winter. -**Hydroseeding**. Expensive but if the machinery is available to protect mobile sandy steep batters, windblown material then it is feasible. -**Oversowing** by hand or machine. Care on seed type/mix and fertiliser.	See definition sec 4.8 NES-PF

	-**Wetlands** natural or manmade using a variety of vegetation eg flax, toi toi, sedges, Tussocks and the like can help trap fine sediment. Very beneficial on small floodplain areas where runoff flows onto neighbouring pastoral land.	
Stabilising & Mitigating Earthworks-various types	Not a complete list: -**Using excavators** and or dozers benching vulnerable slopes -**Planting of vegetation** either short cover pasture/legume type material (Over sow) mitigate particle erosion (e.g., rill, sheet, wind, gullying erosion) or taller cover with suitable root systems for deeper slope stability. Planting of shrubs and forest trees either exotic (e.g., Pines, Eucalyptus, alders, Blackwoods or native depending on site and location. Other options to use shrub willows or as vegetative material which is layered and knit together to act like a barrier. Various options depending on severity of the erosion and site. -**Hydro seeding**. Spray seed mix onto batters especially where infertile sites. -Spreading various types of **Mulch** -Using **weed mats and geotextile** covers (wired down) over banks/batters -**Applying slash** in some sites e.g., old manuka branches (will reseed naturally) and minimise water scouring and act as a filter. -**Engineering design and structures** depending on site and importance of the asset to be protected e.g., steep batter at entry of a large logging bridge. Use of rock gabions, rock baskets, driven in (steel or wooden poles/piles), large rocks and the like.	

General Thresholds Summary on Forest Activities-aligned to NES-PF for Otago **APPENDIX THREE**

First Threshold	First Threshold		Second Threshold	Second Threshold	General
ACTIVITY	SITE RISK	MEASURABLE LIMITS			
2.. Afforestation	ESC	--	Wildings	Setbacks	
3.. Pruning & Thinning	-	--	Setbacks	--	
4.. Earthworks	ESC	Volume and Area	Sediment/Fish	Setbacks	Management Plan
5.. River Crossings	?	Flow Rate	Erosion/Sediment/Fish	By Crossings type	
6.. Forest Quarrying	ESC	Volume and Area	Erosion/Sediment/Fish	--	Management Plan

7.. Harvesting	ESC	--	Sediment/Fish	Setbacks	Management Plan
8.. Mechanical Land Prepn	ESC	--	Sediment/Fish	Setbacks	
9..Replanting	ESC	--	Wildings	Setbacks	
10.. Ancillary Activities	--	Area	---	---	
11.. General provisions	--	Indigenous Veg REG 93	---	---	Bird Nesting/Fuel

Forestry Assessment of Environmental Values and Issues Matrix for Otago **APPENDIX 4**

Environmental Values/Issues

Forestry Operational activities	Erosion & sediment control	Water Quality	Water Quant	Air Quality	Soil Conservation And quality	Aquatic Life	Native Wildlife	Native Vegetation	Historical & Cultural Values	Landscape Visual Values	Neighbour	Public Utilities	Recreation Values
Mechanical Land Preparation	●	●	●	●	●	●	●	●	●	●	●	●	●
Burning	●	●	●	●	●	●	●	●	●	●	●	●	●
Stream Crossings	●	●	●		●	●	●	●	●	●	●	●	●
Agri chemical use	●	●		●	●	●	●	●	●	●	●	●	●
Earthworks	●	●	●	●	●	●	●	●	●	●	●	●	●
Planting			●					●	●	●	●	●	●
Tending		●				●					●	●	●
Fertiliser application		●		●	●	●					●	●	●
Oil & Fuel Management		●	●		●	●	●	●	●		●	●	●
Waste Management		●	●		●	●	●		●	●	●		●
Harvesting	●	●	●	●	●	●	●	●	●	●	●	●	●
Slash Management	●	●	●	●	●	●	●	●	●	●	●	●	●
Forest Protection	●	●				●	●	●	●		●		●

Source based on "NZ Environmental Code of Practice for Plantation Forestry Part One BEMP. (Version 1 2007 page 5).. Abbrev by M J Harris.

The process of assessing risk due to operations is shown above as "Assessment of Environmental Effects". The matrix table is useful in matching key environmental values/issues that are potentially adversely affected by given forestry operations activities in the Otago region.
Refer to Appendix 5 for a more detailed but only an indicative assessment and ranking of 6 key common Environmental Effects in Otago.

Forestry Assessment Ranking of Six Environmental Values and Issues for Otago **APPENDIX 5**

Forestry Operational activities	Erosion & sediment control	Air Quality	Soil Conservation And quality	Aquatic Life	Water Quality	Water Quantity	General comments
Mechanical Land Prepn	4+	2-3 Dust	3-4 Planting unstable land	4 Ecology impacts	4+	4 Size of area/rainfall	Type of soil and regolith, slope angle and vegetation cover
Burning	2-3	4-5 Smoke	3	4 Ash on water	3 ash maybe temporary	4 as above	Could be escaped fire/natural. Impurities on water
Stream Crossings	3-4 Construction	1	2-3	4 Fish ladders etc	4 Construction Discolouration	3	Fords may cause more sedimentation/turbidity esp
Agrichemical use	3	3 spray drift	3	4 If spray drift	4+ Check MSDS & HAZNO Req	1 dilute spray ?	May kill protective plant cover or Sensitive/native bush-neighbours
Earthworks	4+	2-3 Dust	3-4	4-5	4-5	1 not sure	Stream bedload
Planting	1 Manual 2 Machinery	1	2	1-2	1	3 *	* Depends if water short catchment-can thin out trees more
Tending	2 ?	1	1	1-2	1-2	1 **Runoff	**Thin out trees, remove canopy cover so more interception
Fertiliser application	2 Tree nutrient deficiencies	3? Onto waterways	2 may need for deficiencies	2+ is not common	2	1 dilution effect	Usually small application rates by helicopter-using trace elements
Oil & Fuel Management	2	1	2	3-4 Spill	3-4	2-3 dilution effect	Unless accidental spill
Waste Management	2	1?	2+	3 not common	4?	2	Should be a specific forest management Plan
Harvesting	4 steep slopes, loess, colluvium	1-2 ?	2-3	4-5	4 Silt loading, debris, flooding	3-4 flood impact	Depends on site, Operative Management Plan
Slash Management	3 windrow slash	1-2 ORC Rules	2+	3-4 remove slash	3-4??	3+ could be flood issue	Harvest management plan to highlight slash mitigation.

Forest Protection	2-3 Forest fire Storm/erosion	Fire	2-3 Plant Pest & animal pests	2	3	1	Monitor forest health & disease security & trespass. Infrastructure eg erosion/blockages.

Refer to the main Appendix 4 *Source based on NZ Environmental Code of Practice for Plantation Forestry (Version 1 2007).. Abbrev by M J Harris.*

This table is based on the potential risks, the impacts & effects that could result on 6 key environmental Forestry issues. It is based on 13 potential operational activities. The risks could be natural events as storm damage or escaped fire. **Note: The Risk assessment is indicative only & based on M. Harris knowledge as Ranking eg: 1 =Negligible, 2= Low, 3 =Moderate, 4= High, 5= Very High risk (ie based on likely effects-not peer reviewed).**