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Southland Forestry Profit Analysis

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Executive Summary

This report describes the set of assumptions and approaches used to estimate the financial returns ($/ha) from plantation Pinus radiata and Douglas fir forestry in Southland. The spatial economic framework used to estimate the financial returns is called the Forest Investment Finder+ (FIF+) developed by Harrison et al. (2012). GIS surfaces produced by the FIF+ framework represent the estimated returns that could be expected for establishing these two plantation forestry types on new areas of land across Southland.

Results indicate that the distance to the final destination of the harvested timber has a major impact on the profitability of planation forestry and areas within 50km of Invercargill show the greatest profitability. The data is represented by maps in this report.

Estimated revenue from carbon is also calculated. Estimates are reported for four different prices, New Zealand Units (NZUs) $6, $10, $15 and $25. Returns from carbon are determined by the productivity of the location and areas of high productivity show the greatest return regardless of distance from Invercargill. The resulting data is again represented by maps in this report.

The description of the avoided erosion component of the FIF+ framework estimates the reduction in erosion/sediment yield (tonnes/ha/yr) by changing land use from the status quo to forestry. Results indicate that afforestation would reduce sedimentation rates across Southland (approx. 13%). In absolute terms this would, in fact, be a small reduction as the sedimentation rates in Southland are already low.

The outline of the expected impacts of the proposed National Environmental Standards for Plantation Forestry (NES-PF), outlines impacts that the NES may have on the overall economic and environmental performance of planation forestry in Southland. Due to the low erosion risk of much of the available land for forestry within Southland, it is suggested that the proposed NES-PF will have minimal economic and environmental impact.

All maps presented in this report are available as separate GIS layers.

Harrison, D.R, Barry, L.E., Palmer, D.J, Kimberley, M.O., Turner, J.A., Hock, B.A. and Hall, P. (2012). Developing a forest investment finder for New Zealand. Technical Report. Future Forest Research, Rotorua.

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Spatial Economic Framework (Forestry Investment Finder+)

Key assumptions

Cost and price assumptions

While all data on costs and prices are estimates, there has been consultation with forestry professionals to match, as closely as possible, with how the sector operates in Southland. However these may not represent site specific costs precisely.

Data was created for a blanket cover (excluding urban, water bodies, wetlands, Department of Conservation areas, and areas with an annual average temperature of below 8°C) of a Pinus radiata **General Unpruned** regime, thinned to 500 stems per hectare (stems/ha) from initial planting of 1200 stems/ha, with a rotation length of **28 years.** This is also done for a Douglas fir regime, thinned to 600 stems/ha from an initial planting of 1600 stems/ha, with a rotation length of 40 years.

Unless otherwise stated, the costs for Douglas fir are assumed to be the same as the Pinus radiata regime.

A discount rate of **8%** is used as it broadly represents the range of discount rates used currently by forest growers for forest market valuations.

Prices for timber (Table 1) were based on an average price for each grade over 12 quarters, (June 2012 – June 2015, inclusive), taken from Ministry for Primary Industries (MPI) indicative log price reports [1] and AgriHQ log price database [2]*.

Table 1: Regime, log grades and carbon price

Regime	**Discount Rate**	**Timber NZ$/tonne at Mill or Wharf gate**	**Carbon $/NZU**
General Unpruned regime (thinned to 500 stems/ha from initial planting of 1200 stems/ha)	8%	**Export** Unpruned A grade – $100 Unpruned K grade – $95 **Domestic** S1 – $105 S2 – $100 S3 – $89 Pulp – $50	$6
Douglas fir regime (thinned to 600 stems/ha from initial planting of 1600 stems/ha)	8%	A grade / Medium SL - $135 B grade / Small SL - $115 C grade/ Small SL - $105 Pulp/firewood - $70	

The carbon price per tonne of carbon dioxide (CO_2) sequestered was based on the forecast by CommTrad (Online commodity trading facility) that indicates the price will increase to $7 in May 2016. (https://commtrade.co.nz/). The spot price for carbon as of 19th of June stood at $6.80 per New Zealand Unit (NZU) (the market is for carbon sequestered, but is calculated as a CO^2 equivalent).

For each regime the Net Present Value (NPV) of forestry in perpetuity was determined using discounted cash flow analysis. The analysis uses a discount rate of 8%, which is the Treasury's recommended rate. The economic analysis follows largely from that of Polglase et al. (2008) [3]. The NPV represents the difference between costs and revenues, all related to the present values. Each cost and revenue surface was discounted to the present depending on the year for which the cash-flow occurred. The cash-flow analysis followed that of Boardman et al. 2001 [4].

*Data from AgriHQ is a pay service and requires a subscription and log in.

Table 2: Data used to estimate the financial return

Costs (C)	Revenues (R)
Establishment (years 1,2,3 $/625m²)	Timber ($/tonne)
Silviculture (Thinning, year 7 $/625m²)	
Access road* construction ($/km)	
Internal landings ($/625m²)	Carbon ($/NZU)
Internal road construction ($/625m²)	
Harvesting ($/tonne)	
Transport# ($/tonne/km)	
ETS compliance ($/625m²)	

*Due to the complete covering of the catchments with forest, the programme assumes that no access roads need to be constructed.
#Transport was estimated using a distance for each cell to both the port of Bluff and an Invercargill saw mill. Results were calculated for 45% of timber to the port of Bluff, and 55% to processing plant or mill.
1m³ of *Pinus radiata* timber = 1 tonne

Carbon assumptions

A standard annual compliance cost of $60 per hectare for the ETS (Emissions Trading Scheme) was added to costs to cover reporting and measurements [5]. To estimate the carbon revenue, it was assumed that the forest was managed to provide a non-declining yield (NDY) [6], based on volume control [7]. This non-declining yield is defined as:

$$\underline{NDY =}\, \bar{C}/T,$$

Where $\bar{C}$ is the average expected carbon stock (tonnes/ha), assumed to be half the total carbon stock at rotation end ($0.5C_F = \bar{C}$), where C_F is the total carbon stock at rotation end; while T represents the rotation length in years. The calculations are in perpetuity (without end), which is used to estimate the present value of carbon.

A non-declining yield is a concept where the carbon sequestered is presumed not to decrease over time. However in plantation forestry, carbon credits must be repaid at time of harvest. In reality some credits are retained due to the carbon that remains on site in logs, stumps and soil. While these carbon stores are decomposing new trees have been planted and begun to sequester carbon again. It is therefore assumed that in a forest managed for a non-declining yield, will in perpetuity retain approximately 50% of its total carbon stock.

The revenues from carbon are received as carbon credits expressed in New Zealand Units (NZUs). One NZU is equivalent to one tonne of carbon dioxide sequestered [8]. The productivity surfaces for carbon measured the total carbon sequestered in tonnes/ha. This was then converted to CO_2 equivalents using the mass ratio of carbon to CO_2 (1:3.67) [9]. The annual carbon revenue is then the non-declining yield times the price of carbon[1].

Carbon revenue was calculated at $6/NZU, $10/NZU, $15/NZU and $25/NZU.

All data is calculated at $/625m², data is derived from dollars per hectare ($/ha) estimates and divided by 16. This is due to the scale of the spatial resolution of the model which is 25m * 25m cell. The final results are represented with a more conventional dollars per hectare value.

Methodology

Modelling plantation forest establishment costs

The cost of establishing a new plantation forest involves purchasing and planting the crop, and the control of weeds to allow maximum tree growth during the crop establishment period. Some assumptions were made in order to develop the cost estimates, these were:

Pinus radiata

- Labour cost: $36 per hour (this is a labour cost not a wage rate, and includes transport, equipment, consumables and contractor overhead)
- Releasing operations base time: 3.5 hours per hectare
- Planting operations base time: 8 hours per hectare
- Tree stock: $250 per thousand seedlings
- Releasing chemical: $80 per hectare
- Mechanical preparation (cultivation or slash management): $20 per hectare, applied to 50% of the total area to be established*.

Douglas fir

- Labour cost: $36 per hour (this is a labour cost not a wage rate, and includes transport, equipment, consumables and contractor overhead)
- Releasing operations base time: 3.5 hours per hectare
- Planting operations base time: 8 hours per hectare
- Tree stock: $390 per thousand seedlings
- Releasing chemical: $80 per hectare
- Mechanical preparation (cultivation or slash management): $20 per hectare, applied to 50% of the total area to be established.

An adjustment factor was developed to adjust costs based on slope steepness. For the modelling the catchments were divided into four slope classes (Table 3).

[1] Carbon is calculated using an annuity rather than actual estimates of carbon sequestered and emitted over time. The former was used for ease of evaluating the economics of carbon within the GIS, and that the two accounting approaches lead to similar, though not the same, estimates of NPV of carbon credit revenues. The former provides a lower estimate NPV than the latter so it is more conservative.

Table 3: Slope adjustment factors for plantation forest establishment costs.

Slope°	Description	Slope adjustment factor
0 - 5	Flat	1.00
5 - 15	Rolling	1.08
15 - 25	Steep	1.25
> 25	Very Steep	1.72

A hindrance adjustment factor was also developed to allow for the extra time/cost based on how difficult it is to travel across a site because of obstacles such as vegetation and slash (Table 4). A hindrance factor of *moderate* was assigned for initial planting and preparation spraying stages.

Table 4: Hindrance adjustment factors for traversing across a site while undertaking establishment.

Hindrance	Description.	Hindrance adjustment. factor
No hindrance	Nil	1.00
Occasional impedance	Light	1.08
Frequent impedance	Moderate	1.15
Constant impedance	Heavy	1.54
Constantly struggling	Very heavy	1.97

The final establishment costs per hectare for the first, second, and third years are given in Table 5 for a general unpruned regime established at 1200 stems/ha. Table 6 provided establishment costs in year 1, 2 and 3 for a Douglas fir regime established at 1600 stems/ha. Establishment costs were derived in a spreadsheet calculator and included the following:

- Pre-plant spraying (assumes a manual spot operation, including labour and chemical)
- Planting (labour and tree-stocks)
- Two post-plant aerial release operations (including labour and chemical) – Year 3 release is calculated as 20% of year 2 costs. Due to the fact that approximately 20% of the total land requires a 3rd release.
- The costs (labour, chemical and trees) were adjusted for stockings

The final establishment costs were converted to a cost per 625m^2 cell.

Table 5: Cost of plantation forest establishment for a general unpruned regime established at 1200 stems/ha.

		Planting regime at 1200 stems/ha		
Slope	**Description**	**Year 1 ($/ha)**	**Year 2 ($/ha)**	**Year 3 ($/ha)**
0 - 5	Flat	1260.00	250.00	58.00
5 - 15	Rolling	1296.00	305.00	62.00
15 - 25	Steep	1380.00	331.00	66.00
> 25	Very Steep	1604.00	399.00	79.00

Table 6: Cost of plantation forest establishment for a Douglas fir regime established at 1600 stems/ha

		Planting regime at 1600 stems/ha		
Slope	**Description**	**Year 1 ($/ha)**	**Year 2 ($/ha)**	**Year 3 ($/ha)**
0 - 5	Flat	1585.00	250.00	58.00
5 - 15	Rolling	1620.00	305.00	62.00
15 - 25	Steep	1704.00	331.00	66.00
> 25	Very Steep	1927.00	399.00	79.00

It is assumed that all trees are planted on locations that are new land and/or ex-farm sites and land preparation costs will be minimal. It should be noted that for second rotation land preparation can vary from $400 - $600/ha.

Modelling thinning costs

A thinning regime was developed for a general unpruned log regime with an initial stocking of 1200 stems/ha, and thinned to 500 stems/ha at age 9 (table 8), and a Douglas fir regime with an initial stocking of 1600 stems/ha, and thinned to 600 stems/ha at age 15 (table 9). Table 7 describes the hindrance adjustment factors used in assessing pruning of the stands. As the modelling occurred across large area the *moderate* adjustment factor was used to estimate all thinning costs.

Table 7: Description of the adjustment factors for traversing across a site while undertaking thinning

		Thinning	
Hindrance	**Description**	**Clear**	**Walk**
No hindrance	Nil	0.00	0.14
Occasional impedance	Light	0.01	0.17
Frequent impedance	Moderate	0.01	0.20
Constant impedance	Heavy	0.02	0.31
Constantly struggling	Very heavy	0.02	0.44

Labour costs for the thinning operations were assumed to be $45 per hour (including the costs of chainsaws, fuel, protective clothing, transport and overheads). Production rates and costs per hectare pruning and thinning were derived from relevant silvicultural time standards

Table 8: Cost of thinning for a general unpruned regime with an initial stocking of 1200 stems/ha, and thinned to 500 stems/ha at age 9 years

	Thinning costs	
	General unpruned regime	
Slope	**Description**	**Year 9 ($/ha)**
0 - 5	Flat	658.00
5 - 15	Rolling	672.00
15 - 25	Steep	720.00
> 25	Very Steep	810.00

Table 9: Cost of thinning for a Douglas fir regime with an initial stocking of 1600 stems/ha, and thinned to 600 stems/ha at age 15.

Thinning costs		
General unpruned regime		
Slope	**Description**	**Year 15 ($/ha)**
0 - 5	Flat	960.00
5 - 15	Rolling	980.00
15 - 25	Steep	1030.00
> 25	Very Steep	1160.00

A python programming language script was developed to automate model calculations using ArcGIS™ software.

Estimating within plantation forest landing and road costs

Modelling the cost of landings and roads was undertaken using landing and road density estimates. The density at which landings and roads occur within a forest was assigned to slope classes 0-10, 10-20, and >20 degree slope (Table 9).

Classification of landing density (L_{den}) was estimated from maximum haul distance (*MHD*) associated with rubber-tyred ground-based (0-10 degree slope), tracked ground-based (10-20 degree slope), and hauler (>20 degree slope), with estimated maximum haul distances of 325 m, 350 m, and 370 m, respectively.

Table 9: Landing and road densities developed across slope classes

Slope (°)	**Landing density (ha/landing)**	**Road density (km/ha)**
0-10	10.6	0.062
10-20	12.3	0.057
>20	13.7	0.054

Road density used the same slope classification as landing density, but was calculated using:

$$R_{den} = (MHD * 2 / L_{den}) / 1000 \qquad (1)$$

The spatial datasets developed and used to estimate landing costs are grouped into three soil classes (Table 10), and into three slope classes (Table 9). Soil class was developed by identifying the main soil occurring within the New Zealand Soil Classification (NZSC) field of the Land Resource Inventory (LRI) digital data and assigning an easy, moderate, or hard *difficulty of earthworks* using expert knowledge provided by forest industry roading engineers and publications [10,11]. The *difficulty of earthworks* was assigned to all 15 soil orders with the exception of the Brown Soil Order. The rationale for separating out this class is that the Brown Soil Order tends to contain disparate soils that often struggle to fit within other soil orders. Therefore it was considered appropriate to separate out Brown Soils at the finer group level of NZSC system.

Table 10: Description of soil classes for estimating the *difficulty of earthworks* at landings based on prominent soil occurring within a LRI unit using the NZSC field

Desc.	Soil Order and Group description	Class
L	Allophanic	Easy
A	Anthropic	Easy
BL	Brown Allophanic	Easy
BS	Brown Sandy	Easy
BX	Brown Oxidic	Hard
BM	Brown Mafic	Moderate
BA	Brown Acidic	Moderate
BF	Brown Firm	Hard
BO	Brown Orthic	Moderate
G	Gley	Hard
N	Granular	Hard
E	Melanic	Hard
O	Organic	Hard
X	Oxidic	Hard
P	Pallic	Moderate
Z	Podzols	Moderate
M	Pumice	Easy
W	Raw	Easy
R	Recent	Easy
S	Semiarid	Hard
U	Ultic	Hard

Using the three soil and slope spatial datasets, Table 11 provides the estimated cost of landing construction. Costs were based on expert knowledge and published reports [10]. Landing construction times were derived by soil type and slope, and costs were calculated using 2011 machine costs.

Table 11: Estimated cost associated with the establishment of landings based on slope and soil class (refer to Table 10).

Soil class	Slope°		
	Flat (0-10)	Moderate (10-20)	Steep (>20)
Easy	$1,645	$2,820	$3,760
Moderate	$2,115	$3,290	$4,700
Hard	$2,820	$3,760	$7,520

For the estimation of internal road costs, a simplified version of impedance cost was developed from three slope classes, 0-5, 5-15, and >15 degree, and four classes of erosion [12]. The Erosion Susceptibility Classification (ESC) relates soil erosion to forest resource management by assigning a low, moderate, high, or very high ESC class. Table 12 provides the estimated cost for the construction of internal road networks within a forest. Expert knowledge and published data [11, 13] were used to estimate realistic densities and costs across the ESC and slope classes.

Table 12: Construction costs associated with the construction of internal roads within potential future forests

Slope°	Erosion Susceptibility Classification			
	Low	**Moderate**	**High**	**Very high**
0-5	$33,990	$35,020	$37,080	$41,200
5-15	$40,170	$49,440	$58,710	$63,860
>15	$64,890	$73,130	$80,340	$103,000

Landing density (Table 9) was used to calculate the number of landings required for each slope class area within each forest. The costs associated with these landing densities where portioned to the number of landings required per cell (625 m^2) within each slope class.

Slope classes in Table 9 were also used to estimate the road density requirements on a kilometres per hectare basis within a forest. The construction cost (Table 12) was then used to estimate the realistic cost of road construction within forests on a per cell basis assigned across the slope and ESC classes.

Calculating harvesting costs

Harvesting costs (H_{cost}) were given to forests using slope classes for the South Island by assigning the Agrifax value (Table 13). The stems/ha to be harvested were converted to stems per 625 m^2 cell and given the Agrifax value associated with harvesting costs. Harvesting cost was calculated using:

H_{cost} = *Yield* * Agrifax value

Table 13: Estimated logging cost ($ per tonne) by terrain/system and location

Slope	Island	Extraction type	Agrifax value ($)
0-10	South Island	Flat Ground-based	26
10-15	South Island	Tracked Ground-based	26
15-20	South Island	Steep Tracked	31
>20	South Island	Hauler	33

A python script was developed to automate model calculations using ArcGIS™. The costs associated with establishing each landing and road construction costs were calculated using lookup tables.

Calculating transport costs

The calculation of transport cost was undertaken by first creating a GIS raster surface, this surface is used to show the distance to travel across each cell. The distance from each cell to the port of Bluff and a saw mill, located in Invercargill, was calculated using the cost distance tool within ArcGIS™. This distance was then taken and used in the final cost distance calculation.

The total tonnage of timber* produced from each raster cell was multiplied by distance in kilometres and the cost of transport, estimated to be $0.22 per kilometre.

$$Total\ Cost\ = distance\ (km) *\ wood\ volume\ (m^3) * Transportation\ costs\ (\$0.22)$$

“Transportation costs” is an industry standard estimate and is an aggregated cost that includes fuel and operational wages.

*the FIF+ framework calculates log grade mix for the domestic market only (s1, s2, s3 and pulp). In this calculation it is assumed that all s1, s2 and pulp is sent to the mill/processing plant and all s3 logs are sent to the port. The reason being that approximately 45% of the total timber is exported, and s3 logs are approximately 45% of the total log grade mix.

All Douglas fir logs are assumed to be for the local New Zealand market and are only sent to the mill location.

Development of productivity surfaces

Pinus Radiata

The productivity surfaces for *Pinus radiata* [14,15,16] was developed by combining advanced statistical techniques with mapping technology to predict 300 Index and Site Index for any location in New Zealand. The 300 Index is an index of volume mean annual increment, and Site Index measures height at a reference age. The maps of Site Index and 300 Index were developed using growth measurement data from trees in 1,146 permanent sample plots in radiata pine stands planted between 1975 and 2003. The data was combined with a number of climate, land use, terrain and environmental variables to predict forest productivity under a range of conditions. For more details refer to Palmer et al. 2009 [14].

A purpose written python routine calculates volumes of each log grade in cubic metres per hectare for a structural regime, from the 300 Index and Site Index surfaces in association with regression model coefficients. A similar routine calculates annual carbon sequestration surfaces in tonnes of CO_2.

Douglas fir

The productivity surfaces for Douglas fir were created using 3-PG (physiological processes for predicting growth), which is a process-based model developed by Landsberg and Waring [17]. The spatial version of the 3-PG growth model, 3-PG2S, was used for this study [18]. Process-based modelling involves the simulation of tree growth based on: (i) the underlying physiological processes or mechanisms that regulate tree growth on a stand basis; and (ii) the way the processes are affected by the site conditions.

The resultant process-based models can then be applied to sites, ages, and situations beyond the original data sets. 3-PG is a canopy leaf area driven model that uses physiological growth limitations for a particular species to simulate productivity for any one site. The sensitivity of a species to site conditions (e.g. temperature, frost days, and soil properties) differs from species to species. 3-PG has been applied to a number of different species and environments throughout the world. In New Zealand, the 3-PG model has been parameterised for *E. fastigata* model. It has been used to generate productivity surfaces for MyLand and Future Forest Research stakeholders [19], and to model the potential impact of climate change on the species [20, 21].

For details of the methodology with 3-PG modelling, refer to Meason and Mason [21]. The climate data used in the study was provided by National Institute of Water and Atmospheric research (NIWA), and was normalised from actual climatic data for the period 1989 to 1999 and extrapolated nationwide on a 0.05^o (5km) grid. To reduce computation time, a mean annual temperature 9^oC mask was applied to the dataset. It was assumed that grids with MAT less than 9^oC would be too cold for commercial forest stands. Douglas fir 3-PG parameters were developed for New Zealand grown Douglas fir from an earlier study [22]. This 2008 study validated their model using nationwide plot data. Due to time constraints of this study, no additional validation was done using Douglas fir plot data for Southland.

Results

The estimated financial returns ($/ha) from plantation Pinus radiata and Douglas fir forestry in Southland ($/ha) are shown in figures 1–4. The most profitable areas for an unpruned Pinus radiata regime are within a 50 km radius from the city of Invercargill, with profit gradually declining as the distance from the city increases. This indicates that distance from market is a dominant factor controlling the profit of a planted forest. Figure 2 shows the estimated returns from carbon with an NZU of $6 per tonne.

Returns from carbon are closely aligned to total productivity can be seen that areas to the north of the region have a comparable return from carbon as those areas closer to the city of Invercargill, thus reinforcing the fact that distance from market is an important factor controlling profitability of plantation forestry. Figure 3 indicates estimated returns from four different carbon scenarios, with NZU set at $6, $10, $15, and $25. As would be expected, increasing NZU price corresponds with increasing returns from carbon. What is interesting is that areas that have low returns for timber could, with an increasing carbon price, have very attractive potential returns.

Douglas fir shows similar returns near to the port but much higher returns further away unlike Pinus radiata. A distinct falling away can still be observed, though not as pronounced as that of Pinus radiata. This may be explained in part with the modelled scale of the total volume. For Pinus radiata this is at 25m pixel scale, for Douglas fir it is 500m. This may be the cause for some areas to have a higher predicted volume than expected. In lower productivity areas, Douglas fir predicted volume is greater, as much as 3 times greater than that of Pinus radiata. This is not unexpected and this higher volume can account for the greater profitability over one rotation. However, rotation lengths for Douglas fir can be 15 – 25 years longer than that of Pinus radiata. In some areas, it may be possible to harvest two crops of Pinus radiata to one of Douglas fir.

Note:

1) Research and modelling of productivity and total volume in New Zealand has focused on Pinus radiata, therefore, confidence in the accuracy of results is significantly higher for this species.
2) Scale differences in the spatial mapping between Pinus radiata pine (25m) and Douglas fir (500m) makes comparison more difficult.
3) Returns from Douglas fir production thinning can have a tangible bearing on the economics of planting this species.
4) Carbon prices and/or destinations of timber can be altered based on different sets of assumptions to develop new scenarios.
5) While it is recognised eucalyptus is an important tree species for the Southland region, the modelling capability of eucalyptus productivity at this time is not sufficiently robust to be able to produce meaningful outputs. As a result, it was preferable to not include eucalyptus in this analysis.

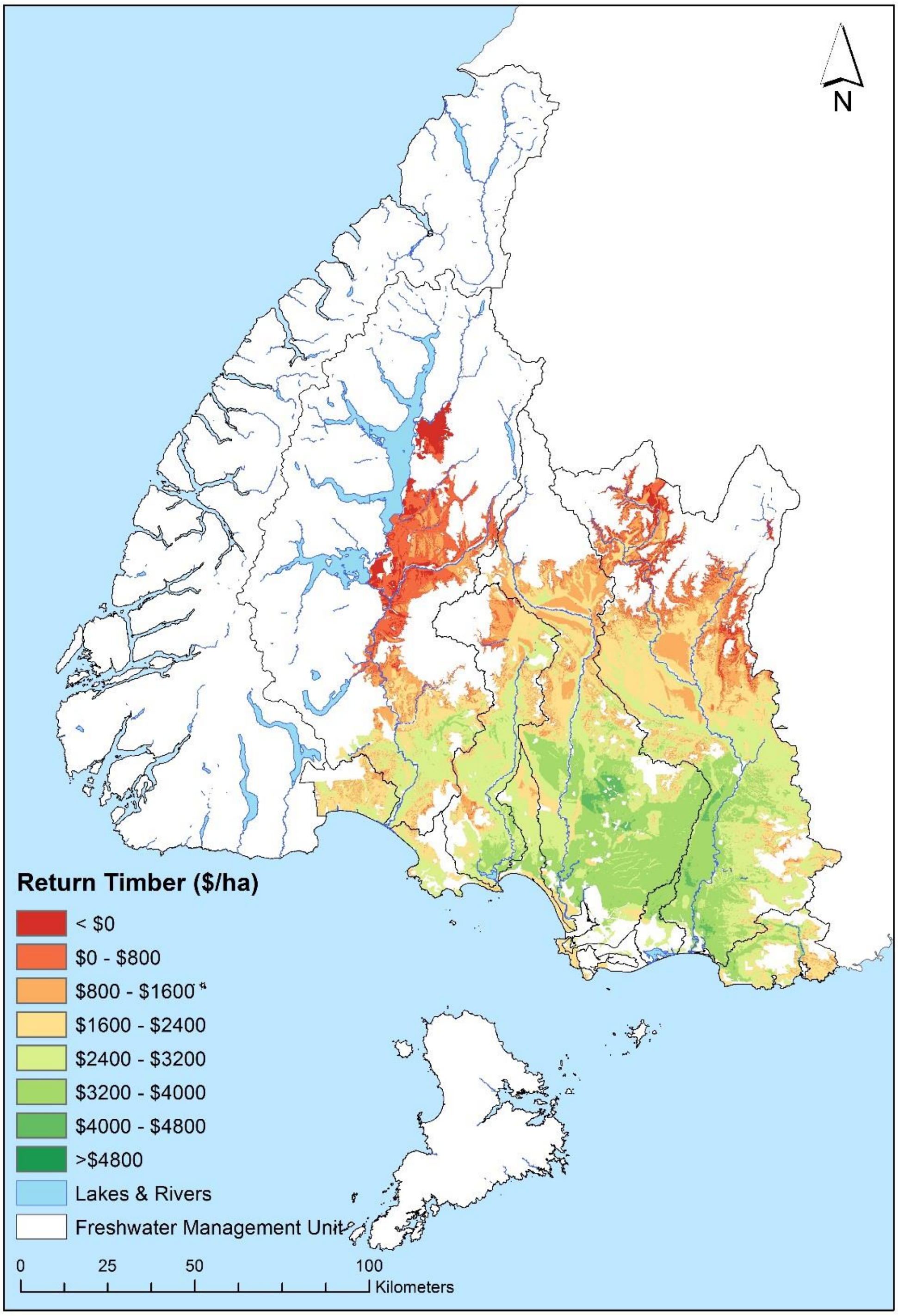

Figure 1: Estimated return in $/ha (NPV) for an unpruned Pinus radiata regime

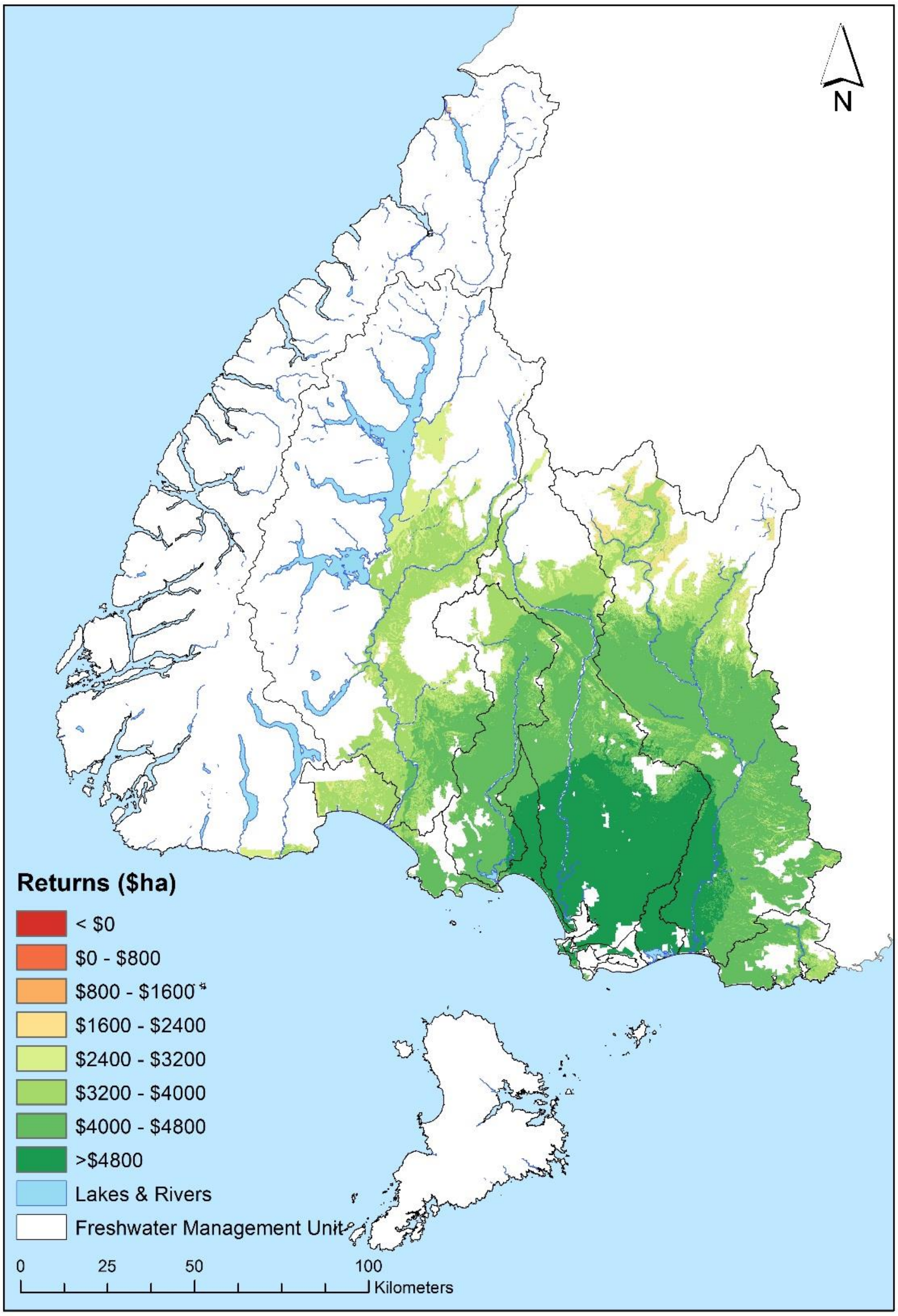

Figure 2: Estimated return in $/ha (NPV) for a Douglas Fir regime

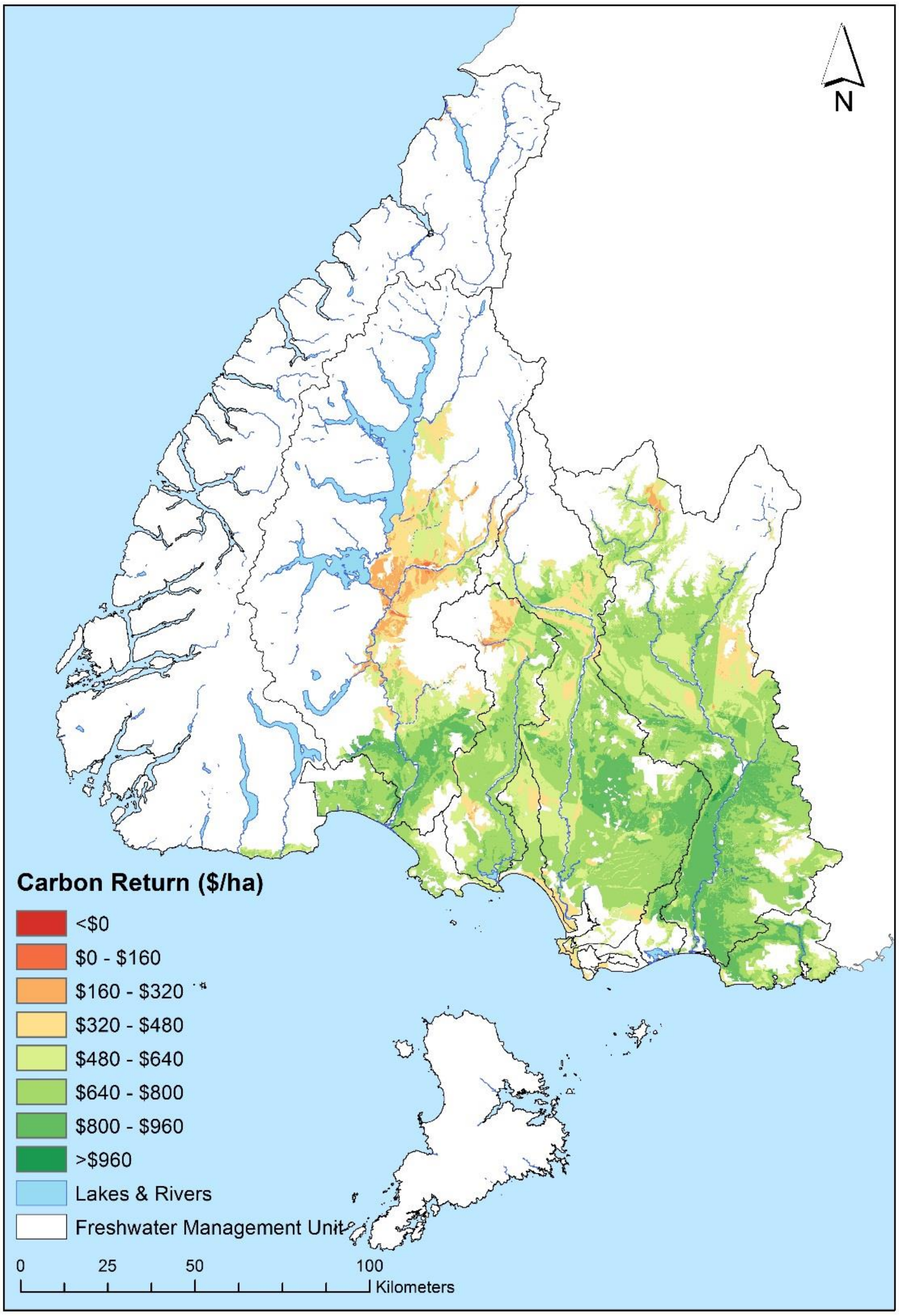

Figure 3: Estimated Return in $/ha (NPV) for carbon with NZU at $6 per tonne

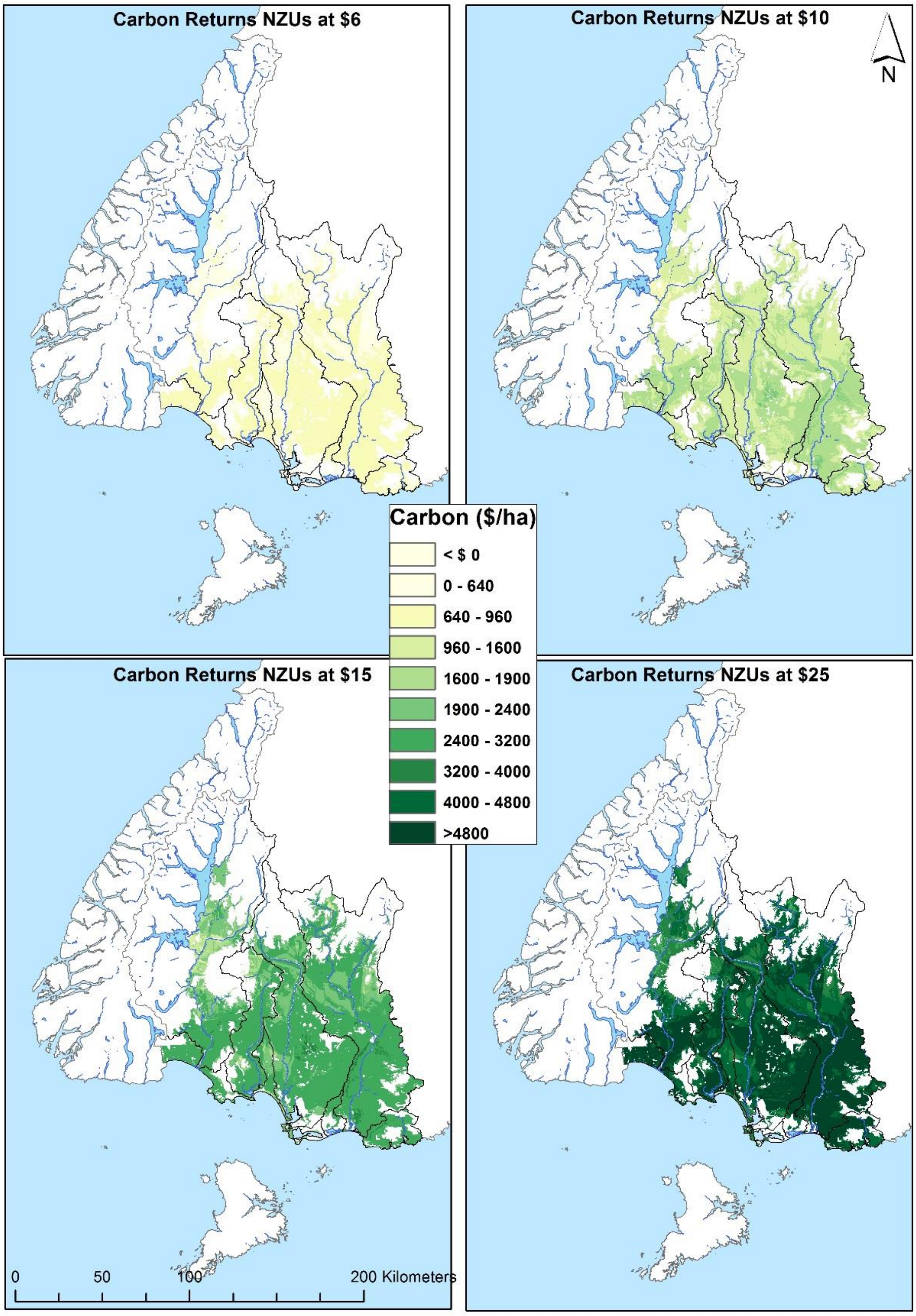

Figure 4: Estimated Carbon Return in $/ha for an unpruned Radiata regime with NZU at $6, $10, $15 and $25.

Soil Erosion

Avoided erosion in this project is measured as the change in sedimentation levels from afforestation, and is estimated using the New Zealand Empirical Erosion Model (NZEEM) [23]. The main forestry activities that generate sediment are roading, earthworks, logging (harvesting) and post-harvest land preparation [24] (Fahey et al., 2006). There is also an increased risk of erosion from forestry during the early establishment years, as roots from harvested trees decay before newly planted trees reach canopy closure. Usually between 4-7 years.

Calculating Avoided Erosion

Total sedimentation under current land use and forestry values are calculated for catchments in Southland using NZEEM [23]. It should be noted that Environment Southland's Science Programme is currently calculating sediment loss across the Southland region. These figures could be used to validated or substituted for the NZEEM figures. Forests reduce erosion when compared to other land uses. However, sedimentation from forestry may be the same or worse than other land uses during harvesting and early establishment periods. Therefore, a range of estimated values of sedimentation level with forest age are used to further estimate the sedimentation avoided over an entire forest rotation compared to the current land cover for the same time period. See Barry et al. 2014 [25] for a full description of the sedimentation calculation. As no age class data is available for the region, all erosion and sedimentation estimates are calculated for a single harvest event.

The transformation of tonnages of sediment load into more proximate water quality attributes (e.g. water clarity, light penetration, sediment deposition in estuaries) is complex and beyond the scope of this work.

Table 13: The total estimated sediment yield for current land use (status quo) and an afforestation scenario of current land use (future erosion) over a forest rotation (28 years). Also the total avoided erosion (status quo minus future erosion) by catchment.

NAME	STATUS QUO (T/YR)	FUTURE EROSION (T/YR)	AVOIDED EROSION (T/YR)
ESTUARIES	25	21	5
APARIMA	126,550	112,315	14,235
ORETI	240,537	214,149	26,388
MATAURA	424,417	375,136	49,282
WAIAU	329,239	270,582	58,657
TOTALS	**1,120,768**	**972,202**	**148,566**

Impacts of the National Environmental Standards for Plantation Forestry

The Proposed National Environmental Standards for Plantation Forestry (NES-PF) aims to establish a set of standards to be applied across all regions of New Zealand. MPI commissioned reports from Scion [26], NZIER, and HG [26], to estimate the economic and environmental benefits from the introduction of the NES. Both found that while it is expected the NES will deliver both economic - as a reduction in the cost of forests plans - and environmental benefit, the size and nature of these benefits is hard to quantify.

Southland, like all areas in New Zealand, is affected by erosion particularly small pockets in the west along the border with Fiordland and larger areas of high erosion in the North (figure 5). However the majority of current Southland forests have a low erosion/sedimentation rate when compared to other areas of New Zealand (G.Morgan pers. Comm., November 2014. See Appendix 1). Much of the regions forests have a value of < 2 t/ha/yr, this compares to 18t/ha/yr for the Waipaoa catchment in Gisborne [29].

The NES uses an erosion potential layer to categorise erosion risk. In Southland (figure 6) it is only the mountainous west and north of the region that are categorised as high or very high. These areas would be subject to more stringent rules and consent requirements under the NES. However, due to the Department of Conservation status and the projected unviability of these high or very high categories, it makes commercial plantation forestry either impossible or highly unlikely. For those reasons it is assumed that the NES will have no impact on the current erosion or sedimentation of these areas. Areas that could support commercial plantation forestry (figure1) have either low or moderate erosion susceptibility class and as such, would be not bound by the more stringent NES regulations of the other erosion classes.

Due to the low erosion risk it is likely, as suggested by the proposed NES, that most forest activity in Southland (land preparation, thinning, earthworks and harvesting) will remain a permitted activity following submission of a forestry management plan to the regional council. This, as presented by Harrison et al. [28], should have minimal economic impact on medium to large forest corporate companies.

Monge et al. [26] investigated the affects NES regulation may have on small forest areas in Southland. Table 14 shows the sedimentation and erosion that would result from harvesting small forests located in orange and red susceptibility zones under the status quo and a potential reduction under the NES.

Table14. Erosion and Sedimentation Yields from Harvesting (tonnes/year) in Small Forests Located in Orange and Red Susceptibility Zones Under a Status Quo and NES (Adapted from Monge et al. [25]).

ESC	AREA (HA)	STATUS QUO (T/HA/YR)	SEDIMENT REDUCTION UNDER NES (T/HA/YR)		
			2%	5%	7%
ORANGE	2,695	5,527	111	276	387
RED	600	5,700	114	285	399

Tables 14 and 13 show:

1. Afforestation will decrease sedimentation in all catchments.
2. The decrease in sedimentation caused by afforestation would be small in absolute terms (approx. 13% of an already small total).
3. Small forest lots in the red zone are about a fifth of the area of those in the orange zone.
4. Both zones have approximately the same sediment yield.
5. The NES may only have minimal effect on sediment reduction in Southland.
6. If small forest blocks located in red or orange susceptibility zones in Southland were harvested at the same time, they would contribute less than 1% of Southlands current yearly sedimentation.

Of the productive land area in Southland (capable of agricultural or forestry production), only a small percentage (less than half of one percent) falls into the high or very high erosion susceptibility categories, and would require consents for forestry activities.

Under the proposed standards, the majority of the current estate would operate under permitted activity conditions. These conditions are designed around forestry best practice.

If a company is not following best practise, or creating and submitting comprehensive harvest plans, a financial cost may be incurred. However, some costs should be reduced for forestry operations by having standard operating conditions across districts and regions.

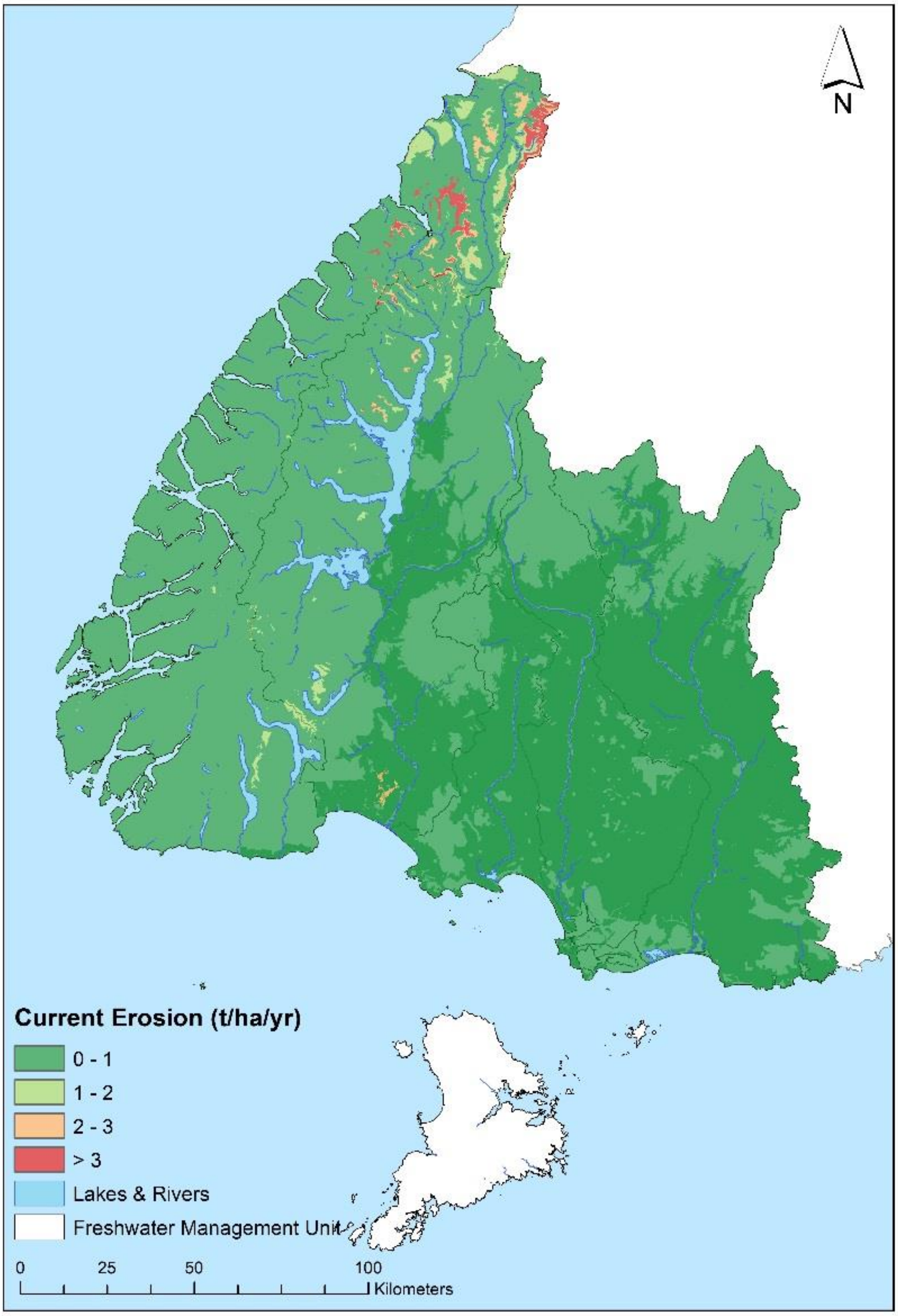

Figure 5: Current erosion/sedimentation rates as calculated by NZEEM [23]

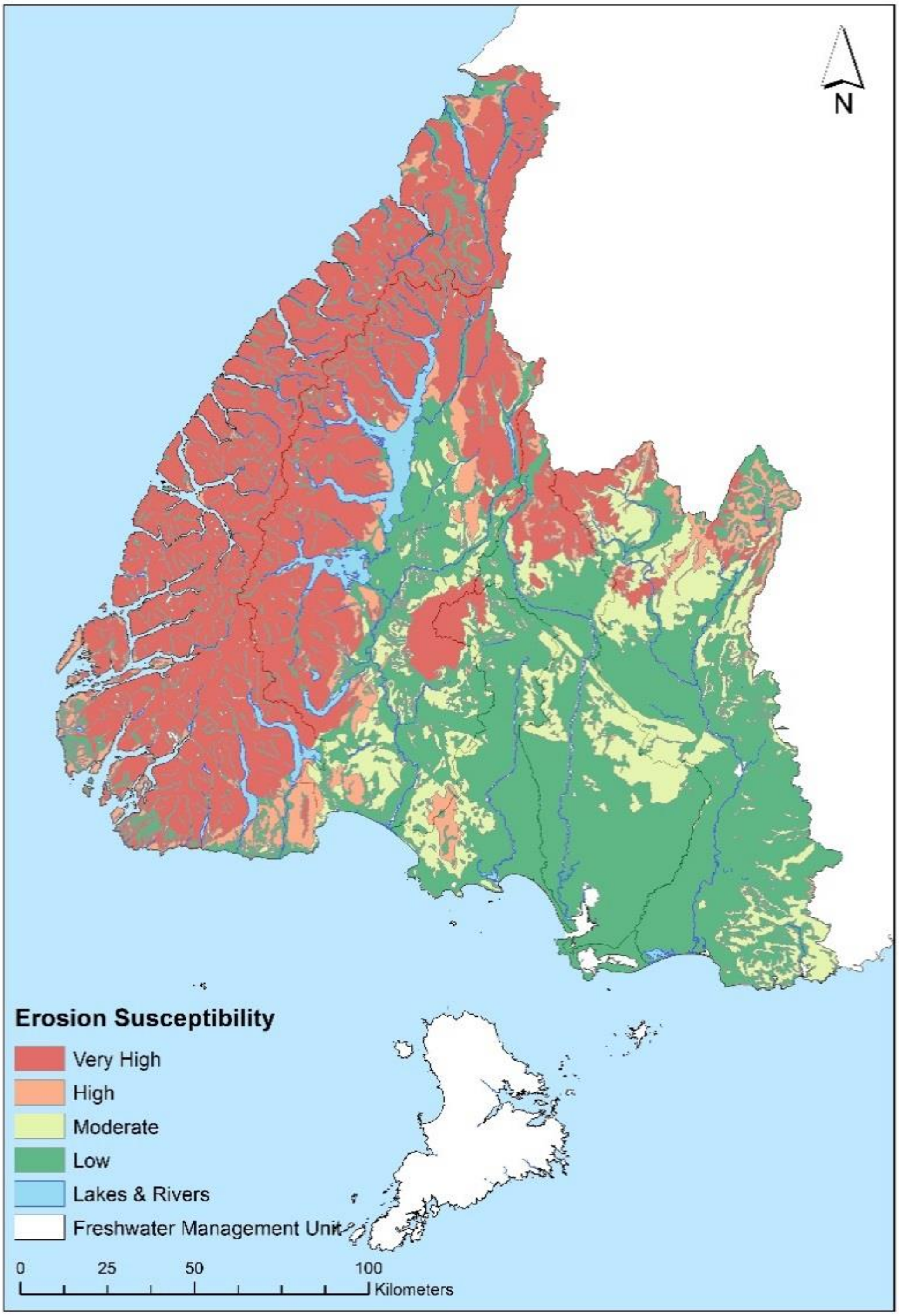

Figure 6 Erosion Susceptibility Class across Southland [12]

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Appendix 1

Gary Morgan – Senior Land Sustainability Officer, Environment Southland. November 2014

"The majority of planted forests in Southland occur on the stable hill country of the Southland Syncline. These areas include the Taringatura, Hokonui Hills and the Slopedown area of eastern Southland. The geology of the syncline is well indurated sandstone and siltstone of Triassic-Jurassic age.

The Land Use Capability (LUC) classes that these planted forests occupy are Class VIe6, VIe10, VIe15 and VIe28. These LUC Classes are described as strongly rolling to moderately steep hill country with an erosion potential of moderate sheet and soil slip. The slope classes are D and E (16-25 degrees).There are also planted forests on the northern flank of the Longwood range (volcanic intrusives of the Takitimu subgroup). These forests are on LUC Class Vie21. Again, strongly rolling to moderately steep hill country, with an erosion potential of moderate sheet and soil slip and D and E slopes.

There are also scattered forest estates on easier country across Southland's downlands. These are mainly located on Quaternary outwash gravels, tertiary sandstones and lignite measures. This is mainly rolling country, LUC Class IV with low erosion potential.

Northern Southland experiences occasional localized heavy rainfall events which in the past have resulted in land slips. These have occurred on mainly extensive pastoral hill country and the conservation estate. There is a sizeable area of recently planted forest in the Upper Mataura Valley which can be subject to these localized intense rainfall events. To date there has been no evidence of erosion within the forest estate."