Understanding your landscapes's resilience: Beyond Regulation

CASE STUDY 2

Farm Type
Sheep & Beef

Location
Wendonside (Upper Mataura)

THRIVING SOUTHLAND
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LAND & WATER SCIENCE

Understanding your landscape's resilience: BEYOND REGULATION

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Definition of Terminology

Physiographic approach – assesses the dominant processes within the landscape in influencing environmental outcomes by combining existing soil, geological, topography and climate data to understand the landscape factors controlling variation in water quality.

Landscape susceptibility mapping – takes a high-resolution physiographic approach and maps it for a property (the resolution is at paddock scale). This identifies the landscape susceptibility to contaminant loss and soil GHG emissions.

Summary

Many farmers are actively seeking opportunities to reduce their environmental impact in order to meet their own goals, as well as regulations, consumer and community expectations.

Land and Water Science Ltd (LWS) has undertaken a new, high-resolution physiographic approach to mapping the inherent and varied susceptibility of the landscape to land use activities at property scales. Landscape variability has a significant role in governing the type and severity of water quality outcomes, even when land use is the same. Landscape variability also significantly affects soil greenhouse gas (GHG) production.

Linking the landscape susceptibility and farm system allows farmers to target mitigations and contaminant load reductions to reduce their environmental impact.

Method

A multi-disciplinary team met with a case study farmer. The team's expertise included landscape susceptibility mapping, water quality science, forestry and farm systems. Current options/technologies available were considered as mitigations. Options for reducing environmental impact were discussed and perspectives sought on practicality, cost, impact on farm system, and impact on environmental mitigation.

The farm

This case study was conducted on a 733-ha sheep and cattle farm owned and operated by a farming family and located near Wendonside, north of Gore. The farm is a multi-generational property, and the next generation now leases the property, working towards farm ownership. The farmers have a good awareness of the changes required of farming and the related pressures (water quality, greenhouse gases, animal welfare, and attracting and keeping good quality people). The farmers goals are to:

- Set up succession planning within the business going forward
- Improve animal performance to increase returns

Top of mind for them in the short to medium term is generating cash surpluses to position their business now and for the next generation.

The farm ranges in contour from flat to steep faces and gullies. The Garvie Burn Stream runs along the Western boundary and several small spring fed streams are located on the property and lead into the Rob Roy Creek which runs along the northern and eastern boundaries. There is a range of soils on the property, with the predominate soil types being Crookston (moderately well drained), Claremont (poorly drained) and Fairlight (moderately well drained).

The farm is at an elevation of 200 to 600 meters above sea level, with a mean annual rainfall of 910 to 1020 mm and an annual temperature of 9.1 to 10.1°C.

The farm operates as a sheep and beef farm. In total there are 7659 revised stock units (RSU). This is broken down into:

- Beef 1597 RSU (21% beef)
- Sheep 6062 RSU (79% sheep)

The average per total hectare stocking rate is 10.5 RSU / hectare.

The Catchment

The farm is located within the Wendonside Catchment, which is a sub-catchment of the larger Mataura River Catchment. Land use and various industrial and municipal water discharges are key contributors to the degradation of water quality in the Mataura catchment. Overall, surface water quality in the Mataura Catchment is characterised by elevated *E. coli* (faecal bacteria), nitrogen, phosphorus, and degraded macroinvertebrate community index (MCI).

The Wendonside and Waimea areas have a number of small but locally important areas of elevated groundwater nitrate that exceed the WHO drinking water standards. The hill country surrounding the lowland plains is prone to runoff and associated sediment, *E. coli*, and particulate phosphorus loss. Localised water quality issues are manifest as exceedances against regional and national guidelines for freshwaters.

Currently, the Toetoes Estuary, where the Mataura river discharges at Fortrose, is assessed as being in poor condition.

Landscape susceptibility

Variability in climate, topography, geology, and soils significantly influence the type of contaminant and severity of water quality outcomes even when land use is the same.

The susceptibility models for Case Study 2 property show a predictable pattern that is consistent with topographic controls. Topography controls aspect, slope, and soil depth. These landscape factors interact to determine the susceptibility of the land to saturation and erosion. Soil saturation and the runoff of water are the key controls over the susceptibility of the property. Where the land is flat, susceptibility is lower overall, whereas the steeper parts of the property, especially the western and to a lesser degree the north facing slopes, are most prone to contaminant loss. This pattern of differential susceptibility is typical of hill country settings, where topography and aspect interact to determine contaminant susceptibility profiles.

Ground truthing of the property is required to support a more robust assessment. However, this preliminary desktop evaluation raises a range of opportunities to mitigate elements of the natural susceptibility of the property. For example, conversations around carbon farming of steep land, mainly western facing slopes, may provide additional revenue or offset GHG emissions and improve water quality across the more productive parts of the property. However, much more work is required to evaluate the feasibility of any proposed changes against the economic sustainability of the farming enterprise.

When hydrology and landscape susceptibility insights are combined, the ability to identify where investment needs to be made to minimise losses from the property can be considered.

Environmental mitigation opportunities

Analysing landscape susceptibility risk and farm systems analysis identified opportunities to build a resilient farm system and reduce environmental impact. Changes in environmental impact were estimated using OverseerFM modelling and wetland calculations and compared to the 2020/21 season. Estimated change in total greenhouse gas emissions (methane, nitrous oxide and carbon dioxide combined) are reported. In addition, the estimated change in nitrous oxide emissions are identified to align with the specific opportunities identified in the landscape susceptibility mapping.

The high-level impact of farm system change on capital investment and farm working expenses was explored through partial budgeting. Where there were significant changes to the farm system the impact was modelled through Farmax.

Mitigation options

During the site visit it was identified through landscape susceptibility, farm systems analysis, and investigation of forestry opportunities that there were opportunities to reduce environmental impact.

The property is an extensive sheep and beef property, comparative with other land uses / land classes in the catchment, but is not a high intensity property. While some reductions can be achieved through mitigation of the current low intensity farm system, reductions of a larger scale will be achieved through landscape intervention and land use change.

Table 1. Mitigation options within the current farm system

	Description	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change	Farm system/financial impact
Option 1	Use of 5% plantain in 315 ha of pastures	No change	1% decrease	1% decrease	No change	No change	Include 1 kg plantain seed in regrassing mix. Approximate cost $400 per year.
Option 2	Replace 11.1 ha of kale with 5.8 ha fodder beet (for beef animals)	1% decrease	3% decrease	2% decrease	4% decrease	No change	Need 25T DM fodder beet crop to be a similar cost to kale based on a cents per kg of DM basis. Management of heavy crops during wet weather can be challenging.
Option 3	Replace swedes with grass wintering (for sheep)	7% increase	10% increase	4% decrease	23% decrease	No change	Need to build more feed up in autumn. Assumed increased nitrogen use by 33 kg N / ha and no sale of supplement. No significant difference financially.

	Description	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change	Farm system/financial impact
							Certainty of winter feed supply may be riskier if dry summer autumn. May need to consider some grass-to-grass regrassing.
Option 4a	Install a standoff pad (for the R1 and R2 beef animals)	No change	No change	1% increase	No change	No change	To use overnight for 30 days in winter. Difficult to model mitigation during adverse weather events. Site preparation and fencing not costed (site specific). May require a consent (not costed). Annual cost of $9,400 in wood chip.
Option 4b	Install a covered barn (for the R1 and R2 beef animals) Remove 11.1 ha kale crop	1% increase	2% decrease	9% decrease	2% decrease	1% increase	To use for 24 hours per day for 92 days in winter. Annual cost of $49,320 (no crop, debt serving, depreciation, running, R&M, supplement making, purchasing woodchip).

Mitigation options with landscape intervention / land use change

The wetlands have been specifically sited to target the discharge and junction nodes to mitigate loss of environmental contaminants by targeting transport pathways. Due to the rolling to steep contour where wetlands are sited check dams have been integrated. Check dams are installed to slow the water going into the wetlands to improve wetland performance during high water flow events.

There is an opportunity to integrate forestry into the landscape, especially those areas that are less productive and have a higher landscape susceptibility risk (in particular for phosphorus, sediment and DRP loss). Forestry has been provided additional revenue from carbon rather than off setting GHG emissions.

Table 2. Mitigation options with landscape intervention / landuse change

	Description	**Total GHG change**	**Nitrous oxide change**	**N loss change**	**N surplus change**	**P loss change**	**Farm system/ financial impact**
Option 5	Install 23.35 ha of wetlands (with associated check dams)	–	–	20% decrease	–	16% decrease	The areas that are repurposed into wetlands are of very low pasture productivity and will require no farm systems change. Significant cost of wetland fencing, and check dams $174,454. Assumes that rock available on farm, wetland plants will regenerate. Prioritising wetlands where existing reticulated stock water system is available and where the wetland is calculated to provide the most mitigation for cost.

	Description	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change	Farm system/ financial impact
Option 6	Plant 36.9 ha of plantation forestry and slightly reduce sheep numbers	<1% decrease	No change	1% decrease	2% decrease	3% decrease	Small reduction in sheep numbers. Reduction in annual profit from the farm system of $11,160 36.9 ha forestry: IRR first rotation 9.5% (carbon @$60). Peak cash deficit of ($173,048). IRR second rotation 5%.
Option 7	Plant 134 ha of plantation forestry and remove beef breeding cow operation	12% decrease	10% decrease	10% decrease	14% decrease	15% decrease	Significant farm system change. Reduction in annual profit from the farm system of $24,222 134 ha of forestry: IRR first rotation 7.2% (carbon @$60). Peak cash deficit of ($183,760). IRR second rotation 5.2%.

Farm system optimization

Farm system optimization / scenarios through Farmax showed an opportunity to improve the sheep enterprise performance and significantly improve profitability whilst reducing environmental effects. There are options for pathways to improve sheep performance such as utilising the beef breeding herd across the entire property for pasture quality control, investigating different lamb breeds or investigating a reticulated water system.

Table 3. Farm system optimisation

	Description	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change	Farm system/ financial impact
Option 8	**System optimization**	1% decrease	1% decrease	1% decrease	2% decrease	No change	Increased lambing, lambs finished earlier and heavier. Annual increase in profit of $33,724

Conclusion

The main landscape susceptibility issues across the case study property align with topographic controls, topography controls aspect, slope, and soil depth. These landscape factors interact to determine the susceptibility of the land to saturation and erosion. Soil saturation and the runoff of water are the key controls over the susceptibility of the property. Where the land is flat, susceptibility is lower overall, whereas the steeper parts of the property, especially the western and to a lesser degree the north facing slopes, are most prone to contaminant loss. This pattern of differential susceptibility is typical of hill country settings, where topography and aspect interact to determine contaminant susceptibility profiles.

Farm systems evolve over time to match land, stock class with variability in weather and product prices. Change to the farm system and capital investment need to be carefully considered due to the interlinked nature of farm system and the low returns that sheep and beef farmers operate in. The case study farm is not a high intensity farm system, so mitigation within current farm system has minimal overall impact on environmental losses.

Mitigation options with land use change and landscape intervention such as installation of wetlands which showed a greater opportunity to reduce environmental impact. Installation of wetlands within the landscape has a cost attached to it, and these wetlands should be prioritized and targeted to areas with the most mitigation potential and may take a period of time for installation to be realistic (within financial and time constraints). Land use change to forestry show positive returns, the key determinant is the opportunity cost of how the land is currently utilized and a long-term view needs to be considered in planning to take account of no carbon revenue after the first rotation.

Farm system optimisation / scenarios through Farmax showed an opportunity to significantly improve profitability through improved lambing rates and faster growth rates whilst also reducing environmental impacts. The options to achieve these results require further investigation however may include utilising the beef cows across the whole farm, changing ram breed and installing reticulated water.

1. The project

Many farmers are actively seeking opportunities to reduce their environmental impact to meet their goals, regulations, consumer, and community expectations.

Farmers have long-term skills and knowledge balancing a range of internal and external factors in their decision-making. Uncertainty in on-farm decision-making has increased in recent years due to:

- Changing consumer and processor expectations
- Supply chain issues and change in cost structures
- Cost of and access to capital
- Concerns about climate change
- Change in regulation
  - Essential Freshwater Package (including National Policy Statement and National Environmental Standard, Freshwater Farm Plans)
  - National Policy Statement for Highly Productive Land
  - Proposed GHG emissions pricing
  - Proposed National Policy Statement on Indigenous Biodiversity
- Price of carbon supporting land use change.

Combining information on the landscape and farm system provides an opportunity to reduce environmental risk and inform farmer decision-making.

2. The farmers and their goals

The 733-ha sheep and beef farm is located near Wendonside, North of Gore. The farm is a multi-generational property, and the next generation now leases the property, working towards farm ownership.

The farm operators have been working hard over the last 18 years since coming home to the property to:

- Position themselves to lease the property and then ultimately purchase the property
- Set up succession planning within the business going forward
- Improve animal performance to increase returns.

Top of mind for them in the short to medium term is generating cash surpluses to position their business now and for the next generation.

The farmers have a good awareness of the changes required of farming and the related pressures (water quality, greenhouse gases, animal welfare, and attracting and keeping good quality people).

3. Method

Variability in climate, topography, geology, and soils significantly influence the type of contaminant and severity of water quality outcomes even when land use is the same.

A multi-disciplinary team met on-farm with the farmers. Expertise in the team included landscape susceptibility mapping, water quality science, forestry and farm systems. Current options/technologies available were considered as mitigations.

During the on-farm visit with the farmer, the following was discussed:

- The farmers goals
- The farmers background on the property and achievements to date
- Catchment issues
- Landscape susceptibility mapping with onsite ground truthing
- Estimated environmental losses from the farm system modelled through Overseer FM from information provided.

During the visit opportunities to reduce environmental impact were discussed. Perspectives were sought on practicality, cost, impact on the farm system and impact on environmental mitigation. The open discussion with different perspectives allowed opportunities to be identified and refined.

4. Case study farm setting

4.1 Physical setting

Hydrology

The Garvie Burn Stream runs along the Western boundary of the property, and the Rob Roy Creek runs along the Northern and Eastern boundaries. Several small spring fed creeks are located throughout the property and flow into both the Garvie Burn stream and the Rob Roy creek. The Mataura River is located ~ 3 km to the west of the property.

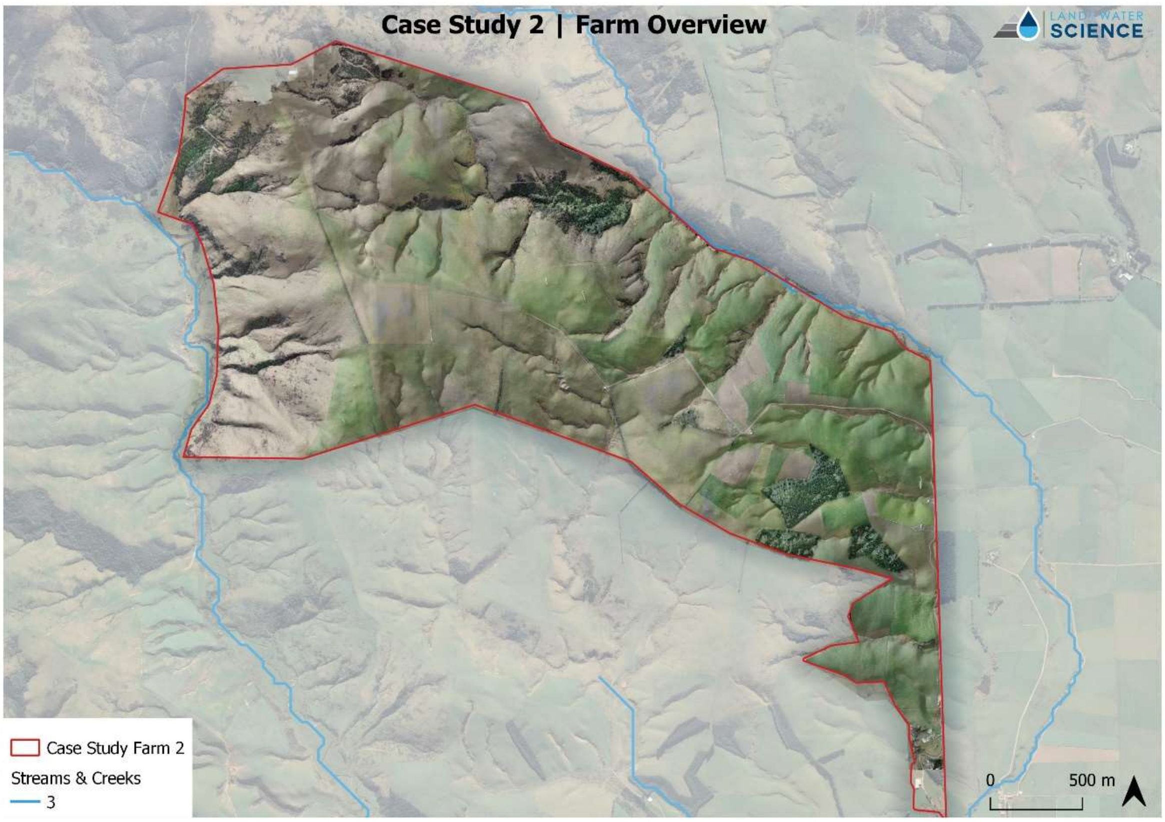


Figure 1. Case Study 2 property – hydrology setting.

Water is the vehicle that ultimately transports contaminants from land to streams. A drone was deployed to survey the property using photogrammetry, and that data was then used to develop a hydrologically enforced digital terrain model to identify watershed or basins, along with identifying nodes or discharge points, i.e., the location at which water joins an intermittent or perennial stream or leaves the property.

Drone capture photogrammetry

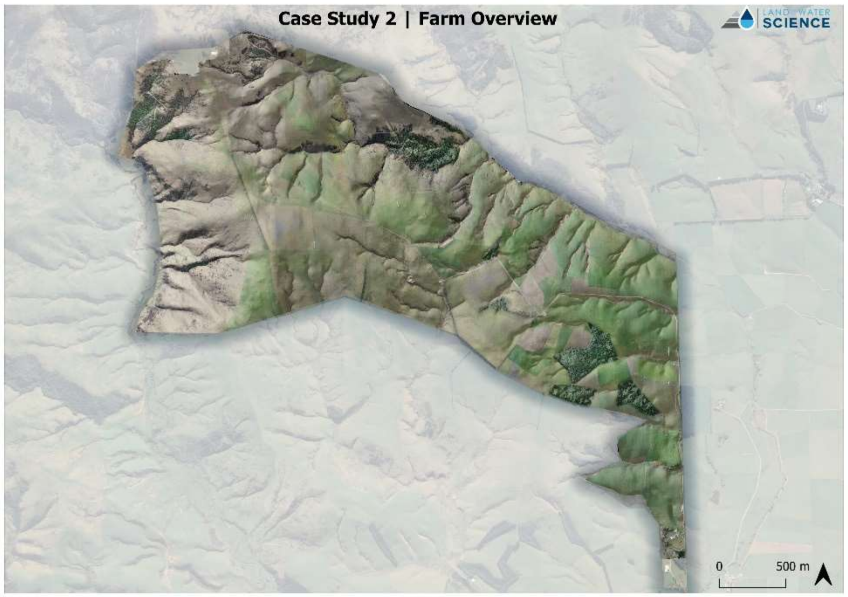


Figure 2. Case Study 2 property – overview from drone captured photogrammetry

Major drainage basins and channels

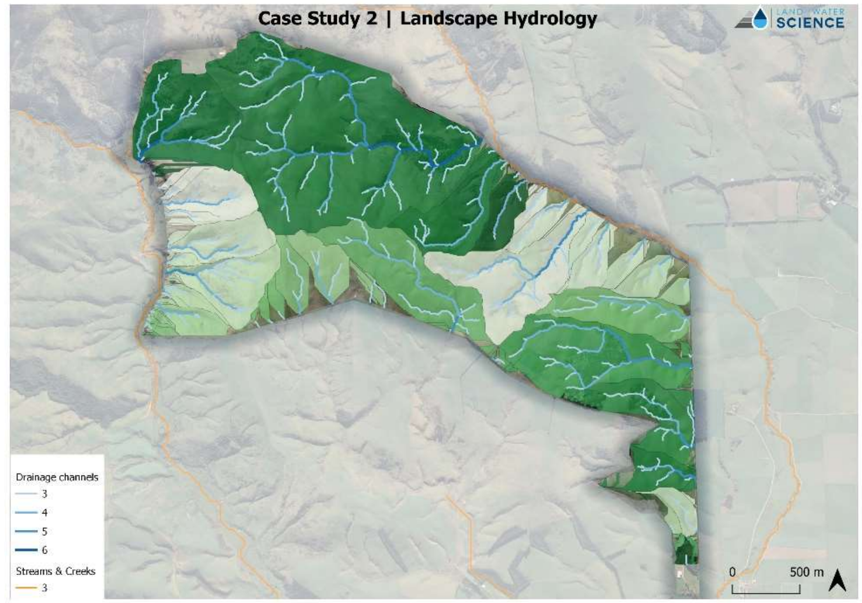
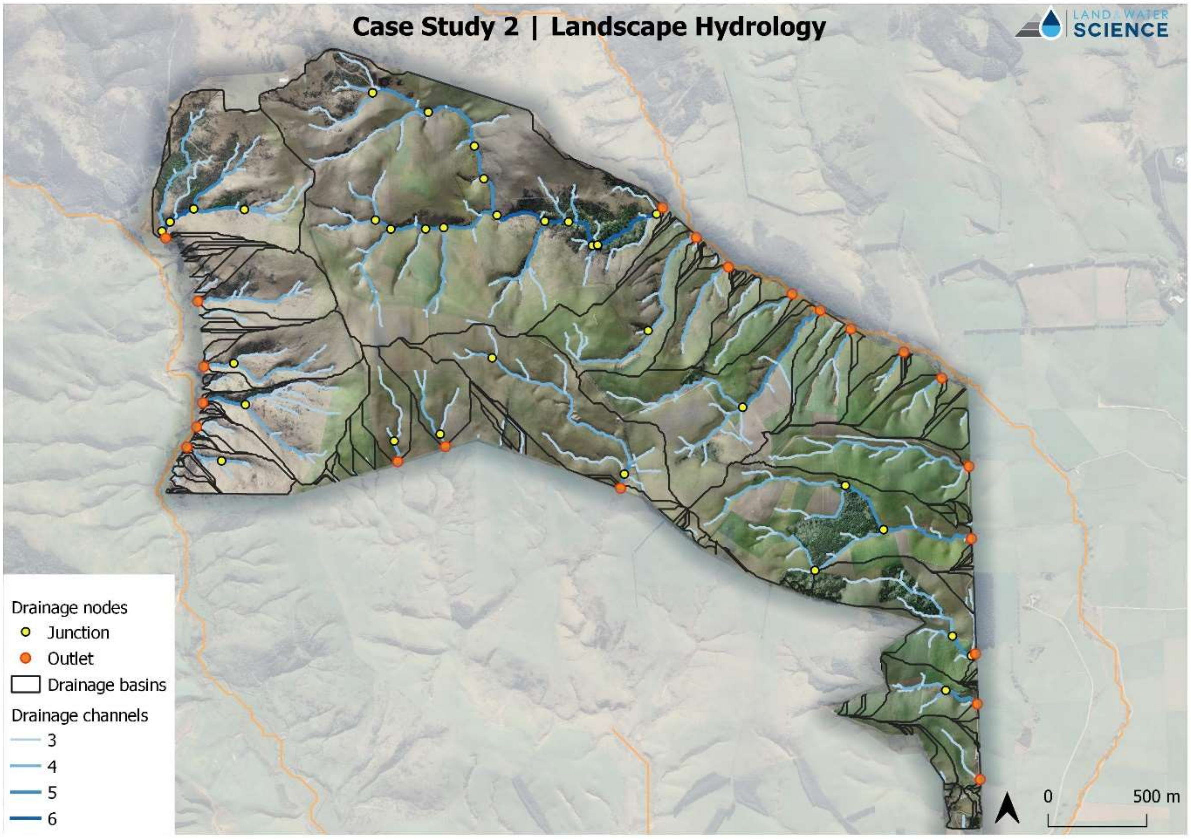


Figure 3. Case Study 2 property – major drainage basins (green shade), along with the major drainage channels

Discharge nodes
 *Figure 4. Case Study 2 property – discharge nodes (orange dots), where the water departs the property and junction nodes (orange dots), the location at which water joins an intermittent or perennial drainage channel.*

Topography and climate

The majority of the property lies between the 200 and 400 m RSL contour (parts of the property reach 600m).

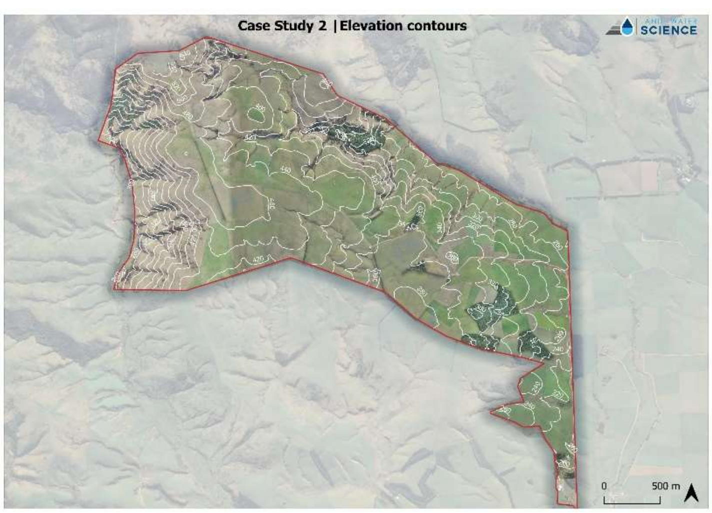


Figure 5. Elevation contours and property outline (red) in meters relative to sea level. Note the gentle fall in elevation from west to east, and the broad area of relatively low relief land through the middle of the property. The steepest parts of the property are associated with valley incision and side slopes

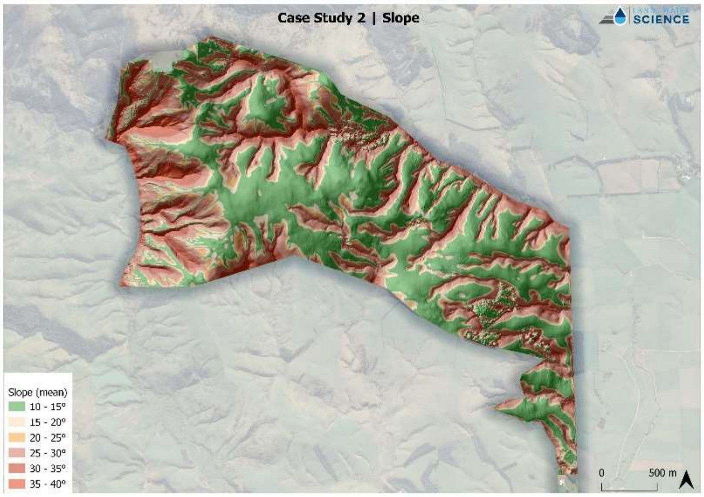


Figure 6. Slope map

The mean slope is 16.9° with a range of 1 to 57°.

There is a range of climate data on the property (dependent on altitude) average annual temperature ranges from 9.1 to 10.1 °C and mean annual rainfall ranges from 910 to 1020 mm[1].

[1] Derived from NIWA interpolation of climate observations 1991 to 2020

Geology

The property occurs within the Caples Geological Terrane. The main rock type is sandstone which is described as "weakly foliated grey-green sandstone with minor mudstone" by the regional geological survey (Q-Map V3). The maximum age estimate of this landform is 2.4 million years old, although the land surface is considered much younger. As the geology is relatively uniform, the majority of variation in landscape properties is associated with the topography of the land.

Soils

As S-Map only accounts for c. 35% of the land area of New Zealand, the Fundamental Soil Layer (FSL) provides soil information for the majority of the country. The FSL originates from an expert derived joining of the National Soils Database (NSD) and the polygon boundaries of the New Zealand Land Resource Inventory (NZLRI). As with most parts of New Zealand, the coarse nature of the soil maps provides limited control over the accuracy of soil variability across the property. Bearing in mind the accuracy of soil maps, the FSL designates a large part of the centre of the property as 'Crookston soil series', which is described as an imperfectly drained silt loam. The 'Fairlight soil series' are associated with the steeper sections of the property and are defined as moderately well drained silt loam soils that are shallow in places where rock outcrops occur close to the surface. Assuming the soil drainage and textural assignments are correct, the nitrate leaching risk is elevated for Fairlight soils and moderate for Crookston soils. Due to fine textures, runoff risk is elevated where slope exceeds 8°. Susceptibility to nitrous oxide loss is a factor of soil saturation, soils that are prone to saturation, due to either slow permeability and/or internal drainage limitations are more susceptible to nitrous oxide loss. However, steeper areas of the landscape should drain more rapidly, reducing the susceptibility of fine textured soils to saturation and nitrous oxide generation.

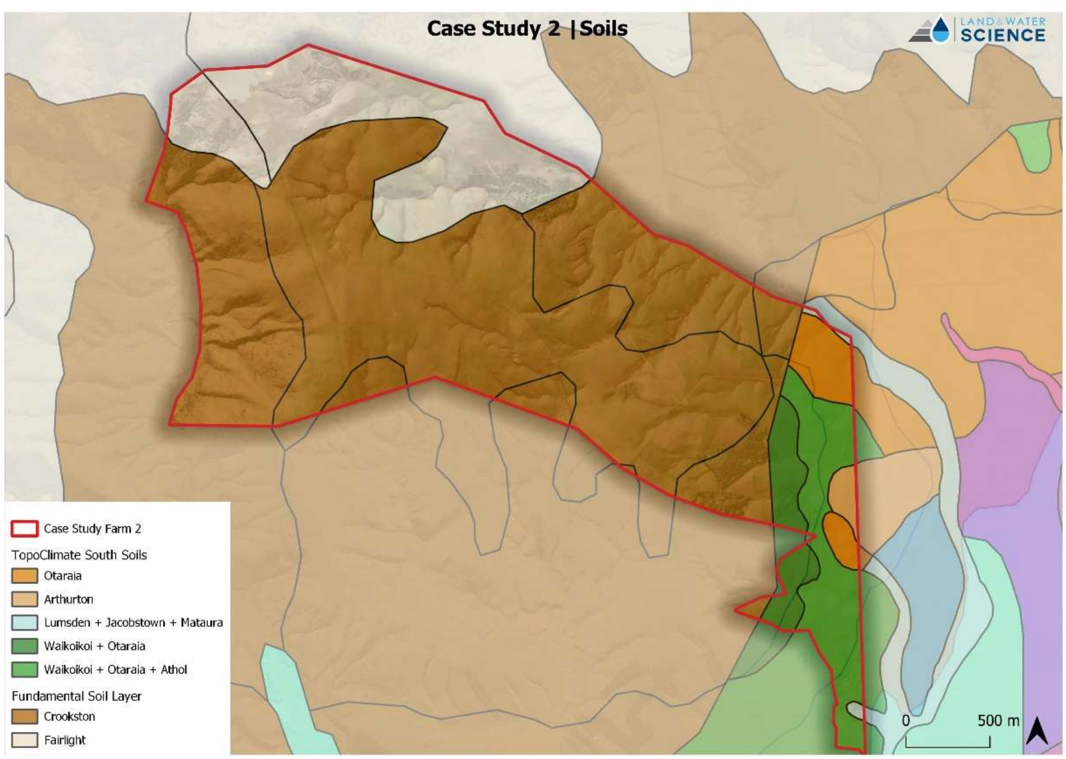


Figure 7. Case Study 2 property - soils map. TopoClimate South soil series and Fundamental Soil Layer mapped at 1:50,000 scale.

The S-Map (portal) survey only covers a minor area of the property along the eastern boundary and reflects Otaraia soil covering part of the north-eastern edge, and designates these soils as deep, well drained silt. Such soils are likely to be associated with elevated nitrate leaching. Claremont soils occur through the south-eastern edge of the property, and designates these soils as moderately deep, and poorly drained silt. Claremont soils are likely to have lower nitrate leaching loss but may be more susceptible to soil nitrous oxide and runoff related contaminant loss. The S-Map portal specifies 'low' confidence in the accuracy of the siblings reflected across this part of the property.

4.2 The sheep and beef farm

The 733 ha farm is utilised as a sheep and beef unit. The contour on the property ranges from flat to steep, with a range of pasture productivity throughout the property. Estimates of relative pasture productivity between blocks has been provided by the farmer. The contour and pasture productivity can be summarised as follow:

Land topography	**Pasture productivity**	**Area (hectares)**
Flat	1	99.2
Rolling	1	252
Easy hill	1	14
Flat	60%	25.2
Rolling	60%	9
Easy hill	60%	96.3
Easy hill	40%	14
Steep	40%	4
Steep back face (cattle only)	40%	105.4
Gullies	20%	40.2
Native scrub blocks		34
Douglas fir		9.2
Macrocarpa		3.8
Pine		5.2
Non productive		21.8
	Total	**733.3**

Farm System Description

The farm operates as a sheep and beef farm. In total there are 7659[2] revised stock units (RSU). This is broken down into:

- Beef 1597 RSU (21% beef)
- Sheep 6062 RSU (79% sheep)

The average per total hectare stocking rate is 10.5 RSU / hectare.

The sheep part of the operation comprises of 3700 perendale ewes wintered. Replacements hoggets are kept (1030 wintered), no hogget lambing occurs. The ewe lambing percentage is 135%. All non-replacements lambs are sold either to works or store (500), with a small number carried through winter (80) to be sold on the spring market.

The beef part of the operation comprises of 115 angus / hereford cross beef breeding cows wintered. Breeding bulls used over the cows are Charolais. 110 mixed sex beef cross calves are born, 65% are sent to the works prior to their second winter. The remainder are all gone to works before spring. 15 replacement rising 2 year old beef heifers are purchased each year in April and enter the beef breeding herd. The cattle are grazed solely on the steep back face and control pasture quality on the remainder of the farm throughout the year.

Crops rotate through the property on the flat to rolling areas. For the 2020/2021 season winter crops were 13.7 ha swedes (grazed by sheep) and 11.1 ha kale (grazed by beef). The kale follows the swede crop. 14 ha pasja was used as a summer / autumn feed and followed the kale. Following the pasja, a short rotation ryegrass was sown. This short rotation is typically utilised for 12 months before being regrassed into permanent pasture.

On the more productive areas of the farm the Olsen P is 24, while potash levels and sulphur levels tend to be below optimum. Low amounts of nitrogen are used on the more productive areas (12 kg N / ha / yr). Other fertiliser (phosphate, potash, sulphur) is applied based on soil test results and financial considerations. In the 20/21 season maintenance fertiliser was applied to a portion of the farm.

Table 4. Farm summary

	20/21 season
Total area (ha)	733
Stock and Production	
Ewes wintered	3700
Hoggets wintered	1030
Lambs	4995
	135 % lambing
Wool weight	20,000 kg
Breeding cows wintered	115
Bulls	3
Sold to works	110 R2s
Purchased replacements	15
	10.5 revised SU / hectare
Feed and Fertiliser	
Fodder crop (winter)	24.8 ha
Fodder crop (summer / autumn)	14 ha
Sold supplements	120 bales of baleage
Fertiliser applied	Applied to 427 ha (on average 13 kg N / ha and 21 kg P / ha)

[2] Estimated by OverseerFM

Farm Nutrient and Green House Gas Emissions

Estimates of nutrient and greenhouse gas emissions have been modelled using OverseerFM (Table 5).

"OverseerFM provides a way to estimate how nutrients are cycled within a farm system. This allows the user to better understand annual average nutrient requirements and the likely effects of changing management practices on the farm's overall nutrient inputs and losses”.[3]

OverseerFM models nutrient flows to the farm boundary. The farm boundary is to the farm gate and to rooting depth. It does not model what happens to those nutrients beyond this boundary, nor does it model extreme weather or events.

OverseerFM greenhouse gas estimates have been calculated using IPCC global warming potentials. Estimated change in total greenhouse gas emissions (methane, nitrous oxide and carbon dioxide combined) are reported. In addition, the estimated change to nitrous oxide emissions are identified to align with the specific opportunities identified in the landscape susceptibility mapping.

Modelling biological systems is not exact and there are uncertainties, results are intended to give a ‘direction of travel’ rather than accuracy.

Table 5. OverseerFM estimates of farm nutrient and greenhouse gas emissions

	Case Study 2 – 20/21 season OverseerFM v6.5.2
Total farm emissions (eCO_2 t/yr)	2937.9 20% nitrous oxide 72% methane 8% CO2
Emissions per hectare (eCO2 /kg/ha/yr)	4008
Total Farm N Loss (kg/yr)	9002
N Loss/ha (kg N/ha/yr)	12
N Surplus (kg N/ha/yr)	56
Total Farm P Loss (kg)	420
P loss/ha (kgP/ha/yr)	0.6

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[3] New Zealand Dairy Statistics 2020-21, LIC, DairyNZ

Not included in the above farm emissions profile is the carbon being sequestered in the existing forestry blocks (these are not registered in the ETS). The existing forestry blocks on the property comprise of 9.2 ha Douglas Fir, 3.8 ha of macrocarpa and 5.2 ha of pine. At the current age of these trees they are calculated to be sequestering 425.6 t eCO_2 t/yr[4]. No account has been taken of the sequestering impacts of the 34 ha of native scrub, as these areas are not eligible to be included in ETS and the MPI carbon stock "look up tables". Going forward there may be an opportunity to fence off these areas to enhance regeneration and meet inclusion criteria.

Tree Block	**Age (years)**	**eCO_2 t/yr sequestered**
9.2ha Douglas Fir	28	211.6
3.8 ha Macrocarpa	26	52.8
5.2 ha Pine	28	161.2
		425.6

[4] Estimated by OverseerFM, based on lookup tables for post 1989 forest land by MPI

5. Environmental Contaminants

5.1 Environmental Contaminants

Green House Gases

Rising concentrations of greenhouse gases in the atmosphere increase the earth's temperature. Greenhouse gases comprise of long lived (carbon dioxide and nitrous oxide) and short lived (methane).

The New Zealand Government has the following legislated emissions targets:

- Methane (CH4) emissions to reduce by 10% below 2017 levels by 2030, and by 24 to 47% by 2050
- Nitrous oxide (N_2O) and carbon dioxide (CO_2) to reduce to net zero by 2050.

Both methane and nitrous oxide are very potent greenhouse gases. Methane warming potential is circa 30 times more powerful than carbon dioxide. The predominate source of methane in NZ farming systems is from ruminant digestive systems.

Nitrous oxide warming potential is circa 300 times more powerful than carbon dioxide. Nitrous oxide forms in the soil in response to soil saturation, mainly topsoil saturation. The volume of nitrous oxide produced is a factor of the surplus of nitrate in the soil, soil temperature, and the duration of saturation of the soil. Low volumes of nitrous oxide are generated when soil temperatures are low, soil nitrate concentrations are low, and the topsoil is not saturated. High volumes of nitrous oxide are generated when soil temperatures are elevated, soil nitrate concentrations high, and topsoil becomes saturated.

Nitrate

Nitrate is highly soluble and is easily transported through the soil if not used by plants and microorganisms. Nitrates can be transported to ground and surface waters, where it may cause human health and ecological issues. Nitrogen is an essential element for plant growth and is generally added to pastures through biological fixation (in clovers), as fertiliser (in synthetic and organic forms), as effluents or as urine from livestock. Slope and associated soil thickness are important factors determining nitrate generation. Flatter land with deeper soils generates a greater proportion of nitrate, which may be lost below the root zone during periods of soil water drainage which usually occurs during the cooler/wetter months of the year.

Organic and Ammoniacal Nitrogen (TKN)

Total Kjeldahl Nitrogen (TKN) is a measure of organic and ammoniacal N. Organic nitrogen is mineralised to form ammoniacal N, ammoniacal N is oxidised to nitrite and ultimately nitrate. The loss of excessive TKN from land is therefore an important factor controlling stream health. However, it is important to note that all natural systems contain TKN, with TKN loss occurring from natural state landscapes as well as farmed land. The main difference between natural state and any developed landscapes are the magnitude of losses. Commonly, TKN losses are elevated for soils that are poorly drained or prone to saturation for extended periods of the year. Soils with elevated organic carbon contents, e.g., peat, podzols etc, are more likely to lose high concentrations of TKN than well drained mineral soils.

Ammoniacal nitrogen (NH_4-N) is the form of nitrogen present as either ammonia (NH_3) or ammonium (NH_4). It can be toxic to aquatic life at high concentrations. There is often a high susceptibility for ammoniacal nitrogen associated with "reducing" soils. This includes poorly drained soils with higher organic matter content and poor aeration. Ammoniacal nitrogen is less mobile than nitrate and tends to bind to soil particles, particularly those with a high clay content. As a result, it can be more easily transported to waterways during runoff after rain.

Particulate Phosphorus

Phosphorus is a nutrient for plants and algae. High concentrations in waterways can cause weed growth and algae blooms. Sources of phosphorus are weathering of rocks, erosion of soil and the addition of phosphate fertilisers to pastures and dung from livestock.

Particulate phosphorus (PP) refers to phosphorus that is associated with particles such as suspended sediments. Phosphorus binds to soil particles, and when soil is lost by runoff it takes the phosphorus with it.

Particulate phosphorus loss requires water to erode and carry sediment that is enriched in phosphorus to a waterway. The risk of runoff is elevated with increasing slope of land. Soils with elevated P-retention can sequester a large amount of P from fertiliser or animal wastes. Erosion of such soil can transport large amounts of P to waterways where it drives eutrophication. Soils that are imperfectly to poorly drained tend to be more susceptible to P loss via runoff or mole-pipe drainage. Well drained soils tend to have a low susceptibility to PP loss as they are less likely to runoff. However, well drained soils with elevated Olsen P values can release higher concentrations of dissolved P into soil solution. Ensuring Olsen P values do not exceed optimal values is a good way of limiting dissolved P leaching.

Dissolved Reactive Phosphorus

Dissolved reactive phosphorus (DRP) refers to the soluble phosphorus compounds in water and is the dissolved P fraction that is not attached to sediment. They are a nutrient for plants and algae and high concentrations in waterways can cause weed growth and algae blooms.

Sediment

Sediment is the loose sand, silt, clay, and other organic particles suspended in a waterway or settled on the bottom. Sediment can come from soil erosion or the decay (decomposition) of biological material and is transported by water, wind, and ice to waterways. Although sediment is a natural part of a waterway, the type and amount potentially available to transport is influenced strongly by the geology and topography of the surrounding area and land use practices. Weaker or fine textured rock types, such as mudstone, naturally have a higher sediment load and more turbid water due to these rock types being more easily erodible. This natural sediment load is elevated by land use practices that cause structural damage to soils or leave soil bare and exposed. Under agriculture, sediment can also be enriched with nutrients. Nutrient-rich sediment has a much larger detrimental effect in waterways than sediment from natural state or areas with a low land use intensity.

Sediment includes organic matter and clay and silt. Sediment loss from the land occurs in a variety of ways. Mass wasting, the movement of soil and earth under gravity generates slumps, slips, and terraces (‘sheep tracks’) that increase the surface roughness of the land. Water running across the rougher parts of the landscape, smoothing these areas off, and carry sediment to waterways. The fine sediment content of soils, i.e., silt and clay, is also an important control over sediment generation and loss. Soils formed in mudstones for example tend to have a high clay content which is more easily lost to water, than soils formed in a coarse sandstone. Surface runoff across wet soils is one of the main mechanisms driving sediment loss.

E. coli

Microbes are the hardest contaminant to model. They are dynamic and vary with sunshine intensity, temperature, soil pH, stream types (soft vs. hard bottomed) and with land use activities (calving/lambing etc). As a general rule, *E. coli* loss is from the land is correlated with runoff, mainly as overland flow. Water running across the land surface entrains animal waste. Bacteria and virus are very sticky, adhering to soil particles, piggy backing their way into streams. Tile drainage can also export significant quantities of bacteria to streams. Any modification of the soil to speed up water drainage can increase the susceptibility of microbial export. However, overall, runoff is the main vehicle for bacterial transport.

For more information on environmental contaminants, see landscapedna.org/science/water-quality-contaminants/.

5.2 State of the Mataura Catchment

Land use and various industrial and municipal water discharges are key contributors to the degradation of water quality in the Mataura Catchment[5].

The Mataura River and the Toetoes Estuary are an important source of mahinga kai, particularly kanakana, inanga and tuna. Land use and various industrial and municipal water discharges are key contributors to the degradation of water quality in the Mataura catchment. Currently the Toetoes Estuary is considered to be in poor condition.

Water quality in this catchment is showing stress in terms of *E. coli* (faecal bacteria) (surface water), nitrogen (surface water), phosphorus (surface water and groundwater), and the macroinvertebrate community index (MCI).

For further information on water quality in Mataura Catchment refer to appendix 1.

6. Landscape susceptibility

Variability in climate, topography, geology, and soils significantly influence the type of contaminant and severity of water quality outcomes even when land use is the same. We refer to the variability in climate, topography, geology and soil as 'landscape factors'. These are the physical, chemical, and biological (organic matter) components of the earth that control the susceptibility ('risk') of the landscape to contaminant loss (Figure 4). Landscape factors, especially soil texture and drainage also have a significant effect on governing soil greenhouse gas (GHG) production. For geologically diverse landscapes, such as New Zealand, the type and severity of contaminant loss vary significantly. Even in relatively simple landscape settings, variation in landscape factors may account for the majority of spatial variation in water quality relative to land use on its own.

[5] Norton, N., Wilson, K., Rodway, E., Hodson, R., Roberts, K. L., Ward, N., ... & Greer, M. (2019). Current environmental state and the "gap" to draft freshwater objectives for Southland. *Environment Southland Technical Report*, *12* .Moran, E., Pearson, L., Couldrey, M., & Eyre, K. (2017). The Southland economic project: agriculture and forestry. *Environment Southland Technical Report Publication*, (2017-02).

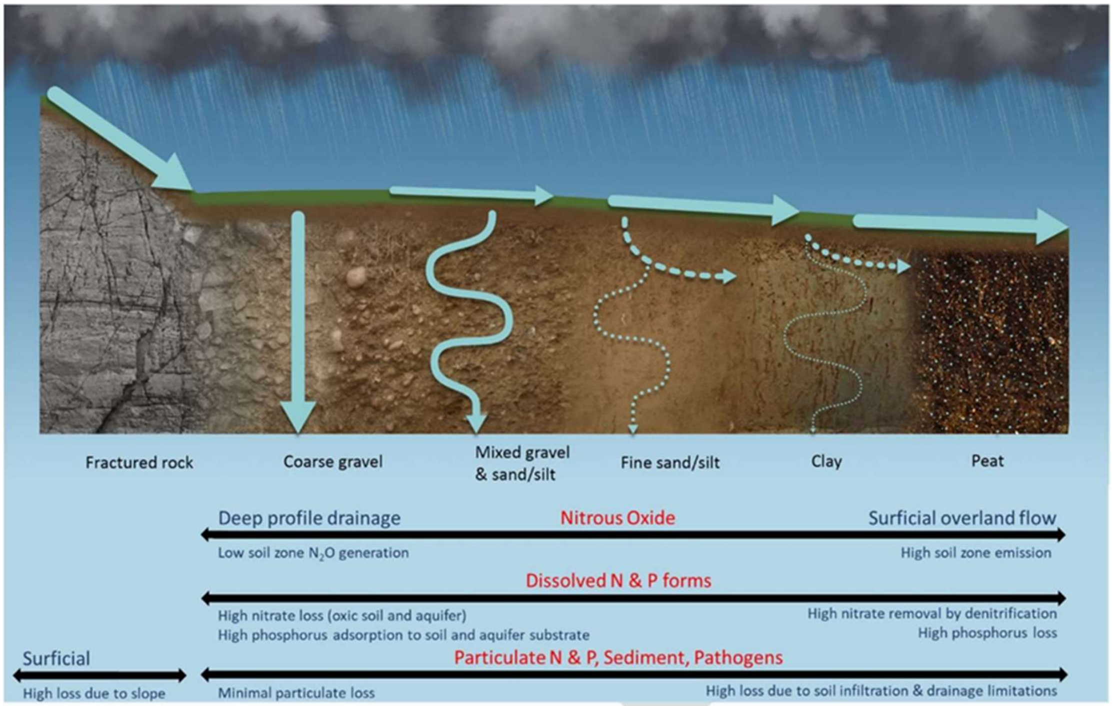

Figure 8. Conceptual diagram of susceptibility for contaminant loss under various landscape properties. Susceptibility for contaminant loss is strongly controlled by the pathway water takes to leave the land and the chemical processes of reduction-oxidation 'redox' that takes place within the soil and geological materials.

LWS has generated a classification that maps the landscape factors controlling variation in the type and severity of water quality issues. The classification, Physiographic Environments of New Zealand (www.LandscapeDNA.org) is designed to support land users in understanding how and why water quality variation occurs across the landscape and identify the most important susceptibility on their property. In doing so, LandscapeDNA seeks to support targeting actions specific to their location and the issues they face. This mapping is undertaken by combining existing soil, geological, topography and climate data to understand the landscape factors controlling variation in water quality. The map has a resolution of 1:50,000. At this scale, it is appropriate for providing catchment context and describing the general farm environment but is not at the resolution suitable for paddock scale management decision-making.

Mataura River Catchment's physiographic setting is provided in Figure 9. Alpine and bedrock environments comprise 53 percent of the catchment with the lowlands dominated by the reducing soil oxidising aquifer (18.2 percent of the catchment) and oxidising soil and aquifer environment (16.1 percent of the catchment). For specific details on each physiographic environment and its landscape susceptibility, see landscapedna.org/science/physiographic-environments/.

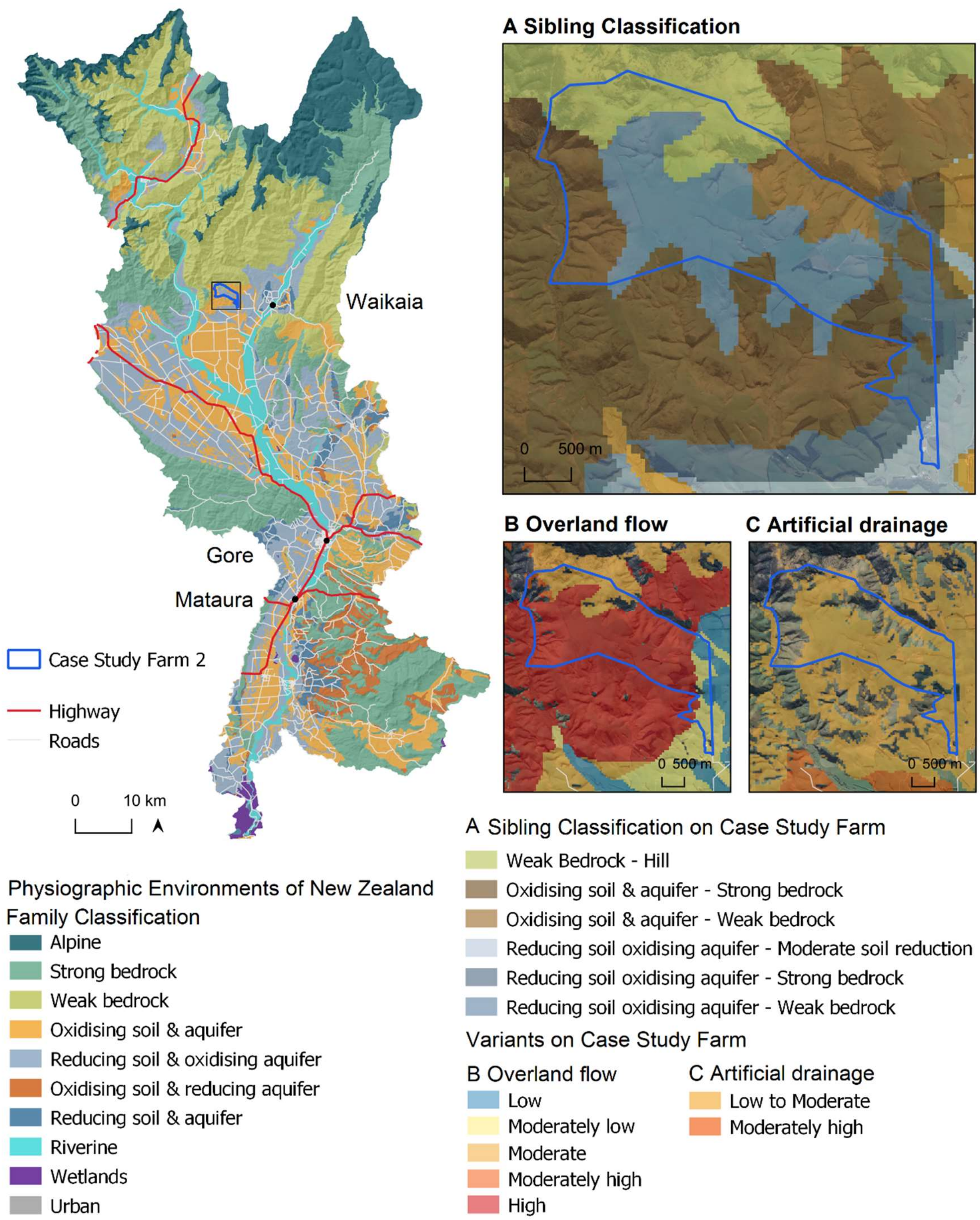

Figure 9. Physiographic environments of the Mataura Catchment and case study farm

The case study farm is located predominantly within the reducing soil oxidising aquifer environment (349 ha, 48 percent of the property; Figure 5A). Lateral or artificial drainage is the dominant hydrological pathway as indicated by the sibling class of increased lateral and overland flow (Figure 5B). The second largest physiographic environment is oxidizing soil and aquifer (254 ha, 35 percent of the property) where deep drainage is the dominant hydrological pathway to the aquifer. The balance of the property is reflected as weak bedrock environment (130 ha, 18 percent of the property; Figure 5A).

The Wendonside and Waimea Valley are characterised by distinct water quality challenges that relate to the highly variable landscape. The Wendonside and Waimea areas have a number of small but locally important areas of elevated groundwater nitrate that exceed the WHO drinking water standards (11.3 ppm), and in the case of the Waimea, discharge high concentrations of nitrate in groundwater to the Waimea Stream. Poorly drained soils across low lying areas are prone to runoff, and the export of contaminants via mole-pipe drainage. More broadly, the hill country surrounding the lowland plains is prone to runoff and associated sediment, *E. coli*, and particulate phosphorus loss. Localised water quality issues are manifest as exceedances against regional and national guidelines for freshwater.

6.1 Susceptibility of case study farm

LWS undertook a new, high-resolution physiographic approach to mapping the inherent and varied susceptibility of the landscape to land use activities at property scales. The resolution of the mapping is 50 x 50 m providing a much more resolved understanding of contaminant susceptibility than physiographic environments on their own. The maps are of sufficient resolution to show paddock scale variation in susceptibility.

The maps of landscape susceptibility highlight the various contaminants and their forms using a scale of 0 – 100 (0 being low and 100 being high susceptibility). The landscape's dominant influence on contaminant production and transport means that much more attention needs to be paid to these spatially driven factors.

It is important to emphasise the following for the susceptibility models presented below. They:

A. Are entirely independent of land use and only identify the natural susceptibility of the landscape to contaminant loss that is associated within soil, geology, and topographic factors (e.g., slope, elevation),

B. Do not consider any existing environmental management practices or physical mitigations that are already in place (e.g., sediment traps, wetlands),

C. Do not represent actual losses or contaminant loads.

The susceptibility maps are coloured from red, reflecting elevated susceptibility to the contaminant or emission in question, to blue, reflecting low susceptibility.

Nitrous Oxide and NNN

<table>
<tr><th>Landscape susceptibility – N2O (soil nitrous oxide)</th><th>Landscape susceptibility – NNN (nitrate-nitrite-nitrogen)</th></tr>
<tr><td>

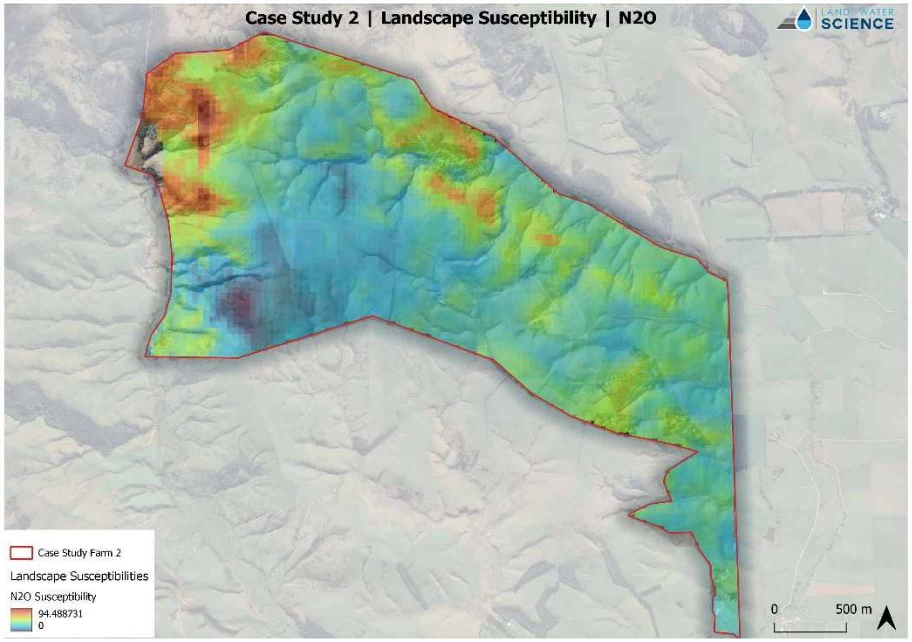

Figure 10. Landscape susceptibility to nitrous oxide

N2O model indicates elevated landscape susceptibility across the steeper portions of the property that are known to saturate during the cooler months of the year. Soils across these areas are shallow and overlie sandstone, and like many such soils may rapidly saturate. The westerly and northerly aspect of these steep slopes is another factor favouring elevated susceptibilities. Thin soils, with a westerly and northern aspect are more prone to saturation during the winter months. However, low stocking rates and lower temperatures are likely to offset the natural susceptibility of these areas to nitrous oxide loss.

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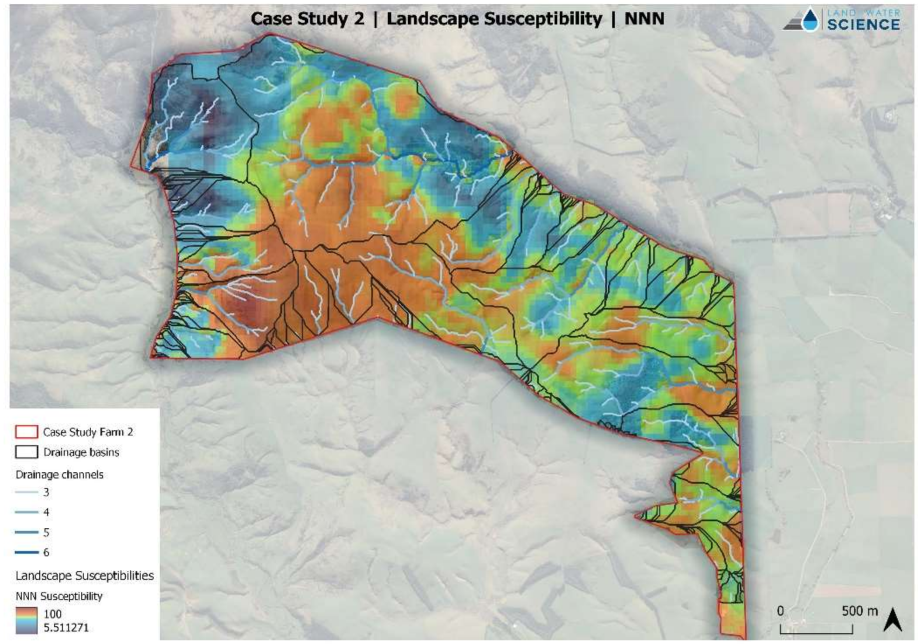


Figure 11. Landscape susceptibility to NNN (Nitrate- Nitrite-Nitrogen)

The highest susceptibility areas are predominately located in the central and south-western area of the property where soils are deeper. The lower relief and imperfectly drained Crookston soils are not expected to generate highly concentrated leachate, especially relative to lowland dairying on well drained soils, but they will lose some nitrate. Leached nitrate may be exported from the property as baseflow (spring fed). It may be instructive to monitor the nitrate concentration in the small spring-fed streams that drain the larger area of relatively flat and well drained soils.

</td></tr>
</table>

The susceptibility of the landscape to nitrous oxide loss is the opposite to that of NNN leaching (Figures 10 and 11). This reflects the role of redox processes (e.g., oxidation and reduction reactions) in controlling whether or not NNN is removed or able to accumulate.

Sources of nitrogen in Case Study 2 include biological fixation by clovers and a small amount of synthetic nitrogen applied. The nitrogen surplus is 56 kg N / ha / yr, with an estimate of 2 to 4 ppm of nitrogen leaving the root zone as leachate on the pastoral areas. On crop areas the concentration of nitrogen in drainage increases up to 21 ppm.

Particulate phosphorus and dissolved reactive phosphorus

Landscape susceptibility – PP (particulate phosphorus)

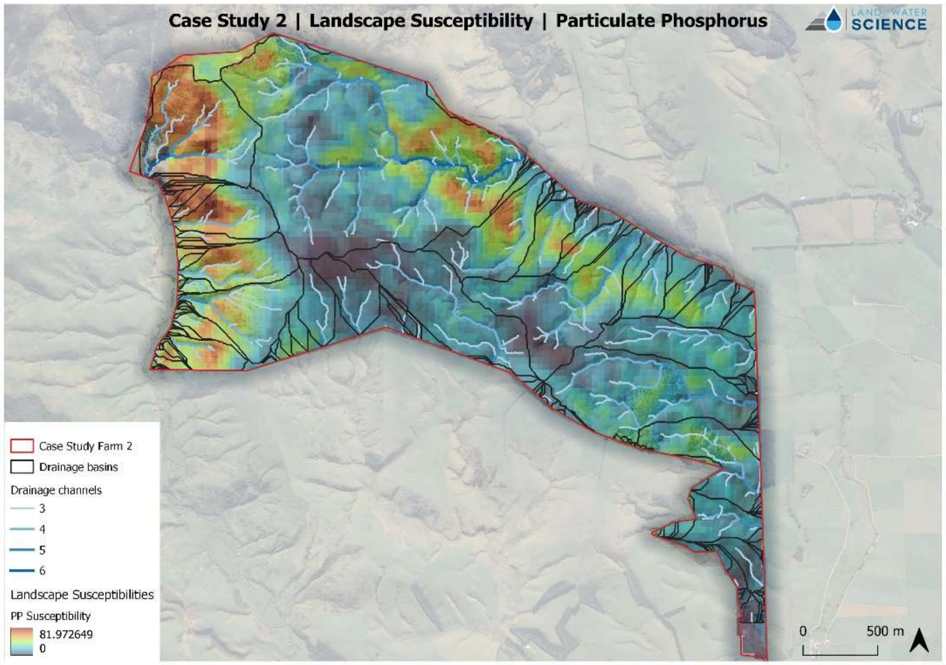


Figure 12. Landscape susceptibility to PP (particulate phosphorus)

The above map indicates the areas of elevated landscape susceptibility to particulate phosphorus occur along the north-western boundary, along with scattered pockets along the central-north boundary of the property. Parts of these higher susceptibility areas have already been planted in trees. Here the land is steep, soils are thin and overlie bedrock (sandstone). Thin steep land soils are commonly prone to saturation during the winter months and as such are more inclined to runoff resulting in the loss of particulates including phosphorus.

Landscape susceptibility – DRP (dissolved reactive phosphorus)

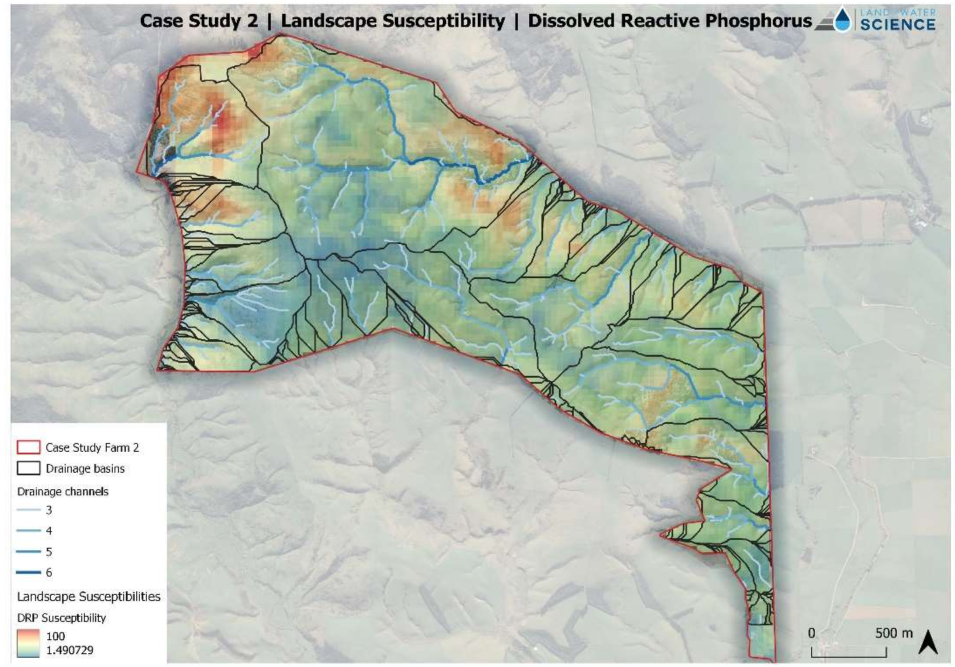


Figure 13. Landscape susceptibility to DRP (dissolved reactive phosphorus)

The above map reflects the highest susceptibility areas for this property are located across the north-western corner of the boundary and the northernmost facing slopes. Elevated DRP susceptibility across these areas is consistent with high rates of soil saturation, especially during the winter months. Saturated soils have higher DRP loss rates than well or better drained soils. As such, the pattern of DRP susceptibility is consistent with wetter soils.

The topsoil P-retention ranges from low (22 percent on the Claremont soils) to medium on the Fairlight soils (45%) and Otaraia, Crookston soils (43 percent).[6]

Soil tests were taken in December 2019, across 4 sites on the farm. The Olsen from soil test results[7] ranged from 18 to 29 mg/l across the property. For sedimentary soils on sheep and beef farms the target Olsen P is 20 to 30[8]. In the 2020/21 season, fertilizer was applied targeted areas in the form of super phosphate and serpentine super.

[6] Manaaki Whenua Landcare Research S-Map soil reports
[7] Hill Laboratories Report - soil testing completed December 2019 by Ballance Agri-nutrients
[8] Fertiliser Use on New Zealand Sheep and Beef Farms, Fert Research

Turbidity and organic & ammoniacal nitrogen

Landscape susceptibility – Sediment (turbidity)

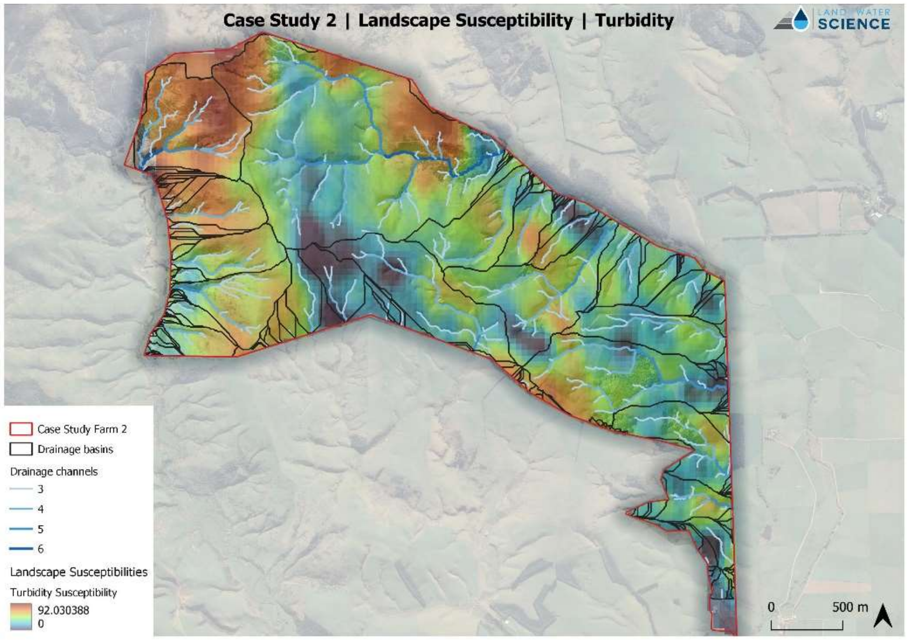


Figure 14. Landscape susceptibility for sediment as indicated by turbidity

The susceptibility model for the Case Study 2 property indicates the areas of greatest sediment susceptibility occur along the north-western boundary, along with an area along the central-north boundary of the property. Parts of these higher susceptibility areas have already been planted in trees. Here the land is steep, soils are thin and overlie bedrock (sandstone). Thin steep land soils are commonly prone to saturation during the winter months and as such are more inclined to runoff and as a result erosional losses of sediment.

Flatter portions of the property host deeper soils that are less prone to runoff and erosion. Water that drains through these soils' likely pools at the contact with basement rock, and flows to discharge points i.e., springs.

Landscape susceptibility – TKN (organic and ammoniacal nitrogen)

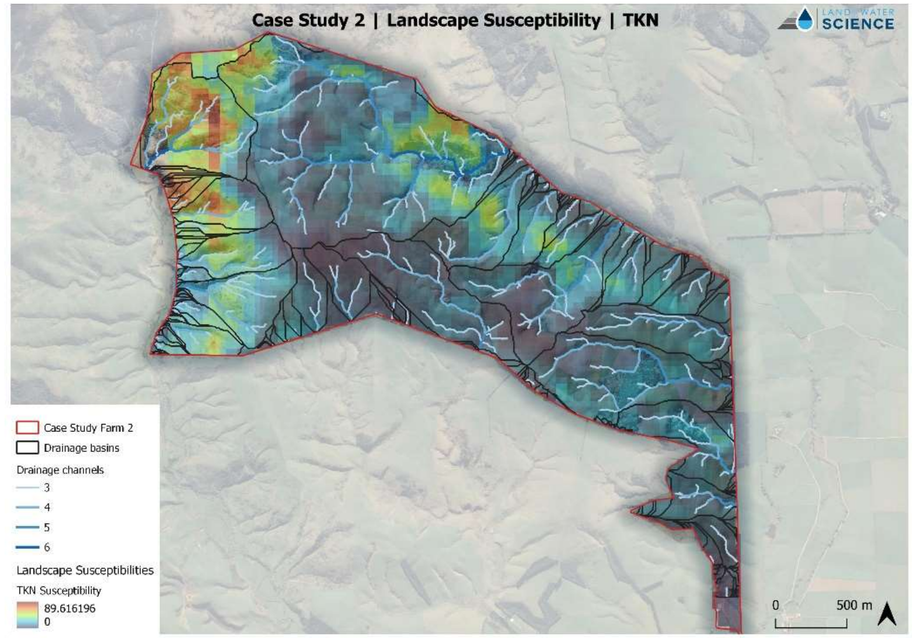


Figure 15. Landscape susceptibility to organic and ammoniacal nitrogen

The above map reflects the highest susceptibility areas for this property are located around the north-western corner of the boundary, this is similar to DRP and nitrous oxide. The similarities are to be expected as soil saturation plays a critical role over the susceptibility of each of these contaminants to loss. Again, steepland soils that are prone to saturation are associated with the highest susceptibility to TKN loss. The westerly and northerly aspect of these steep slopes is another factor favouring elevated susceptibilities.

The small spring fed streams also collect surface runoff during periods of high rainfall. During periods of peak discharge, small streams can be sites of erosion and sediment export. All of these processes are natural phenomenon that occur throughout hill and high-country areas that confer naturally elevated susceptibilities to sediment loss.	

E. coli

Landscape susceptibility – *E. coli*

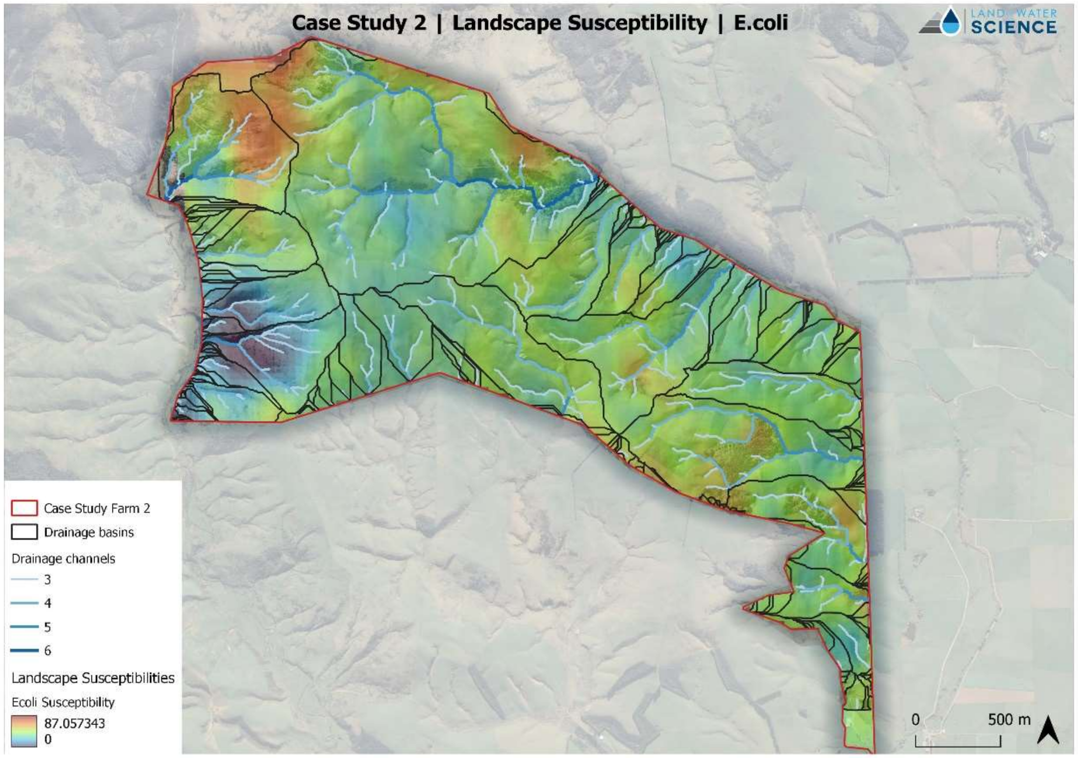



Figure 16. Landscape susceptibility to E. coli (Escherichia coli) contaminants. Microbial contaminants are disease-causing organisms. E. coli (Escherichia coli) is just one type of bacteria commonly found in the gut of warm-blooded animals and people The above map reflects the highest susceptibility areas for this property are located around the north-western corner, along with a medium scattering through the central and south-eastern areas of the property. However, there is low confidence in the susceptibility model for *E. coli* relative to the other contaminants.

The susceptibility models for Case Study 2 property show a predictable pattern that is consistent with topographic controls. Topography controls aspect, slope, and soil depth. These landscape factors interact to determine the susceptibility of the land to saturation and erosion. Soil saturation and the runoff of water are the key controls over the susceptibility of the property. Where the land is flat, susceptibility is lower overall, whereas the steeper parts of the property, especially the western and to a lesser degree the north facing slopes, are most prone to contaminant loss. This pattern of differential susceptibility is typical of hill country settings, where topography and aspect interact to determine contaminant susceptibility profiles.

Ground truthing of the property is required to support a more robust assessment. However, this preliminary desktop evaluation raises a range of opportunities to mitigate elements of the natural susceptibility of the property. For example, conversations around carbon farming of steep land, mainly western facing slopes, may provide additional revenue or offset GHG emissions and water quality across the more productive parts of the property. However, much more work is required to evaluate the feasibility of any proposed changes against the economic sustainability of the farming enterprise.

When hydrology and landscape susceptibility insights are combined, the ability to identify where investment needs to be made to minimise losses from the property becomes obvious.

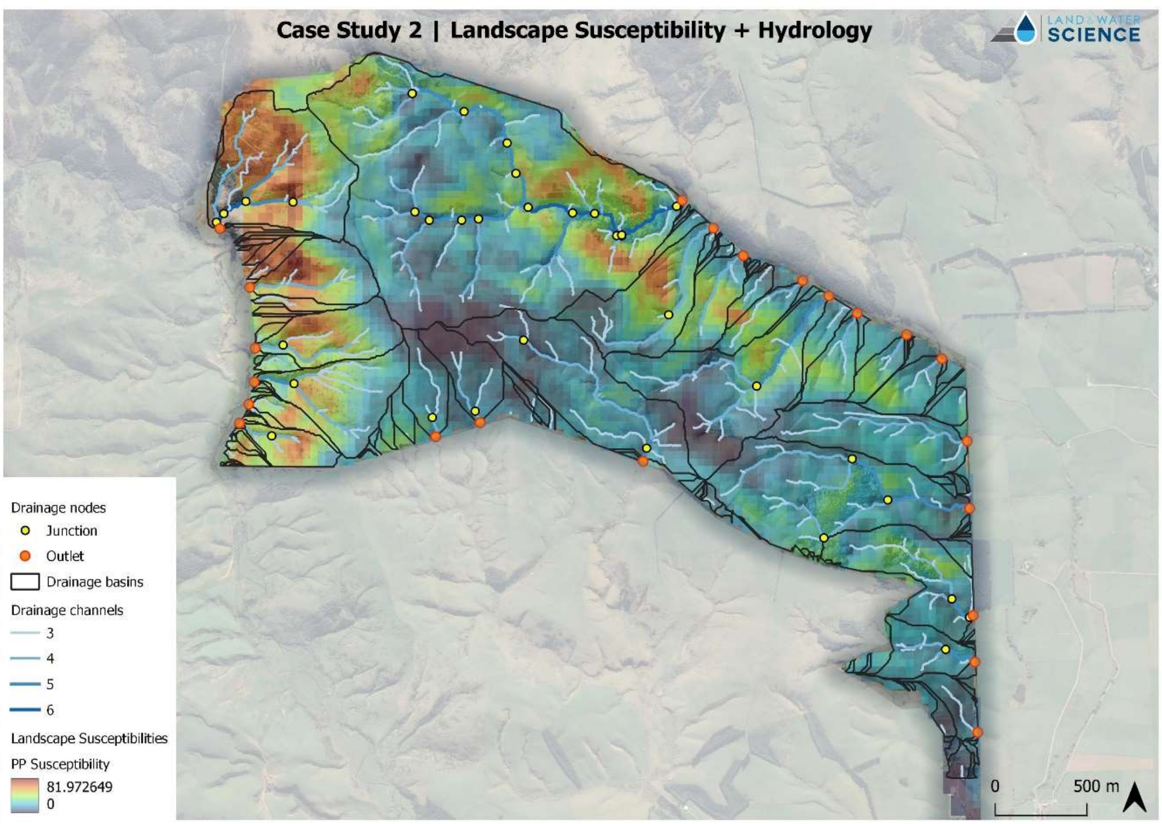


Figure 17. Case Study 2 property – example combination of Landscape Susceptibility plus Landscape Hydrology to provide relevant insights

7. Environmental mitigation opportunities

During the site visit it was identified through landscape susceptibility, farm systems analysis, and investigation of forestry opportunities that there were opportunities to reduce environmental impact.

The property is an extensive sheep and beef property, comparative with other land uses / land classes in the catchment but is not a high intensity property. While some reductions can be achieved through mitigation of current low intensity farm system, reductions of a larger scale will be achieved through landscape intervention and land use change.

Options considered:

- Mitigations within current farm system
  1. Use of plantain in pastures
  2. Replace kale with fodder beet (for beef animals)
  3. Replace swedes with grass wintering (for sheep)
  4. Install a standoff pad (for the R1 and R2 beef animals)

- Scenarios with significant capital investment
  5. Wetlands
  6. Plant 36.9 ha of plantation forestry and slightly reduce sheep numbers
  7. Plant 134 ha of plantation forestry and remove beef breeding cow operation.

- Optimisation of current farm system
  8. Optimisation of the farm system (lifting lambing percentage, finishing lambs earlier and slightly heavier).

Opportunities to reduce environmental impact were investigated through OverseerFM and wetlands estimates and compared against the 2020/21 season.

Considering actions that are high farm system change/cost requires extensive analysis, as these changes impact:

- Income
- Costs
- Capital requirements
- Profitability
- Stock and pasture/feed management
- Skills required to operate changed farm system.

Partial budgeting was utilised to explore the high-level impact of farm system change on capital investment and farm working expenses. This method has been chosen so farmers can follow the approach and relate it to their own situation. Where there were significant changes to the farm system the impact was modelled through Farmax.

Further analysis should be undertaken before finalising any decisions, using a model such as Farmax to analyse farm system feasibility and detailed budget/cashflow implications completed.

7.1 Mitigations within current farm systems modelled

Each option below has been modelled separately and compared against the 2020/21 season.

Option 1: Use of plantain in pastures

Description

Plantain is a herb, that when included in pastures is shown to reduce environmental impact. Research has shown a reduction in both nitrate leaching and GHG (specifically nitrous oxide) in pastures containing plantain. Further research is on going in terms of environmental mitigation, pasture persistence and the palatability of plantain.

It has been assumed in this scenario that the average plantain in the pasture sward over 315 ha is 5% plantain. This reflects that in new pasture plantain will be up to 30% of the pasture sward and after 3 years very little plantain will be evident. It has not been assumed that plantain will be established into existing pastures (only when regrassing).

Impact on environmental contaminants

OverseerFM modelling has estimated the environmental impact of (Table 6).

Table 6. OverseerFM estimated impact of mitigation for Option 1

Total GHG change	**Nitrous oxide change**	**N loss change**	**N Surplus change**	**P loss change**
No change	1% decrease	1% decrease	No change	No change

(Compared with the Year End 2020/21)

Farm system

Minimal impact. Assumes plantain only included in regrassing. No broadcasting / direct drilling of plantain into existing pastures.

Financial impact

Regrass approximately 20 ha per year. Include 1 kg plantain seed in regrassing mix. Approximate cost $400 per year.

Other impacts

Persistence and palatability of plantain would need to be considered for this property.

Option 2: Replace kale with fodder beet (for beef animals)

Description

Winter cropping is a high nutrient loss activity. In this scenario the area winter cropped has been reduced by using 5.8 ha of fodderbeet instead of the 11.1 ha of kale currently used. The fodderbeet is a higher yielding crop and the amount of dry matter available for beef cattle grazing is unchanged.

Impact on environmental contaminants

OverseerFM modelling has estimated the environmental impact of (Table 7).

Table 7. OverseerFM estimated impact of mitigation for Option 2

Total GHG change	Nitrous oxide change	N loss change	N Surplus change	P loss change
1% decrease	3% decrease	2% decrease	4% decrease	<No change

(Compared with the Year End 2020/2)

Farm system

Fodder beet is a heavier crop, managing in wet weather to maintain utilization and reduce risk of run off of contaminants is more challenging. Less land area will be required for cropping which will have an impact on feed supply and area available for re grassing post cropping.

Financial impact

Cost comparison between kale and fodder beet dependent on fodder beet yield. Need 25T DM fodder beet crop to be a similar cost to kale based on a cents per kg of DM basis.

Other impacts

Transitioning animals onto fodder beet needs to be undertaken carefully to avoid animal health issues. May achieve higher stock growth rates.

Option 3: Replace swedes with grass wintering (for sheep)

Description

Winter cropping is a high nutrient loss activity. In this scenario the area winter cropped has been reduced. 25.1 ha of swedes has been replaced with all grass wintering.

Impact on environmental contaminants

OverseerFM modelling has estimated the environmental impact of (Table 8).

Table 8. OverseerFM estimated impact of mitigation for Option 3

Total GHG change	Nitrous oxide change	N loss change	N Surplus change	P loss change
7% increase	10% increase	4% decrease	23% increase	No change

(Compared with the Year End 2020/21)

Farm system

Grass wintering sheep over the winter with baleage. Would need to build up more feed in autumn. Increased use of urea (extra 33 kg N / ha in autumn on more productive pasture areas). Assumes regrassing not required post winter. Assumes do not sell stock earlier in autumn.

No sale of supplement.

Less area regrassed per annum (as less cropping, may need more grass-to-grass regrassing)

Financial impact

Table 9. Partial budget for Option 3

Increased Income None	Reduced income Not selling 150 bales of baleage @$80 / bale = $12,000
Reduced costs Not planting 25.1 ha of swedes @$1800/ha = $45,180	Increased costs 32.5 t of urea @$1005 / t = $32,663
$45,180	**$44,663**

Overall therefore, there is not a significant difference between the swede crop and grass wintering.

Other impacts

If there is low growth in the summer / autumn (e.g., drought) less assured supply of feed than a winter bulb crop that has been established pre-Christmas. Building suitable covers through autumn to ensure quality and quantity of feed through winter will require careful management, as well as optimal timing of any supplement harvest to maintain growth rates throughout the season.

Option 4a: Install a standoff pad (for the R1 and R2 beef animals)

Description

Low cost, uncovered wintering pad for beef R1s and R2s (bark pad, unlined, used to stand animals off overnight for 30 days of the winter), used in conjunction with the 11.1ha kale crop.

Impact on environmental contaminants

OverseerFM modelling has estimated the environmental impact of (Table 10).

Table 10. OverseerFM estimated impact of mitigation for Option 4a

Total GHG change	**Nitrous oxide change**	**N loss change**	**N Surplus change**	**P loss change**
No change	No change	1% increase	No change	No change

(Compared with the Year End 2020/21)

Farm system

Provide flexibility during adverse weather (difficult to model the impact of this).

Financial impact

Would need to buy in wood chip, at a cost of $9,400 per annum (to buy in). In addition to this removal costs and spreading not calculated.

Other impacts

Site preparation and fencing not costed as is site specific. Would need to check if it met permitted activity requirements or require a consent.

Option 4b: Install a covered barn (for the R1 and R2 beef animals)

Description

Kale crop of 11.1 ha removed and a covered wintering pad for beef R1s and R2s (plastic cover, concrete feeding area, bark loafing area), used to house R1 and R2 beef animals 24 hours per day for 92 days of the winter.

Impact on environmental contaminants

OverseerFM modelling has estimated the environmental impact of (Table 11).

Table 11. OverseerFM estimated impact of mitigation for Option 4b

Total GHG change	Nitrous oxide change	N loss change	N Surplus change	P loss change
1% increase	2% decrease	9% decrease	2% decrease	1% increase

(Compared with the Year End 2020/21)

Farm system

Less area regrassed per annum (as less cropping, may need more grass to grass regrassing).
Change in stock performance between beef cattle grazed on crop and housed unknown.
Some trial work suggests that calves on a pad would have a lower growth rate than those on crop.[9]

Financial impact

Significant capital investment – approximately $300 – 400,000 (depending on sizing, location).

Table 12. Partial budget for Option 4b

Increased Income	Reduced income
None	None
Reduced costs Not planting 11.1 ha of kale @$1800/ha = $19,980	**Increased costs** Annual debt servicing of $350,000 @ 8% = $28,000 Depreciation (25 yrs straight line) = $14,000 Running cost and R & M (approx.) = $5,000 Make extra 390 bales of baleage @$40 per bale = $15,600 Purchase woodchip = $6,700
$19,980	**$69,300**

The resultant annual cost is $49,320.

Other impacts

Site preparation and fencing not costed as is site specific.

[9] https://www.nzsap.org/system/files/proceedings/Little%20et%20al.%20Beef%20cattle%20wintering.pdf

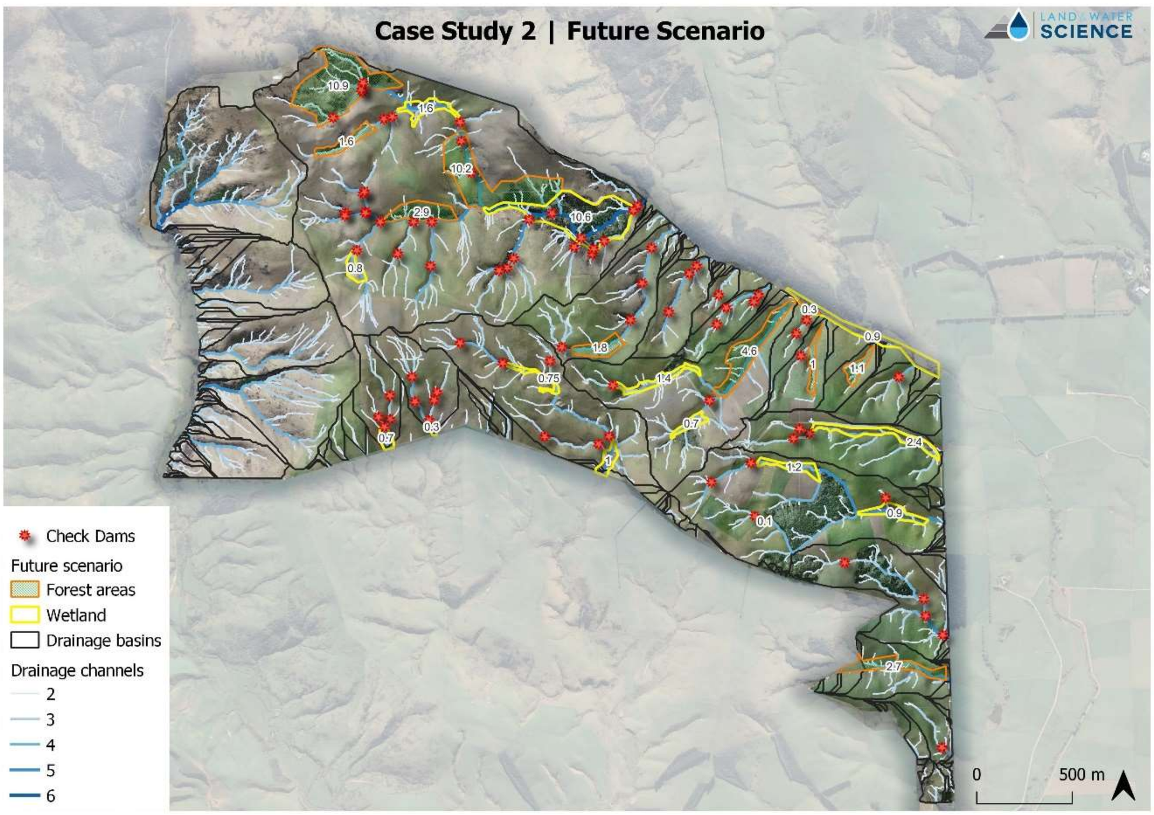
7.2 Mitigations with landscape intervention / land use change

The main landscape susceptibility issues across the case study property align with topographic controls, topography controls aspect, slope, and soil depth. These landscape factors interact to determine the susceptibility of the land to saturation and erosion. Soil saturation and the runoff of water are the key controls over the susceptibility of the property. The steeper parts of the property, especially the western and to a lesser degree the north facing slopes, are most prone to contaminant loss.

Option 5: Wetlands

Description

There is an opportunity to target the areas that have a higher landscape susceptibility risk with wetlands. Wetlands provide an opportunity to improve water quality, provide biodiversity and wildlife habitat. The performance of wetlands is determined by their design, wetland size and



catchment size.

Figure 18. Wetland sites / size shown in yellow. Check dam locations shown in red

The wetlands have been specifically sited to target the discharge and junction nodes to mitigate loss of environmental contaminants by targeting transport pathways. Due to the rolling to steep contour where wetlands are sited check dams have been integrated. Check dams are installed to slow the water going into the wetlands to improve wetland performance during high water flow events.

Figure 19. Illustration of check dams used to slow water into wetlands

Practically the installation is likely to need to be staggered:

- Cost and time in installing the wetland
- Aligned with availability of reticulated stock water.

Farm mapping of these wetlands has identified 23.35 ha of wetlands installed with a catchment area to these wetlands of 397.1 ha. It is estimated[10] that 1758 kg N / year will be mitigated and 66 kg of phosphorus (in the particulate form).

See appendix 2 for further detail on the location and size of wetlands, location of check dams and size of catchment area.

Impact on environmental contaminants

With the installation of 23.35 ha of wetlands, performance estimates have been calculated[11].

Table 13. Estimated impact of wetland mitigation for future scenario

Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
-	-	20% decrease	-	16% decrease

(Compared with the Year End 2020/21)

The proposed wetland will sequester carbon and also could release methane, the impact of this has not been calculated.

Farm system

The areas that are repurposed into wetlands are of very low pasture productivity and will require no farm systems change

Financial impact

It is estimated to be $174,454 to install 14 wetlands comprising of a total of 23.35 ha.

To reduce cost potential wetlands sites have been located in natural depressions / natural drainage channels (likely where historic wetlands were located). Fencing and removing grazing pressure (while controlling any weed species) may be sufficient for wetlands to generate plant populations naturally.

<u>For each wetland the following has been calculated:</u>

- New fencing required[12], materials and labour (prices from 2016)
- Number of check dams required.[13]

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[10] https://www.dairynz.co.nz/media/5795688/wetland-practitioner-guide-web-aug-2022.pdf
[11] https://www.dairynz.co.nz/media/5795688/wetland-practitioner-guide-web-aug-2022.pdf
[12] Costed at $16.64 per/m, NZ average for sheep/cattle, non-electric 8 wire, steep https://www.mpi.govt.nz/dmsdocument/16537-ministry-for-primary-industries-stock-exclusion-costs-report
[13] Costed at $350 per check dam (2 hours' time / tractor work @$175 per hour)

The following assumptions have been made:

- Wetlands are located in areas that will regenerate (so no planting required)
- Weed control already happens in these areas (so not an extra cost)
- Any earth works required can be completed with gear and skills already available
- Materials (rocks) for check dams are available freely on farm
- No consents are required for the installation of wetlands and check dams

Further individual site investigation will be required to finalise wetland design, cost and installation. The above assumptions make the costs a "best case scenario".

Some of the areas identified to be fenced off for wetlands may be currently providing stock with access to natural water sources. There is currently a reticulated stock water system supplying 150 ha of the property. It is intended to install a reticulated stock water system into a further 280 ha of the property. The plans include storage, pumps and a solar unit. The estimated cost of materials and installation of this system is $120,000 (refer Appendix 3).

It is suggested that the installation of wetlands is completed in a staged approach based on considering location of existing stock water system and the amount of mitigation achieved relative to establishment cost of wetlands and check dams (refer table 11). Once wetlands and check dams are established there could be on-going costs (weed control, fence maintenance, maintaining structural integrity) depending on the site.

Other impacts

Cost and benefits of installation of a stock water system:

- Cost of installation
- Opportunities for further subdivision and improved grazing management
- Improved animal performance (weight gain in cattle, lambing percentage, stock losses)
- Certainty of water supply to stock
- Less damage on the edge of water ways from stock accessing water
- Able to exclude stock from water ways (as no longer reliant on these to supply the stock water)
- Added value / saleability to the property.

	Wetland area	Catchment Area	Wetland as % of catchment	Potential N mitigation	Potential particulate P mitigation	New fencing required (m)	Number of check dams required	TOTAL COST ($)	Cost / unit N mitigated ($/kg N)	Cost / unit PP / mitigated $/kg PP	Within current Reticulated Water System Area?
1	1.6	48	3%	184	7	905	6	17159	93	2422	N
2	0.8	12	7%	58	2	470	1	8171	142	3783	N
3	10.6	132	8%	634	24	1956	26	41648	66	1753	N
4	0.7	9.9	7%	48	2	297	4	6342	133	3559	N
5	0.3	13.2	2%	43	2	212	4	4928	115	3050	N
6	0.75	21.4	4%	95	4	920	3	16359	172	4616	N
7	1	24	4%	107	4	442	3	8405	79	2115	N
8	1.4	14.5	10%	70	3	582	1	10034	144	3845	Y
9	0.7	12.6	6%	60	2	306	0	5092	84	2245	Y
10	0.9	27.1	3%	104	4	970	5	17891	172	4473	Y
11	2.4	26.2	9%	126	5	1015	3	17940	143	3804	Y
12	1.2	20	6%	96	4	412	2	7556	79	2099	Y
13	0.1	6.6	2%	21	1	127	1	2463	115	3049	Y
14	0.9	29.6	3%	114	4	608	1	10467	92	2396	Y
	23.35 ha	**397.1 ha**		**1758 kg N / yr**	**66 kg PP / yr**	**9222m**	**60**	**$174454**			

Table 14. Wetland mitigation establishment cost and location relative to existing stock water system. For example, wetlands 9, 12 and 14 provide a lower cost mitigation (compared with other wetlands) and are located within the existing stock water scheme area

Option 6 and 7: Plant a portion of the property in plantation forestry

There is an opportunity to integrate forestry into the landscape, especially those areas that are less productive and have a higher landscape susceptibility risk (in particular for phosphorus, sediment and DRP loss).

In the future, depending on Agricultures obligations in the ETS, forestry could be used to offset on-farm emissions. Farm forestry can not be used for both revenue (carbon units) and offset, that would be "double counting" the carbon sequestration. Farmers could also use income from carbon units to pay for on farm emissions going forward.

Forestry takes a significant amount analysis and expert advice should be sought on:

- Appropriateness to site for planting, management and harvesting
- Cost and income streams
- Meeting regulatory obligations
- Implememtation and management of a forestry block

(For further information on forestry refer to appendix 4).

There are benefits and risks with forestry, for plantation forests there are two main income streams:

- Harvest (e.g., logs)
- Carbon units (traded as NZUs under the ETS)

For a forest to be eligible for carbon units it needs to meet the requirements of the Emissions Trading Scheme (ETS). If a forest is eligible to be registered in the ETS (and claim carbon units), as from January 2023 the following carbon accounting options are available:

- Average accounting – carbon units are only earnt on the first planting rotation
- Permanent forestry (stock change accounting) – it must remain in forest for at least 50 years.

In simple terms, under average accounting:

For the first rotation – carbon units at $60

Table 15. Summary of assumed income and expenses for forestry (Southland) - First rotation

	Pine	**Douglas Fir**
Income **Carbon – average accounting Southland** (first rotation only)	$18,120 / ha	$26,160 / ha
Income **Harvest revenue (100% yield)**	$30,080 / ha at 28 yrs	$31,200 / ha at 40 yrs
Expenses	$7,050 / ha	$9,280 / ha
Net	**$41,150 / ha**	**$48,080 / ha**

Note – harvest revenue is based on a 100% yield, this will vary from site to site

For the second and subsequent rotations – no carbon units

Table 16. Summary of assumed income and expenses for forestry (Southland) - Second and subsequent

rotations

	Pine	Douglas Fir
Income **Harvest revenue**	$30,080 / ha	$31,200 / ha
Expenses	$6,926 / ha	$8,938 / ha
Net	**$23,154 / ha**	**$22,262 / ha**

Option 6: Plant 36.9 ha of plantation forestry and slightly reduce sheep numbers

Description

There is an opportunity to plant 36.9 ha of higher risk areas (in particular for phosphorus, sediment and DRP loss) in trees. Harvesting will need to be undertaken in a way to minimize risk of soil disturbance to minimize contaminant loss during the harvest event.

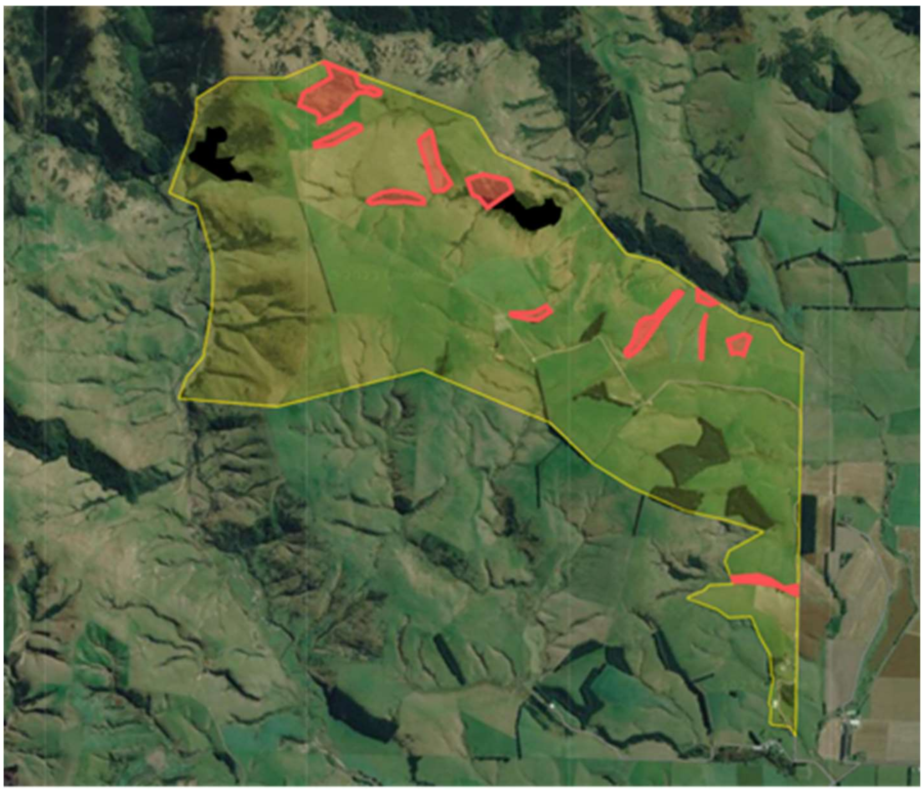

Figure 20. Map showing proposed location of forestry blocks

(Refer appendix 5 for details).

The forestry blocks range from being planted into scrub (and requiring preplant spraying and preparation) to blocks being planted into pastoral areas. The harvest yield has been assessed for each block and ranges from 80 to 100% yield.

Impact on environmental contaminants

Table 17. OverseerFM estimated impact of mitigation for future scenario (36.9 ha forestry) and small reduction in sheep numbers

Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change

<1% decrease	No change	1% decrease	2% decrease	3% decrease

(Compared with the Year End 2020/21)

Farm system

While the areas that are planted into plantation forestry are of low productivity, they will still require a small reduction in stock numbers to account for the reduced grazing area. There is assumed to be a 1 % decrease in sheep numbers (across all classes) and no change in cattle numbers.

This reduction in sheep stock numbers results in a reduction in EBIT (as estimated by FARMAX) compared to the 2020-21 farm system of $11,160 due to fewer lambs sold annually with similar expenses. The reduction in ewe numbers has been modelled with a proportionate reduction in lamb numbers. If the lambing percentage can be increased through the targeted culling of poor performing ewes, it is expected the reduction in EBIT would be less.

Selling of the sheep capital stock releases some capital to partially pay for fencing required of the forestry blocks.

Financial impact

First rotation

Table 18: Financial impact - 36.9 ha forestry (first rotation)

	Carbon Price $40/ unit	**Carbon Price $60/ unit**	**Carbon Price $60/ unit**	**Carbon Price $80/ unit**
Area planted	36.9 ha	36.9 ha	36.9 ha	36.9 ha
Species	Pine	Pine	Douglas Fir	Pine
Rotation	First	First	First	First
Peak cash deficit	($173,786)	($173,048)	$35,755	($172,827)
Years of deficit	8	7	nil	6
Carbon units	11,144	11,144	16,088	11,144
Carbon value	$445,752	$668,628	$965,304	$891,504
Harvest age	28	28	40	28
Harvest value	$987,857	$987,857	$1,024,639	$987,857
IRR	7.2%	9.5%	6.6%	11.8%

<u>Results – First Rotation (at $60 per carbon unit):</u>

The internal rate of return (IRR) is calculated at 9.5% for pine. The IRR for douglas fir is calculated at 6.6%. The IRR is the average rate of return on the investment, the IRR takes into account the time value of money This compares with the return from the current sheep operation of 5.5%.

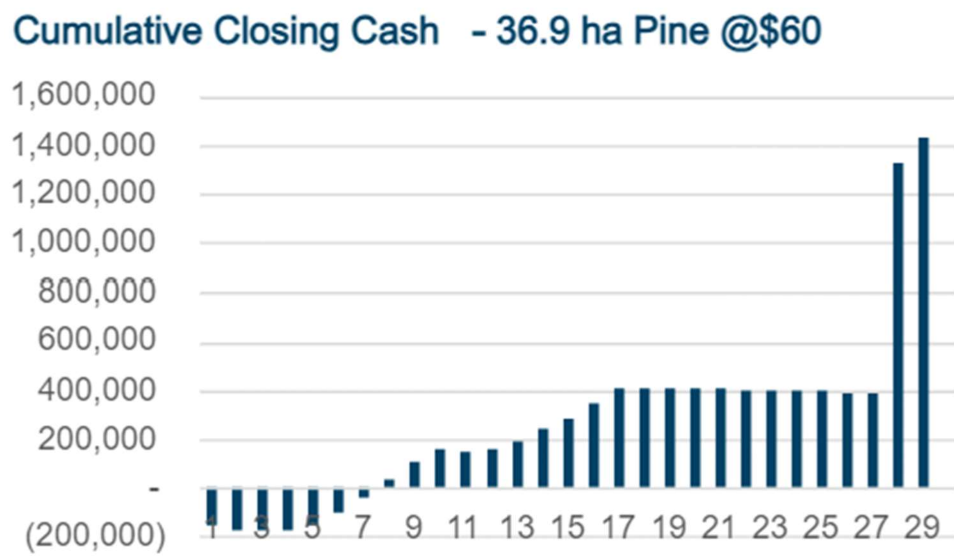

Figure 21. Cumulative closing cash - 36.9 ha forestry (first rotation)

As the planting is spread across many blocks there is the opportunity to spread it across multiple years and reduce the peak cash deficit.

Second rotation

Table 19: Financial impact - 36.9 ha forestry (second and subsequent rotations)

	Carbon Price $0/ unit
Area planted	36.9 ha
Species	Pine
Rotation	Second
Peak cash deficit	($195,350)
Years of deficit	28
Carbon units	0
Carbon value	0
Harvest age	28
Harvest value	$987,857
IRR	5%

Results - Second Rotation (no carbon units):

The internal rate of return (IRR) is calculated at 5%, this is the average rate of return on the investment. This compares with the return from the current sheep operation of 5.5%.

A portion of the harvest revenues from the first rotation could be used to fund the peak cash deficit of the second rotation.

Comments

The returns from the first rotation of forestry (taking into account carbon and harvest revenues) is higher than the sheep grazing operation. The second rotation when only harvest revenues when only harvest revenues are available has a lower return than the current operation.

Table 20. Comparison of return from current sheep operation to 36.9 ha forestry

	Sheep Grazing	**First Rotation**	**Second and Subsequent Rotations**
Area planted	0	36.9 ha	36.9 ha
Species	n/a	Pine	Pine
Rotation	n/a	First	Second +
Carbon price	n/a	$60	n/a
IRR	7.2%	9.5%	5%

A key aspect would be the ability to leverage the returns from the first rotation to make further investment to set the farming business up for the future.

Option 7: Plant 134 ha of plantation forestry and remove beef breeding cow operation

Description

There is an opportunity to plant the back face into forestry. The back face is of steep contour and is a low pasture productivity area currently utilized for cattle grazing. No sheep graze this area. The back face has higher landscape susceptibility risk (especially for phosphorus and sediment). The back face is fenced off from the rest of the property and would require no additional fencing if the whole area was planted at once.

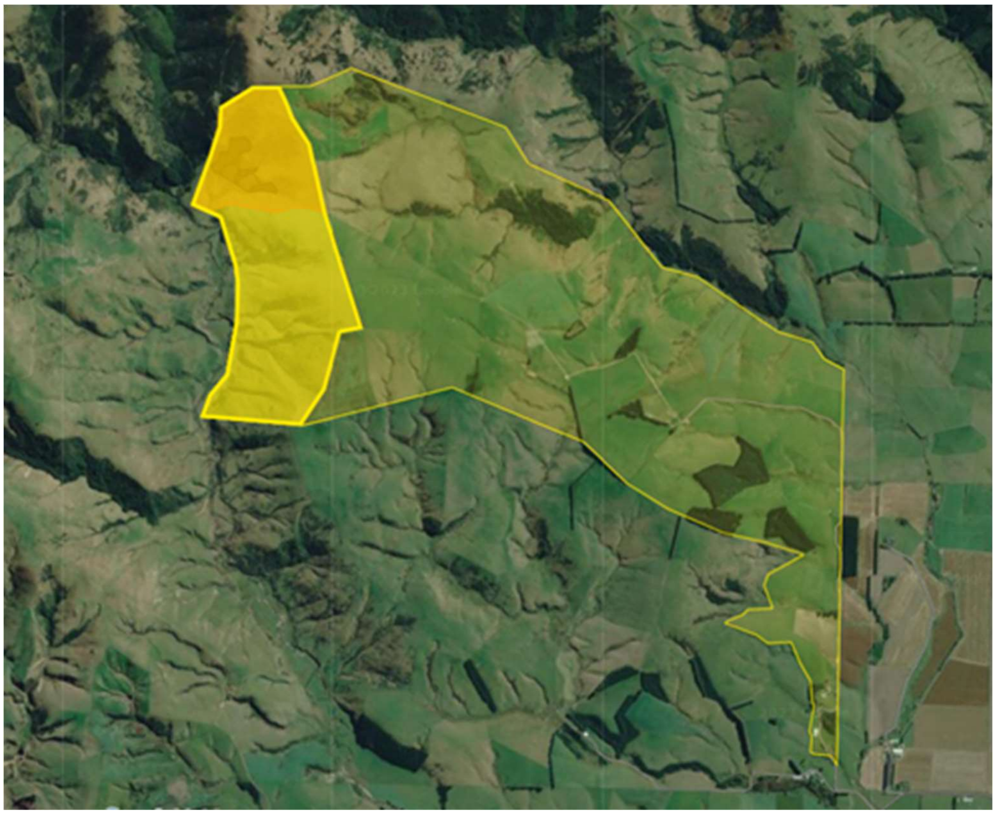

Figure 22. Map showing proposed location of forestry blocks

(Refer appendix 6 for further information).

Impact on environmental contaminants

Estimated by modelling in OverseerFM, with removal of the back face and planting into forestry of forestry.

Table 21. OverseerFM estimated impact of mitigation for blue sky scenario (134 ha of forestry)

Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
12% decrease	10% decrease	10% decrease	14% decrease	15% decrease

(Compared with the Year End 2020/21)

Farm system

While the back face is of low pasture productivity it is a large portion of the farm (18%). Therefore, has a significant impact on the farm system. Under this scenario the beef breeding cow operation would be discontinued. The capital from selling the beef breeding cows and bulls ($170,000) would be utilized for planting the back face.

There is a significant change to the farm system with this scenario:

- Removal of the beef breeding cows and bulls
- No buying in of beef replacements
- Buy in beef weaner calves and finish under the same programme as the current beef calf enterprise.

Due to the significance of the farm system change (and potential impacts on feed quality at different times of the year), further analysis was undertaken using Farmax to ensure farm system feasibility and to further quantify the financial implications of the farm system change. The removal of the beef cows and conversion of 134 ha to forestry reduced the EBIT from the pastoral enterprise by $24,222 due to the cost of purchasing beef calves rather than breeding .

Financial impact

First rotation

Table 22. Financial impact - 134 ha forestry (first rotation)

	Carbon Price $40/ unit	**Carbon Price $60/ unit**	**Carbon Price $60/ unit**	**Carbon Price $80/ unit**
Area planted	134 ha	134 ha	134 ha	134 ha
Species	Pine	Pine	Douglas Fir	Pine
Rotation	First	First	First	First
Peak cash deficit	($186,440)	($183,760)	($372,700)	($182,956)
Years of deficit	6	5	11	5
Carbon units	40,468	40,468	58,424	40,468
Carbon value	$1,618,720	$2,428,080	$3,505,440	$3,237,440
Harvest age	28	28	40	28
Harvest value	$3,829,184	$3,829,184	$3,971,760	$3,829,184
IRR	5.5%	7.2%	5.2%	8.9%

Results – First Rotation Pine (at $60 per carbon unit):

The internal rate of return (IRR) is calculated at 7.2% for pine. The IRR for douglas fir is calculated at 5.2%. The IRR is the average rate of return on the investment, the IRR takes into account the time value of money. This compares with the return from the current beef operation of 4.2%.

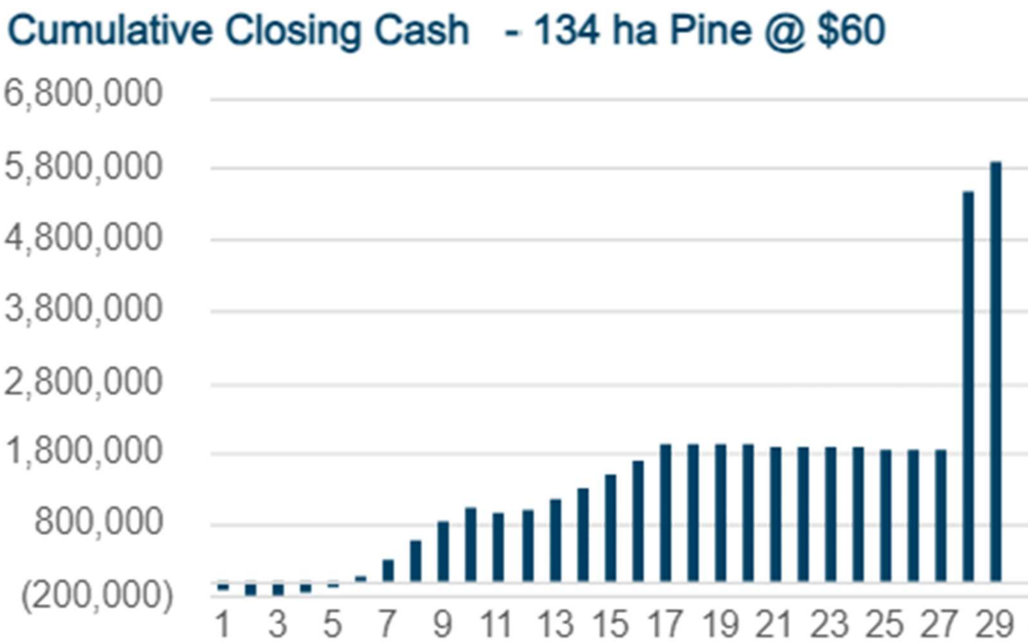

Figure 23. Cumulative closing cash - 134 ha forestry (first rotation)

Second rotation

Table 23. Financial impact - 134 ha forestry (second and subsequent rotations)

	Carbon Price $0/ unit
Area planted	134 ha
Species	Pine
Rotation	Second
Peak cash deficit	($670,000)
Years of deficit	27
Carbon units	0
Carbon value	0
Harvest age	0
Harvest value	$3,829,184
IRR	3%

Results - Second Rotation (no carbon units):

The internal rate of return (IRR) is 3%, this is the average rate of return on the investment, the IRR takes into account the time value of money. This compares with the return from the current beef operation of 4.2%.

A portion of the harvest revenues from the first rotation could be used to fund the peak cash deficit of the second rotation.

Comments

The returns from the first rotation of forestry (taking into account carbon and harvest revenues) are higher than the current beef breeding operation. The second rotation when only harvest revenues when only harvest revenues are available has a lower return than the current operation.

Table 24. Comparison of return from current beef breeding operation to 134 ha forestry

	Beef Breeding	**First Rotation**	**Second and Subsequent Rotations**
Area planted	0	134 ha	36.9 ha
Species	n/a	Pine	Pine
Rotation	n/a	First	Second +
Carbon price	n/a	$60	n/a
IRR	4.2%	7.2%	3%

A key aspect would be the ability to leverage the returns from the first rotation to make further investment to set the farming business up for the future.

7.3 System Optimisation

All mitigations (both landscape and farm system have been modelled using the current farm system (the 20/21 season) as a comparison.

The farmer wanted to explore the opportunity of improving the stock performance in the current farm system and the impact that would have financially and environmentally:

- Increases in lambing percentage (10% higher compared with the 2020-21)
- Finishing lambs 2 weeks earlier and at 0.5 kg carcass weight heavier

The pathway to these improvements has not been modelled (i.e the steady state farm system post improvements has been modelled) and would require additional advice and planning. The options discussed for increasing lamb performance include;

- Grazing of beef cows across the property rather than solely the "cow block" with the aim to improve pasture quality and parasite control
- Change in ram breed
- Development of reticulated water system (cost of system not modelled but estimated at $120,000).

It is likely it would take several years to implement and see the results of these changes (five plus years).

Impact on environmental contaminants

OverseerFM modelling has estimated the environmental impact of the farm system optimisation:

Table 25. OverseerFM estimated impact of farm system optimisation

Total GHG change	**Nitrous oxide change**	**N loss change**	**N Surplus change**	**P loss change**
1% decrease	1% decrease	1% decrease	2% decrease	No Change

(Compared with the Year End 2020/21)

Financial impact

The farm system change has been modelled in Farmax and results in an increase in Earnings Before Interest & Tax of $33,724. This is due to increased income from lamb sales from heavier carcasses, more lambs sold and lambs sold earlier at a higher price with little impact on farm expenses.

8. Conclusion

The main landscape susceptibility issues across the case study property align with topographic controls, topography controls aspect, slope, and soil depth. These landscape factors interact to determine the susceptibility of the land to saturation and erosion. Soil saturation and the runoff of water are the key controls over the susceptibility of the property. Where the land is flat, susceptibility is lower overall, whereas the steeper parts of the property, especially the western and to a lesser degree the north facing slopes, are most prone to contaminant loss. This pattern of differential susceptibility is typical of hill country settings, where topography and aspect interact to determine contaminant susceptibility profiles.

Specific options considered for this property were:

Table 26. Mitigation options within current farm system

		Net cost	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
Option 1	Use of plantain in pastures	Approximate cost $400 per year.	No change	1% decrease	1% decrease	No change	No change
Option 2	Replace kale with fodder beet (for beef animals)	Need 25T DM fodder beet crop to be a similar cost to kale based on a cents per kg of DM basis.	1% decrease	3% decrease	2% decrease	4% decrease	No change
Option 3	Replace swedes with grass wintering (for sheep)	No significant difference financially	7% increase	10% increase	4% decrease	23% decrease	No change
Option 4a	Install a standoff pad (for the R1 and R2 beef animals)	Annual cost of $9,400 in wood chip	No change	No change	1% increase	No change	No change
Option 4b	Install a covered barn (for the R1 and R2 beef animals) Remove kale crop	Annual cost of $49,320	1% increase	2% decrease	9% decrease	2% decrease	1% increase

Mitigation options with landscape intervention / landuse change. Forestry has provided additional revenue from carbon rather than off setting GHG emissions.

Table 27. Mitigations with significant capital investment

		Net cost	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
Option 5	23.35ha of wetlands	$174,454	-	-	20% decrease	-	16% decrease

		Forestry IRR Carbon @$60	Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
Option 6	Plant 36.9 ha of plantation forestry and slightly reduce sheep numbers	1st rotation – 9.5% 2nd rotation – 5%	<1% decrease	No change	1% decrease	2% decrease	3% decrease
Option 7	Plant 134 ha of plantation forestry and remove beef breeding cow operation	1st rotation – 7.2% 2nd rotation – 5.2%	12% decrease	10% decrease	10% decrease	14% decrease	15% decrease

Farm systems evolve over time to match land, stock class with variability in weather and product prices. Changes to the farm system and capital investment need to be carefully considered due to the interlinked nature of farm systems and the low returns that sheep and beef farmers operate in. The case study farm is not a high intensity farm system, so mitigation within the current farm system has minimal overall impact on environmental losses.

Mitigation options with land use change and landscape intervention such as installation of wetlands showed a greater opportunity to reduce environmental impact. Installation of wetlands within the landscape has a cost attached to it, these wetlands should be prioritized and targeted to areas with the most mitigation potential and may take a period of time for installation to be realistic (within financial and time constraints). Land use change to forestry show positive returns, the key determinant is the opportunity cost of how the land is currently utilized and a long-term view needs to be considered in planning.

Table 28. Farm system optimisation

Option 8: system optimisation	Increased lambing, lambs finished earlier and heavier	Annual increase in profit of $33,724	1% decrease	1% decrease	1% decrease	2% decrease	No change

Farm system optimization / scenarios through Farmax showed an opportunity to improve the sheep enterprise performance and significantly improve profitability whilst reducing environmental effects. There are options for pathways to improve sheep performance such as utilising the beef breeding herd across the entire property for pasture quality control, investigating different lamb breeds or investigating a reticulated water system.

Appendices

Appendix 1 - State of the Mataura Catchment

The property sits within the Wendonside Catchment, which is a sub-catchment of the larger Mataura River Catchment. The Mataura River Catchment is located within the Southland and Gore districts of New Zealand. It extends from the lower reaches of Lake Wakatipu in the north, all the way down to the coast at Fortrose where the Mataura River discharges into the Toetoes Estuary. The total area of the catchment is approximately 640,000 hectares (ha) and is the second largest developed river catchment in Southland. Approximately 550,000 hectares (86% of the area) is developed, which represents the highest % of any catchment in the region.

The Mataura River and the Toetoes Estuary are an important source of mahinga kai, particularly kanakana, inanga and tuna. Land use and various industrial and municipal water discharges are key contributors to the degradation of water quality in the Mataura catchment. Currently the Toetoes Estuary is considered to be in poor condition.

Water quality in this catchment is showing stress in terms of *E. coli* (faecal bacteria) (surface water), nitrogen (surface water), phosphorus (surface water and groundwater), and the macroinvertebrate community index (MCI).

At a more local level, the Wendonside and Waimea Valley are characterised by distinct water quality challenges that relate to the highly variable landscape. The Wendonside and Waimea areas have a number of small but locally important areas of elevated groundwater nitrate that exceed the WHO drinking water standards, and in the case of the Waimea, discharge high concentrations of nitrate in groundwater to the Waimea Stream. Poorly drained soils across low lying areas are prone to runoff, and the export of contaminants via mole-pipe drainage. More broadly, the hill country surrounding the lowland plains is prone to runoff and associated sediment, *E. coli*, and particulate phosphorus loss. Localised water quality issues are manifest as exceedances against regional and national guidelines for freshwater.

Toetoes Estuary

Currently the Toetoes Estuary where Mataura River discharges at Fortrose is considered to be in poor condition. Toetoes Estuary has areas that are currently assessed as D band (poor) for macroalgae, Gross Eutrophic Zone (GEZ), mud content and sediment oxygen levels. recent NIWA report stated that most (~95 percent) of the nutrient load to the estuary comes from the Mataura River[14]. The nutrients from the Mataura River dominate the Mataura arm and lower estuary, but also supply ~ 38 percent of total nitrogen (TN) and total phosphorus (TP) in the Titiroa arm of the estuary. Overall, a reduction in nutrient and sediment inputs is needed to improve the estuary classification above D band (poor). Faecal bacteria also needs to be reduced to at least C band (fair) or better at the estuary monitoring sites.

[14] Plew, D., Dudley, B., Shankar, U. (2020) Eutrophication susceptibility assessment of Toetoes (Fortrose) Estuary. NIWA Client Report, 2020070CH: 58.

Appendix 2 – Wetlands

Sites of wetlands and check dams are shown in detail below:

Drainage basin 1 = 192 hectares in total

The drainage basin includes the following proposed mitigations: -

- 25.6 hectares of new forestry area
- 13.0 hectares of new wetlands
    - the 1.6 ha wetland has a capture zone of 48 hectares,
    - the 0.8 ha wetland has a capture zone of 12 hectares,
    - and the large 10.6 ha wetland has a capture zone of the balance (132 hectares)
- fencing - 1,956m fencing, 435m would be shared with the forestry area to be fenced.
- 33 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out.

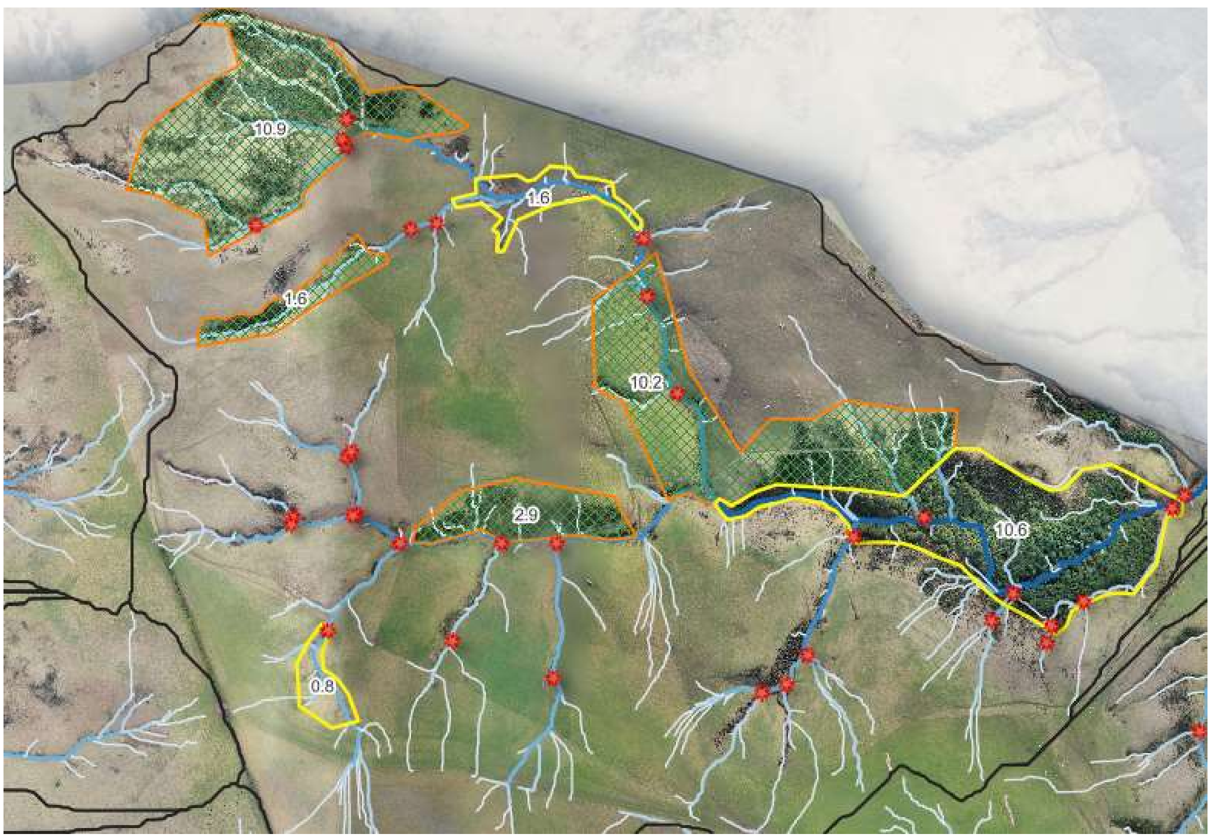

Figure 24. Snip reflecting drainage basin 1

Drainage basin 2 = 9.9 hectares in total

The drainage basin includes the following proposed mitigations:

- 0.70 hectares of new wetland
- 4 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 1956m, a further 51m of fencing would utilise the existing boundary fence.

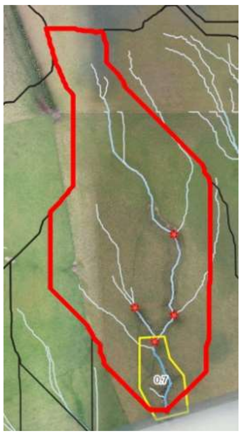

Figure 25. Snip reflecting drainage basin 2

Drainage basin 3 = 13.2 hectares in total

The drainage basin includes the following proposed mitigations:

- 0.30 hectares of new wetland
- 4 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 212m, a further 22m of fencing would utilise the existing boundary fence.

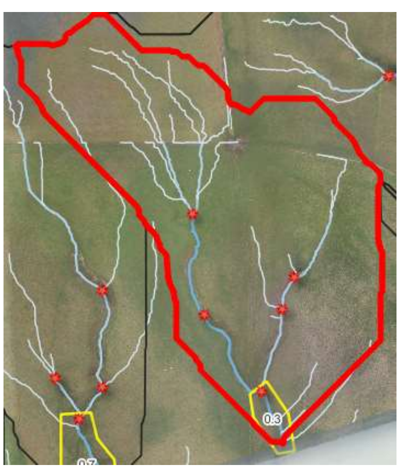

Figure 26. Snip reflecting drainage basin 3

Drainage basin 4 = 45.4 hectares in total

The drainage basin includes the following proposed mitigations:

- 1.75 hectares of new wetlands
    - the upper 0.75 ha wetland has a capture zone of 21.4 hectares,
    - the lower 1.0 ha wetland has a capture zone of 24 hectares
- 6 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 442m, a further 66m of fencing would utilise the existing boundary fence.

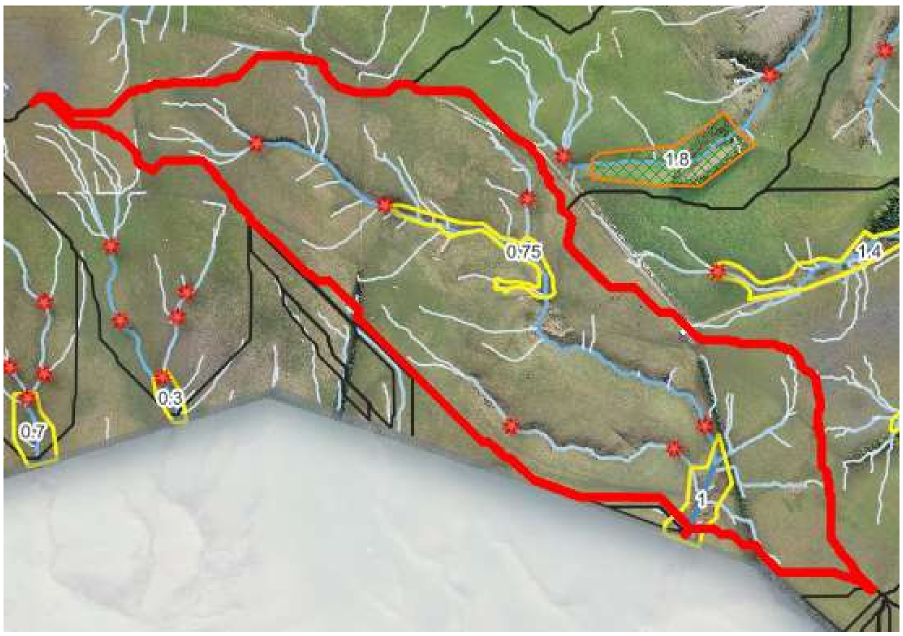

Figure 27. Snip reflecting drainage basin 4

Drainage basin 5 = 47.9 hectares in total

The drainage basin includes the following proposed mitigations:

- 4.6 hectares of new forestry area
- 2.1 hectares of new wetlands
    - the 1.4 ha wetland has a capture zone of 14.5 hectares,
    - the 0.7 ha wetland has a capture zone of 12.6 hectares,
    - also note the bottom of this drainage basin connects to the proposed 0.9 hectare wetland running along the north-eastern boundary
- 2 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 888m, A further 775m of fencing would utilise existing fences and/or existing fenced off areas.

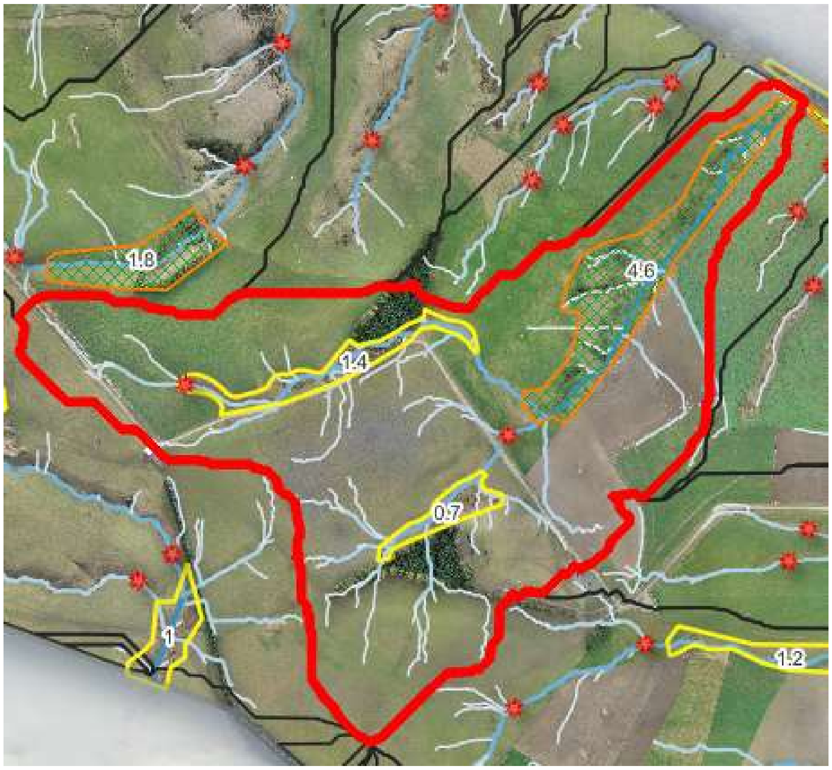

Figure 28. Snip reflecting drainage basin 5

Drainage basin 6 = 27.9 hectares in total (combination of several drainage basins)

The drainage basin includes the following proposed mitigations:

- 2.4 hectares of new forestry area,
- 0.9 hectares of new wetland that sits along the bottom of these combined drainage basins running along the edge of the north-eastern boundary,
- 4 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 970m and would utilise existing boundary fence.


Figure 29. Snip reflecting drainage basin 6

Drainage basin 7 = 26.2 hectares in total

The drainage basin includes the following proposed mitigations:

- 2.4 hectares of new wetland that services the entire drainage basin,
- 3 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 1015m, a further 540m of fencing would utilise existing fences.

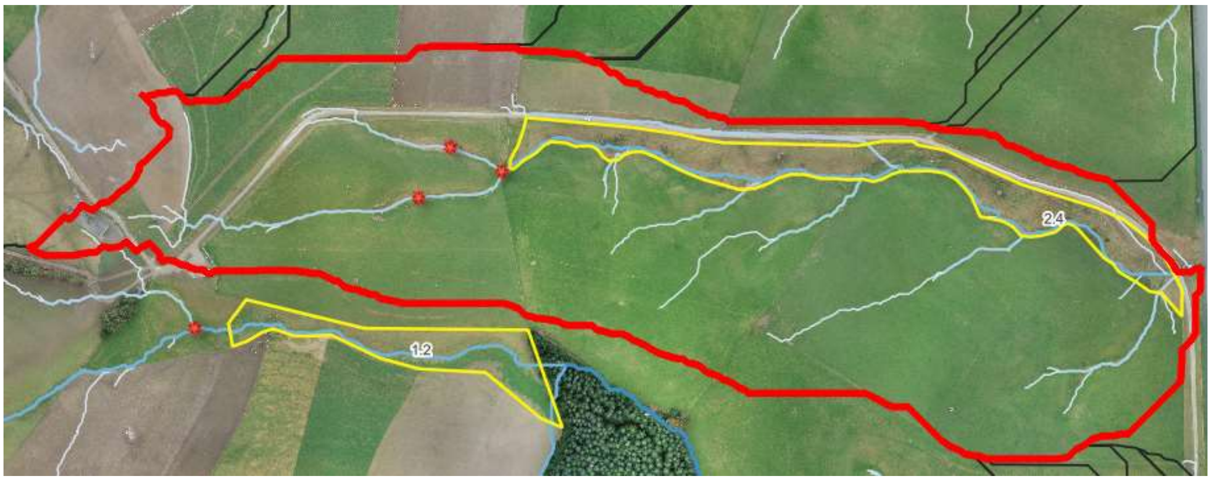

Figure 30. Snip reflecting drainage basin 7

Drainage basin 8 = 56.2 hectares in total

The drainage basin includes the following proposed mitigations:

- 2.2 hectares of new wetlands
  - the northern 1.2 ha wetland has a capture zone of 20.0 hectares,
  - the small 0.1 ha wetland has a capture zone of 6.6 hectares,
  - and the far right 0.9 ha wetland captures the balance of the drainage basin area (i.e., 29.6 hectares)
- 4 check dams strategically place throughout the drainage basin to slow water down and allow sediment / particulates to settle out
- Fencing – 1147m, a further 665m of fencing would utilise existing fences.

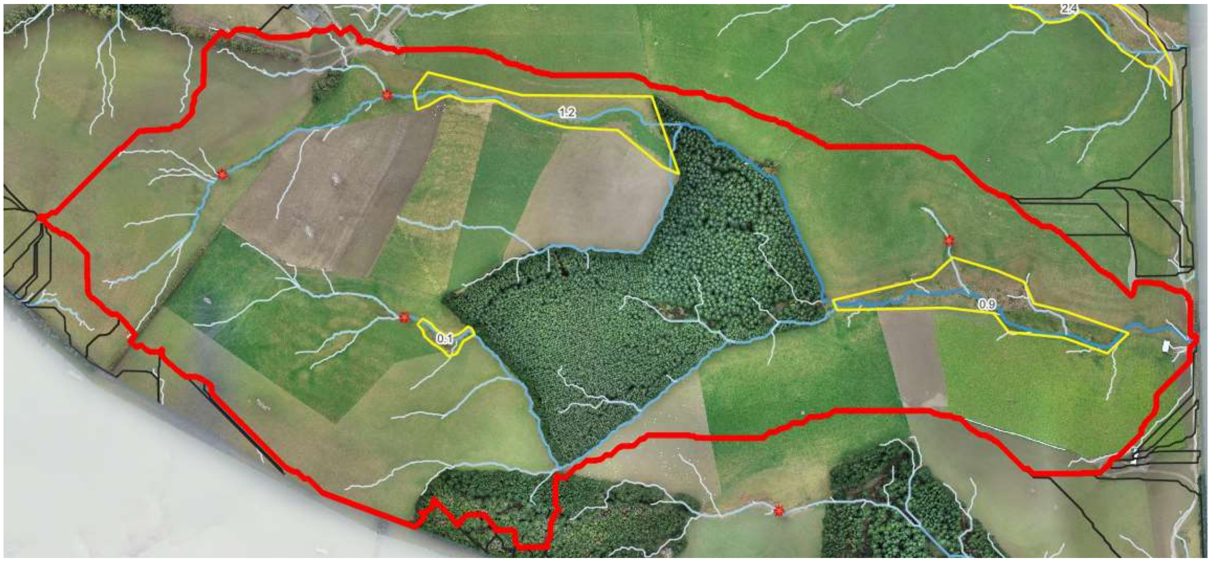

Figure 31. Snip reflecting drainage basin 8

Drainage basin 9 = 11.4 hectares in total

The drainage basin includes the following proposed mitigations:

- 2.7 of new forestry area

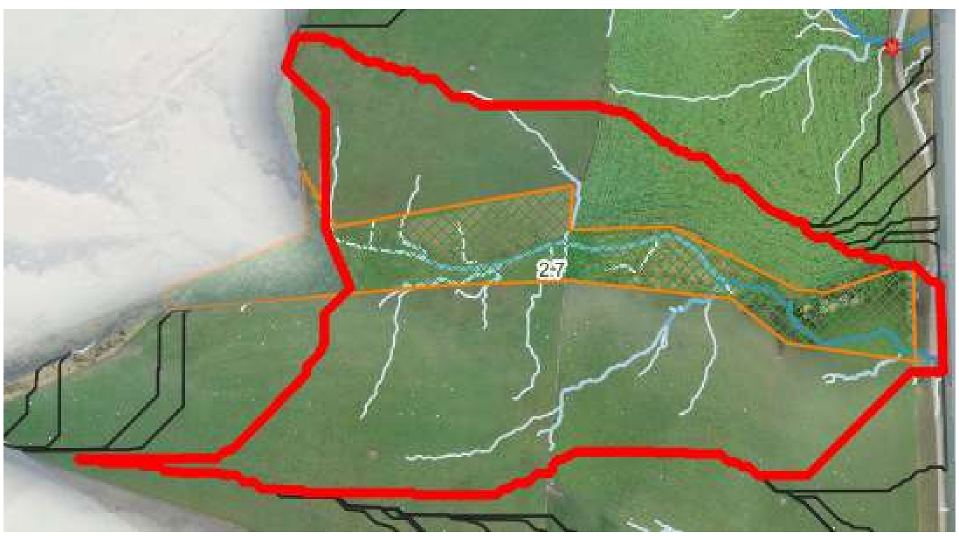

Figure 32. Snip reflecting drainage basin 9

Appendix 3 – Stock Water System

Description

There is currently a reticulated stock water system supplying 150 ha of the property. It is intended to install a reticulated stock water system into a further 280 ha of the property. The plans include storage, pumps and a solar unit. The estimated cost of materials and installation of this system provided by their contractor is $120,000.

Having a fully functioning stock water system across the property will be required to establish all proposed wetlands. The establishment of wetlands will remove the majority of the access for animals to natural water sources.

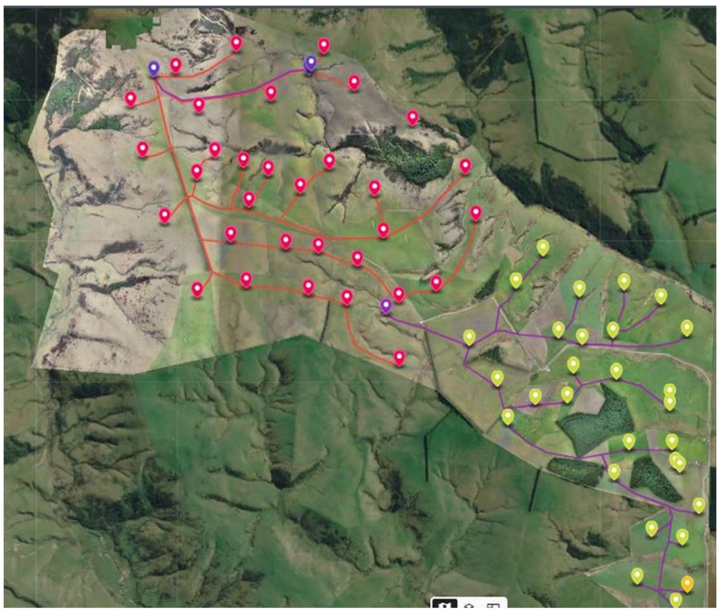

Figure 33. Yellow dots and network reflect the existing reticulated stock water system, and pink dots reflect the planned/proposed reticulated stock water system. Purple dots are the location water source / water storage for the current and proposed reticulated system.

Reticulating stock water on sheep and beef hill country can provide several benefits[15], depending on the quality and adequacy of the current water supply:

- Opportunities for further subdivision and improved grazing management
- Improved animal performance (weight gain in cattle, lambing percentage, stock losses)
- Certainty of water supply to stock
- Less damage on the edge of water ways from stock accessing water
- Able to exclude stock from water ways (as no longer reliant on these to supply the stock water)
- Added value / saleability to the property.

The environmental impact of a stock water system has not been analyzed through OverseerFM, as only the stock exclusion aspect could be modelled and show a minimal impact on results. The environmental benefits are likely to be larger than what Overseer could model (especially for sediment and phosphorus loss).

[15] Economic evaluation of stock water reticulation on hill country. P Journeaux and E van Reenan, December 2016

Appendix 4 – Forestry

There is an opportunity to integrate forestry into the landscape, especially those areas that are less productive and have a higher landscape susceptibility risk (in particular for phosphorus, sediment and DRP loss).

Forestry takes a significant amount analysis and expert advice should be sought on:

- Appropriateness to site for planting, management and harvesting
- Cost and income streams
- Meeting regulatory obligations
- Implememtation and management of a forestry block

There are benefits and risks with forestry:

Table 29. Benefits and Risks of Forestry

Benefit	Risk
Change of policy / regulations	Significant risk in change of policy / regulations[3] Uncertainty on impact in future carbon pricing.
Ability to use forestry to retire land less suitable for pastoral farming	Significant risk in long timelines - adds uncertainty in terms of future pricing for carbon and log pricing
Help soil retention on steep slopes	Lack of access to plants and expertise to establish and manage (may impact on timing and interlink with lack of certainty in change in policy / regulation)
Biodiversity	Soil disturbance and sediment / phosphorus loss during harvesting
Ability to earn a different income stream on farm or offset potential cost	Poor plant establishment and growth (e.g., due to pests such as deer)
Flexible in terms of harvest window	Requirement for ongoing compliance and reporting
Provide shelter and shade for livestock	Fire or windthrow risk, particularly late in the rotation

For plantation forests there are two main income streams:

- Harvest (e.g., logs)
- Carbon units- traded as units (NZUs under the ETS)

Can also receive income for other products in specific situations (e.g., mauka honey).

Options for forestry can include having complete control / ownership of the land and forest, a joint venture with a forestry company. Alternatively, land could be sold to a forestry company to release capital.

For a forest to be eligible for carbon units it needs to meet the requirements of the Emissions Trading Scheme (ETS):

[3] NZ ETS review (including NZ ETS permanent forestry category redesign) currently under consultation (submissions close August 2023)

- Must not have been in forest pre-1990, or have undergone land use change prior to 31st December 2007
- Cover at least 1 hectare in area
- Contain species that can reach at least 5 metres in height when mature in that location
- Have (or be expected to reach) crown cover of more than 30% in each hectare
- Be at least (or expected to reach) 30 metres across on average.

If a forest is eligible to be registered in the ETS (and claim carbon units), as from January 2023 the following carbon accounting options are available:

Average accounting

i. Earn units until the forest reaches a set age, you can then harvest without having to surrender units (as long as you replant). Carbon units are only earned on the first planting rotation. Under averaging a participant is obliged to replant within 4 years of harvest or face significant deforestation penalties

Permanent forestry

i. Must use stock change accounting (earn and pay units as carbon increases and decreases) it must remain in forest for at least 50 years. Required to pay units back and a penalty if fell within 50 years.
ii. After 50 years
    Either   Move to average accounting (pay difference in units earnt back)
    Or   Remove the land from the ETS and repay the units earnt
    Or   Remain in forest for another 25 years (and continue to earn carbon units)

Forestry

The income from forestry can be simplified as follows:

Table 30. Revenue stream for forestry, carbon units for Southland

	Pine	**Douglas Fir**	**Native**
Average accounting (carbon units first rotation only)	Carbon units = 302 Set age = 16 years Harvest revenue (100% yield) $30,080/ha at year 28	Carbon units = 436 Set age = 26 years Harvest revenue (100% yield) $31,200/ ha at 40years	Carbon units = 193.9 Set age = 23 years Need permit to sustainably harvest and export of timber largely prohibited
Permanent Forest	Carbon units = 1309 50 years	Carbon units = 957 50 years	Carbon units = 323.4 50 years

Note – harvest revenue is based on a 100% yield, this will vary from site to site

Carbon revenues

The carbon price has a major impact on returns, historically these prices are far from stable so completion of a sensitivity analysis based on a range of carbon prices is recommended
The above table assumes that the forest is registered in the ETS and carbon credits are as per the look up tables (for forests under 100 ha) (https://legislation.govt.nz/regulation/public/2008/0355/latest/DLM1633733.html?search=ts_act%40bill%40regulation%40deemedreg_climate+change_resel_25_a&p=1)

Forests above 100ha are required to use the field measurement approach rather than look up tables to assess site specific growth. Overall carbon credits for production forests over 100ha are typically significantly higher than the MPI default tables

Harvest revenues

Harvest returns can vary significantly based on the following factors:

- Roading cost- typically a function of distance from forest to county road, soil type, metal availability, topography
- Cartage cost – distance to market
- Growth conditions and management regime
- Harvest machinery requirements and availability

It is assumed that pine harvested at 28 years, yielding a Total Recoverable Volume (TRV) of 640 m3/ha, an average sales price of $132 per m3, with a harvest cost of $85 per m3. The income net of harvest costs is $47 per m3.

It is assumed that Douglas r is harvested at 40 years, with a TVR of 800m3/ha, at a value of $124 per m3, with a harvest cost of $85 per m3. The income net of harvest costs is $39 per m3.

It is assumed there is no harvest of native.

Forest costs

Costs can vary significantly:

- Land preparation costs depend on topography and vegetation cover (and often best completed a year in advance of planting), range of $0 to $1500/ha
- Establish costs vary depending on scale, difficulty, access, contractor and seedling availability
- Release spraying costs depend on vegetation species and virulence, topography, location and chemical price (multiple sprays may be necessary), range of $400 to $600/ha
- Thinning and pruning costs range from $800 to 1,800/ha per treatment

In simple terms the cost on a per hectare basis for planting forestry (for a rotation) can be summarized as follows:

Table 31. Summary of costs on a per hectare for forestry (for a single rotation)

Year	Cost description	Pine	Douglas Fir	Native
Every year	Insurance and admin	$50	$50	$50
Every 5 years	Carbon reporting	$60	$60	$60
-1	Weed control and land prep (into scrub)	$500	$1,000	$1,000
0	Planting	$1,500	$2,000	$8,000
0	Registration in ETS (10 to 50 ha forest, less per hectare for a larger forest)	$50	$50	$50
1	Weed control and blanket spray	$500	$500	$2500
2	Weed control		$250	$500

10	Thin	$1,300		
18	Thin		$1,500	
27	Roads / skids	$1,500		
39	Roads / skids		$1,500	
	TOTAL	**$7,050**	**$9,280**	**$14,530**

The above costs assumes that pine harvested at 28 years and Douglas fir harvested at 40 years. No pruning events have been assumed.

Income and costs for forestry (simplified, not taking into account the time value of money over such a long investment)

For the first rotation – carbon units at $60

Table 32. Summary of assumed income and expenses for forestry (Southland) - First rotation

	Pine	Douglas Fir	Native
Income **Carbon - average accounting** (first rotation only)	$18,120	$26,160	$11,634
Income **Harvest revenue**	$30,080 at 28 yrs	$31,200 at 40 yrs	-
Expenses	$7,050	$9,280	$14,350
Net	**$41,150**	**$48,080**	**($2,716)**

The above example uses averaging for pine, Douglas fir and native for comparative purposes. Native is more likely to be planted in permanent forest and use stock change accounting.

For the second and subsequent rotations – no carbon units

Table 33. Summary of assumed income and expenses for forestry (Southland) - Second and subsequent rotations

	Pine	Douglas Fir
Income **Harvest revenue**	$30,080	$31,200
Expenses	$6,926	$8,938
Net	**$23,154**	**$22,262**

Expenses for the second rotation summarised below:

Table 34. Summary of assumed expenses for forestry (Southland) - Second and subsequent rotations

Year	Cost description	Pine	Douglas Fir	
Every year	Insurance and admin	$50	$50	
Every 5 years	Carbon reporting	$60	$60	
-1	Windrowing	$750	$750	
0	Planting	$1,500	$2,000	
1	Weed control and blanket spray (site dependent)	$500	$500	
2	Weed control (site dependent)		$250	
10	Thin	$1,300		
18	Thin		$1,500	
27	Road upgrade	$1,126		
39	Road upgrade		$1408	
	TOTAL	**$6,926**	**$8,938**	

Appendix 5 –

Option 6: Plant 36.9 ha of plantation forestry and slightly reduce sheep numbers

Description

There is an opportunity to plant 36.9 ha of higher risk areas (in particular for phosphorus, sediment and DRP loss) in trees. Harvesting will need to be undertaken in a way to minimize risk of soil disturbance to minimize contaminant loss during the harvest event.

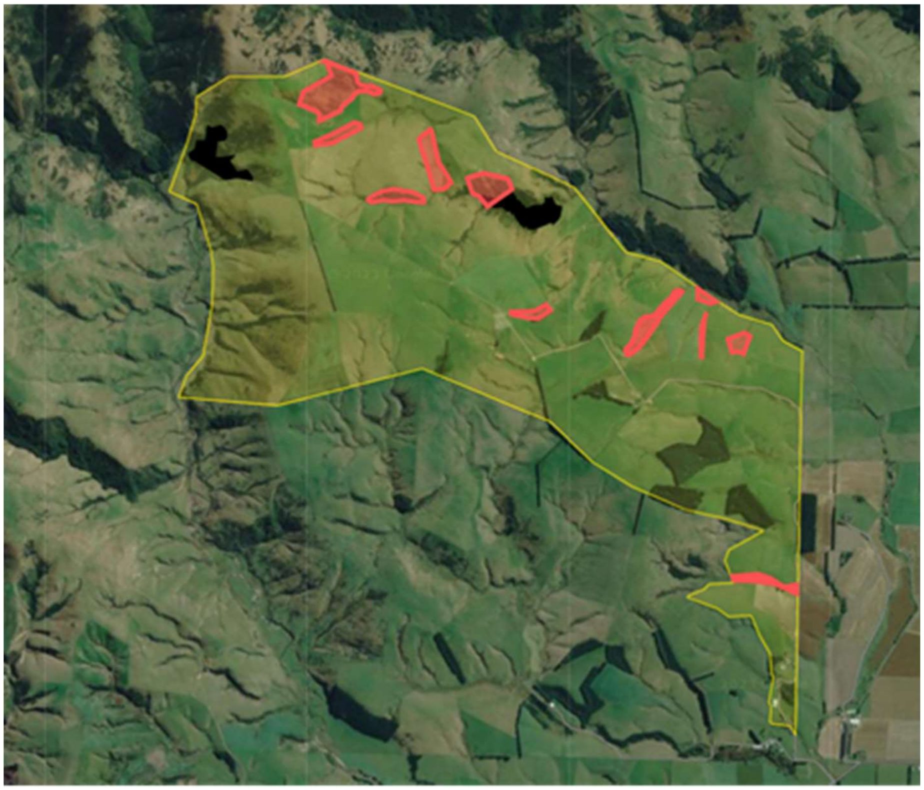

Figure 34. Map showing proposed location of forestry blocks

The forestry blocks range from being planted into scrub (and requiring preplant spraying and preparation) to blocks being planted into pastoral areas. The harvest yield has been assessed for each block and ranges from 80 to 100% yield.

Table 35. Assumed forestry yields per block for Option 6

	Current Land Use Pasture (hectares)	Current Land Use Plantable scrub (hectares)	Total Forest (hectares)
Plantation (100% yield)	7		
Plantation (95% yield)		4.8	
Plantation (90% yield)	5.6	6.9	
Plantation (80% yield)	2.6	10	
	15.2	**21.7**	**36.9**

Impact on environmental contaminants

Estimated by modelling in OverseerFM, with the planting of 36.9 ha of forestry.

Table 36. OverseerFM estimated impact of mitigation for future scenario (36.9 ha forestry) and small reduction in sheep numbers

Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
<1% decrease	No change	1% decrease	2% decrease	3% decrease

(Compared with the Year End 2020/21)

Farm system

While the areas that are planted into plantation forestry are of low productivity, they will still require a small reduction in stock numbers to account for the reduced grazing area. There is assumed to be a 1 % decrease in sheep numbers (across all classes), no change in cattle numbers and no selling of supplement.

This reduction in sheep stock numbers results in a reduction in EBIT (as estimated by FARMAX) compared to the 2020-21 farm system of $11,160 due to fewer lambs sold annually with similar expenses. The reduction in ewe numbers has been modelled with a proportionate reduction in lamb numbers. If the lambing percentage can be increased through the targeted culling of poor performing ewes, it is expected the reduction in EBIT would be less.

Selling of the sheep capital stock releases some capital to partially pay for fencing required of the forestry blocks.

Financial impact

Currently the land is used for sheep grazing and generates a return of 5.5% based on:

- Land value of $152,000 (15.2 ha of pasture at $10,000 / ha - based on estimated current price for forest land in Southland)
- An annual return of $9,042 (73.3 sheep SU at $123.36 / SU = $9,042[1])
- Stock value of $12,828 (73.3 SU at $175 / SU = $12,828).

<u>First rotation - key assumptions</u>

- Land value of $152,000
- The salvage value of the land post harvest of $3000 / ha (value based upon the opportunity cost of the land being required to remain in trees under the ETS)
- Capital released - stock sold to partially fund forestry establishment of $12,828
- Cost of fencing – 6000 m, sheep / cattle netting fence on steep land @ $16.01[16] (labour and materials) = $96,060
- 21.7ha of land ex scrub (and required weed control and land preparation), 15.2ha ex pasture, other costs as per table 18
- First rotation, average harvest yield of 89%
- Planted in pine plantation under averaging accounting, harvested in year 28.

[16] https://www.mpi.govt.nz/dmsdocument/16537-ministry-for-primary-industries-stock-exclusion-costs-report, NZ average steep nonelectric netting

Table 37. Financial impact - 36.9 ha forestry (first rotation)

	Carbon Price $40/ unit	Carbon Price $60/ unit	Carbon Price $60/ unit	Carbon Price $80/ unit
Area planted	36.9 ha	36.9 ha	36.9 ha	36.9 ha
Species	Pine	Pine	Douglas Fir	Pine
Rotation	First	First	First	First
Peak cash deficit	($173,786)	($173,048)	($217,477)	($172,827)
Years of deficit	8	7	13	6
Carbon units	11,144	11,144	16,088	11,144
Carbon value	$445,752	$668,628	$965,304	$891,504
Harvest age	28	28	40	28
Harvest value	$987,857	$987,857	$1,024,639	$987,857
IRR	7.2%	9.5%	6.6%	11.8%

Results - First Rotation (at $60 per carbon unit):

The internal rate of return (IRR) is calculated at 9.5% for pine. The IRR for douglas fir is calculated at 6.6%. The IRR is the average rate of return on the investment, the IRR takes into account the time value of money. This compares with the return from the current sheep operation of 5.5%.

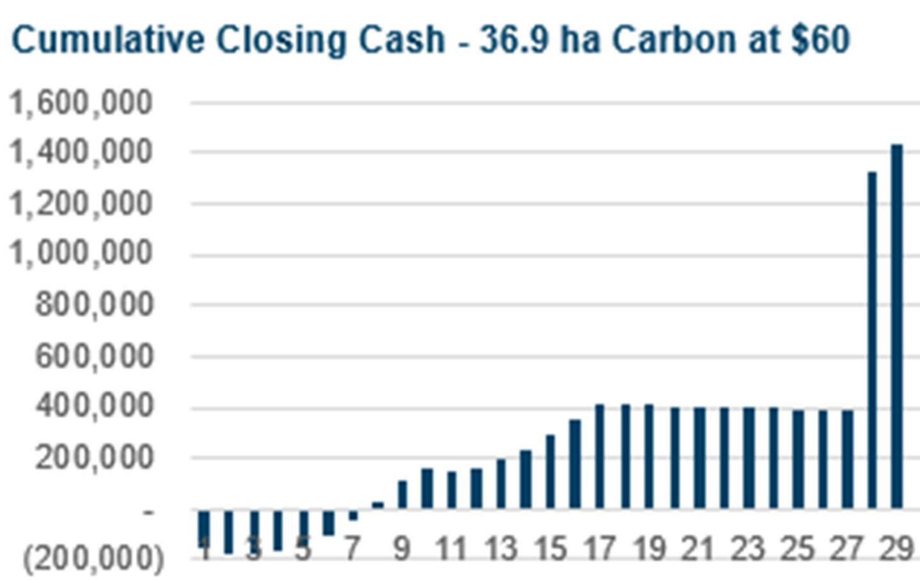

Figure 35. Cumulative closing cash - 36.9 ha forestry (first rotation)

As the planting is spread across many blocks there is the opportunity to spread it across multiple years and reduce the peak cash deficit.

Second rotation - key assumptions

- No land preparation required
- Second rotation, average harvest yield of 89%
- No carbon revenue, harvested in year 28.

Table 38. Financial impact - 36.9 ha forestry (second and subsequent rotations)

	Carbon Price $0/ unit
Area planted	36.9 ha
Species	Pine
Rotation	Second
Peak cash deficit	($198,930)
Years of deficit	27
Carbon units	0
Carbon value	0
Harvest age	28
Harvest value	$987,857
IRR	4.7%

Results - Second Rotation (no carbon units):

The internal rate of return (IRR) is calculated at 34.7%, this is the average rate of return on the investment. This compares with the return from the current sheep operation of 5.5%.

A portion of the harvest revenues from the first rotation could be used to fund the peak cash deficit of the second rotation.

Comments

The returns from the first rotation of forestry (taking into account carbon and harvest revenues) is higher than the sheep grazing operation. The second rotation when only harvest revenues when only harvest revenues are available has a lower return than the current operation.

A key aspect would be the ability to leverage the returns from the first rotation to make further investment to set the farming business up for the future.

Appendix 6 –

Option 7: Plant 134 ha of plantation forestry and remove beef breeding cow operation

Description

There is an opportunity to plant the back face into forestry. The back face is of steep contour and is a low pasture productivity area currently utilized for cattle grazing. No sheep graze this area. The back face has higher landscape susceptibility risk (especially for phosphorus and sediment). The back face is fenced off from the rest of the property and would require no additional fencing if the whole area was planted at once.

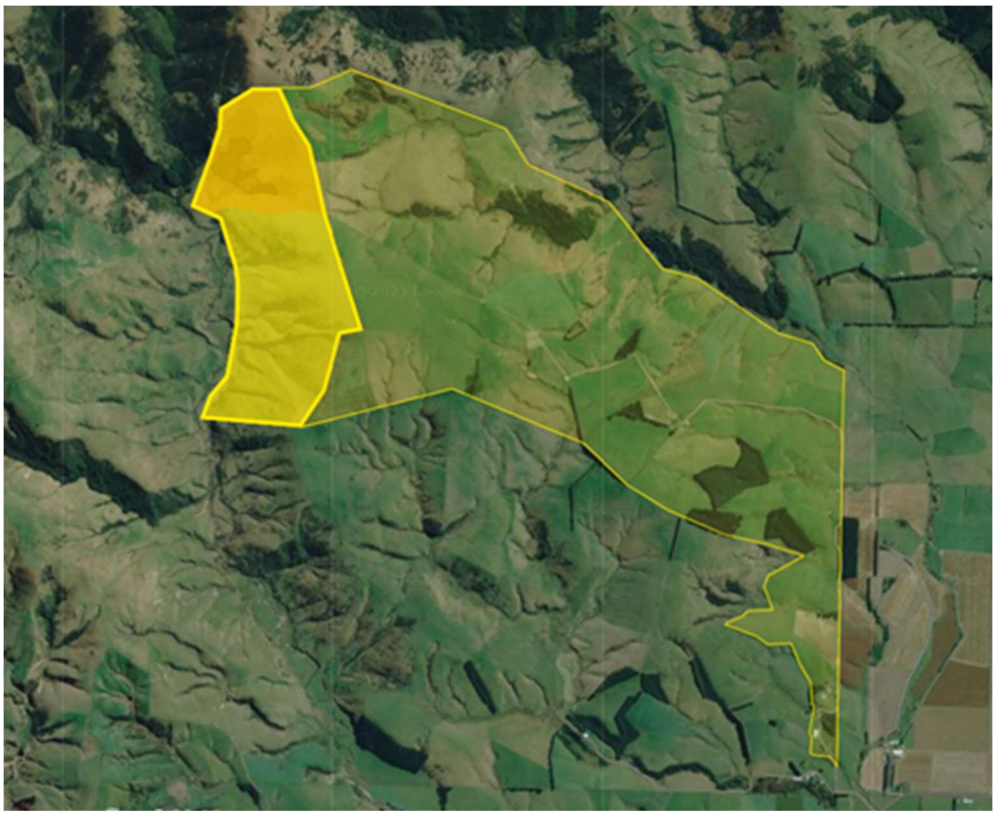

Figure 36. Map showing proposed location of forestry blocks

Impact on environmental contaminants

Estimated by modelling in OverseerFM, with removal of the back face and planting into forestry of forestry.

Table 39. OverseerFM estimated impact of mitigation for blue sky scenario (134 ha of forestry)

Total GHG change	Nitrous oxide change	N loss change	N surplus change	P loss change
12% decrease	10% decrease	10% decrease	14% decrease	15% decrease

(Compared with the Year End 2020/21)

Farm system

While the back face is of low pasture productivity it is a large portion of the farm (18%). Therefore, has a significant impact on the farm system. Under this scenario the beef breeding cow operation would be discontinued. The capital from selling the beef breeding cows and bulls ($170,000) would be utilized for planting the back face.

There is a significant change to the farm system with this scenario:

- Removal of the beef breeding cows and bulls
- No buying in of beef replacements
- Buy in beef weaner calves.

Due to the significance of the farm system change (and potential impacts on feed quality at different times of the year), further analysis was undertaken using Farmax to ensure farm system feasibility and to further quantify the financial implications of the farm system change. The removal of the beef cows and conversion of 134 ha to forestry reduced the EBIT from the pastoral enterprise by $24,222 due to the cost of purchasing beef calves rather than breeding .

Financial impact

Currently the land is used for beef breeding cow grazing, the beef breeding is generating a return of 4.2% based on:

- Land value of $1,340,000 ($10,000 / ha - based on estimated current price for forest land in Southland)
- An annual return of $62,687
    - Income
        - Cull cows (14 @ 750) = $10,500
        - 110 beef calves each year at $650 / hd = $71,500
    - Costs
        - Replacement bull annually (1 @ 3000) = $3,000
        - Replacement heifers (15 @ 800) = $12,000
        - Annual weed and pest control on back face (720 SU @ 3.99) = $2,873
        - Animal health associated with breeding cows / bulls (720 SU @ $2) = $1440
- Stock value of $170,000
    - 115 cows @$1300 / hd, 5 bulls @$1800 / hd, 15 heifers @ $800 / hd = $170,000

<u>First rotation - key assumptions</u>

- Land value of $10,000 / ha
- The salvage value of the land post harvest of $3000 / ha (value based upon the opportunity cost of the land being required to remain in trees under the ETS)
- Capital released - stock sold to partially fund forestry establishment of $170,000
- Cost of fencing – nil, existing fences used
- The whole area requires weed control and land preparation, other costs as per table 18
- First rotation, average harvest yield of 95%
- Planted in pine plantation under averaging accounting, harvested in year 28
- Assumes on using look up tables – over 100 ha will require measurement.

	Carbon Price $40/ unit	Carbon Price $60/ unit	Carbon Price $60/ unit	Carbon Price $80/ unit
Area planted	134 ha	134 ha	134 ha	134 ha
Species	Pine	Pine	Douglas Fir	Pine
Rotation	First	First	First	First
Peak cash deficit	($186,440)	($183,760)	($372,700)	($182,956)
Years of deficit	6	5	11	5
Carbon units	40,468	40,468	58,424	40,468
Carbon value	$1,618,720	$2,428,080	$3,505,440	$3,237,440
Harvest age	28	28	40	28
Harvest value	$3,829,184	$3,829,184	$3,971,760	$3,829,184
IRR	5.5%	7.2%	5.2%	8.9%

Table 40. Financial impact - 134 ha forestry (first rotation)

<u>Results - First Rotation Pine (at $60 per carbon unit):</u>

The internal rate of return (IRR) is calculated at 7.2% for pine. The IRR for douglas fir is calculated at 5.2%. The IRR is the average rate of return on the investment, the IRR takes into account the time value of money. This compares with the return from the current beef operation of 4.2%.

The internal rate of return (IRR) is 7.2%, this is the average rate of return on the investment, the IRR takes into account the time value of money. This compares with the return from the current beef operation of 4.2%.

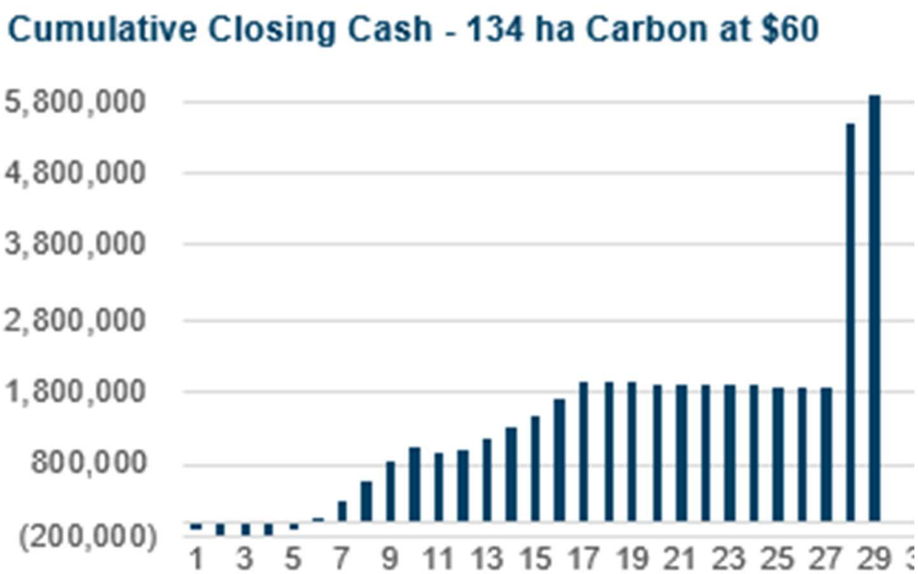

Figure 37. Cumulative closing cash - 134ha forestry (first rotation)

Second rotation - key assumptions

- No land preparation required
- Second rotation, average harvest yield of 95%
- No carbon revenue, harvested in year 28

	Carbon Price $0/ unit
Area planted	134 ha
Species	Pine
Rotation	Second
Peak cash deficit	($763,800)
Years of deficit	27
Carbon units	0
Carbon value	0
Harvest age	0
Harvest value	$3,829,184
IRR	2.7%

Table 41. Financial impact - 134 ha forestry (second and subsequent rotations)

Results - Second Rotation (no carbon units):

The internal rate of return (IRR) is 2.7%, this is the average rate of return on the investment, the

IRR takes into account the time value of money. This compares with the return from the current beef operation of 4.2%.

A portion of the harvest revenues from the first rotation could be used to fund the peak cash deficit of the second rotation.

Comments

The returns from the first rotation of forestry (taking into account carbon and harvest revenues) is higher than the current beef breeding operation. The second rotation when only harvest revenues when only harvest revenues are available has a lower return than the current operation.

A key aspect would be the ability to leverage the returns from the first rotation to make further investment to set the farming business up for the future.