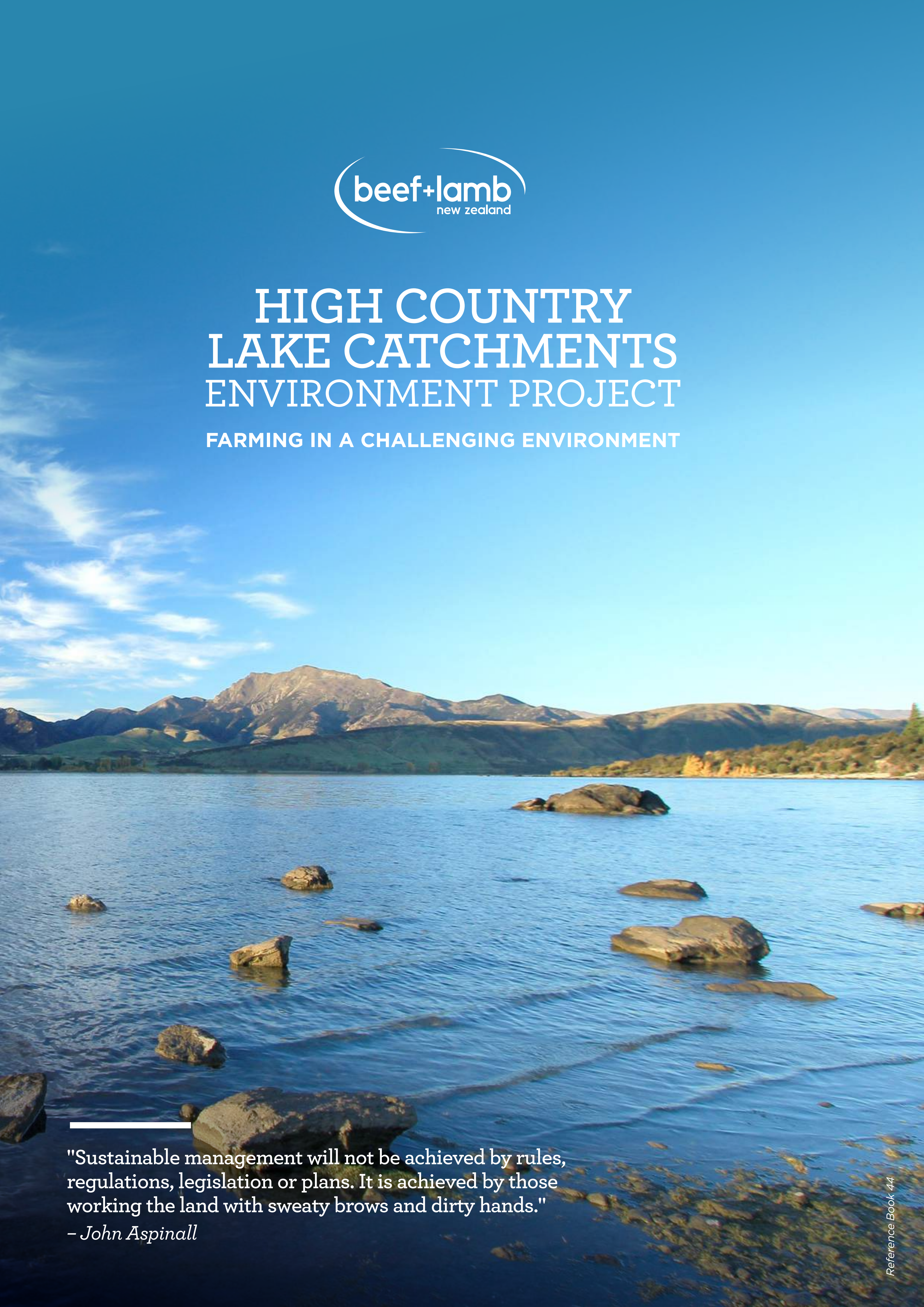


HIGH COUNTRY LAKE CATCHMENTS ENVIRONMENT PROJECT

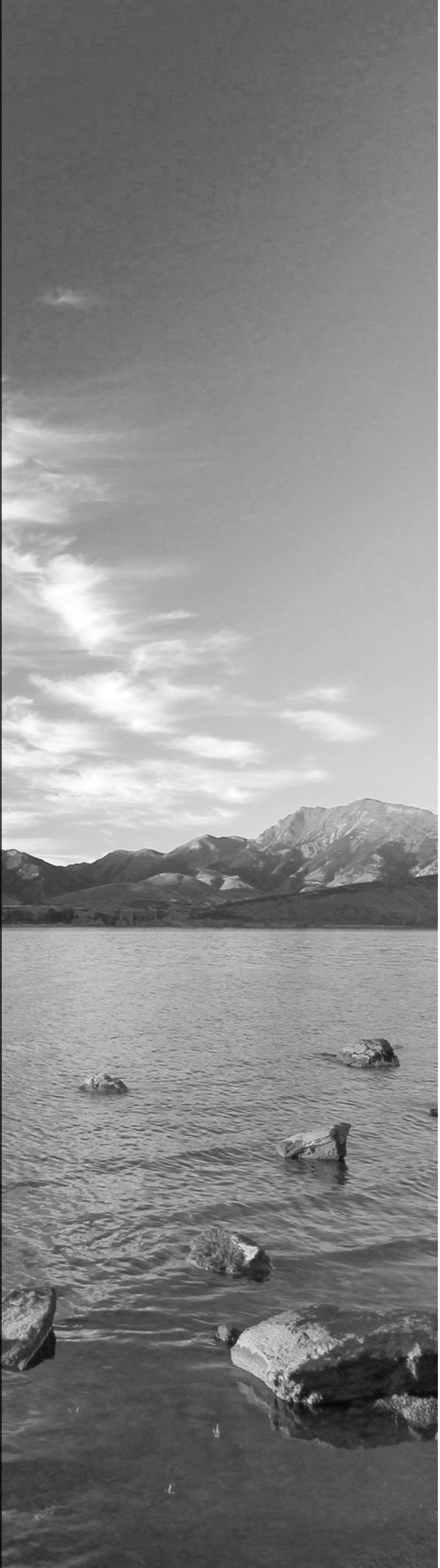
FARMING IN A CHALLENGING ENVIRONMENT

"Sustainable management will not be achieved by rules, regulations, legislation or plans. It is achieved by those working the land with sweaty brows and dirty hands."
– *John Aspinall*

Reference Book 44

By farmers.
For farmers

Published October 2017



Contents

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ASPIRING ENVIRONMENTAL

Photographs by:
Chris Arbuckle from Aspiring Environmental.

References:

Smith, C., Monaghan, R., McDowell, R., Carrick, S. 2016. Nitrogen and phosphorus concentrations and fluxes in drainage from pasture, winter forage crop and native bush sites in the West Matukituki Valley, RE500/2016/013. AgResearch.

Introduction

Beef + Lamb New Zealand (B+LNZ) is focussed on creating a confident and profitable sheep and beef industry that is sustainable and meets regional environmental priorities.

Through Land and Environment Planning (LEP), B+LNZ provide guidance, advice, strategies and information regarding priority management approaches which can be implemented in practical ways to address environmental issues such as water quality decline at a farm scale.

The High Country Lake Catchments Environment Project began in 2014 and worked with three Otago stations; Mt Aspiring Station in the Lake Wanaka catchment, Mt Burke Station in the Lake Wanaka and Lake Hawea catchments, and Rees Valley Station in the Lake Wakatipu catchment, with the aim of advancing environmental sustainability in these iconic parts of New Zealand.

The focus for this two-year project, was to work with run holders to advance their farm systems and environmental management while building upon a growing awareness amongst farmers in the Otago sensitive lake catchments regarding resource limits set by the Otago Regional Council (ORC). One of the key tools to facilitate and enable a shift is the LEP 3.

Year one of the project focused on mapping and gathering farm information to build a LEP Level 3 for each of the three stations. A detailed nutrient management plan (using OVERSEER®) was also completed to build an understanding of nutrient loss associated with these large, complex farms.

Wishbone Falls—West Matukituki valley, Mt Aspiring Station.

Year two focussed on advancing application of the LEP by identifying key mitigation strategies on-farm, evidencing the predictions from OVERSEER® and then testing farm financial performance (using FARMAX) against nutrient loss limits (primarily nitrogen) as set by the Otago Regional Council.

LEPs are a useful method to consider farm environmental resources and identify risks for contaminant loss. As part of the LEP process, each of the farms developed a detailed action plan to help front-foot on-farm environmental management, while also meeting expectations as outlined in the Regional Plan: Water for Otago. An additional outcome associated with developing LEPs, was linking a risk assessment that aligned the likely sources of key contaminants to Good Management Practices (GMPs) on-farm. This primarily targeted a reduction in nitrogen (N), phosphorus (P), sediment and faecal microorganism losses to water by facilitating more considered farm management and targeted mitigation strategies.

Key findings

- There are costs associated with on-farm environmental management; however, some costs are definitely bigger than others. Meeting blunt rules focussed on whole farm contaminant losses can have dire effects on farm profitability, resulting in conflicting environmental and community outcomes.
- Overseer is a useful tool for estimating on-farm contaminate losses, however the results need to be carefully considered. Considerable expertise and attention to detail is required to setup Overseer to model large high-country stations in this environment.
- In some cases, the costs associated with improving farm environmental management can be mitigated by farm system changes to increase the economic farm surplus.
- A range of simple, tailored environmental mitigations can be identified by Land and Environmental Planning and adopted to improve water quality at little cost the farm business.
- Opportunities that complement farming are worth exploring to add resilience to farming systems that face resource limits, e.g. Eco-Tourism.
- Environmental risk is often less obvious when hidden in a model or in blanket rules. This is exacerbated for many high-country stations by separate processes such as tenure review.
- Ultimately, environmental improvements for high country stations will only be realised by the people who are making a difference on farm. We ignore this at our peril, and have an obligation to provide practical tools to help prioritise on-farm environmental management—the Land and Environment Plan is one of these tools.

OVERSEER®

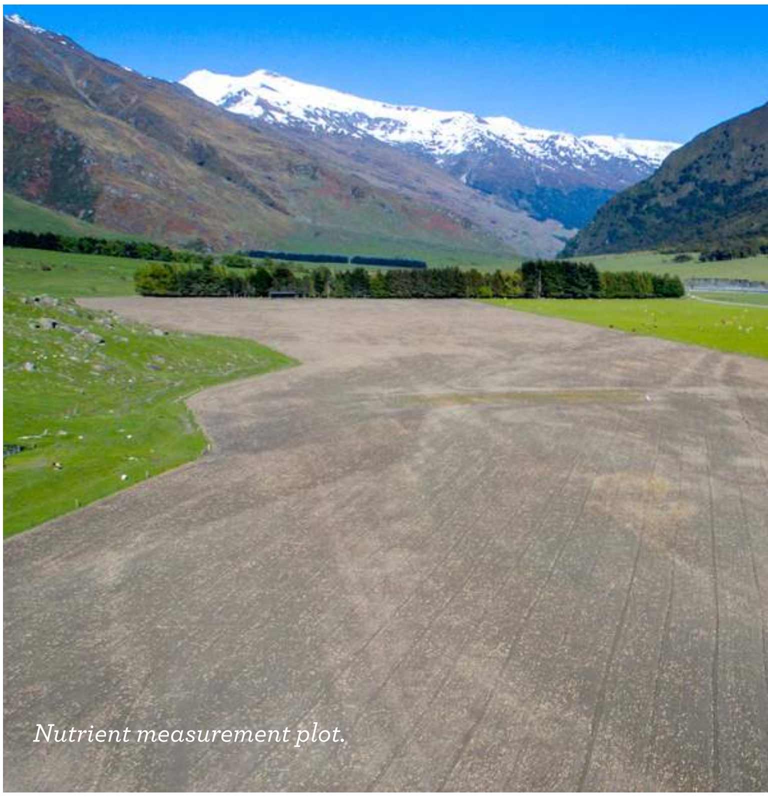
Considerations for use in regulation in the high country

The nutrient budgeting tool OVERSEER® (Overseer) is widely used throughout New Zealand for guiding on-farm nutrient management decisions.

The model was originally designed in the 1990s to assist farmers with fertiliser management decisions with the aim of improving New Zealand farm production. However, over the years the use of Overseer has evolved into a farm decision support tool that is also used to evaluate potential environmental impacts by estimating nutrient losses and greenhouse gas emissions. The primary development focus for the model has been to ensure Overseer operates at the farm-scale, but this in turn has resulted in the model having to address a wide range of very specific farm management practices and environmental conditions. The farm scale relevance of Overseer has enabled resource managers (Regional Councils) to apply an effects based approach to managing losses from land use (both greenhouse gases and nutrients) consistent with the Resource Management Act, instead of controlling the inputs to a farm system (e.g. fertiliser, stock, etc).

Regional Council use of Overseer is increasing as councils implement their water management and nutrient limit setting policies in response to the National Policy Statement on Freshwater Management (NPS-FM). The model is also likely to play a role in any greenhouse gas (GHG) emission accounting frameworks. Over a relatively short period of time, the use of Overseer by Regional Councils has moved from general farm management advice to a focus on environmental limit setting, considering diffuse nutrient losses to the environment often associated with poorer water quality but focusing on contaminants is not easily measured.

While Overseer has the ability to generate nutrient budgets for many types of farm system (e.g. sheep, beef, dairy, goats and pigs), it has most commonly been used for modelling in the dairy industry. This is primarily because dairy farms typically utilise a higher level of inputs (e.g. fertiliser, feed, etc.) than other farm systems and in turn often have the greatest efficiencies to gain by considering nutrient management. It is generally recognised by technical specialists who regularly use Overseer that dairy systems are relatively simple to model compared to arable or sheep and beef farms (such as those selected in this project). For example, dairy farms classically have one or two stock classes, whereas a sheep and beef farm will typically have several. Sheep and beef properties are often also larger in size and located across a wide range of climates and topographies.



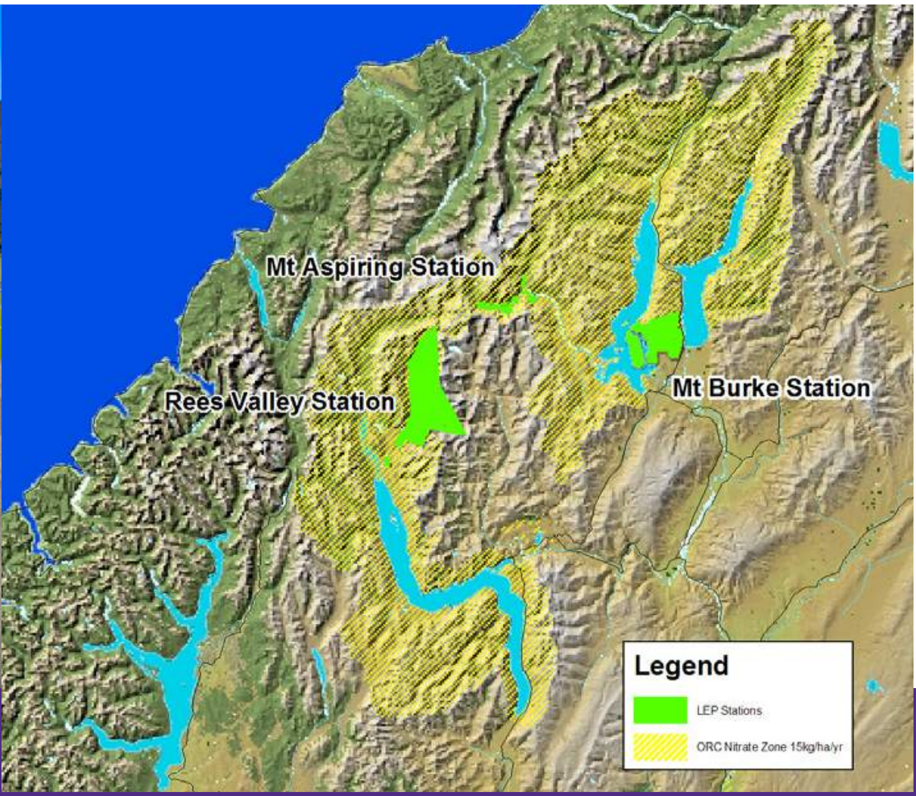
Nutrient measurement plot.

The complex nature of high country farms requires a comprehensive level of farm systems understanding to ensure the Overseer model is setup appropriately. This, coupled with the fact that these predominantly sheep and beef systems have evolved to incorporate other farm systems (e.g. dairy grazing, arable crops, and deer production) provides the model user with a significant challenge to represent emission losses effectively. These challenges are likely to remain as farmers look to further diversify income sources and make their farms more market resilient.

The three high country stations associated with this project find themselves impacted by a restrictive 15kg/ha/yr nitrogen loss limit as directed in the ORC Regional Plan: Water for Otago. By 2020, farms will be required to report their nitrogen losses to the ORC as estimated in an Overseer nutrient budget. While this is a regulatory requirement for properties to undertake for future nutrient use reporting, the outcome of this could also influence decisions regarding future farm development and overall nutrient management.

Because Overseer has not been comprehensibly validated in high rainfall and shallow soil environments, the outputs generated for this project have needed to be properly scrutinised.

Below: Location of the three project stations within the Nitrogen Sensitive Zone of 15kgN/ha/yr.



Some of the key challenges associated with the use of Overseer which were identified during this project include:

1. Improving knowledge of the data needs for use of the model in the high country setting.
2. Examining if model input requirements can actually be met:
    a. How to approach the inclusion of significant rainfall gradients
    b. The state of soils data in this area
    c. How to represent complexity of multiple stock classes and movements.
3. Examining predicted losses as measured by Overseer against measured losses.
4. Discussion around the implications of predicted nutrient losses as modelled by Overseer at a farm scale with regard to farm management and limit setting.

FARMAX

FARMAX (Farmax) is a farm financial decision support tool for pastoral farmers. Use of the tool helps farmers better plan, monitor and analyse their farm operations to optimise their farm financially. Commercially launched in 1993, Farmax was developed by AgResearch and was born out of 20 years of research. It is an evidence-based software system developed for the industry, by the industry. Farmax can be used to model the complexity and variables in the farm system, and predict production and financial outcomes. Testing changes to the existing farm system can identify potential opportunities and benefits.

In using Farmax, a model of the farm is built which considers how it is currently performing, profit/loss and production. Farmax is used to calculate annual pasture production, and this can be split around different blocks where properties have different land classes. In doing so, production patterns can be examined. One key benefit of this is the support for decision-making around changes to farm operation that might better utilise existing feed supply or look at options for increasing feed supply at certain times of the year.

Once the base model has been developed to accurately represent the farm system, Farmax can be used to examine any potential impacts of changes with a high degree of confidence. For example, a user could analyse the impact of a change to their cropping system i.e. simulating a drought or other seasonal growth variations to test options for dealing with these. Farmax is also increasingly being used by farm environmental consultants in tandem with Overseer to examine the role and effect on-farm mitigations and management changes might have towards farm financial performance.

After completion of the LEP and Overseer nutrient budgets in year one, Mt Aspiring and Mt Burke Stations were also assessed using Farmax. Scenario testing of the mitigations and various management changes identified in the LEP response plans and Overseer budgets, were modelled using Farmax to see if the costs associated with these recommendations were financially feasible. Many of these scenarios either related to modifications in management (e.g. changes to crop, stock policy and water use), or a farm system investment such as fencing of waterways, irrigation efficiency improvements or wetland establishment.

The farms

View of 'Hells Gates' from Cameron Flat.

Mt Aspiring Station

Mt Aspiring Station is owned by Randall and Allison Aspinall with their sons Johnny, Josh and Randall's Mother, Sue Aspinall. Established in 1920, Mt Aspiring Station has been in the Aspinall family now for 4 generations. Originally around 29,000 ha, in 1957 Jerry and Phyllis Aspinall voluntarily surrendered 20,235 ha to the Crown to help form Mt Aspiring National Park in 1963. This left just under 10,000 ha of lease hold. The Station recently went through land tenure review and is now comprised of just over 2,300 ha freehold (and a 175 ha grazing lease), nestled in the west and east branches of the Matukituki river.

The station has been reported to have around 80,000 people pass through a year to venture into the national park, including students staying at the Old Homestead and Otago Boys High School lodge, adding a further set of unique challenges for the farming enterprise to manage.

The farm has been divided up into various paddocks and runs. It can be summarised as having steep faces, river terraces and river flats.

Mt Aspiring Station information summary—2015

Rainfall

Rainfall varies significantly from around 3,000 mm per annum up the head of the west branch, to around 2,024 mm at the homestead at the branch of the west and east Matukituki valley.

Soils

Soils are very light and described as a mix of recent soils, young deposits from the river (silt, sand and gravel) and brown soils, mostly loamy silt.

Stock

Sheep: Romdales

Ewes	3,980	Breeding Replacements	946
Hogget's	160	Rams	45
Lambs	3,118		

Cattle: Angus/Hereford cross

Cows	500	Mixed Age Heifers	240
Bulls	20	Mixed Age Steers	70

Sheep graze the hills near the homestead.

Crop and pasture

Swedes, kale, turnips and rape

2015–16 crop (Swedes/kale 19.1 t DM/ha), with average N and P contents of 1.6%, and 0.278%, respectively. Crop ME and CP contents averaged 10.6 MJ/kg DM and 13.2%, respectively.

2015-2016 Pasture production is characterised by peaks in November and March with potential for low points over summer. Production for the 2015 year was 8,251 kg DM/ha. Analysis of botanical composition showed that, on average, the pasture consisted of 71% grass (ryegrass oversown but predominantly browntop, yorkshire fog, dogs tail, fescue), 8% white clover 7% weeds and 14% dead material.

The clover content peaked at 13% in February and early December, while the amount of dead material peaked in late autumn and over the winter months (Smith et al., 2016).

The AgResearch N + P loss study plot—West Matukituki.

Mt Burke Station

At close to 10,000 ha, Mount Burke Station is located on the north-eastern shore of Lake Wanaka and is farmed by Tim Burdon with farm manager Grant Ruddenklau and two farm staff.

The station is currently supported by a 171 ha freehold block (Ridgeway) and 285 ha block leased from Ruddenklau Farming Ltd. Like many other New Zealand high country pastoral leases, Mt Burke has been going through tenure review, which may have a significant bearing on the future size and development potential of the property.

Mt Burke Station has hundreds of streams flowing through the property that present challenges for water quality management, but it also has an added challenge of a vast open lake frontage. Therefore, farm management and environmental initiatives need to be targeted and prioritised. Mt Burke Station is a part of a small group of farms which have the sensitive lake zone (and associated 15 kg/ha/yr nitrogen loss limit) bisecting part of the property. This is an important consideration, influencing decisions about future development and overall nutrient management strategies.

Angus/Hereford—White face cattle as a result of the cross.

Mt Burke Station information summary—2015

Mt Burke Crown Lease: 10,000 ha

Mt Burke Free Hold: Ridgeway—171 ha

Ruddenklau Farms: Lease—285 ha

Rainfall

Rainfall varies from 750 mm per annum on the flats, to 1,000 mm on hill country blocks.

Soils

Young shallow fluvial soils on the flats and terraces. Shallow brown soils on hill country blocks.

Stock

Sheep: Headwaters

Ewes..7,465
Hogget's......................................1,948
Lambs..8,492
Breeding Replacements..........1,957
Rams..102

Cattle: Angus/Hereford cross

Cows..135
Bulls...5
Mixed age heifers.....................70
Steers..44

Deer: Red Deer

Hinds...210
Stags...230
Weaners......................................50

Stock image.

Crop and pasture

Swedes, peas, fodder beet, turnips and lucerne

2015-16 crop

Rape	yield ~6 t DM/ha
Swedes	yield ~12 t DM/ha
Turnips	yield ~6 t DM/ha
Fodder beet	yield ~23 t DM/ha

Pasture/clover composition, primarily ryegrass oversown but predominantly browntop, yorkshire fog, dogs tail, fescue.

Irrigation

Pivot	56 ha
Border dyke	84 ha (potential)
K-Line	49 ha (potential)
Gun	23 ha (potential)

A view of Mt Burke Station's lakeside pivot.

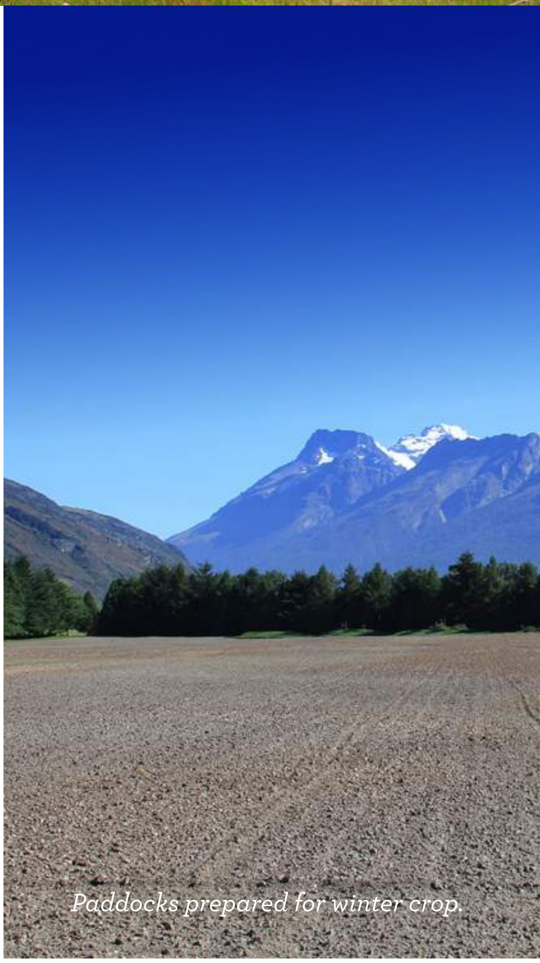
Rees Valley Station

Extensive use of shelter belts at Rees Valley flats.

Iris, Kate, Diane and Eric Scott own the 150-year-old, 19,500 ha Rees Valley Station at the head of Lake Wakatipu, near Glenorchy.

Farm income is generated primarily from fine wool production and Hereford beef, supplemented at times from by eco-tourism business operators, a boutique ski field (Invincible Snowfields) and film making enterprises. Iris's life on Rees Valley has been captured in the book *A High-Country Woman* which is the engaging story of Iris Scott's love of our high country and her determination to farm it successfully while upholding high conservation and land-guardianship values. The book also covers the fascinating history of the area, long known to locals as The Head of the Lake. The area associated with William Rees' great sheep run, established not long after he and Nicolas von Tunzelman became two of the earliest Europeans to travel into the area in an epic exploration feat in 1860.

Rees Valley is another station caught with a foot either side of the ORC nitrogen loss limit of 15/kg/ha/yr. Most of the lease hold block sits within this zone, but about 3,300 ha of mountainous high country in the Shotover Catchment falls outside the sensitive lake zone and is capped at a nitrogen loss limit of 30 kg/ha/yr. Like Mt Burke Station, the use of Overseer to predict N loss on such a huge farm needs careful consideration. Stream water quality throughout the property, including the Rees River is generally excellent to pristine, however there are some challenges for the station managing stock access to the waterways flowing throughout their home farm on the flats.



Paddocks prepared for winter crop.

Rees Valley Station information summary—2015

Rees Valley Crown Lease........... 19242.5 ha

Rees Valley Free Hold (Rees flats and upper terrace) .... 330.4 ha

Rainfall

Rainfall varies from 1,250 mm on flats to 3,000 mm on hill country.

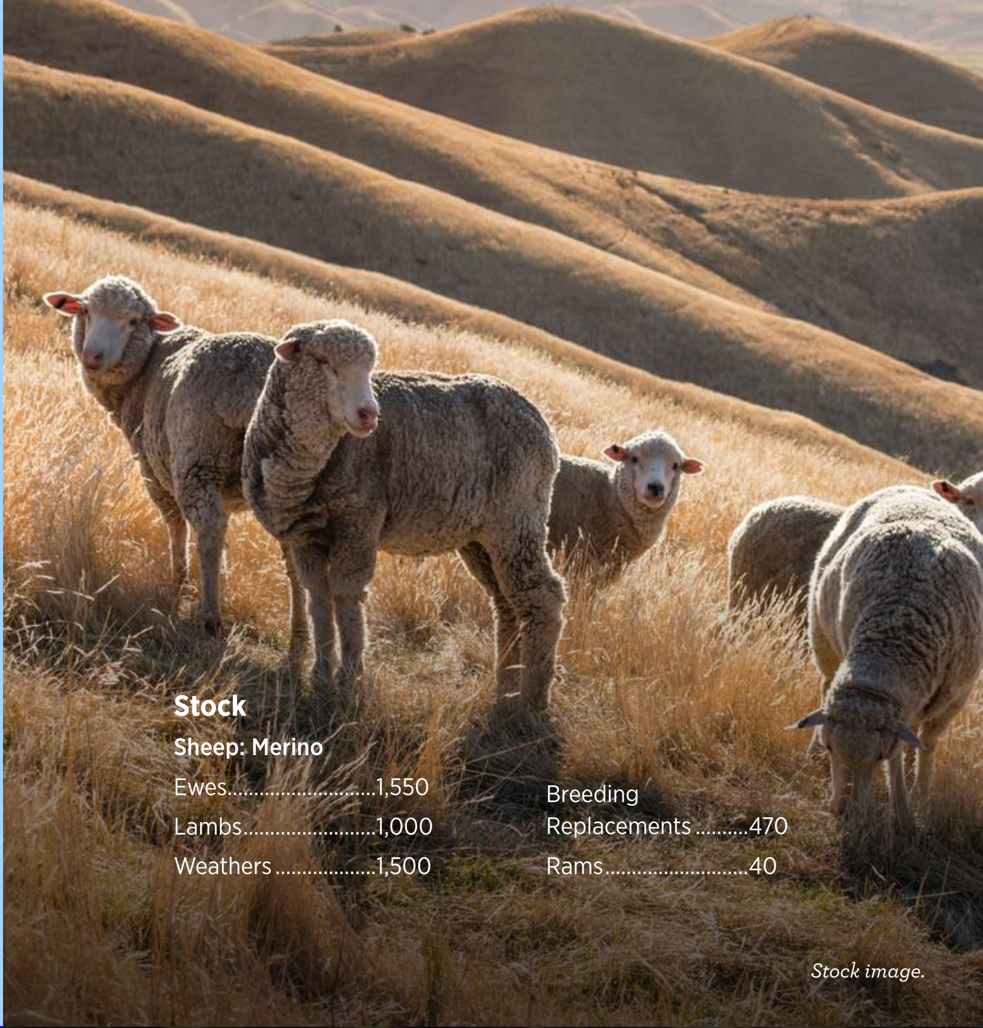
Dart at the Hillocks..................... 1,677 mm

Dart at Paradise........................... 1,896 mm

Shotover at Peats Hut .... 872 mm

Soils

Young shallow fluvial soils on the flats and terraces. Shallow brown soils on hill country.



Stock

Sheep: Merino

Ewes.............................1,550

Lambs..........................1,000

Weathers 1,500

Breeding Replacements 470

Rams...........................40

Stock image.

Crop and pasture

2015-16 Crop

Swedes...................... 6 ha (~8 t DM/ha)

Oats............................ 6 ha (4t DM/ha)

Lucerne .... 3 ha

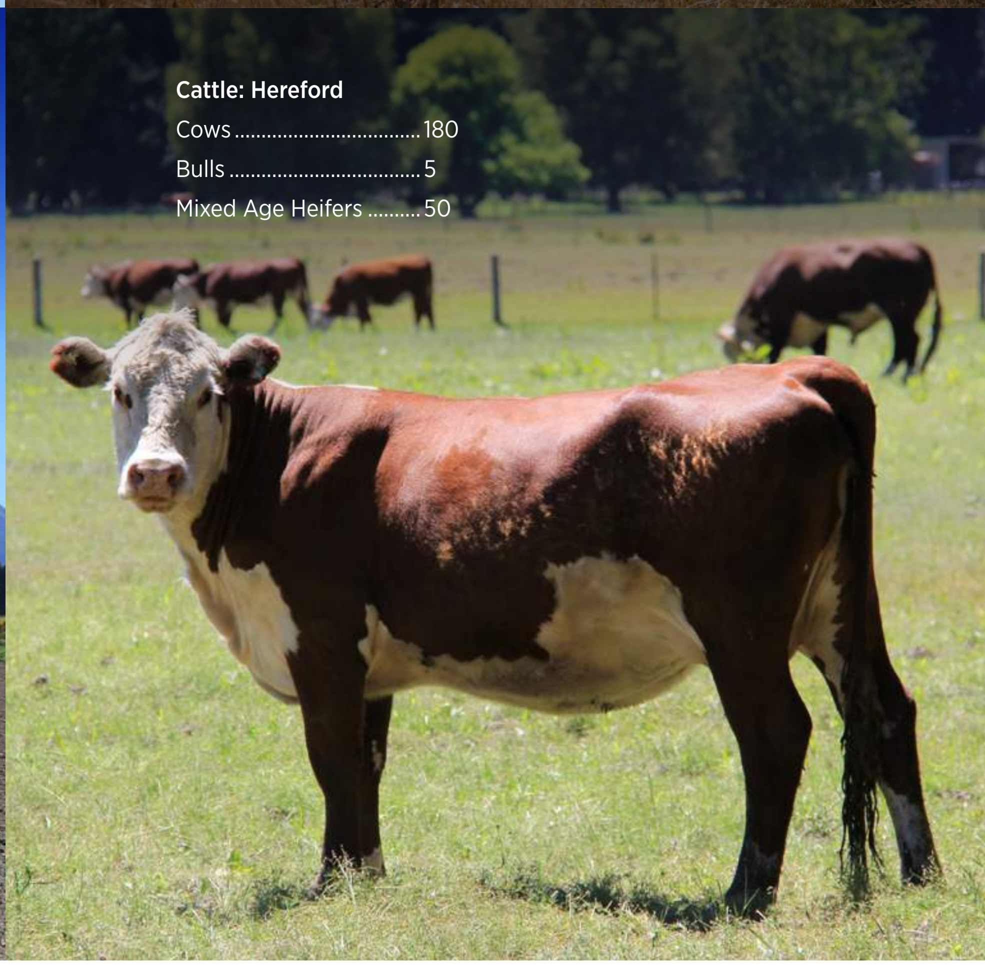
Meadow hay .... 25 ha (400 Bales per annum)

Cattle: Hereford

Cows 180

Bulls 5

Mixed Age Heifers 50



LEP and environmental

For each farm, a Land Environment Plan was completed. Resource information provided in this included stocking rate information, summaries of Land Use Capability (LUC) and soils information. Key information is summarised in Table 1 below.

Table 1: High Country Station LEP information comparison.

Unit	Rees Valley	Mt Burke	Mt Aspiring
Rainfall (mm)	1,250–3,000	750–1,000	2,000–3,000
Area (Ha)	19,000	10,000	2,309
Tenure	Free and lease hold	Free and lease hold	Freehold
Soils	Recent/older brown	Shallow fluvial/deeper brown soils lake side/ older shallow brown hills	Recent/older shallow brown
LUC	LUC 3 1% / LUC 7/8 86%	LUC 4 4%/LUC 6&7 64%	LUC 3 6%/LUC 6&7 89%
Irrigation	No	Pivot, gun, k-line and border dyke	No
Stock Units (Total)	4,429	14,018	12,143
Stock Units per ha (SU Grazed area)	0.3 (0.6)	1.3 (2)	5 (6)
Stock	Sheep/cattle	Sheep/cattle/deer	Sheep/cattle
Total farm N loss (kg/ha/yr)	4	8	25
Total farm P loss (kg/ha/yr)	2.2	1.2	3.1

Stocking rate

The stocking rates indicate the estimated Revised Stock Unit (RSU) per hectare on a grazed area and total farm basis for all animal enterprises present on the farm. RSU is defined as an animal with an intake of 6,000 MJ ME intake per year—similar to a standard stock unit measure. This enables the carrying capacity of dairy and non-dairy systems to be compared, based on feed intake.

Other definitions adopted as set out below:

SU grazed area Stocking rate on grazed pasture for each animal enterprise, estimated as total RSU of an animal enterprise divided by the grazed area (area of pastoral and fodder crops blocks). In farms with only pastoral blocks, this is the effective area (RSU/ha).

SU total The total carrying capacity, as RSU, for each animal enterprise.

comparisons

LUC assessment
(number of classes, area, %)

Description

Mapping that delineates land areas classified according to their capability to sustain continuous production. Land Use Capability (LUC) is a hierarchical classification identifying: the land's general versatility for productive use; the factor most limiting to production; and a general association of characteristics relevant to productive use (e.g., landform, soil, erosion potential, etc.). LUC classifications have been constructed for each NZLRI survey region. These individual classifications have been correlated too North and South Island classifications to permit wide-area analyses.

Origin

Interpreted, for each predefined land unit delineated in the 1:63 360/1:50 000 scale New Zealand Land Resource Inventory survey, from reference to the inventory of physical factors mapped and from a knowledge of climate and the effects of past land use.

LUC Class code

Description

1. Land with virtually no limitations for arable use and suitable for cultivated crops, pasture or forestry.
2. Land with slight limitations for arable use and suitable for cultivated crops, pasture or forestry.
3. Land with moderate limitations for arable use, but suitable for cultivated crops, pasture or forestry.
4. Land with moderate limitations for arable use, but suitable for occasional cropping, pasture or forestry.
5. High producing land unsuitable for arable use, but only slight limitations for pastoral or forestry use.
6. Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forest.
7. Non-arable land with severe limitations to use under perennial vegetation such as pasture or forest.
8. Land with very severe to extreme limitations or hazards that make it unsuitable for cropping, pasture or forestry.

Soils

Primary soil features for all the stations are dominated by recently deposited shallow fluvial soils (light soils) on the valley floor and terraces and older shallow brown soils on hill country on steep hill country. Detailed soil maps for this area are not available.

Nutrient management and reporting

Overseer version 6.2.2. was used to predict each high-country station's nitrogen lost to water for the 2015/2016 year. Rees Valley and Mt Burke Stations are caught with a foot either side of the Otago Regional Council nitrogen limit of 15 kg/ha/yr making Overseer setup more complicated.

Looking over the Upper Clutha Valley. B+LNZ image.

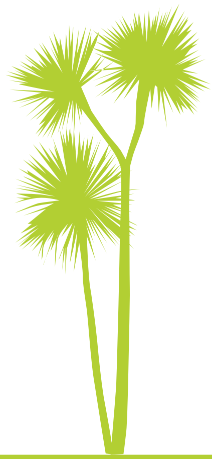
LEP response planning

Developing the Land and Environment Plan (LEP) identified several key areas for improving on-farm environmental management common to all properties.

This included considering mitigations to intercept overland flow, restrict stock access to priority waterways where farming activities are more intensive (e.g. cropping) and for Mt Burke Station, an examination into irrigation management and infrastructure. A summary of some key actions identified in the various LEPs is presented in Table 2 below.

Table 2: Key areas/actions to improve on-farm environmental management.

Challenge	Primary issue	Response
Stock access management.	Water quality—ditches, and several streams flowing through fenced paddocks that have direct stock access (especially cattle).	Fence off paddock drainage ditches and wetlands using a combination of strategic electric fencing and permanent fencing in critical source areas.
Stock access management and conservation management.	Water quality—some creeks and drains have direct stock access, especially by cattle. Water quality—wetland degradation.	Fence off and look to restore creek riparian zones and wetlands for interception of paddock run off.
Nutrient management.	N and P loss to water.	Overseer/nutrient budget.
Native scrub and bush.	Potential degradation of native biodiversity.	Fence off areas of native vegetation.
Irrigation—border dyke shallow soils.	Water quality—nutrient (P and N)/sediment and faecal loss to lake, both surface (by-wash) and groundwater losses likely to be significant at times of high stocking/winter fodder cropping.	Focus on better water management in the paddocks on slopping terraces and the more intensive paddocks in direct proximity to the lake. Eliminate irrigation bye wash to the Lake. Install interception wetlands.
Irrigation—pivot shallow soils.	Water quality—nutrient loss to lake via connected groundwater, low surface run off risk via ephemeral creeks. A significant change in management will elevate losses.	If used for fodder cropping nutrient and soils management will be extremely important.



Action	RMA Rules
Short term. Year 1—fencing. Year 2–3 plant riparian zone if practical.	ORC 6A Schedule 15 + 16 WQ Standards.
Long term. Year 1–3 fencing. Year 4–5 plant riparian zone with native plants. Retire as a functional wetland/use as a mitigation in Overseer for the fenced block for N retention.	ORC 6A Schedule 15 + 16 WQ Standards.
Long term. Provide data for Overseer of N + P Loss by 2020. Consider N and P management practices (fertiliser use/stock policy) in high loss areas e.g. winter cropping blocks.	ORC 6A 15 kgN/ha/yr.
Long term. Five years plus.	N/A—QEII, Stock management and Biodiversity.
Short term. Examine change to more efficient irrigation practice (e.g. pivot). Eliminate irrigation bye wash to the Lake. Install interception wetlands where possible.	ORC 6A 15 kgN/ha/yr Schedule 15 + 16 WQ Standards.
Improve pivot management and water use efficiency and monitor nutrient use and losses.	ORC 6A 15kgN/ha/yr Schedule 15 + 16 WQ Standards.

Farming to limits

Mt Burke Station.

The purpose of the land and environment planning process was to identify the land and water resources, analyse environmental risks and identify actions that could be taken to minimise risks while operating within the farm system.

As mentioned earlier, future management options for Rees Valley, Mt Aspiring and Mt Burke Stations are influenced by the management of nitrogen within the sensitive lakes catchment as identified by Otago Regional Council and are all required to meet a nitrogen leaching loss limit of 15 kgN/ha/yr by 2020.

Results as modelled in Overseer during the development of the LEP (presented in Table 3 right), indicate that the predicted nitrogen and phosphorus losses at a farm level for Mt Aspiring Station would exceed the load limit of 15 kgN/ha/yr by 10 kgN/ha/yr. Conversely, Rees Valley and Mt Burke Station were well within the nitrogen loss limit (at 4 kgN/ha/yr and 8 kgN/ha/yr respectively). However, the LEP and Overseer results did indicate that certain areas of the properties that were at higher risk of N and P loss to water, and that changes to farm management could reduce farm nutrient losses and potentially increase farm profit.

Priority environmental practices, as identified in the LEP response plan in Table 2, also consider modifications to farm management that effect contaminant losses such as sediment and pathogens from faecal contamination. However, it is worth noting that some of the mitigations proposed to address these contaminants (e.g. riparian fencing and planting to reduce overland flow and direct deposition of stock faeces into waterways) are not reflected in Overseer modelling.

To further test if potential changes to farm systems (stock policy) and management options could influence N and P loss to water, a financial model of the farms was developed using Farmax and then system change scenarios run in conjunction with Overseer to examine if these changes influenced modelled farm nutrient losses. The farm systems analysis was made using Farmax monitoring in long-term mode.

This required establishing a base system—representing current farm management, and then modelling different scenarios to utilise changes in feed or stock management and was conducted on Mt Aspiring and Mt Burke Stations.

Financial results are presented as Economic Farm Surplus (EFS)—the return available to the owner-operator of a freehold, unencumbered farm after allowance has been made for labour and management input. It is calculated as follows: EFS = farm profit before tax + managerial salaries + interest paid + rent paid—assessed managerial reward (equivalent to the ruling wage for an experienced farm worker + 1% of farm capital for management).

Mt Aspiring Station

The future challenge for Mt Aspiring Station is to reduce nitrogen loss below the existing limit. A confounding factor, is that Mt Aspiring Station has already gone through tenure review and reduced its overall property size. ORC nitrogen loss rules are ambivalent to the tenure review process, so properties that have large areas of underutilised land will always meet the rule. Whereas properties that have gifted back to the crown large areas of their runs may not, as nitrogen loss is averaged across the current property. This issue is significant, because it represents a negative outcome for farms going through review. They will likely have to get a consent to farm, where as those who don't—often will not, while the overall environmental effect is much the same.

To examine if whole farm nitrogen losses could be reduced to meet the required limit of 15 kgN/ha/yr by changing the existing farm system, realistic as well as not so practical scenarios were developed and run. These results are summarised below. Overseer modelling did indicate most farm nitrogen losses were generated from feeding sheep on crop during the winter months, however it was unrealistic to remove sheep from the system over winter.

Several scenarios were developed and are summarised below in bold:

Base scenario

» 4,100 breeding ewes (118%)
» 520 breeding cows (82%)
» Just under half of steer calves kept through to 4yo —grazed off for winter
» All lambs sold store
» Winter cropping with swedes and turnips
» Silage
» Hay

Scenarios modelled:

Reduce cattle numbers. Reducing the number of all cattle on the farm by 20%.

Sell all steers as calves. Currently just under half of steer calves kept through to 4 years of age.

Fence the Matukituki streams. Currently only main paddocks are fenced. This scenario looked at the modelled response to fencing every steam on the farm. Capital cost was just shy of $500K to fence and was unrealistic from a farm financial perspective, however interesting from a modelling aspect.

Drop to 15kgN/ha/yr. Adjust whole farm system to meet 15kgN/ha/yr limit. This involved reducing cattle and sheep numbers by around 50%.

Results

Results are presented in the following summary table which includes the Overseer output for each scenario. The realistic scenarios run did not alter nitrogen loss greatly, however the "Sell all steers as calves" scenario did provide a small reduction in both nitrogen and phosphorus loss as well as an increase in profitability. This new stock policy also provides some benefits not shown through Overseer modelling, such as removal of heavy stock from the landscape which would benefit soil structure, especially over successive winters.

The "Fence the Matukituki Streams" scenario did not provide the environmental results which may have been expected. In Overseer, the model prioritises nitrogen loss from stock urine direct to soil and the influence of any riparian fencing or buffer is secondary. In this area rainfall and the shallow soils are also key driver of nitrogen loss. Also, we would expect with the further definition of paddocks the landscape would intensify and paddock management would go from extensive to more intensive, with break feeding becoming more common on fragile terraces. This in turn would lead to higher soil based losses than at present. The net outcome being little improvement in both nitrogen and phosphorus loss at the farm scale and a huge change in landscape.

Dropping farm losses to 15 kgN/ha/yr cannot be done while retaining a profitable farm. No matter the mix of stock polices within the current farm footprint we could not have a viable farm operation meeting this limit. There are several drivers or ancillary factors influencing this outcome that will be discussed later.

Table 3: Summary of modelled results.

	Base	Reduce cattle—20%	Sell all steers as calves	Fence Matukituki	Drop to 15 kgN/ha/Yr
Total farm N loss to water (kgN/ha/yr)	25	24	24	26	15
Total farm P loss to water (kgP/ha/yr)	2.9	2.9	2.8	2.8	2
EFS ($/ha)	98	92	105	122	*-19*

Mt Burke Station

The primary environmental risk identified as part of the LEP is the existing border dyke system and its management. Management of these irrigation systems is challenging and at times, by-wash may reach Lake Wanaka, carrying nutrients or faecal matter from the surface of the paddock along with it. In addition to this, Overseer indicated that this area of the farm was the most "leaky" and had the highest risk of nitrogen and phosphorus loss from cultivated areas.

Therefore, conversion of this area to centre pivot spray irrigation would minimise the risk from bye-wash and would improve the efficiency of water use. Additionally, the border dyke is not currently very efficient in terms of increasing feed supply, and thus, investing in centre pivot irrigation would also likely deliver production gains, grown under the potential new pivot.

The primary aim for this modelling was to increase profitability without increasing the environmental losses significantly and to examine the role irrigation management and farm system type was playing in overall farm nutrient losses and farm profitability.

The farm systems analyses for Mt Burke Station were made using Farmax monitoring in long-term mode. This required establishing a base system—representing current farm management, and then modelling different scenarios to utilise the extra feed grown under the potential new pivot. Pasture growth rates under the new pivot were modelled based on growth rates under the current pivot. Each scenario was optimised by Farmax to best utilise the additional growth under the new pivot. Stock numbers were determined by this optimisation. Scenarios were selected by the farm management team. A 20-year investment analysis was also used to analyse the return on the capital investment required over 20 years. A range of the scenarios were modelled with this. Capital requirements were based on information provided by a local irrigation company who had already completed a proposal for Mt Burke Station.

Several scenarios were developed and are summarised below in bold:

Base scenario

- 7,650 breeding ewes (135%)
- 135 breeding cows (89%)
- 150 breeding hinds (85%)
- 170 MA stags
- 2/3 lambs prime, 1/3 lambs store
- Winter cropping with swedes, turnips, fodder beet
- Oats, barley, lucerne
- Silage and hay.

Scenarios modelled:

Increase status quo: This scenario optimised current stock to utilise the additional feed grown under the centre pivot compared to border dyke with sheep and deer (cattle remain the same):

- Ewes: 8,490
- Hinds: 166
- Stags: 189
- Finish 550 more lambs.

Bull beef: Purchase 191 bull calves, finish 40% at 18 months, and the remainder at 2-years of age, drop ewe numbers. Ewes: 7,575.

Dairy grazing: 368 heifer calves come on-farm in May and are grown to 20 months of age prior to their first calving. An additional 368 cows are wintered for four months, drop ewe numbers. Ewes: 7,575.

Winter dairy cows: 650 dairy cows are wintered on-farm between May and August, drop ewe numbers. Ewes: 7,102.

Dryland Lucerne: Convert the border dyke area to dryland Lucerne (involves relinquishing current water-right). Increase sheep numbers accordingly. Ewes: 7,978.

Sheep in yards—Mt Burke Station.

Assumptions

- Analysis was based on 111 ha block.
- Per hectare analysis was based on an effective area of 6,800 ha.
- Feed supply increased from 3,744 kgDM/ha/year under current border dyke system, to 12,638 kgDM/ha/year under the new centre pivot.
- The base and all scenarios include a 10 ha swede crop on the 111 ha block yielding eight tonnes DM/ha.
- Discount Rate: 8%.
- Interest Rate: 6.5%.
- Operating costs of pivot included in Economic Farm Surplus calculation.
- Capital costs of stock, fencing, yards, etc included in interest payments but not investment analysis).
- Capital cost for irrigation used in investment analysis: $950,000, capital cost of regressing used in investment analysis: $40,000 in development year, and $30,000 in year one of operation.
- Analysis based on 2015/16 results in CashManager and stabilised for long-term analysis (e.g. stock rec balanced open/close).
- Farm Working Expenses for each scenario are altered by either using current cost per stock unit, or a reasonable expectation.
- Unless otherwise stated, stock numbers in the base scenario are retained.
- Depreciation is not accounted for.
- No salvage value has been accounted for.
- Prices for stock are based on actuals for Mt Burke, or on the long-term average in Farmax.

Results

Results are presented in summary table 4 below which includes the Overseer output for each scenario. Note, it can be challenging to reflect the exact revenue from stock in Farmax when setting up a model. Therefore, interpretation of these results should be based on a comparison to the base model and not relying entirely on the actual numbers.

Reminding ourselves that the primary aim for this modelling was to increase profitability without increasing the environmental losses significantly and to examine the role irrigation management and farm system type was playing in overall farm nutrient losses and farm profitability the results show some interesting outcomes. Generally, across all systems, both nitrogen and phosphorus loss to water remained low at a farm scale, primarily because of the influence of an efficient irrigation system and overall lower rainfall.

Ideally, the internal rate of return on the irrigation investment should exceed the discount rate (in this case 8%), so the results show a positive internal rate of return (IRR) for winter dairy cows and dairy grazing (heifers and cows). However, both positive options carry significant risk. Wintering dairy cows and dairy grazing relies on contracts and a secure feed supply which can be challenging in Wanaka winters. It also lifts potential nitrogen and phosphorus losses to water for the property, with high block level losses close to the lake frontage of 60 kgN/ha/yr. If the farm were to go through tenure review, then the 15 kgN/ha limit may be reached by wintering dairy cows or grazing dairy heifers and cows as ORC rules allow nitrogen losses to be "virtually" spread across the whole 10,000 ha farm. Public perception of dairy cattle in the catchment is also generally not favourable.

On the other hand, converting the border dyke area (111 ha) to dryland lucerne and increasing sheep numbers to utilise the extra feed results in an improvement in status quo, would eliminate the by-wash risk from the border dyke, and increases the EFS and farm profit. However, this may mean the suspension of the current water-right, which has value for drought resilience and may limit future development of this area.

Table 4: Summary of modelled results.

	Base	Increase status quo	Bull beef	Winter dairy cows	Dairy grazing	Dryland lucerne
Total farm N loss to water (kgN/ha/yr)	8	8	8	11	10	8
Total farm P loss to water (kgP/ha/yr)	1.1	1.1	1.4	1.6	1.4	1.1
EFS ($/ha)	47	57	58	68	81	50
Internal Rate of Return % (IRR)	-	3	3	12	21	-

Discussion

Overseer

A primary focus of this project was an assessment of the use of Overseer to represent farm scale contaminant losses in high country farm environments. Learnings from this project showed us that we had to be realistic when interpreting the results from Overseer in this environment.

The key challenges regarding the use of Overseer in this project are summarised below. These factors influence how the model responds to the data entered as well as how it functions to represent the farm. For comparison, the variables encountered in the high country farm environments have been compared to what might be considered a "typical" dairy farm setup—a common application for Overseer. We also noted in this project that Overseer is poorly validated in sheep and beef systems and especially high rainfall, shallow soil environments—factors common to all these properties, therefore, we used the results not as discrete defensible numbers, but to track a change in contaminant loss trajectory and compare like with like.

Key factors to consider:

- **Stock classes**—these farms had 18–24 stock classes (depending on how the deer herd might be treated). A typical dairy farm may have 1–2 stock classes.
- **Stock movements**—are complex and spread through the year, over many blocks (23+), often driven by environment and reactionary management opportunities. A dairy farm will often apply consistent stock rotation across a farm in confined blocks (often around five).
- **Fertiliser**—is used sparingly based for pasture management and patchy for crop establishment. Dairying farming often uses consistent fertiliser applications to maintain feed quality and production.
- **Soils**—there is a paucity of fundamental soil information at a national scale (soil test data) for many of these high country soils. Because dairy farming occurs mainly in lowland areas, these are often mapped more accurately and have good soils information.
- **Climate**—extremely variable rainfall at a farm scale.
- **Landscap**e—high country farms will have significant areas of un-grazed land, such as alpine areas, river beds and steep faces. An important step in defining that total effective farm areas was to include information from the Land Cover Database of New Zealand and a digital elevation model (Slope), which enabled the accurate mapping of "un-grazed" land to be more precisely determined. This better represented the reality. By using Overseer alone this would have been highly inaccurate and unlikely to be able to predict losses across the farm.

A key finding to help better inform for future use of Overseer on high country farms would be the use of a standard approach and perhaps the development of a high-country template, especially when considering the influence of the above factors and key drivers such as rainfall and shallow soils. Also, stock class type is a key driver of modelled losses and its important that movement of stock across farm blocks across the year is well delineated. One important learning found from including the Land Management Unit mapping alongside Overseer, developing the "block" components for Overseer using the LMU's as a base provided a very useful visual framework to define the blocks and paddocks for Overseer. This made tracking stock movements across these farms also easier to represent in Overseer, providing a more realistic farm model.

Farm system change scenarios—learnings

The tenure review anomaly

There are ancillary factors that influence Mt Aspiring breach of the nitrogen loss limit as well as Rees Valley and Mt Burke Stations ability to remain well below it. One primary difference between the three farms modelled is that Mt Aspiring Station has gone through tenure review. It has returned land to the crown for conservation and therefore reduced the farm area footprint, however the stocking rates are reported as similar from when it was a 10,000 ha property. While some practices have changed, like the use of winter fodder crops concentrating animals in smaller areas, feed efficiency has also increased, leaving less wasted nitrogen. So if Mt Aspiring Station had retained the 10,000 ha property footprint, it would like others, be able to spread total farm nitrogen loss across a greater area, therefore reducing the whole farm loss to water which is all that is required for reporting purposes. This illustrates some of the challenges associated with the ORC Nitrogen Load Limit rule which does not help inform farm scale management decisions, particularly for large farms.

As found in this project, key management decisions are often made at a paddock scale (e.g. riparian fencing, irrigation management etc) and its these decisions that most dramatically improve water quality as they tend to be practical in nature and can be fitted into the farm management approaches.

Gross change of farm system and radical reduction in stocking rate in this case results in providing a non-profitable farm and to some measure, questionable community and environmental outcomes.

In the case of high-country farms, just using Overseer in combination with a blunt whole farm nitrogen loss rule in itself will not help farmers reduce nitrogen loss on farm. Other tools to investigate, such as the B+LNZ LEP allow farmers to tailor specific mitigations as appropriate to their farm system, while financial modelling tools such as Farmax are useful options to test the viability of considered changes to a farm system.

Modelling of Mt Burke Station also supported this finding. During Farmax modelling, we also introduced successive models that removed land through a hypothetic tenure review process. We removed around 7,000 ha of land that could be returned to the Crown to reduce the farm foot print to around 3,000 ha. This immediately increased the total farm nitrogen loss in excess of 15 kg/ha/yr, whereas all the risk areas on farm (e.g. the border-dyke irrigation) remained a primary environmental focus as it had the highest risk of both nitrogen and phosphorus loss and was a potential source of sediment and bacteria to the lake.

Rees Valley Station.

Mt Aspiring Station

A key finding from this project for Mt Aspiring Station was that whole farm nitrogen loss to water was not able to be reduced to the 15 kg/ha/yr limit as modelled by Overseer while functioning as a viable farm business as modelled by Farmax. This has significant ramifications for the future of this farm under the sensitive lake catchment rules. Development of the LEP level 3 indicated that most of the contaminant loss risk was from direct stock access to small waterways and winter crop management. The direct influence of changing a range of relevant management factors on water quality (such as stock policies, land retirement, strategic critical source area management) is not really addressed in Overseer as Best Management Practices are assumed when the model is run.

However, it is worth noting that regardless of what Overseer has predicted, the owners at Mt Aspiring Station have adopted key recommendations from the LEP level 3, including fencing, wetland restoration as well as some changes to their stocking management policy. While Overseer does not demonstrate significant reductions in whole farm nitrogen and phosphorus loss to water from these farm management changes, they represent practical and measurable benefits, targeted at priority sites for the improvement of water quality at a farm scale and therefore will result in benefits for the catchment as a whole.

Mt Aspiring Station. (B+LNZ image).

Mt Burke Station

Mt Burke Station has more options going forward than Mt Aspiring Station, in large part because it has not progressed tenure review and currently can easily meet the nitrogen loss limit, regardless of any realistic changes in stock policy or farm management.

Prior to investing in any costly new irrigation methods such as centre pivots, Mt Burke Station has options to improve environmental outcomes by using k-line irrigators which are less capital intensive (albeit more labour intensive). Mt Burke Station also has the potential to increase the area of dryland lucerne, and therefore increase sheep numbers to an optimal level. Further profit might be realised by grazing other stock on this, although this may incur other costs (e.g. investment in capital fencing for deer).

Regardless of being able to meet the nitrogen loss limits for the catchment, Mt Burke Station has changed stock policy regarding cattle grazing near the lake margin during summer, fenced key paddocks from the lake, changed management to better intercept irrigation by-wash in wetland areas, as well as now using Overseer nutrient budget information to improve fertilizer use and refine irrigation practice. Advanced soil mapping conducted by Lincoln University as part of a student project has also reinforced their knowledge of the soil resource, enabling better crop and pasture planning. Knowing the role tenure review now plays in the future of the farm, there may be a disincentive to in fact return land to the crown as this will push them much closer to the 15 kgN/ha/yr limit.

NOTES

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