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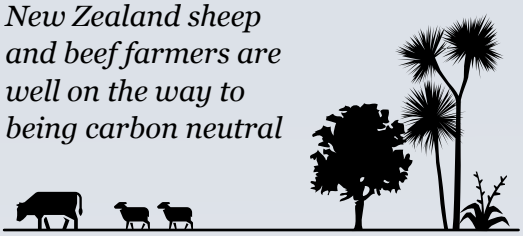
Summary report

Analysis of carbon stocks and net carbon position for New Zealand sheep and beef farmland

Key findings of the research include:

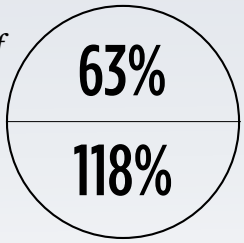
- There is a significant amount of carbon-sequestering woody vegetation on sheep and beef land – covering approximately 2 million hectares, or just under 20% of all sheep and beef land area.
- As a result, New Zealand sheep and beef farmers are likely close to being carbon neutral.
- Total annual on-farm agricultural emissions for sheep and beef production are +16,537 kt CO_2e[1], based on official governmental figures.
- The woody vegetation on sheep and beef farms has annual equivalent GHG sequestration of between -10,394 kt CO_2e and -19,665 kt CO_2e.
- The net emissions position for New Zealand sheep and beef farmers is between a net annual credit of 3,093 kt CO_2e and a net deficit of 6,143 kt CO_2e.
- Woody vegetation on sheep and beef farms is therefore offsetting between 63% and 118% of their on-farm agricultural emissions.
- If a mid-point in the range is used, the woody vegetation on sheep and beef farms is offsetting approximately 90% of their on-farm agricultural emissions.
- Of the 2 million hectares of carbon-sequestering woody vegetation approximately 77% is indigenous.
- Approximately 12% of New Zealand's woody carbon stocks, and over 40% of the country's total carbon stock (including both above and below ground carbon) is held on sheep and beef farmland.

New Zealand sheep and beef farmers are well on the way to being carbon neutral



30% REDUCTION *in absolute greenhouse gas emissions since 1990*

Woody vegetation on NZ sheep and beef farms is offsetting between 63% and 118% of their on-farm agricultural emissions



	Total	% of on-farm agricultural emissions being offset by sequestration
Total emissions	+16,537 kt CO_2e	
Total sequestration (lower estimate)	-10,394 kt CO_2e	63% offset
Sequestration (higher estimate)	**-19,665 kt CO_2e**	**118% offset**

Note: The net carbon emissions estimation assumed a net-neutral rate for soil sequestration. While there is fairly good information about soil carbon stocks, there is not good data about yearly changes in soil sequestration. The science on this is still in development.

Background

Beef + Lamb New Zealand (B+LNZ) commissioned an independent analysis of the carbon sequestration taking place on New Zealand sheep and beef farms, with a primary objective of estimating the net carbon position of New Zealand sheep and beef production (ie GHG emissions minus GHG sequestration).

In 2018, B+LNZ set a target of sheep and beef farmers being carbon neutral by 2050[2]. A key objective of the analysis was to understand where the sector is now, to assist work going forward on how to achieve the target.

The purpose of this research was also to build a better understanding of the distribution of woody vegetation on sheep and beef farms, and also to inform discussions with the Government about farmers getting recognition for the sequestration occurring on their farms.

The independent study was headed by Dr Bradley Case, Senior Lecturer in GIS and Remote Sensing in the Applied Ecology Department, School of Science, Auckland University of Technology (AUT).

The research was peer reviewed by Dr Fiona Carswell, Chief Scientist, Manaaki Whenua – Landcare Research and Dr Adam Forbes, Senior Ecologist, Forbes Ecology and Research Associate with the New Zealand School of Forestry, University of Canterbury.

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[1] The report uses GWP100, because this metric is used internationally to compare greenhouse gases and to estimate emission and substract sequestration on the same basis.

[2] www.beeflambnz.com/environment-strategy

Implications of the report

This is a very significant report for the sheep and beef sector but further than that it is potentially a game changer for New Zealand's quest to be carbon neutral by 2050.

The implications of this report are significant, both for continuing to build understanding of the overall greenhouse gas contribution of the sheep and beef sector, but also for farmers getting recognition for the sequestration happening on their farms.

The report also underlines previous independent work by the University of Canterbury that sheep and beef farmers are making an unparalleled contribution to New Zealand's indigenous biodiversity.

Building understanding of livestock's greenhouse gas contribution

This report helps to build a broader understanding of the net greenhouse gas contribution of sheep and beef production.

To date there has been considerable focus on the emissions from livestock production, but little recognition of the sequestration also taking place on-farm as part of the biological system. As with any business it makes sense to take a whole of operation perspective of both emissions and sinks (sequestration).

Not only have absolute emissions from New Zealand sheep and beef production reduced by more than 30 percent since 1990, but this research shows that most of the remaining on-farm emissions are being offset by woody vegetation. Sheep and beef farmers are potentially close to being carbon neutral as a whole.

This is even without taking into account soil carbon, which is the focus of a lot of research globally. This remains an important area of further investigation in a New Zealand context.

B+LNZ intends to use this research to calculate the net carbon footprint to produce a kilo of New Zealand beef and lamb, taking into account sequestration. Current carbon footprint methodologies are currently based on just emissions.

Farmers should get proper recognition for the sequestration happening on their farms

The research reinforces the importance of farmers getting formal recognition for the sequestration happening on their farms.

It is no accident this significant indigenous biodiversity exists, as farmers over the last few decades have made a deliberate decision to retire significant parts of their farms, and have spent money either fencing off or protecting native vegetation and habitats from pests and weeds.

Last year the Government passed the Zero Carbon Act which sets targets for gross methane reductions and for net emissions of other gases. The Government is now working with the agricultural industry and iwi on developing a framework that will ultimately help achieve these targets.

If farmers are going to face a cost for their emissions, it is vital they also get credit for the genuine sequestration happening on their farms.

The Emissions Trading Scheme (ETS) currently only allows companies or individuals to register a narrow range of forestry to claim a credit for sequestration, being post-1990 and at least one contiguous hectare. This criteria is driven by international rules which were based on a range of factors back in the 1980s, such as how accurate satellite imagery was at the time.

Most of the native vegetation on New Zealand sheep and beef farms is unable to be included in the ETS because it is pre-1990 and in small blocks, but it is making a major contribution to climate change mitigation as well as biodiversity, soil erosion management, water quality mitigation, and providing shelter for animals etc.

B+LNZ strongly supports farmers getting credit for the sequestration happening on their farms. This is an integral part of He Waka Eke Noa, the regulatory framework that industry, iwi and government are currently developing to manage agricultural emissions and recognise on-farm sequestration.

We also support the AUT recommendation to develop a data collection protocol for farmland to assess its current carbon stocks and prioritise a spatial vegetation mapping programme for agricultural farmland that would enable an accurate dataset to be compiled on vegetation components and relative sequestration rates.

This could be used to develop a new type of system to give farmers credit for current non-ETS vegetation and also support targeted revegetation interventions at a farm or landscape level to support further net GHG emission reduction. This is an obvious step for New Zealand to take as part of its global leadership positioning.

Scope for further improvements in biodiversity

The research provides useful advice on where the greatest potential exists for further revegetation activities by farmers.

The regional maps in the research indicate where management is most needed to ensure mature/old growth forests are managed to prevent them becoming sources of atmospheric carbon.

Based on this research, it may be useful for the sheep and beef sector to target future revegetation within appropriate lowland ecosystem types that are under-represented or threatened and which would also promote added benefits such as for the mitigation of water quality.

B+LNZ strongly supports the integration of trees on farms, particularly native trees, which are often the most appropriate form of vegetation for steep gullies and erosion prone areas. They not only sequester carbon, but improve our biodiversity, provide important habitat for native animals and can improve water quality.

B+LNZ has commissioned separate research to understand the changes in the native biodiversity on our farms and is currently developing a component for farm plans that help farmers to map their native vegetation and identify the best places to increase it.

Overall methodology

For this research, AUT undertook the following analyses:

1. A quantification of the area of land in sheep and beef farming using GIS mapping.
2. A quantitative, spatial analysis of national spatial datasets to classify and map the extent of different vegetation types on New Zealand sheep and beef farms.
3. An estimation of the amount of carbon currently held in vegetation biomass and soils across New Zealand using a number of datasets and processes.
4. AUT then used this information, and published sequestration rate values, to quantify the annual sequestration from the woody vegetation.
5. The net carbon position for sheep and beef production was then estimated by using the GHG inventory for emissions for sheep and beef, minus the estimated sequestration.
6. Finally, AUT undertook a case study to compare the quality of the results based on the LUCAS (Land Use and Carbon Monitoring System) data to more fine level satellite imagery.
7. Two peer reviews were undertaken by Dr Adam Forbes (Senior Ecologist, Forbes Ecology and Research Associate with the New Zealand School of Forestry, University of Canterbury) and Dr Fiona Carswell (Chief Scientist, Manaaki Whenua – Landcare Research).

Woody vegetation mapping

Sheep and beef farm property boundaries were identified using the Agribase dataset, a national spatial database of farm information (AsureQuality 2018). Property boundaries of all privately owned sheep and beef farms were then spatially overlaid in GIS with the New Zealand Land Cover Database (LCDB v 4.1) polygon dataset, comprising the major land cover and vegetation types occurring across the country.

This GIS operation provided a map of all land cover types (woody and pasture) occurring across sheep and beef farmland. The inclusion of non-woody vegetation (eg wetlands and tussock grasslands) was beyond the scope of the study.

To get a more accurate assessment of carbon storage from woody vegetation on sheep and beef farms, AUT then overlaid the Terrestrial Ecosystem Classification (TEC) datasets across the outcome above to identify the "potential" ecosystem-based indigenous forest types for each polygon.

Results: National-scale distribution of vegetation on sheep and beef farmland

The total sheep and beef farmland area, as quantified using AUT's methodology was 10.2 million hectares. The table below summarises the main different types of vegetation and area.

Pasture	8.2 million	80%
Indigenous forest	0.81 million	8.2%
Mānuka/kānuka	0.56 million	5.5%
Exotic forest	0.34 million	3.3%
Indigenous scrub	0.17 million	1.7%
Exotic scrub and shrubland	0.14 million	1.3%
Total	**10.2 million**	**100%**

Vegetation and carbon stocks for sheep and beef farmland

The estimation of existing carbon stocks is the first step in quantifying the potential for future carbon sequestration. Carbon stocks represent cumulative past carbon sequestration up to the time of measurement and are largely reflective of the spatial distribution and age of live woody vegetation biomass carbon and the distribution of soil organic carbon components, which together represent the largest carbon sinks.

AUT used a number of accepted methodologies and data sets to identify the vegetation and carbon stocks on sheep and beef farmland, using LUCAS survey plot data. Plot location co-coordinates were overlaid with the TEC-derived vegetation type spatial layer in order to assign a potential vegetation type of each plot. Estimated carbon values per type were then multiplied by the area of each vegetation type occurring on each sheep and beef farm to give total carbon per vegetation type.

Using Agribase sheep and beef farm property boundaries and mapped vegetation and carbon stock data within the GIS, AUT quantified for each region in New Zealand: (i) mean farm size, (ii) the mean proportion of farms comprising exotic forest, indigenous forest and indigenous and exotic shrubland and scrub, (iii) the mean total above carbon stock (kt C) within each of these woody components per farm, and (iv) the mean soil organic carbon stock per farm (including woody and pasture soil carbon).

Results: Carbon stocks in woody vegetation types on sheep and beef farmland

The total above ground and below ground carbon stocks held on sheep and beef farms was estimated to be 1,295,222 kt C.

Types of vegetation holding carbon stocks	Amount of carbon
Above Ground Carbon in live woody vegetation (AGC)	182,486 kt C
Below Ground Carbon in mineral soil organic carbon (BGC)	1,042,736 kt C
Live root carbon	36,500 kt C
Dead wood carbon	20,500 kt C
Litter carbon	13,000 kt
Total carbon stocks on sheep and beef farms	**1,295,222 kt C**

Relative to recent total carbon stocks reported by the Ministry for the Environment, the amount of carbon stored in sheep and beef farmland woody biomass represents approximately 12% of New Zealand's woody carbon stocks and 43% of New Zealand's total carbon stock with the inclusion of soil carbon.

There was unequal distribution of woody vegetation and carbon stocks among and within the regions.

As a proportion of region size, regions such as Gisborne, Whanganui-Manawatu, and Northland contain relatively higher stocks of farm biomass carbon while many of the South Island's regions in general have low carbon densities and total carbon stocks.

On sheep and beef farms, the mean relative proportion of woody vegetation per farm was about 15%, although some regions (eg Gisborne, Northland, Taranaki, Nelson, and the West Coast) had much higher mean proportions per farm. The types of woody vegetation, however, varied greatly between the regions.

Net carbon position

The quantification of carbon sequestration is underpinned by information regarding the amounts, types, ages and spatial distributions of woody vegetation elements and their associated biomass carbon sequestration rates.

The quantification and spatial mapping of carbon stocks and sequestration rates associated with specific vegetation types in New Zealand has had relatively limited research effort and there have been no published carbon quantification studies for sheep and beef farmland. Much of the work on quantifying carbon stocks and sequestration rates for indigenous and plantation forest at the country scale has been carried out via the LUCAS programme.

The sequestration occurring was calculated by assessing sequestration values from a range of published sources for the different types of vegetation/land cover types. AUT provided a low-end (conservative) and higher-end (optimistic) estimate, to allow for the uncertainties in the quality and state of the woody vegetation. AUT used the most appropriate sequestration rates based on the published scientific literature to provide values for both the conservative and optimistic ends of the range. Research is also being conducted by NIWA scientists that suggests that sequestration by native forest may be higher than estimated with current methodologies.

The on-farm emissions from sheep and beef production were provided by the Ministry for Primary Industries based on the NZ GHG Inventory report for methane; nitrous oxide and carbon dioxide components related to agricultural practices. The NZ GHG inventory does not specify specific sector estimates for N_2O emissions from urine and dung disposition at the farm sector level and so these were apportioned to the sheep and beef sector according to available statistics on relative stock numbers, relative farm areas or management practices relating to sheep and beef farming.

Soil carbon

Soil carbon was excluded from the net sequestration calculation because there is a gap in the science about how soil carbon stocks are changing on a yearly basis. New Zealand also has very high soil carbon stocks compared to other countries globally (because we are a relatively young country and because our soils have been well managed through sustainable practices like rotational grazing) and there is less scope to increase these.

Results: National-scale net carbon position estimate for sheep and beef farmland

Under lower-end and higher-end published sequestration rate values for different vegetation types and amounts, there is a total annual carbon sequestration on sheep and beef farmland of between -10,394 kt CO_2e and -19,665 kt CO_2e.

Total equivalent 2018 annual GHG gross emissions from various agricultural sources for sheep and beef farmland are +16,537 kt CO_2e, comprising about 20% of New Zealand's – and 45% of the agricultural sector's – gross emissions (based on 2018 GHG totals).

On balance, total net on-farm agricultural emissions for sheep and beef production ranges between net positive annual emissions of +6,143 kt CO_2e as a lower-end estimate, and net positive annual sequestration of -3,128 kt CO_2e as a higher-end estimate.

Sequestration component	Area (x 1,000 ha)	Sequestration rate (CO_2e t ha^{-1} yr^{-1})		Total sequestration (kt CO_2e)	Notes
Indigenous tall forest	812.2	Lower end	1.1	-893	Paul et al. 2019[*a]
		Higher end	3.3	-2,680	
Exotic conifer forest	310.1	Lower end	22.5	-6,982	Mean of ETS values for *P. radiata* at 20 years old Wakelin et al. 2016
		Higher end	31.7	-9,836	
Exotic deciduous forest	34.7	Lower end	4.4	-153	Burrows et al. 2018 – pole plantings ETS look-up value for exotic hardwoods at 20 years
		Higher end	27.0	-937	
Indigenous scrub and shrubland	170.0	Lower end	1.7	-289	Paul et al. 2019 ETS look-up value for 'Indigenous Forest' at 50 years old[*b]
		Higher end	6.5	-1,105	
Mānuka and/or kānuka	562.3	Lower end	3.2	-1,799	Paul et al. 2019 Carswell et al. 2014
		Higher end	5.5	-2,980	
Exotic scrub and shrubland	139.0	Lower end	2.0	-278	Carswell et al. 2009 Carswell et al. 2013 – estimate for gorse
		Higher end	15.3	-2,127	
Pasture	8,233.2		0	0	Assuming no net sequestration[*c]
Soils	10,261.5		0	0	Assuming no net sequestration[*c]
		Total sequestration lower end		**-10,394 kt CO_2e**	
		Total sequestration higher end		**-19,665 kt CO_2e**	

Emissions component [*d]	2017 Emissions (kt CO_2e)	
Enteric fermentation	+13,792	
Manure management	+160	
Agricultural soils	+1,762	
Inorganic fertiliser	+446	
Liming and dolomite	+249	
Urea CO_2	+128	
Total emissions	**+16,537**	
Net carbon position – lower end	**+6,143**	kt CO_2 e yr^{-1} (net positive emissions)
Net carbon position – higher end	**-3,128**	kt CO_2 e yr^{-1} (net positive sequestration)

a The latest LUCAS assessment (Paul et al, 2019) calculated a sequestration rate of 0.6 ± 0.3 tC/ha/year for indigenous forest falling outside of Public Conservation Land (ie on farmland). The numbers presented here use the lower (0.3 tC/ha/year) and upper (0.9 tC/ha/year) confidence limits of this estimate as the lower end and higher end scenario sequestration rates for tall forest. These have been converted into CO_2 equivalents.

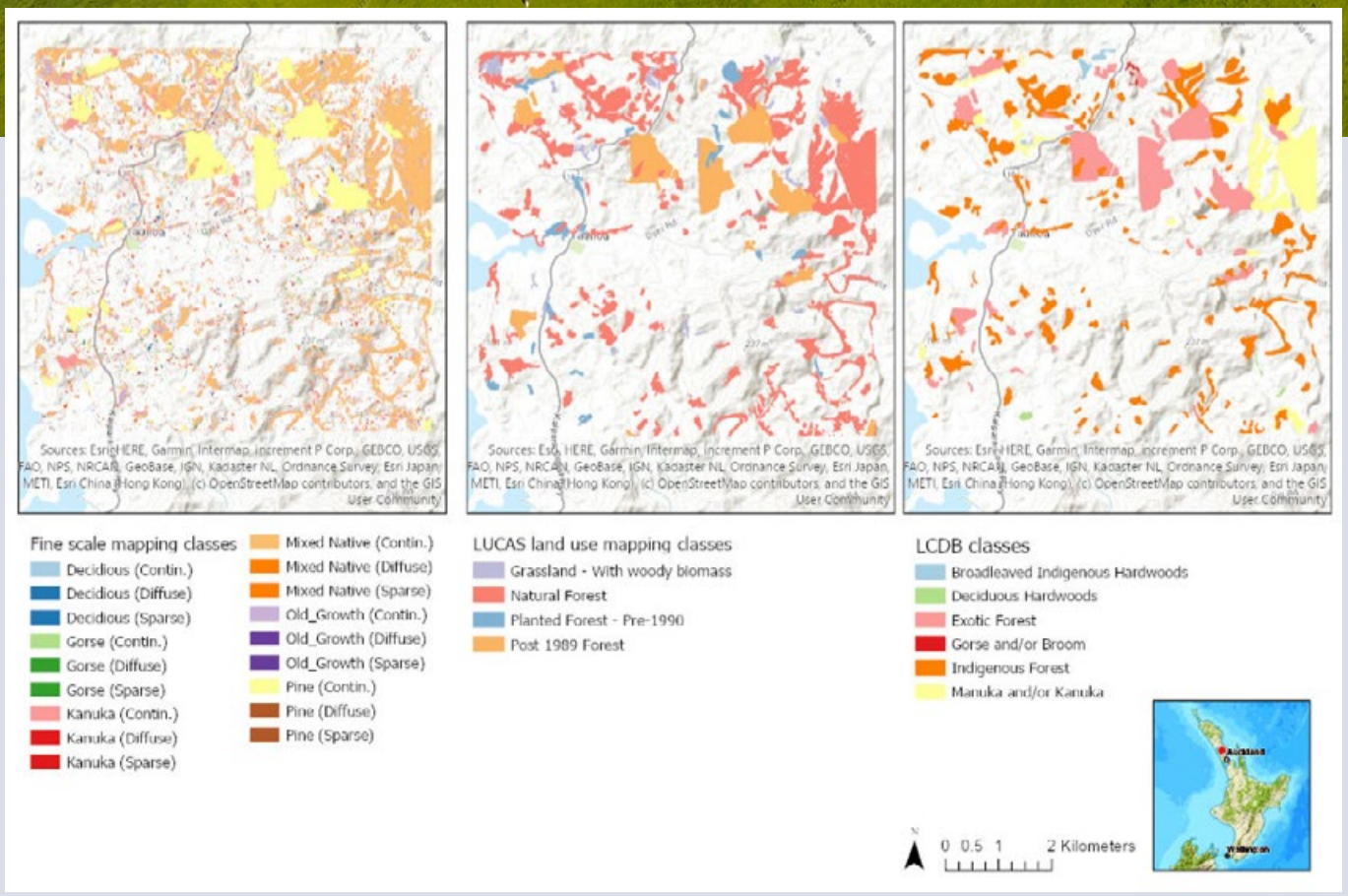
b As there are no readily available published values for 'indigenous shrubland' (excluding mānuka/kānuka, which is dealt with separately in our analysis), we have used the MPI age 50 look up table sequestration rate for 'Indigenous Forest' as the upper end value, which has been derived from data for regenerating indigenous shrubland (Ministry for Primary Industries, 2017).

c There is no definitive quantification of soil carbon sequestration rates for New Zealand. Generally, the evidence indicates that net sequestration is null for undisturbed soils, negative for managed pasture soils, negative for eroded soils, and potentially positive for soils where land conversion has occurred from grassland to forest. We have decided here to assume no net sequestration.

d Provided by MPI based on 2018 NZ GHG data.

Case study

To test the LUCAS and LCDB information, AUT ran a case study where it mapped vegetation using high-resolution aerial imagery for a 55 sq km area in the Kaipara district and compared the sequestration from the finer satellite imagery.



Results: Case study

The fine scale image analysis detected significantly more woody vegetation on the sheep and beef land in the Kaipara than the LUCAS and LCDB 4.1 data and therefore more sequestration.

This reinforces the importance of more up to date and finer detail spatial mapping. Reliable, high resolution vegetation data will help underpin accurate GHG accounting exercises, particularly as part of the He Waka Eke Noa process.

Further information

For more information email **enquiries@beeflambnz.com**

For information about He Waka Eke Noa – the Primary Sector Climate Action Partnership go to **www.hewakaekenoa.nz**