NATURAL CAPITAL MANAGEMENT REPORT: GLENWOOD

Case Study1: Glenwood, Wellington NSW

23 February 2021

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ABSTRACT:

On-farm Natural Capital refers to the natural resources including soil, vegetation and animals that comprise an agricultural property.

Natural Capital (Environmental) Accounting can link environmental condition to economic returns and presents information about the type and condition of ecosystems. This information can be used alongside financial accounts to give a broader perspective on Farm Profit.

Environmental Accounting is an adaptation and extension of the International Accounting Standards.

This case study presents a Natural Capital Management report created from the base Natural Capital Accounts, for a commercial grazing property, Glenwood, in the Central West Region of NSW

Acknowledgement:

This project was funded by Australian Wool Innovation and represents one of a series of case studies on Natural Capital on commercial wool-growing properties. The authors would like to thank Mr Angus Ireland and Mr Sam Ropert from Australian Wool Innovation for their assistance. We would also like to acknowledge and thank Dr Steve Wiedemann, Integrity Ag and Environment, for his technical review and input.

Natural Capital Snapshot:

Natural Capital (Environmental-Economic) Accounting is a new knowledge field for Farm Business Management. This report applies a Natural Capital Accounting and Environmental Profit and Loss approach to calculate the impact of the farm's management on its Natural Capital.

This report can be positioned alongside yearly Farm Financial Management Reports, prepared by the Farm Accountant or Adviser. Having information on the change in the condition of the major business asset (Land), along with financial performance, can give a broader view of Farm Profit. Over time we hope industry benchmarks of natural capital will start to emerge.

Information for this report was compiled through a combination of field assessment by a trained ecologist, use of Farm Map4D Satellite data and farm Financial Statements provided by the farm accountant.

The report finds that while operating as a successful commercial wool growing operation, Glenwood has:

- 78% of its landscape transitioning into new ecological states. These transitions are towards increased canopy cover, improved native species richness (numbers) and improved native ground cover levels. These transitions will help restore the endangered Grassy Woodlands.
- Using standard industry classifications, 96% of Glenwood can be classified as being in Very Good condition for livestock grazing; some 4% is classified as being in Good condition. This provides a strong basis for high levels of animal production.
- Over the last 13 years, ground cover remained above 85% and peaked at 100%. Industry targets suggest a minimum of 70% groundcover is required to minimise water run-off and erosion. High levels of groundcover assist in effective water and mineral cycles.
- A natural capital accounting approach to the measurement of environmental performance suggests that Glenwood produces negligible air pollution, water pollution or waste.
- Glenwood generates approximately 28.2 kg of greenhouse gases per kg of greasy wool, which is 56% of the amount estimated by Kering for greenhouse gas emissions from Regenerated Landscapes and 30% of emissions from Conventional Landscapes.
- A conservative estimate of the natural value affected by Glenwood's commercial business operation suggests that it has impacted the ecosystem services by an average of 50% and that this is not a permanent loss, compared to 80% estimated by Kering for land use impact from conventional wool production.
- Using conservative figures, Connewarran captured and stored a net average of 3445 (tCO_2e/year).
- Glenwood's natural capital is contributing free inputs to livestock grazing (forage) that are worth approximately $64/ha per year.
- The calculations undertaken indicate that the (grazing only) value of the natural capital to the farm business is approximately $333 per hectare.

Estimated Carbon Summary: Using current research information and models
Figures calculated using a GWP of 28 for Methane (IPCC 2015 AR5)

Carbon Summaries	
Data averaged across 10 years	
Farm Name	**Glenwood**
Emissions	
Energy emissions (tCO_2e/year)	49.7
Sheep emissions (tCO_2e/year)	1,469.8
Cattle emissions (tCO_2e/year)	133.8
Fertiliser emissions (tCO_2e/year)	0.0
Pre-farm emissions (tCO2e/year)	575.0
TOTAL emissions (tCO_2e/year)	**2,228.2**
Bio-Carbon Stocks and sequestration (Mg C)	
Estimated Carbon Stocks (Mg C)	148,358
Estimated Carbon Stocks per hectare (Mg C / ha)	49.9
Estimated C sequestration per ha per year (Mg C ha-1 year-1) *1	-0.52
Estimated C sequestration per year (Mg C / year) *1	**-1,547.3**
Emissions balance in tCO_2e/year	
Emissions (tCO2e/year)	2,228
Estimated C sequestration (tCO_2e/year) *1	-5,673
Net position for emissions (tCO_2e/year) *1	**-3,445**
EP&L Factors	
Estimated extent of biomass loss	40%
Estimated extent of species richness loss	46%
GHG emissions for wool (kg CO_2e / kg greasy wool)	28.2
GHG emissions for wool (kg CO_2e / $ wool sold)	2.1
Normalised Stress weighted water use (litres H_2Oe / kg greasy wool) *2	18.3
Normalised Stress weighted water use (litres H_2Oe / $ wool sold)	1.4
Water Stress Index	0.0208

**1 Note a negative number indicates removal of CO2 from the atmosphere*
**2 Normalised stress weighted water use represents the use of water (L) multiplied by the Water Stress Index (WSI) for the local catchment, divided by the global average WSI (0.602).*
Further information on used for Carbon storage and sequestration calculations can be found in the Appendix (Table A6), page 25

How to use Natural Capital Management Reports:

Natural Capital (Environmental-Economic) Accounting is a new knowledge field for Farm Business Management.

This report presents a Natural Capital and Environmental Profit and Loss Management Report for Glenwood, a large commercial wool-growing property in the Central West of NSW.

This report can be positioned alongside yearly Farm Financial Management Reports, prepared by the Farm Accountant or Adviser. Having information on the change in the condition of the major business asset (Land), along with financial performance, can give a broader view of Farm Profit.

The Natural Capital Management Report can be used in the same way that Farm Financial Analysis (such as farm financial benchmarking) can be used to determine changes in key criteria over time. Changes can then be related to management decisions and the Farm Business Goals of the owners. This enables a broadening of perspectives on Farm Profit to encompass Financial and Natural Capital measurements.

Farm businesses can start to quantify contributions of management towards protecting and improving the condition of the long-term natural capital asset base, and investments in the long-term productive capacity of the business, as part of their normal yearly review of performance.

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Introduction to Glenwood:

Glenwood is a 2972 hectare property located north of Wellington in Central West NSW. The country is undulating to hilly and supports large areas of grassy woodlands, ideal for breeding merino sheep.

Norm and Pip and their family are the 5th generation on Glenwood. They run a commercial Merino ewe flock and stud ewe operation. They run up to 9,000 adult sheep, up to 6,500 lambs, plus a small cattle herd. They also operate a growing merino stud.

The Smiths are passionate advocates of regenerative agriculture and, in 2011, were the NSW Farmers of the Year. Over the years, they have developed a grazing approach that has regenerated the land and substantially improved productivity. Today they run a thriving operation, not just on Glenwood but also on three additional leased farms located close by.

After studying at Orange Agricultural College, Norm spent time jackarooing and working on cattle stations before marrying Pip in 1996 and taking control of Glenwood through family succession.

At the time of taking over, the farm was carrying a lot of debt. Focusing management on perennial grasses made a lot of sense, as they already had a range of native perennials alongside introduced species like cocksfoot and phalaris."

Their initial impetus was to cut costs while maintaining productivity, with the ultimate aim of regenerating the property. The first step was to focus on recovery-based grazing. More paddocks were developed through subdivisional fencing and new water troughs to supplement the many dams.

Once the grazing system was fine-tuned, the improvement in pasture production, plant diversity and forage quality was pronounced. The length of grazing in each paddock was matched to the livestock needs and the season (plant growth rates).

The Smith's run plain-bodied, non mulesed sheep. SRS genetic principles underpin their wool growing enterprise. The sheep are resilient and fertile, able to thrive equally well in wet or dry conditions while producing high-quality wool. A real feature of the flock has been its fertility. The flock regularly achieves lambing percentages over 120%.

The recovery-based grazing has made the Glenwood pastures more resilient, with up to 60 different grass species in some paddocks. Maintaining ground cover and enhancing the diversity of the pasture base is a big management focus, along with family wellbeing and achieving a satisfactory level of profit.

Natural Capital accounting and management reporting will allow Norm and Pip the ability to monitor the condition of their land base alongside their Financial reports, giving a more rounded view of profit.

1. Ecosystem Services:

Highly functional Grassy Woodlands can produce a range of ecosystem services while providing grazing for food and fibre production, the foundation of the Glenwood Farm Business.

Ecosystem Services are the direct and indirect contributions to human wellbeing that come from an ecosystem. These services support both quality and survivability of life. They include three main services:

1. Provisioning services (food, fibre and forage production)
2. Regulating services (capacity of an ecosystem to support processes such as water purification, carbon storage and sequestration, micro-climate regulation, pollination and pest control)
3. Habitat services such as biodiversity protection and cultural services such as spiritual and aesthetic values, learning opportunities.

Diverse and highly functional Grassy Woodlands are important. They can produce a range of ecosystem services at the same time as they provide grazing for food and fibre production[1] (McIntyre et al. 2002).

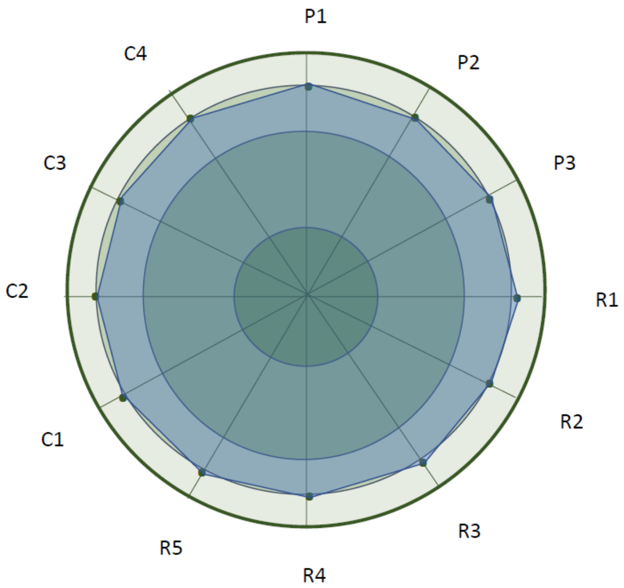
Estimates for the ecosystem services being generated by this property are developed from the Ecosystem Asset Accounts that provide a detailed record of the type of ecosystems on the property, along with the extent and condition of these areas. Estimates are based on scientific literature and are given a High 'H', medium 'M' or low 'L' core depending on the ability of the farm ecosystem to support these ecological services.

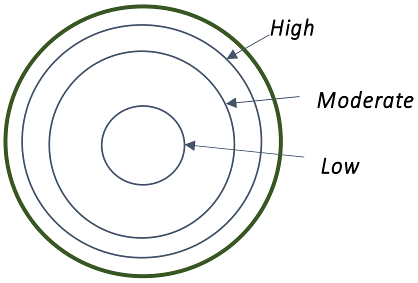
Detailed justification for the attribution of a particular score is given in the Appendix.

A summary of ecosystem services being supported by Glenwood is shown below:

[1] S. Lavorel et al., "Ecological Mechanisms Underpinning Climate Adaptation Services," *Global Change Biology* 21, no. 1 (2015); S. McIntyre, J. G. McIvor, and K. M. Heard, *Managing & Conserving Grassy Woodlands*, ed. S. McIntyre, J. G. McIvor, and K. M. Heard (Canberra: CSIRO Publishing, 2002).

***Figure 1**: Shows the level of ecosystem service provision on Glenwood. Individual services are listed. Concentric rings show whether an ecosystem service is at a high, moderate or low level (see diagram below).*



List of ecosystem services in Figure 1.	
Provisioning **P1. Forage production for livestock (ten-year average)** **P2. Forage for bees** **P3. Timber provision, including firewood** *Regulating* **R1. Soil protection and nutrient retention** **R2. Water quality** **R3. Carbon storage** **R4. Microclimate regulation** **R5. Pollination and pest control services** *Cultural (including habitat)* **C1. Animal biodiversity** **C2. Vegetation biodiversity** **C3. Restoration Potential** **C4. Climate change adaptation potential**	Scoring system applied: 

Carbon Storage is not an ecosystem service under formal accounting standards. We have included it here because the carbon stored in landscapes is very important to society and because the high performing wool-producing landscapes may already be high in carbon and therefore not sequestering much additional carbon.

Comments:

The Ecosystem Services provided by Glenwood are rated as High across most criteria.

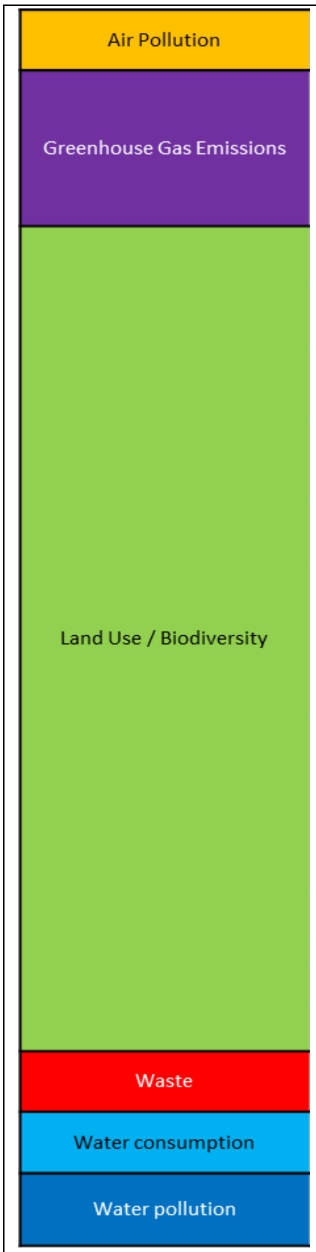
These services are produced from the diverse and highly functional grassy woodlands that occupy a large percentage of Glenwood.

It is important to note that a highly functional and diverse ecosystem produces a range of ecosystem services as well as providing a sound basis for the commercial wool growing business through the production of quality and diverse forage.

2. Understanding Environmental Profit and Loss:

An Environmental Profit & Loss (EP&L) account is one way of assessing the impact that a business has on the environment.

This is a new approach for individual farm businesses to take. This report has taken an E P & L approach to provide management information on the impact of Glenwood on the environment.



Kering developed the Environmental Profit and Loss (EP &L) methodology to help their business understand their environmental impacts and to reduce them. In the past, EP &L has been calculated for industry, using general/generic information. More information can be found here:

https://www.kering.com/en/sustainability/environmental-profit-loss/methodology/

This Natural Capital Management report uses the Kering methodology with information specific to Glenwood to assess the impact of wool production on the environment.

EP &L takes the concept of natural capital and applies it to business decisions. The EP&L measures the resources consumed across the supply chain such as water and land, as well as the outputs such as water pollution, air pollution and waste Trends over time are important to monitor and can be related to management goals and decisions. Some key findings of this report are:

- A natural capital accounting approach to the measurement of environmental performance suggests that Glenwood produces negligible air pollution, water pollution or waste.
- Glenwood generates approximately 28kg of greenhouse gases per kg of greasy wool, which is 56% of the amount estimated by Kering for greenhouse gas emissions from Regenerated landscapes and 30% of emissions from conventional landscapes.
- A conservative estimate of the natural value affected by Glenwood's operation suggests that it has impacted the ecosystem services by an average of 50% and that this is not a permanent loss, compared to 80% estimated by Kering for land use impact from conventional wool production.

Details of the calculations are presented in section 7 of this report (page 13).

Box 1: Inputs to an EP&L assessment were made following methods drawn from published EP&L methods and using a natural capital accounting approach.

Ecosystem Use:

A primary purpose for the ecosystems on this property is to provide feed for the merino sheep, which are the core of the farm business; however, the landscape is also being managed for biodiversity outcomes. Biodiversity is an important component of the owners' written management goal and an overt part of their management decision making. The impact of these management decisions on the farm's Natural Capital and EP&L can be measured over time using the Natural Capital Accounting approach.

The Ecosystem Asset – Primary Use accounts (Table 1) show that the primary use for the land is for Grazing (99%). The landscape consists predominantly of cleared Native Pasture (63%) and Grassy Woodland (35%). The small Riparian area is also strategically grazed.

Table 1: Ecosystem Asset Account (Primary Use; ha). This account organises information about the amount of each type of ecosystem on the property being used to generate economic (financial and non-financial) benefits for the business

Ecosystem Assets - 15th December 2017	Primary Use		
Extent-Use (ha)	**Grazing**	**Biodiversity**	**Total**
Cleared Native Pasture	1871.7	0.0	**1871.7**
Grassy Woodland	1047.5	14.6	**1062.1**
Riparian	38.5	0.0	**38.5**
Property Total	**2957.7**	**14.6**	**2972.3**

Comments:

The primary use for the land is for Grazing (99%). The landscape consists predominantly of cleared Native Pasture (63%) and Grassy Woodland (35%). The small Riparian area is also strategically grazed.

3. Ecosystem type:

In a Natural Capital Accounting approach, the foundation environmental account is the Ecosystem Asset Account (Table 2). This account organises information regarding the extent of different ecosystem types. In this approach, Ecosystem Asset Accounts are prepared in line with guidance from the System of Environmental-Economic Accounting (SEEA), thereby enabling farm-level accounts to be potentially aggregated to national and subnational levels. The Ecosystem Asset Accounts prepared in this project apply the guidance for spatial units as described by the expert working group for the SEEA in "Discussion paper 1.1: An ecosystem type classification for the SEEA EEA". These spatial units are used to prepare a detailed Ecological Asset Register of the different types and uses of natural capital. The summary tables presented in this report are drawn from this. To describe the amounts of different types of natural capital, the accounts apply the internationally accepted notion of ecological state and transition models. These describe the different forms that natural capital can take given its management, use and history.

This property is largely a native system located in the grassy woodland biome of NSW. While parts of the property were converted to improved pastures by previous generations, they have subsequently been managed towards native systems. Accordingly, the ecosystem accounts for this property have been prepared using state & transition models for grassy woodlands[2] Further details of the ecosystem types used in NCA for these case studies are provided in the Appendix.

While operating as a successful commercial wool growing operation, Glenwood has 78% of its landscape transitioning into new states that indicate steady regeneration of the characteristics of grassy woodlands, including biodiversity. These include transitions towards increased canopy cover, improved native species richness (numbers) and improved native ground cover levels. The Ecosystem asset accounts show that approximate 7% of the property is comprised of grassy woodland that is either similar in its ecological characteristics to an intact example of this type of ecosystem or only missing some of the characteristics of this ecosystem. The transitioning areas suggest that Glenwood's operations will help restore these iconic Australian ecosystems; however, the rate of regeneration may be constrained by historical fertiliser use.

Table 2: Ecosystem Asset Account (Type-Extent (ha)). This account organises information about the amount of each type of ecosystem on Glenwood.

Ecosystem Assets @ 15th December 2017				**State or Transition**					
Ecosystem type (ha)	**S1A**	**T2A-1A**	**S2A**	**T2B-2A**	**T3A-2A**	**T3B-2B**	**S4**	**NA**	**Total**
Cleared Native Pasture	0.0	0.0	0.0	0.0	0.0	1434.9	436.8	0.0	**1871.7**
Grassy Woodland	14.6	73.2	167.7	72.7	734.0	0.0	0.0	0.0	**1062.1**
Riparian	0.0	0.0	38.5	0.0	0.0	0.0	0.0	0.0	**38.5**
Domestic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	**2.1**
Total	**14.6**	**73.2**	**206.2**	**72.7**	**734.0**	**1434.9**	**436.8**	**2.1**	**2974.3**

The information in Table 2 is represented in the graph below (Figure 2), which represents the total area (ha) in each State or Transition as a percentage of the total area of the farm.

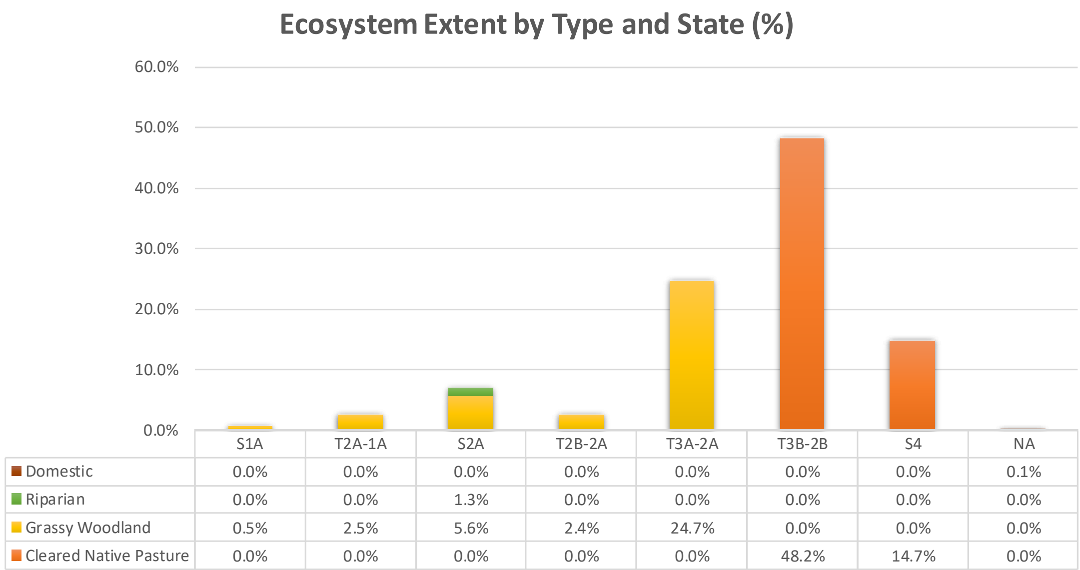


Figure 2: Chart showing the percentage of the farm that is in different grassy woodland states or transition states.

Information contained in the graph above is commented on below:

[2] P. G. Spooner and K. G. Allcock, "Using a State-and-Transition Approach to Manage Endangered Eucalyptus Albens (White Box) Woodlands," *Environmental Management* 38, no. 5 (2006); S.M. Whitten et al., "Multiple Ecological Communities Conservation Value Metric. Final Report to the Australian Government Department of the Environment, Water, Heritage and the Arts," (Canberra, Australia: CSIRO Sustainable Ecosystems, 2010).

Identity state (or transition between states)	***% of farm***	***Comments***
Transition from state 3B to 2B (transition from cleared native pastures with low tree cover and no tree regeneration to grassy woodlands with natural tree regeneration)	48	Nearly half of the farm is transitioning from State 3B into State 2B. This is associated with an increase in tree canopy cover to approximately 15%, increased native species richness (between 16–29 species) and an increase in native ground cover to 69%.
Transition from state 3A to 2A (transition from grassy woodlands with low tree cover and no tree regeneration to grassy woodlands with up to 15% tree cover and natural tree regeneration)	25	A quarter of the farm is undergoing this transition. This is associated with an increase in tree cover to around 15% with regenerating trees evident. Native species richness in the groundlayer is increasing (approximately 16-29 species) and there is an increase in native ground cover to around 70% or more.
Areas in states similar to an intact native ecosystem or transitioning towards this (Stat 1A, States 2A and transitioninc from 2A to 1A.	11	A number of areas of the farm that are already grassy woodlands are increasing in native species diversity. Some of these areas may become areas of high-conservation value (if that is a management goal for that area). Regeneration of some of these areas to high-conservation value however may be constrained by past fertiliser use and these areas are likely to provide high levels of forage production, carbon storage and shelter in an ongoing capacity.
Cleared native pastures with few trees (State 4).	15	Some 15% of the property is in identity state 4. These areas are mostly cleared native pastures with scattered old trees. Typically these areas have less than 7 native species in pastures and <30% native ground cover. This state is typically has received higher rates, more frequent and more recent fertiliser applications.

Note: 1% of land was not assessed (sheds/buildings/laneways)

4. Capacity of the ecosystem to support livestock grazing:

An important aspiration of environmental accounting is to gain a complete understanding of contributions that natural capital condition makes to the performance of a farm business.

In environmental-economic accounting, the forage produced by the farm ecosystems for livestock grazing are classified as provisioning services and can be thought of as farm inputs that nature provides for free to grazing enterprises. The accountings standards recommend that these are estimated in both physical and monetary terms.

Ecosystem Asset Accounts for the use of natural capital for livestock grazing can be prepared in terms of the condition of the natural capital[3] and its capacity to provide forage for livestock. The classifications used in these accounts use the approach developed for grazing management best practice[4]. The accounts (Table 3) show that using the industry-standard classifications, 96% of Glenwood can be classified as being in Very Good condition for livestock grazing, 4% in Good condition. No part of the property is in Poor condition.

This information, coupled with the State/Transition changes evident, demonstrate the landscape on Glenwood is both productive and resilient from a wool-growing perspective while at the same time is restoring the characteristics of an endangered Grassy Woodland.

Table 3: Ecosystem Asset Account showing condition for grazing and production of livestock. Very Good, Good, Fair, Poor and Very Poor capacity for grazing indicates the quality and persistence of pastures with regard to the level of groundcover and proportion of palatable, perennial and persistent species. This table provides information about the extent (ha) of land in each condition class for grazing.

Ecosystem Asset Accounts	**Grazing Condition class**						
15th December 2017	**Very Good**	**Good**	**Fair**	**Poor**	**Very Poor**	**NA**	**Totals**
Cleared Native Pasture	1865.2	6.5	0.0	0.0	0.0	0.0	**1871.7**
Grassy Woodland	963.5	98.5	0.0	0.0	0.0	0.0	**1062.1**
Riparian	38.5	0.0	0.0	0.0	0.0	0.0	**38.5**
Domestic	0.0	0.0	0.0	0.0	0.0	2.1	**2.1**
Property Total	**2867.3**	**105**	**0**	**0**	**0**	**2.09**	**2974.3**

The contribution the natural capital is making to the financial performance of the farm has been estimated using methods for ecosystem valuation that have been developed to be compliant with the accounting standards[5]. Table 4 presents estimates of the monetary value[6] of the annual flow of provisioning services, the net present value (NPV) of these on a per hectare and per DSE basis. Inputs to valuation incorporate a ten-year average of farm income and expenses, and NPV uses a risk-

[3] H. Keith et al., "Discussion Paper 2.1: Purpose and Role of Ecosystem Condition Accounts. Paper Submitted to the Seea Eea Technical Committee as Input to the Revision of the Technical Recommendations in Support of the System on Environmental-Economic Accounting. Version of 13 March 2019," in *System of Environmental Economic Accounting* (New York: UNSD, 2019); S. Ogilvy, "Developing the Ecological Balance Sheet for Agricultural Sustainability," *Sustainability Accounting, Management and Policy Journal* 6, no. 2 (2015); Sue Ogilvy et al., "Accounting for Liabilities Related to Ecosystem Degradation," *Ecosystem Health and Sustainability* 4, no. 11 (2018).
[4] Alessandra La Notte, Sara Vallecillo, and Joachim Maes, "Capacity as “Virtual Stock” in Ecosystem Services Accounting," *Ecological Indicators* 98 (2019).
[5] S. Ogilvy and M. Vail, "Standards-Compliant Accounting Valuations of Ecosystems," *Sustainability Accounting, Management and Policy Journal* 9, no. 2 (2018); UNSD, "Technical Recommendations in Support of the System of Environmental-Economic Accounting 2012- Experimental Ecosystem Accounting," (New York, USA: United Nations Committee of Experts on Environmental-Economic Accounting, 2017).
[6] Note that monetary values used in the formal accounting standards are exchange values and don’t include the full societal value generated by ecosystems. Further, the values presented here are conservative in nature by only including the forage provisioning values and may underestimate other contributions of natural capital.

adjusted discount rate per the recommendations of the corporate accounting standards to reflect the exposure of agriculture to significant interannual and inter-decadal variation in season and market quality[7]

This indicates that by providing reliable and good quality forage, Glenwood's natural capital is contributing free inputs to livestock grazing (forage) that are worth approximately $64/ha per year[8]. These indicate that the (grazing only) value of the natural capital to the farm business is approximately $333 per hectare. As this is the first project (to our knowledge) to attempt to value the monetary contribution of natural capital to a farm business (separately from the real estate value of the land), we have no basis for comparison of Glenwood's natural capital value to that of other businesses.

Over time we hope industry benchmarks can be developed in these metrics.

Table 4: Estimates of the contribution the grazed ecosystems are making to the financial performance of the farm business.

Ecosystem Monetary Values ($) *@ 15th December 2017*	
Metric 1: Average (ten-year) annual flow of provisioning services for livestock (per ha)	64
Metric 2: Value of natural capital (grazing value only) per Ha	333

[7] IASB, "Ifrs 13: Fair Value Measurement," (International Accounting Standards Board, 2011).
[8] These estimates include expenses for activities and purchased inputs to maintain the ecosystem in good condition.

5. Storage of carbon on the property

One of the benefits created by good Natural Capital Management is the maintenance of stocks of carbon stored in the landscape in vegetation and soils. Stocks of carbon represent estimates of the total carbon stored across the whole farm. A farm with high levels of stored carbon is typically in better ecological condition compared to a farm with lower carbon storage across the landscape.

These stocks can be estimated for general carbon accounting by using published 'densities' of carbon for different ecosystem types. Note that these estimates are not appropriate for trading carbon or participating in formal carbon sequestration projects. They indicate the current health of the farm ecosystem, reflecting many years of management, as well as the likelihood of carbon emissions from livestock production being offset by high carbon levels across the whole farm.

Total Carbon storage for Glenwood (shown in Table 4) of 148358 Tons of Carbon are likely to be high in comparison to agricultural properties in the region due to the profile of the ecosystem types.

This Total Carbon Storage represents 50 t/ha of Carbon averaged across the whole farm.

However, published benchmarks are currently difficult to find.

Table 4: Carbon (biocarbon) stocks on the property by ecosystem type. These estimates are prepared from published densities of carbon for different ecosystem types.

Carbon Stocks by Ecosystem Type	**State or Transition**								
(Mg C)	**S1A**	**T2A-1A**	**S2A**	**T2B-2A**	**T3A-2A**	**T3B-2B**	**S4**	**NA**	**Total**
Cleared Native Pasture	0	0	0	0	0	65107	17897	0	**83004**
Grassy Woodland	1650	5929	11130	3972	40115	0	0	0	**62796**
Riparian	0	0	2556	0	0	0	0	0	**2556**
Domestic	0	0	0	0	0	0	0	2	**2**
Total	**1650**	**5929**	**13686**	**3972**	**40115**	**65107**	**17897**	**2**	**148358**

Comments:

While published benchmarks are difficult to find, the level of 148358 Tons of Carbon (50 t/ha) stored over the whole farm is considered a high level due to the profile of the Ecosystem type.

Over time it is hoped industry benchmarks will become available for Carbon Stocks.

Carbon estimates, and references, for each type of ecosystem are shown in the Appendix.

6. Detailed Environmental Profit and Loss:

NOTE: The units used to report some of the metrics in this section differ from those used in the summary tables presented in the Natural Capital Snapshot section (pages 2 and 3). The summary table figures (page 3) are reported using industry-standard units, whereas the figures in this section are reported in units according to the Kering EP&L methodology. In particular, the metrics below are reported per kg of clean wool instead of per kg of greasy wool used earlier in the report. Furthermore, water use is reported in absolute terms (m^3/kg clean wool) rather than as a normalised water stress unit (litres H_2O -e/ kg greasy wool). Whilst the figures reported below are reported as per kg of clean wool, the figures exclude emissions and resource use associated with the scouring process of the wool. The figures represent emissions and resource use for the production process of the wool at the farm gate.

Air Pollution	Dust, particulate matter, SO2 and Nox produced from farm operations (typically from burning of fossil fuels). Calculated per kg of clean wool produced. Proportionally allocated based on other animal products from the farm (cattle, lamb sales)		
Metric 1	Dust generated through farm operations	0.0	kg / kg Clean Wool
Metric 2	Particulate matter generated	0.0	kg / kg Clean Wool

Comments:

Negligible dust emissions due to consistent ground cover. Unable to calculate NO_x and SO_2 particulates due to use of fossil fuels given the insignificant volume of fossil fuel use and the lack of methodologies to derive the values

Greenhouse Gas Emissions	Calculated as per Australian Government Department of Environment and Energy: National Inventory Report 2018 Volume 1. This includes direct Scope 1 emissions from the burning of fossil fuels, indirect Scope 3 emissions from the production / transport of fuels, and the indirect emissions from electricity generation assuming no renewable energy use. This also includes animal based emissions of enteric (CH4), manure (CH4), dung and urine (N2O) and atmospheric deposition (N2O).		
Metric 1	Fossil Fuel emissions	0.96	kg CO_2e / kg Clean Wool
Metric 2	Livestock emissions (IPCC 2014 AR5 factors)	31.41	kg CO_2e / kg Clean Wool
Metric 3	Fertiliser emissions	0.00	kg CO_2e / kg Clean Wool
Metric 4	Pre-farm emissions	5.29	kg CO_2e / kg Clean Wool

Comments:

The GHG emissions have been calculated separately for fossil fuel use vs animal emissions, as these emissions have a very different impact pathway on the biosphere. Emissions from fossil fuel use have a significant impact on the climate due to the fact that it is releasing carbon into that atmosphere that has taken billions of years to be stored in stable carbon in the ground.

In comparison, the emissions due to livestock are part of a relatively short carbon cycle – CO_2 is sequestered in grass through photosynthesis, livestock eat grass, livestock emit carbon in the form of CO_2 (respiration) and CH_4 (respiration, manure, urine). Whilst CH4 does have a higher global warming potential than CO_2, it is short-lived, and the cycle is not introducing any additional Carbon into the atmosphere (Ref: Eckard et al., 2016).

Fertiliser emissions represent emissions related to the production of CO_2 and NO_X on-farm from the breakdown of the products. They are considered long cycle emissions when generated by synthetic fertilisers and short cycle emissions when generated from composts and manures.

The pre-farm emissions relate to the emissions generate during the production of products purchased such as fertilisers, superphosphate and externally sourced grain and fodder, as well as emissions related to purchased livestock.

Land Use / Biodiversity	Natural land areas provide essential services to society which regulate our environment, provide goods and services and support livelihoods. The conversion and degradation of natural areas results in a reduction of these services. The figures below represent a proportional loss of the capacity of the property to generate each ecosystem service compared to an ecosystem in pristine (reference) condition.		
Metric 1	Area attributed to wool production	1205	Hectares
Metric 2	Wool produced	19512	kg
Metric 3	Food from natural/semi-natural ecosystems	44%	Extent of service loss (weighted average across area based on state of ecosystem relative to reference condition)
Metric 4	Fibre, other raw materials	44%	
Metric 5	Domestic and industrial water	41%	
Metric 6	Bio-prospecting & medicinal plants	44%	
Metric 7	Ornamental products	44%	
Metric 8	Air purification	41%	
Metric 9	Recreation	44%	
Metric 10	Spiritual and aesthetic	44%	
Metric 11	Cognitive and learning opportunities	44%	
Metric 12	Stable climate	41%	
Metric 13	Pollution control and waste assimilation	44%	
Metric 14	Erosion control	41%	
Metric 15	Disease and pest control	44%	
Metric 16	Flood control and protection from extreme events	41%	

The metrics demonstrate that whilst some function or capacity to deliver ecosystem services has been lost over timer; the farm still provides a significant amount of capacity for these services. The figures are not direct measures of each ecosystem service but rather have been calculated based on a proxy of biomass loss and/or species richness loss. They represent a very conservative estimate of the capacity to deliver these services.

A conservative estimate of the natural value affected by Glenwood's operation suggests that it has impacted the ecosystem services by around 44%, compared to 80% estimated by Kering for land use impact from Regenerated operations in their E P and L. This impact is not permanent and will reduce over time

While operating as a commercial wool growing operation, a large proportion of the property (84%) has been assessed as transitioning to a higher level of function (biomass, species richness), which will reduce the extent of ecosystem service loss over time.

Waste	Hard waste generated from inputs to the grazing operation. Calculated based on packaging from fodder. Calculated per kg of clean fleece produced. Proportionally allocated based on other animal products from the farm (cattle, lamb sales)		
Metric 1	Non-biodegradable waste	0.000	kg / kg Clean Wool

Comments:

No fodder purchased, so negligible non-biodegradable waste generated for wool production.

Water consumption	Stock consumption of water, and water used for irrigation. Calculated per kg of clean fleece generated from the greasy wool produced. Proportional allocation based on biophysical allocation of wool as a proportion of all sheep products.		
Metric 1	Stock water consumption including evaporation	0.707	m^3 / kg Clean Wool
Metric 2	Water consumption for irrigation of fodder	0.000	m^3 / kg Clean Wool
Metric 3	Normalised Stress weighted TOTAL water consumption including evaporation	24.4	litres H_2O-e / kg Clean Wool
Metric 4	Water Stress Index (Pfister et al 2009)	0.0208	

Comments:

As there is no irrigation to produce fodder on the property, the figures provided represent the water consumed by the stock. The water use has been shown as absolute values (metrics 1 and 2), as well as a normalised stress weighted water use (metric 3).

The total water use for wool production (0.707 m^3/kg clean wool) is higher than Kering's estimate of water use for wool produced from conventional production (0.366 m^3/kg clean wool) due to the evaporation from farm dams but is significantly lower than the comparable water rating for the production of other fibres such as cotton (5.03 m^3/kg conventional cotton) (Kering 2018).

Water Pollution	Water pollution created as a result of the use of agricultural chemicals (eg. fertilisers and pesticides) that are then leached from the ecosystem and runoff into surrounding waterways. Calculated as kg of pollutant per kg clean fleece produced.		
Metric 1	Nitrogen leaching into the waterways	0.000	kg / kg Clean Wool
Metric 2	Phosphorus leaching into the waterways	Not calculated	kg / kg Clean Wool

Comments:

No fertiliser was used. Functioning grasslands ensure that negligible leaching and run-off from manure deposited in grasslands by stock. Riparian areas in good condition also provide increased filtering services to mitigate any pollutants released by leaching.

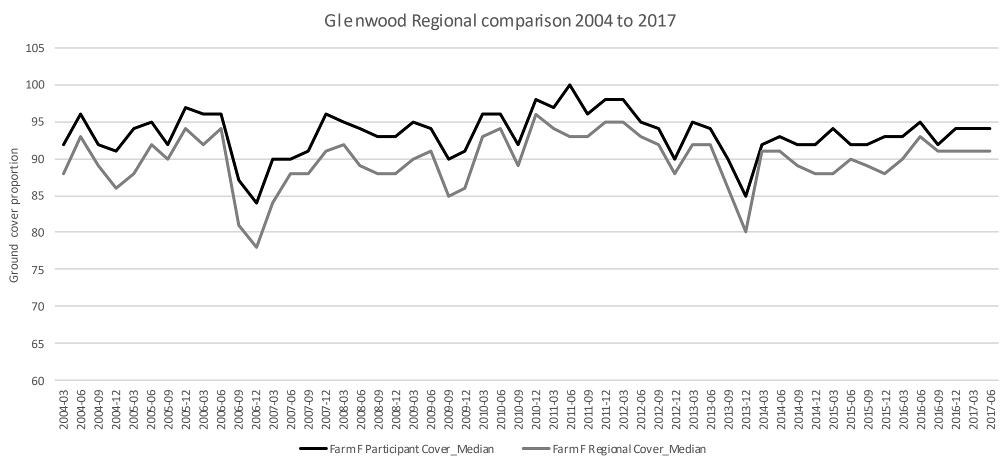
7. Groundcover assessment:

FarmMap4D is a commercially available GIS information system available in an online format. It allows customised and easy to use mapping, reporting and analysis tools to analyse the condition of land over time.

A feature of the program is the ability to track historical changes in groundcover and to create local and regional comparisons.

Managing pastures to maintain adequate levels of groundcover is an effective way to minimise rainfall run-off and soil loss. By reducing rainfall run-off, more water is made available for plant growth. By reducing erosion, soil, nutrients and organic matter are retained in place, and siltation problems are minimised. In addition, groundcover is important for soil health and assists in weed control (Lang 2005). Groundcover provides an important role in the establishment of perennial native grass seeds and hence the regeneration process (AgVic).

Glenwood ground-cover comparison – properties within 5km



Comments:

The graph above uses FarmMap4D to analyse groundcover on Glenwood and compares this with properties within a 5km radius for the period 2004 – 2017 (13 years). It is evident that in every year the ground cover of Glenwood is above that of properties within a 5 km radius. Groundcover remained above 85% and peaked at 100%. Industry targets suggest a minimum of 70% groundcover is required to reduce run-off and erosion (Lang 2005). A high level of ground cover is an important component of an effective water cycle, mineral cycle, weed control and in providing conditions for native plant recruitment.

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Appendix:

1. Descriptions of 'condition for grazing' categories

Categories describing condition for grazing are adapted from the MLA EDGE framework (MLA 2016) to be relevant to temperate pastures. Where areas of a farm were borderline for land condition between these two categories we also applied an important principle relating to the sustainability of grassy woodlands (McIntyre et al 2002) that relates to the potential to slow water flow across the landscape and thus contribute to landscape rehydration as well as efficient use of nutrients.

The categories applied in Table 3 in the report are described in Table A1.

Table A1. *Categories of 'condition for grazing'.*

Category	Description
A (very good)	Very good land condition that has high levels of groundcover, including tussocky perennial species and litter that contribute to landscape functioning, a diverse mix of perennial, palatable and persistent species. a good amount of biomass is retained (>1500 kg/ha). Few weeds are present and soil erosion is absent.
B (good)	Similar to A with good land condition that has high levels of groundcover (<90%). There is a slight decline in perennial, palatable and persistent species and larger tussocky species that contribute to ongoing high levels of landscape functioning are not common. Reasonable biomass is retained and there may be some signs of previous erosion as well as potential for current erosion in some areas. Likely to be a minor presence of weeds.
C (fair)	There are reasonable levels of groundcover (>70%), a moderate diversity of palatable and perennial species but persistent native species that protect soil assets in poor times are missing. Weeds (annual or invasive perennial) are present and noticeable. Bare ground may be significant (>50%) in some years and there are obvious signs of erosion with current susceptibility to erosion high.
D (poor)	A fair proportion of bare ground (>30%), low biomass most of the time and (likely to very low in extended dry times), dominated by unpalatable perennials and annual weedy species.
E (very poor)	Few perennial species are present and a severe and hostile environment for plant growth (i.e. scalding, salinity, severe and continuing gullying in susceptible areas. Potential and likelihood of weed invasion is high.

2. Information on 'identity' classifications:

To determine the condition of an area on a farm it is necessary to assign a category that summarises characteristics of the particular area of land. The condition of this area can then be considered in the context of the purpose for which that area of land is managed. Purposes may include livestock grazing, timber production, honey production or conservation. An area of land may have dual, or multiple, purposes. For example: scattered trees among native grasslands have livestock production, conservation of biodiversity, carbon storage and honey production potential; a timber plantation where plantings are less dense can be used for livestock grazing, shelter, timber production and carbon storage.

Identity states are well established for native ecosystems in Australia. These identity 'states', and the transitions between states, are referred to as 'State and Transition' models. Generally, in areas modified for agriculture, there has been a general move towards lower tree cover and conversion of the ground layer vegetation from native species to exotic improved pastures.

Some producers have chosen to restore characteristics of the original native ecosystem where there has been modification for agricultural production. However, the degree to which this is possible will depend on the level of modification of an area through past practices such as cultivation, fertiliser application, past cropping practices and grazing management. 'Transitioning' to an identity state that more closely resembles the original native ecosystem is likely to impart greater resilience to a farm. The end goal will depend on the goals of the landowners including whether the primary use for an area is for grazing production or for conservation. Management goals for natural capital will also depend on the type of ecosystem services a farm business wishes to use as ‘free inputs from nature’ for livestock production.

As the case studies in this project are situated within the temperate grassy woodland biome, we use published 'state' and 'transition' identity classes for that biome as outlined in Whitten et al (2010). We apply these identity states to areas on a farm that retain general characteristics of the original native ecosystem such as remnant trees and some native herbaceous species. In the context of this project, determining the 'state' or 'transition' identity of an area enables a determination of the potential for provision of a range of ecosystem services. The categories for each 'State' in the recognised State and Transition models are outlined in Table A2. Transitions refer to whether an area of interest is transitioning between these recognised states.

Each 'state' or 'transition' identity implies no value judgement. A value judgement only exists once management and production goals are considered. For example, a management goal for wool production may be to have persistent and palatable forage as well as areas for stock to shelter. These ecosystem services can be provided by a less modified native ecosystem (State 2A/B 3A/B) or by an area forested with exotic or native timber if the canopy is open enough to allow good forage as well as timber production.

If, however, the primary management goal for an area is conservation and to serve markets for biodiversity should they emerge, it would be desirable to be moving towards an identity/state closer to 'reference' condition.

Table A2. Descriptions of the 'identity' states referred to in Table 2.

Identity states are in relation to the natural ecosystem present in the grass woodland biome in reference condition. Transitions are also occurring between these states.

It is possible through planned management decisions to restore characteristics of the original native ecosystem where there has been modification for agricultural production. The degree to which this is possible will depend on the level of modification of an area through past practices. 'Transitioning' to an identity state that more closely resembles the original native ecosystem is likely to impart greater resilience to a farm. The end goal will depend on the goals of the landowners, whether the primary use for an area is for grazing production or for conservation.

Title/code for 'state'	Description	Detailed description
1A	Grassy woodland with a diverse native ground-layer	Tree (canopy) cover >15% and the ground-layer has a high diversity and cover of native species (< 30 species and >70% groundcover of native species). Never fertilised or fertiliser use ceased 3–4 decades previously).
1B	Derived native grassland with a diverse native ground-layer	There is low tree-cover, but the ground-layer has a high diversity and cover of native species (< 30 species and >70% groundcover of native species). Never fertilised or fertiliser use ceased 3–4 decades previously).
2A	Grassy woodland with a diverse native ground-layer	Tree-cover is slightly lower (10–14%) than 1A and the ground-layer has a slightly lower diversity and cover of native species compared to 1A (16–29 species and 50–69% groundcover of native species). Rarely fertilised or fertiliser use ceased 2–3 decades previously).
2B	Derived native grassland with a diverse native ground-layer	There is low tree-cover, but the ground-layer has a high diversity and cover of native species (16–29 species and 50–69% groundcover of native species). Rarely fertilised or fertiliser use ceased 2–3 decades previously).
3A	Some mature trees present and a moderately diverse, mainly native, ground-layer	Mature eucalypts present (but with no tree regeneration). The ground-layer has a moderate diversity of native species (8-15 species) and 30–49% native-ness of the ground-layer. Historically low-moderate fertiliser application.
3B	A moderately diverse and mainly native grassland with few trees	Few mature eucalypts present (but with no tree regeneration). The ground-layer has a moderate diversity of native species (8-15 species) and 30–49% native-ness of the ground-layer. Historically low-moderate fertiliser application.
4	Grassland with a mix of native and exotic species and occasional scattered trees	Grassland with 4–7 native species and <30% cover of native species and the occasional scattered tree with no natural tree regeneration. There has been frequent fertiliser application until present day.
5 (includes improved pastures)	Predominantly exotic grassland with a few native species. No remnant trees present.	No trees remaining and no natural tree regeneration. Pastures are predominantly exotic with <3 native species and <10% cover of native species. There has been frequent fertiliser application until present day.

Commonly, farms in the temperate zone of Australia are a mosaic of more and less modified areas. Where areas have been significantly modified from the original native state through cropping, and/or forestry, we have created alternative 'identity' states to describe the core characteristics of an ecosystem and enable an understanding of the potential to provide a range of ecosystem services. Due to the new ground this project is exploring, these alternative states may require further consideration.

These modified identity categories are outlined in Tables A3 and A4.

Table A3. Modified states

State abbreviation or code	Description	Detailed description
FREDM	Fully Replaced Exotic Dense Mature	The original native community has been fully replaced with alternative vegetation that is introduced/exotic. Plantings are dense (<50% canopy cover) with mature aged trees.
FREDI	Fully Replaced Exotic Dense Intermediate	The original native community has been fully replaced with alternative vegetation that is introduced/exotic. Plantings are dense (projected to be >50% canopy cover) with intermediate aged trees.
FREDY	Fully Replaced Exotic Dense Young	The original native community has been fully replaced with alternative vegetation that is introduced/exotic. Plantings are dense (projected to be >50% canopy cover) with intermediate aged trees.
FRESM	Fully Replaced Exotic Sparse Mature	The original native community has been fully replaced with alternative vegetation that is introduced/exotic. Plantings are sparse (>50% canopy cover) with mature aged trees.
FRESI	Fully Replaced Exotic Sparse Intermediate	The original native community has been fully replaced with alternative vegetation that is introduced/exotic. Plantings are sparse (<50% canopy cover) with mature aged trees.
FRESY	Fully Replaced Exotic Sparse Young	The original native community has been fully replaced with alternative vegetation that is introduced/exotic. Plantings are sparse (<50% canopy cover) with young trees.

Table A4. Native plantings

State abbreviation or code	Description	Detailed description
FRNDM	Fully Replaced Native Dense Mature	The original native community has been fully replaced with alternative vegetation that is native to Australia. Plantings are dense (>50% canopy cover) with mature aged trees.
FRNDI	Fully Replaced Native Dense Intermediate	The original native community has been fully replaced with alternative vegetation that is native to Australia. Plantings are dense (projected to be >50% canopy cover) with intermediate aged trees.
FRNDY	Fully Replaced Native Dense Young	The original native community has been fully replaced with alternative vegetation that is native to Australia. Plantings are dense (projected to be >50% canopy cover) with young trees.
FRNSM	Fully Replaced Native Sparse Mature	The original native community has been fully replaced with alternative vegetation that is native to Australia. Plantings are sparse (projected to be <50% canopy cover) with mature aged trees.
FRNSI	Fully Replaced Native Sparse Intermediate	The original native community has been fully replaced with alternative vegetation that is native to Australia. Plantings are sparse (projected to be <50% canopy cover) with intermediate aged trees.
FRNSY	Fully Replaced Native Sparse Young	The original native community has been fully replaced with alternative vegetation that is native to Australia. Plantings are sparse (projected to be >50% canopy cover) with young trees.

Table A5 explains the allocation of the potential for Ecosystem service provision in Figure 1.

Type of ecosystem service	***ID***	***Score***	***Reasoning***
Production			
Provisioning for livestock (across 10 years i.e. stability of production)	P1	H	Consistency of livestock production across years based on land condition (MLA reference; McIntyre et al 2002; Chapman et al 2006; Dunin and Passioura, 2006; Simpson and Langford, 1996) as well as stock/financial records
Forage for pollinators including bees	P2	H	Extensive areas of eucalypt woodland along with mid and under-story species diversity (Leech 2012).
Firewood/timber resources	P3	M	Abundant trees in the landscape, abundant natural regeneration, knowledge of ongoing income from firewood collection (Brown et al 2009)
Regulating			
Soil protection/nutrient retention	R1	H	High levels of perennial groundcover allow ongoing protection of soils and retain nutrients (Greenwood and McKenzie 2001; Eldridge and Freudenberger, 2005; McIntyre and Tongway, 2005; Tongway and Hindley, 2005).
Water quality	R2	H	High levels of groundcover and retained biomass ensure nutrient and sediment run-off is negligible (Dunin and Passiour, 2006; Tongway and Hindley, 2005)
Carbon storage	R3	H	Large amounts of carbon are stored on this farm due to healthy, perennial grasslands and abundant tree cover (Young et al 2005).
Micro-climate regulation	R4	H	High levels of groundcover, abundant areas with scattered, and sometimes denser, tree cover, abundant taller grasses and well-vegetated riparian areas (Cleugh et al 2002; Bird et al 2007; Bennell and Verbyla, 2008)
Pollination and pest predation services	R5	H	High levels of insect diversity likely due to abundant habitat suitable for pollinators (grasslands and woodlands) present throughout property
Cultural (including habitat)			
Biodiversity - animal	C1	M	Fencing infrastructure across the property, combined with significant areas of a more cleared landscape. Nb. Very few farms with a primary purpose of production would score 'high' for wildlife biodiversity due to the restrictions for movement for larger animals
Biodiversity – non-animal	C2	H	High – most of the farm is in an identity state that supports high levels of plant diversity. (Whitten et al 2010).
Restoration potential (Threatened ecosystem)	C3	H	Most of landscape is in an identity state that is close to high conservation value (Whitten et al 2010). Lack of fertiliser application for past few decades means that native diversity is likely to continue increasing. If allowed (i.e. fitted with management goals), tree cover could also increase.
Climate change adaption.	C4	H	Grassy woodlands in good – and regenerating – condition across most of the property confers significant climate change adaptation potential (Lavorel et al 2015).