SoilsforLife

Production & Ecological Inquiry

Supplementary Information: The 8 families group case study.

2022

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We acknowledge that the contents of this document do not necessarily reflect the views of these contributors.

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For more than a decade, Soils for Life has been producing case studies of farmers' inspiring stories of transition to regenerating their soils and landscapes. It is the largest body of regenerative farming case studies in Australia.

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The case studies have been used by farmers, researchers and policy makers around the country to inspire and inform new ideas and approaches in agriculture.

About Soils for Life

Soils for Life is an independent, not-for-profit organisation that works across Australia to support Australian farmers in regenerating soil and landscapes, to build natural and social capital, and transform food and fibre systems.

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Preface

This document aims to provide a holistic and integrated account of the production and ecological systems of the properties within the 8 families group using information and data available from the producers. By using a systems approach, this report documents the interconnection and "big-picture" processes, ecological functions and management practices. Investigating the four landscape function dynamics – the solar cycle, the water cycle, the soil-nutrient cycle and community dynamics (biodiversity) – provides a holistic understanding of the interconnectedness and methods of monitoring such dynamics.

The collaborative action research undertaken as part of this case study combines local, technical and expert knowledge. We value the farmers as researchers who are constantly undergoing practical experimentation based on their own understanding, monitoring the outcomes in response to those experiments, and adapting their experimentation when required.

Acknowledging the value of both farmer knowledge and specialist technical knowledge, this report draws on information from group workshops, individual interviews, surveys and provided data, including biological monitoring and groundcover mapping using Normalized Difference Vegetation Index (NDVI) satellite imagery produced by Soils for Life using VegMachine®. The data provided and generated provides a platform to find patterns of change within the production and ecological systems and build a greater understanding of the associated outcomes. The detailed information provided by the four focus producers that is presented within this document supports and strengthens the production and ecological outcomes of the 8 families group.

The document is supplementary to the Overview Report - *Working Together to Regenerate Landscapes: A case study of the 8 families group*, which provides a holistic and integrated account of this change process and the associated outcomes of the group.

Key Findings

- Members of the 8 families all have seen visual increases in ground cover since making practice changes on their properties. The spatial mapping results support these observations, showing that all properties maintained higher ground cover than the surrounding 5 km buffer since practice change.
- The lack of a constant approach to soil testing highlights the gap in knowledge many farmers face about what soils measures are fit for their needs.

Background

The group

The group first formed in 2008 and originally consisted of eight family groups. Now, with an additional family, the group comprises nine families who produce a range of products using holistic and regenerative approaches that aim to restore soil and landscape function. This includes cattle and sheep trading, cattle stud, and pasture eggs (see Table 1 for further production information). Within the group, properties are all located in New South Wales and are located within the Mundarlo Valley, Holbrook, Book Book, Sandigo and Wymah Valley areas (Figure 1).

Figure 1: Location of the 8 families farms with inset providing regional locality.

The landscape

The '8 families' group is based in the Gundagai/Holbrook area in the Eastern Riverina, NSW. This region has a warm temperate climate and is dominated by temperate eucalypt woodland (Lindenmayer, 2018).

The Gundagai region is within the Murrumbidgee River catchment, with the Murrumbidgee River flowing from north-east to south-west and joined by many tributaries including the Tumut River which flows north from its headwaters into Kosciusko National Park (ACT Commissioner for the Environment, 2006). The Gundagai Shire embraces a variety of climatic characteristics, landforms, soil conditions and flora and fauna, from the hilly areas around Gundagai to the gentler slopes towards

Junee and Wagga Wagga in the west. The landscape of the Holbrook region broadly consists of undulating hills of Ordovician metasedimentary rocks and Silurian granites in the east, and flat to gently undulating alluvial floodplains of the Billabong Creek and its tributaries in the west.

The Holbrook region is located in the southwest slopes bioregion of NSW. To the west of the Great Dividing Range, the dominant vegetation is the Grassy Box Woodlands. To the east are the foothills of the Great Dividing Range and the transition from western slopes woodlands up to the dry and wet sclerophyll forests (Holbrook Landcare Network, N.D.).

Before European settlement, the vegetation in the Gundagai region would have been characterized by damp-wet sclerophyll forests and box/ironbark woodlands covering an extensive area of the southwest slopes (Thackway & Cresswell, 1997). Despite the historical and ecological importance of these temperate eucalypt woodlands, the Gundagai Shire has been extensively cleared and highly modified. More than 80% of the shire is currently used for cropping and grazing, with less than 1% managed for conservation (ACT Commissioner for the Environment, 2006). Consequently, there are minimal remnant examples of historical vegetation communities left within the region (ACT Commissioner for the Environment, 2006).

Across the Gundagai/Holbrook region, the major soil types include Kurosols (strongly acid duplex soils), Kandosols (structureless soils) and Dermosols (structured soils). In the Holbrook region, there is the addition of Chromosols (duplex soils) and Sodosols (sodic duplex soils) on the slopes and within drainage depressions and older alluvium along Billabong Creek. In the Holbrook region on the more recent alluvium, Chromosols and Dermosols occur. Within swamps and minor areas along the floodplain, the soil type consists of Grey Vertosols (cracking clays). On the slopes of the Gundagai area, Sodosols (sodic duplex soils) occur with the addition of alluvial rudosols (little/no pedologic organisation) and to the east, Ferrosols (iron rich lacking a strong texture-contrast soils). The major soil constraint affecting productivity in pasture and cropping systems in the region is acidity within the Kurosols soils, and in particular subsurface acidity.

The focus farmers

To support the production and ecological outcomes of the group, a deeper dive into four focus farmers was undertaken to better understand their decision-making processes, practice innovations and outcomes. The focus producers were selected based on available ecological and other relevant data, and the extent to which their property and their story illustrated the key themes that the group agreed should be the focus for the case study (namely, land stewardship, holistic approach and community of practice). Vegetation mapping has been produced through the NSW Government Vegetation Information System (VIS) which provides spatial information on Plant Community Types (PCT) vegetation classes. PCT vegetation maps provide available information (pre-2011) on plant communities that may be found within a local area (State Government of NSW and Department of Planning, 2020). In some cases, this information pre-dates property ownership and/or development, therefore within this report is only provided as a guide. Soil mapping has been produced using available data from the Australian Soil Classification through the Central Resource for Sharing and Enabling Environmental Data (SEED) NSW database (Department of Planning Industry and Environment, 2021).

Willowlee

Producers: Michael & Héloïse Gooden - Willowlee			
Enterprise types	Cattle/sheep trading and agistment and Angus cattle stud	**Location**	Sandigo, NSW
Property size range	388 ha owned (45 ha leased) 433 ha = Total area managed	**Rainfall (long-term average)**	432.8 mm Grong Grong BOM Weather Station (74050)
Agro-climatic region	Mediterranean/Temperate sub humid	**Elevation**	157 m
Soil type	Chromosol (duplex soils)		
Social structure	Owner/operators		

Willowlee is a 388-hectare property west of Wagga Wagga near Sandigo, in the Riverina, NSW. The property has been in the Gooden family for 34 years and has been now owned by Michael and Héloïse Gooden since 2008. Initially, the Willowlee property was leased, however in 2015, the Goodens shifted their focus to Willowlee after selling their other property. Since that time, Willowlee has been managed following Holistic Management principles.

Willowlee sits along the Murrumbidgee River floodplain and consists of land systems ranging from grazing country to wetlands and wooded swamp areas and during wet periods, around a third of the property is subject to flooding. Vegetation (PCT) classes on Willowlee comprise eastern and inland riverine forests and tableland clay grassy woodlands (Figure 2a). The soil type according to the available soil maps found on Willowlee consists solely of Chromosols (duplex soils) (Figure 2b) which characteristically exhibit a strong texture contrast between the A and B horizons, where the B horizon is not strongly acidic and are not sodic (Isbell & the National Committee on Soil and Terrain, 2021). Grasses on Willowlee are dominated by warm season/summer active species.

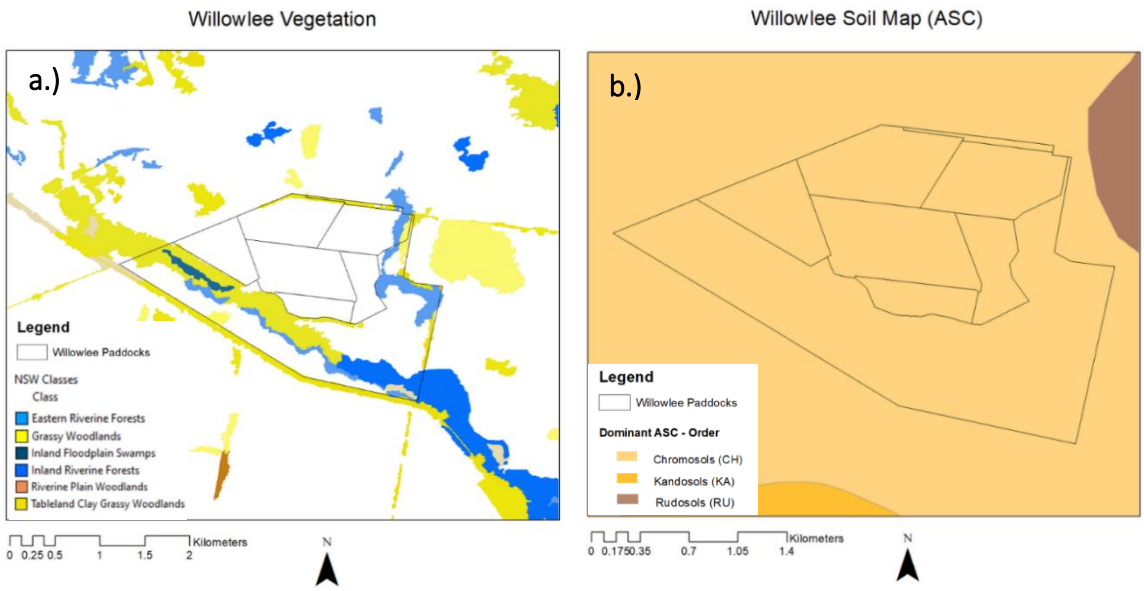

Figure 2: Vegetation and soil mapping for Willowlee. a.) Vegetation PCT communities (map Source: State Government of NSW and Department of Planning, 2020 accessed via SEED NSW database) and b.) Australian soil classification (map source Department of Planning Industry and Environment accessed via SEED NSW database.

Bellevue

Producers: Sam and Prue Pincott - Bellevue			
Enterprise types	Free-range egg production and mixed grazing (sheep and cattle)	**Location**	Holbrook, southern NSW.
Property size range	330 ha	**Rainfall (long-term average)**	539.4 mm Holbrook (Croft St.) BOM Weather Station (72142)
Agro-climatic region	Temperate cool season wet	**Elevation**	289
Soils	Sodosols (sodic duplex soils)		
Social Structure	Owner/operators		

Bellevue is a 330 hectare property in Holbrook, located within the Riverina, NSW. The Pincotts purchased the property in 2013 and began a free-range pastured chicken enterprise with stacked cattle and sheep grazing enterprise. Over this time, the Pincotts have been adopting Holistic Management principles on Bellevue to improve their soil and decrease undesirable weed species by utilising the animals' natural behaviours and processes.

A variety of eucalypt species are found on Bellevue such as River Red Gum *(Eucalyptus camaldulensis),* Forest Red Gum *(E. tereticornis*), Yellow Box *(E. melliodora),* Apple Box *(E. bridgesiana)* along with many wattles and other native shrubs (Livermore, H. et al 2019). Vegetation (PCT) classes mapped for Bellevue show small patches of southern tableland grassy woodland and grassy woodlands (Figure 3a) however this may not provide a good representation of the current vegetation communities. From available Australian Soil Classification maps, soils on Bellevue consist entirely of Sodosols (sodic duplex soils) (Figure 3b) which characteristically exhibits a strong texture contrast between A horizons and sodic B horizons which are not strongly acid (Isbell & National Committee on Soil and Terrain, 2021)

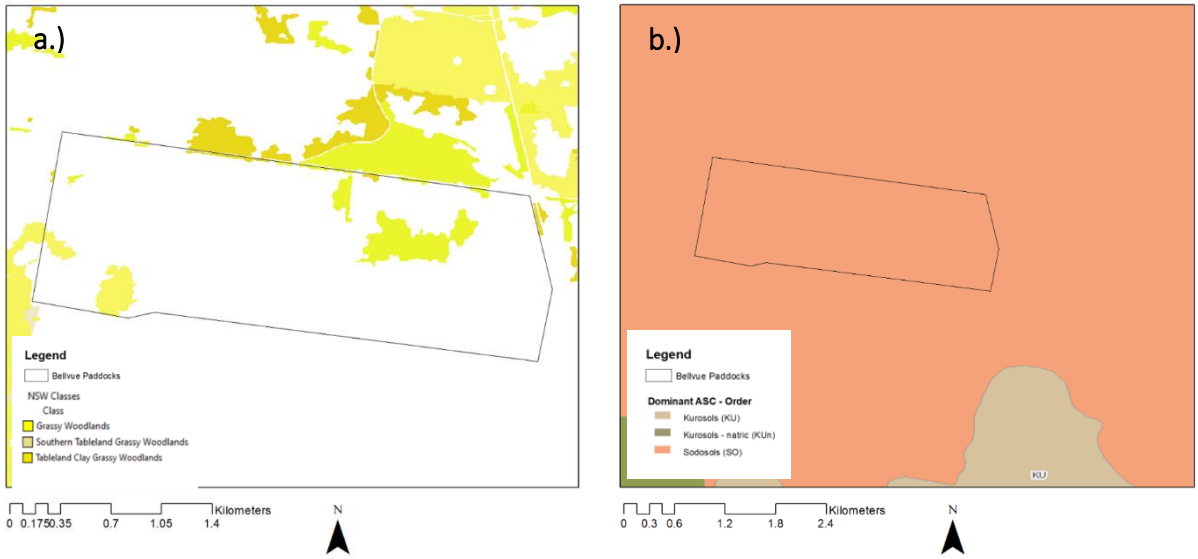

Figure 3: Vegetation and soil mapping for Bellevue. a.) Vegetation PCT communities (map Source: State Government of NSW and Department of Planning, 2020 accessed via SEED NSW database) and b.) Australian soil classification (map source Department of Planning Industry and Environment accessed via SEED NSW database.

Yabtree West

Producers: Rebecca Gorman – Yabtree West			
Enterprise types	Breeding herd of Angus beef cattle	Location	Mundarlo, NSW
Property size range	2428 ha	**Rainfall (long-term average)**	558mm
Agro-climatic region	Temperate cool season wet	**Elevation**	231-378m
Soils	Kurosols (strongly acid duplex soils), alluvial rudosols (soils with little/ no pedologic organisation) and vertosols (clay rich uniform texture, cracking clays)		
Social Structure	Owner/operators on farm manager		

Yabtree West is a 2428-hectare property located in Mundarlo, NSW. The property was purchased in 2013 by Rebecca Gorman and John Sevior and consisted of a cattle and sheep enterprise which had been run by conventional standards. Knowing they wanted to do things differently, Rebecca trained in Holistic Management and began adopting and applying those learnt principles ever since.

The property sits along the Murrumbidgee River and consists of vegetation PCT classes dominated by western slopes dry sclerophyll forests and tableland clay grassy woodlands. Inland riverine forests occur in the north and southern tableland dry sclerophyll forests to the south (Figure 4a). From available Australian Soil Classification maps, soils on Yabtree West are predominately Kurosols (strongly acid duplex soils) with alluvial rudosols and vertosols in the north (Figure 4a) (Isbell & National Committee on Soil and Terrain, 2021).

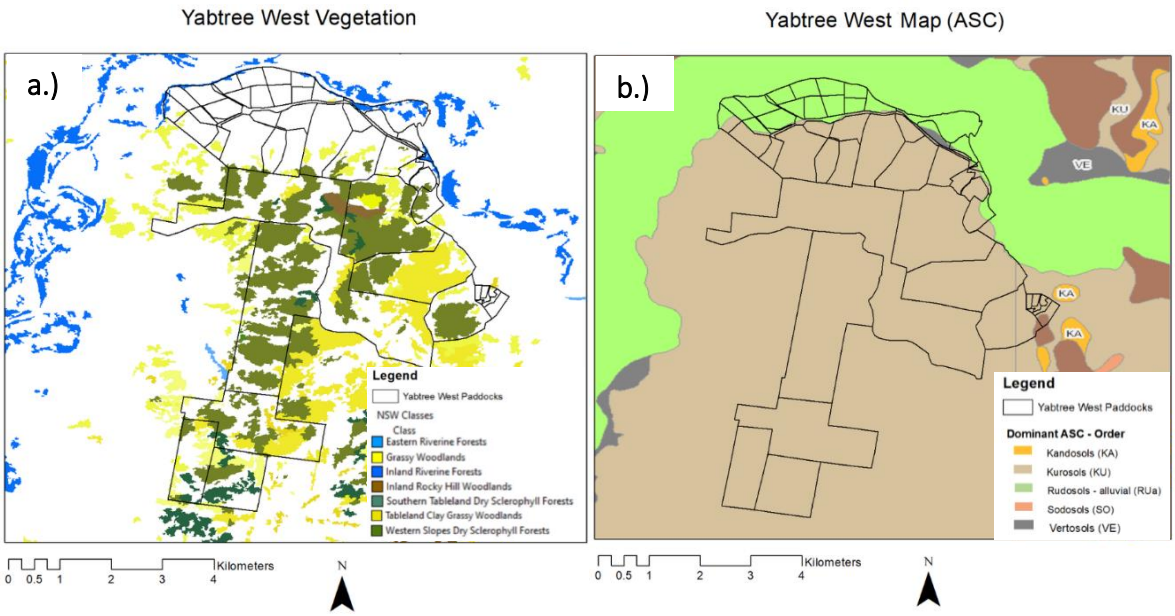

Figure 4: Vegetation and soil mapping for Yabtree West. a.) Vegetation PCT communities (map Source: State Government of NSW and Department of Planning, 2020 accessed via SEED NSW database) and b.) Australian soil classification (map source Department of Planning Industry and Environment accessed via SEED NSW database.

Mundarlo

Producers: Nick and Deanna Austin - Mundarlo			
Enterprise types	Cattle and sheep trading	Location	Mundarlo, NSW
Property size range	1440 ha	Annual rainfall	570 mm. Mundarlo Weather Station
Agro-climatic region	Temperate cool season wet	Elevation	Approximately 300m
Soils	Kandosols (structureless soils), Kurosols (strongly acid duplex soils), Sodosols (sodic duplex soils), Rudosols and Alluvial Rudosols (soils with little/ no pedologic organisation)		
Social Structure	Owner/operators		

Mundarlo is a 1440-heactare property located in Mundarlo, NSW. In 2009 succession was officially finalised and Nick and Deanna Austin were able to begin making decisions for themselves. In 2010, Nick revisited his Holistic Management training and completed a KLR Marketing course and began implementing his learnings on Mundarlo. This began with the reduction of his breeding herd and the introduction of a trading herd. In 2019, sheep trading was added to the mix and the Austins began running stock together as a "flerd" (Flock/herd).

The property sits along the Murrumbidgee River and consists of land systems which range from granite foothills to alluvial river flats. These areas are predominantly comprised of grazing land and PCT vegetation classes which include tableland clay grassy woodlands and southern tableland grassy woodlands (Figure 5a). From available Australian Soil Classification maps, soils on Mundarlo consists predominately of Kandosols (structureless soils), with areas of Kurosols (strongly acid duplex soils), Sodosols (sodic duplex soils), Rudosols and Alluvial Rudasols (little/no pedologic organisation) (Figure 5b).

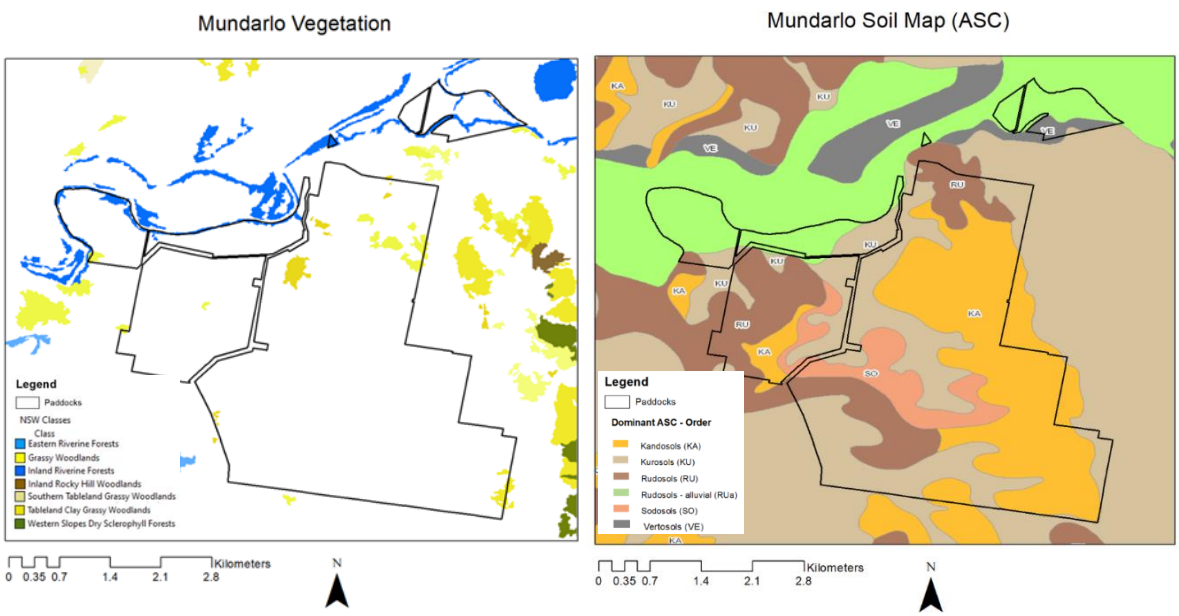

Figure 5: Vegetation and soil mapping for Mundarlo. a.) Vegetation PCT communities (map Source: State Government of NSW and Department of Planning, 2020 accessed via SEED NSW database) and b.) Australian soil classification (map source Department of Planning Industry and Environment accessed via SEED NSW database.

Production systems

The 8 Families

All members within the 8 families have undertaken Holistic Management training which has assisted them to create both a personal Holistic Context (roughly speaking, a vision or goal for the future) for their family, and one collectively as a group. Holistic Management offers a decision-making framework which supports decision making in line with a personal and/or collective 'Holistic Context'. This process has allowed each family to confidently explore production and management system options. Although the group works across a range of different enterprises, they all have the same holistic mindset. Having this commonality also provides a familiar vocabulary and a certain alignment within the group which further enables and strengthens the support network. Table 1 below lists the producers and the range of enterprises within the 8 Families, together with the producers' desired outcomes for their property.

Table 1: Producer and property information for each of the families within the 8 families

Producer	Property	Enterprise(s)	Desired outcomes
Gooden	Willowlee	Angus cattle stud, trading and agistment of cattle and sheep.	Improve soil, groundcover and biodiversity through time controlled cell grazing practices and multi-species cover cropping, improve water infiltration and water holding capacity. Ecological Outcomes Verification™ (EOV) monitoring conducted by Land to Market
Pincott	Bellevue	Production of paddock eggs; trading and agistment of cattle and sheep.	Improve soil, ground cover and diversity of grasses including native perennials through using moveable sheds (chickens) and running livestock in a flerd using time controlled rotational grazing. Tree planting and fencing of wetlands areas through Landcare 'BushLinks' program.
Austin	Mundarlo	Cattle and sheep trading and off-farm health and wellness business and pilates studio.	Improve soils, groundcover and biodiversity through using holistic time controlled rotational grazing practices and tree planting. Ecological Outcomes Verification™ (EOV) monitoring conducted by Land to Market
Gorman	Yabtree west	Beef cattle trading and off-farm work in journalism and policy.	Improve groundcover, halt erosion and increase water infiltration through Natural Sequence Farming and using time controlled rotational grazing. Build habitat for wildlife through tree planting. Ecological Outcomes Verification™ (EOV) monitoring conducted by Land to Market
Sanbrook	Bibbaringa	Trading cattle, tourist accommodation, farm tours, art studios and conferences room hire	Improve soils, groundcover and biodiversity using time controlled rotational grazing management, Natural Sequence Farming and tree planting. Ecological Outcomes Verification™ (EOV) monitoring conducted by Land to Market
Lawson	Trewalla	Beef and lamb production	Improve soils, groundcover and biodiversity through using time controlled rotational grazing management and tree planting.
Wearn	Yammacoona	Beef and lamb production	Improve landscape and animal health using Holistic Management and Natural Sequence Farming principles.
Heijse	Spring Creek	Beef production	Improve soils, groundcover and biodiversity using time controlled rotational grazing and habitat management.
Coughlin	Tarabah & Mt Narra Narra Station	Beef production	Improve soils, groundcover and biodiversity using time controlled rotational grazing and habitat management.

Enterprise selection

Although there is enterprise diversity within the 8 families, there is the common desire to build resilience into their systems, from a social, economic and ecological perspective. One of the ways the 8 families have achieved this is through their holistic approach, incorporating multiple enterprises into their farming business and in some cases, the addition of off-farm enterprises to complement on farm activities. Having the Holistic Management decision-making framework to test ideas against, provides a solid platform in which to make confident decisions considering a 'whole-of-life' perspective.

At Willowlee, Michael made the shift from predominantly trading cattle to breeding Angus bulls as he found trading stressful, particularly regarding the constant trading opportunities as well as the animal welfare aspect. Running stud animals to only 60-70% carrying capacity allows for some trading to occur and gives flexibility within the dry periods. While Willowlee has licence to irrigate, in times when the property requires irrigation, the cost of water is too expensive and therefore cost prohibitive. Maintaining trading and/or agistment at 30% carrying capacity has built resilience into their enterprise as stocking rates can be adjusted to conditions more quickly and easily than what can be achieved (and is desired) with the stud breeding herd. The purchase of the Angus bull stud has additionally provided autonomy by selling through private sales and is now considered their "bread and butter" enterprise.

> *"We've got to be really careful that our stocking rate can actually fluctuate a lot … as its when we need to irrigate the most, is probably when we can't afford to. So, we've got to be really careful about managing that stocking rate through those periods of time." – Michael Gooden (Willowlee)*

For the Austins on Mundarlo, it was all about simplification and focusing on the things that they were good at. This led Nick to reduce the number of on-farm enterprises, ceasing the cropping enterprise and transitioning the focus to trading cattle (2012) and sheep (2018). Rather than focusing on multiple enterprises within the farm, the Austins have complemented their income by opening a wellness center in Wagga Wagga where Deanna runs a Pilates studio. While the enterprises may seem varied, both on- and off-farm enterprises are interconnected and managed holistically. Even with the reduction in on-farm enterprises, the Austin's have seen an overall increase in profitability and their overall wellbeing.

For the Pincotts on Bellevue, chooks were seen as just another layer of animal production within the cattle enterprise. However, one of the difficulties in adding a new enterprise to the mix is the steep learning curve that comes with it. With a limited number of people with a similar enterprise and the time it took to build relationships and support networks, initially, learning naturally came through a lot of trial and error. Once the chicken enterprise was up and running, the cattle enterprise transitioned into an agistment model, and the focus shifted. Chickens became their core enterprise as they could stay on country throughout difficult periods and having agistment cattle allowed numbers to be easily adjusted according to pasture availability.

> "*We came across some great people that could help us. But like anything, our learning has come out of making a lot of mistakes*" - Sam Pincott (Bellevue)

On Yabtree West, Rebecca originally experimented with Wagyu beef. Running the decision through the holistic decision-making framework, it looked positive. However, it was not until they started that they realised it wasn't such a good fit after all in regard to their time controlled rotational grazing practices and personal ethics. Rebecca recognised the Holistic Management principles of plan, monitor, control, replan, and was able to consider the new 'whole-of-life' perspective and let the

Wagyu enterprise go. Continuing with their breeding enterprise until experiencing drought conditions in 2018, the cattle enterprise shifted to a trading model.

There is also an existing 4.5 ha vineyard on Yabtree West which was managed by the neighboring property owners. After several hard years it was handed back to Rebecca along with the decision about what to with it. Again, using the holistic management decision making framework, a range of scenarios were tested against their Holistic Context. Economically it didn't make great sense to keep it, however, ecologically the block was considered to be a good fire break for the summer months. In addition, the social aspect of being able to learn, engage and share knowledge and wine with the local community was also aligned. The decision was made to keep it with the plan to introduce livestock as a tool to reduce weeds and grass under the vines and add nutrients and mulch through their grazing and manure.

Practices & Management

Cattle and sheep grazing

Good grazing management is important not only for animal welfare but for the regeneration of degraded pastures and soil. All members of the 8 families utilise their training and skills in Holistic Management and manage their pastures and animals using time controlled rotational grazing practices. This includes: moving livestock around a property in a single large herd, mimicking the natural behaviour of hoofed herding animals; shifting the mindset from managing the livestock, to managing the pasture and utilising the livestock as the "tool" to do it; and accounting for the time grazing is occurring on any unit of land. Considering the complexities, the group utilises a range of tools to assist them with their grazing management. This includes Holistic Planned Grazing, RCS Grazing for Profit training and support, KLR Marketing training and MaiaGrazing software. These tools assist the producers to budget their grazing pastures, preventing over- or under-grazing, maintain ground cover, avoid compaction and promote diversity, among many other ecological and animal health benefits

Gill at Bibbaringa uses the MaiaGrazing software program to capture animal, pasture and rainfall information and aid in her decision making and pasture management. At Willowlee, Michael is also using MaiaGrazing for determining his optimum stocking rate by considering rainfall and pasture (Figure 6). Using MaiaGrazing software to provide grazing data in graph format, it offers a great tool for reflecting on past management decisions and for forecasting for the future. Since adopting MaiaGrazing, stock on Willowlee has fluctuated within optimum rates. The drought conditions experienced in 2018 -2019 reduced feed availability and therefore carrying capacity which meant the property had a stocking rate higher than optimum (Figure 7). With this information, Michael was able to adjust the stocking rate to the available pasture carrying capacity by selling stud cattle and avoiding the need to bring feed in and the opportunity cost of irrigating during drought. Stock not sold were sent off-property for agistment, which allowed pastures on Willowlee a 90-day rest period to ensure recovery. Currently, stock numbers at Willowlee are below the optimum, however Michael is happy not pushing the system too hard, as it still remains profitable and allows for a bit more flexibility. He says that this is especially important as stocking numbers within the stud enterprise cannot be adjusted as rapidly as a trading enterprise.

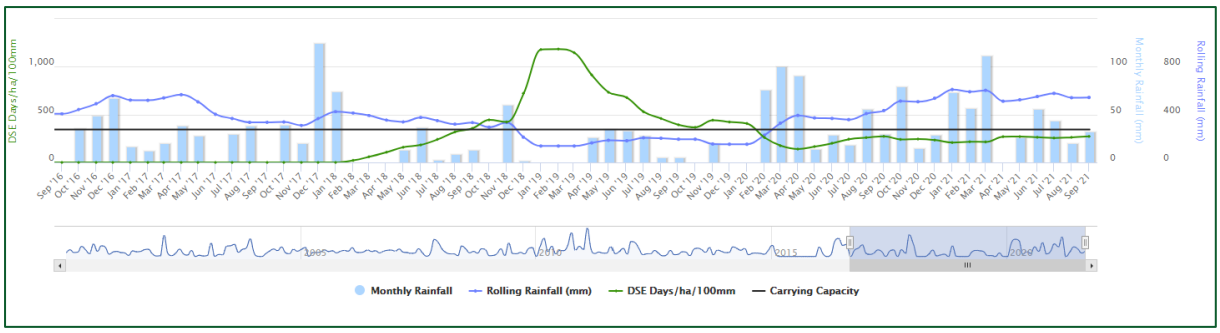

Figure 6: Graphs created through MaiaGrazing software showing stock days per hectare per 100mm rainfall on Willowlee. The blue line indicates the rolling rainfall in millimetres and the green line is the stocking rate in Dry Sheep Equivalent (DSE) days/ha/100mm rainfall. When the green line is above the black line (Carrying Capacity) it indicates where the stocking rate has been above the carrying capacity of the property. Note: the Goodens began using Maia for stocking rates from May 2018.

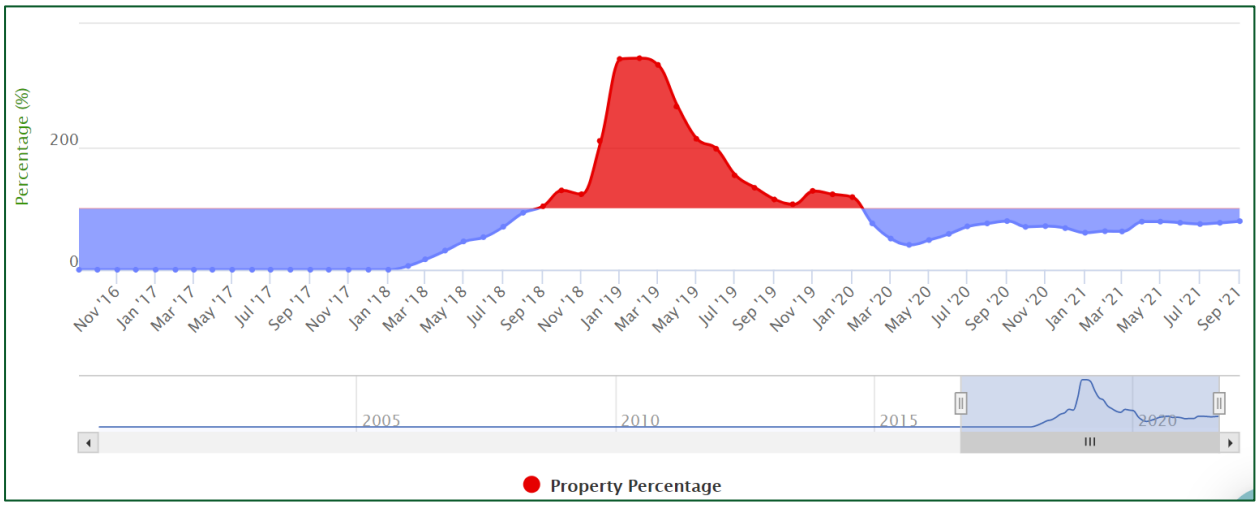

Figure 7: Example of graphs created through MaiaGrazing software showing stocking rates for Willowlee between September 2016 to September 2021 as 'Percentage of Optimal'. From September 2018 to February 2020, stocking rate exceeded the optimal. Note: the Goodens began using Maia for stocking rates from May 2018.

At Mundarlo, stocking rates are variable. However, Nick aims to run around 6000 DSE all year round and use time controlled rotational grazing practices to manage their herd. Recently, they have added sheep trading to the mix and have found that running the two species as a flerd (flock/herd) improved overall grazing coverage, with sheep preferentially grazing the higher ground and cattle the lower areas. Shared access to water points was not an issue either, as the different species drank at different times in the day.

On the neighbouring property Yabtree West, sheep and cattle were originally grazed under the conventional set-stocking regime and upon purchase of the property, Rebecca noted the hillsides had been overworked and in consequence, there was a lot of erosion in the gullies. Since purchasing the property and introducing time controlled rotational grazing principles, Rebecca now uses the cattle to mitigate erosion and regenerate eroded land, showing that it's not the animal that creates the problems, it's the way in which they are managed.

Poultry

On Bellevue, the grazing system incorporates cattle and paddock chickens which are rotated around the property within portable sheds. The chickens are moved to follow the cattle as the shorter, grazed grass is better for the chickens' health, but the chickens also provide a service by producing manure and breaking up and "raking" around the cattle manure. It takes around nine months to complete a full chicken rotation from one end of the property. However, the cattle during this time would have had multiple grazes across those paddocks over those nine months. Recovery periods vary depending on the season and grass growth, which provides the flexibility to be adaptive to conditions. Therefore, grazing management is undertaken by the cattle, and the chickens are providing a fertilisation service. The system needs both the chooks and the cattle; without cattle, the Pincotts would be growing an enormous amount of pasture, and without chooks, they miss out on the additional manure services. Also, tall grass is not ideal for chickens as they will begin burrow down and lay their eggs in the grass rather than in the nesting boxes, which makes finding them impossible. Also, ingesting long pieces of grass can have serious health implications for chickens as it can cause gizzard impaction.

Grazing management in these systems is not always easy. At Bellevue they currently they have 150 dairy heifers on agistment but require a lot more considering the good conditions being experienced. The challenge currently is managing stock numbers to manage pasture for the chooks. Sam is hoping in the long term to get back into owning some livestock at some point. But prices are so high at the moment, it's not ideal.

Sam admits that not every decision has led to the best outcomes. At one-point cattle grazing was low and the chickens started laying eggs out, with a decline in chicken health. The Pincotts made the decision to cut two blocks of the farm for hay, to reduce the grass canopy height. At the time this was the right decision, though longer term it had some negative impacts.

> *"…it really set those two parts of the property well back... We just tried drilling some triticale in last year, just to try and bolster them up. I wished I had done that sooner. ... Maybe doing some basic, organic top fertilizer or something we could have just helped, sped things along. But we're very cash flow short, so it's easy to look back now and sort of think, we could have done that, 'cause we could do it today. But I know at the time, too, that there wasn't necessarily funds in the bank to do that."*- Sam Pincott (Bellevue)

Multispecies cropping for grazing

On Willowlee, Michael has been trialing multispecies cropping for grazing on irrigated areas for a few years with varying levels of success. Michael started off small and worked up to larger areas, sowing directly into existing pasture in a no kill approach. As with all practices however, there needs to be a positive return on investment. This means seed costs must be negated by the additional grazing the crop provides. Michael needs 600DSE days per paddock to make it profitable, which to date has been achieved. Multispecies cropping is something that will continue to be trialed looking further into experimental broadcast application of summer crops and using cattle to trample the seed in.

> *"I always feel good when Gabe Brown sort of says, "Oh, look, the first couple of times you do it, it'll fail." And that was exact- definitely our experience. Um ... We didn't do it that well to start with, but now we're getting a bit better at it"*- Michael Gooden (Willowlee)

Water infrastructure

Each of the producers have put a lot of thought, time and money into their water infrastructure in order to support the reduction in paddock sizes, an important part of the time controlled rotational grazing principles. Gill at Bibbaringa went from having 23 paddocks to over 80, accompanying the reduction in paddock size with extensive grazing planning and record keeping. The Pincotts have redone their entire water system across Bellevue, which includes linking in with the chickens' portable shed system. On Willowlee, upgrades to the water infrastructure developed over time due to the large financial outlay. However, with the experience from setting up a stock watering system on his other property, Michael understood the importance of planning and ensuring the correct flow rate, a core component to a successful system.

For their time controlled rotational grazing system to succeed, the subdivision of paddocks meant water infrastructure upgrades were also a high priority at Yabtree West. The decision to add a whole new water system to the property was in line with Rebecca's Holistic Context and was run through the holistic decision-making framework.

> *"Within our context we want the infrastructure to be simple and easy to use and not a lot of maintenance and mucking around. Because we were kind of in set up phase, we were saying, if we put in a good quality watering system at the very beginning, then that is going to set us up for a smooth operating system for the future". Rebecca Gorman (Yabtree West).*

The decision was made to seek specialist advice to create a good quality and simple watering system to allow for ease of use and low ongoing maintenance.

> *"We got irrigation specialists in because you've have to make sure that the lift and the fall is adequate for the distances that you're covering and the friction of the water in the pipes and the volume of the water, the size of the pipes, so that enough water comes out to fill the hole, to satisfy a whole mob, so a whole mob comes in and they all want water pretty quickly, so it has to have a really good flow rate". Rebecca Gorman (Yabtree West)*

Ecology and outcomes

The 8 families offers a supportive network for members when faced with making decisions to achieve their ecological visions. Over time, many of the members have reported ecosystem health and soil improvements from both visual observation and measured results. The following section presents a synthesis and analysis of supplied data provided by the producers and Landsat satellite imagery produced by the Remote Sensing Centre in the Queensland Department of Science, Information, Technology and Innovation (Queensland Government, 2021 and CSIRO VegMachine®).

For each of the focus farms, we assess data across a chronological timeline incorporating the periods pre- and post-practice innovation and change.

Phase 1 - Before making practice changes
Phase 2 - First stage of practice changes
Phase 3 - Second stage of practice changes
Phase 4 - Now and into the future

Given the complexity of the social ecological systems the 8 families are operating within, we have used an analytical framework to help structure and facilitate the discussion of the available data. This framework incorporates five-landscape dynamics which underpin landscape function; the solar energy cycle, water cycle, nutrient cycle, community dynamics (biodiversity) and the human/social dimension. The first four were derived from Holistic Management (Savory & Butterfield, 2016) and the fifth identified by Charles Massy, (2017). While in this report we will not directly comment on the human social dynamic, it is implicit within each of the other functions the human social dynamic is explored in the 8 families Social Inquiry report. These four cycles are used as they have also been analysed as part of the Ecological Outcome Verification™ (EOV) monitoring. In addition, these four cycles offer accessible, relatable and simple concepts when interpreting a range of data, and for which key measurement and assessment indicators can be chosen to describe and assess ecological system health and function.

> "*We just wanted to work with nature… we wanted to stop putting Band-Aids on things and just improve things once and for all, and just build on that, bank on that improvement every year*"- Sam Pincott (Bellevue)

The four landscape dynamics discussed in this report include;

- **The solar-energy cycle:** Focuses on capturing solar energy via plants (photosynthesis), and converting this energy to sugars using carbon drawn from the atmosphere. It also includes the cycling and storage of carbon in and out of soil, plants, and animals.
- **The water cycle:** Focuses on the cycling of water in the landscape including soil water infiltration, storage and retention, runoff, replenishing water bodies (above and below ground), rainfall, transpiration and evaporation.
- **The soil-mineral cycle:** Focuses on following the cyclical pattern as nutrients move through the various organisms in the landscape both above and below ground. Nutrient cycling and availability in the soil, for plant growth and animal growth and health are crucial concepts. This is tightly linked to the other landscape functions – relying on living organisms, water and energy cycles.
- **Community (ecosystem) dynamics:** Focuses on the biodiversity required for a healthy functioning ecosystem. This includes inter-dependence of the range of species, including symbiotic relationships and a focus on collaboration rather than competition.

Annual rainfall variation

Rainfall data has been gathered from the closest Bureau of Meteorology (BOM) weather station to each of the properties, or, in the instance of Mundarlo, data has been provided by the producer. Rainfall variations from annual mean for each of the focus farms are shown depicting the rainfall surplus or deficit experienced over the management period (
Figure 8). These time periods differ for each of the focus farms.

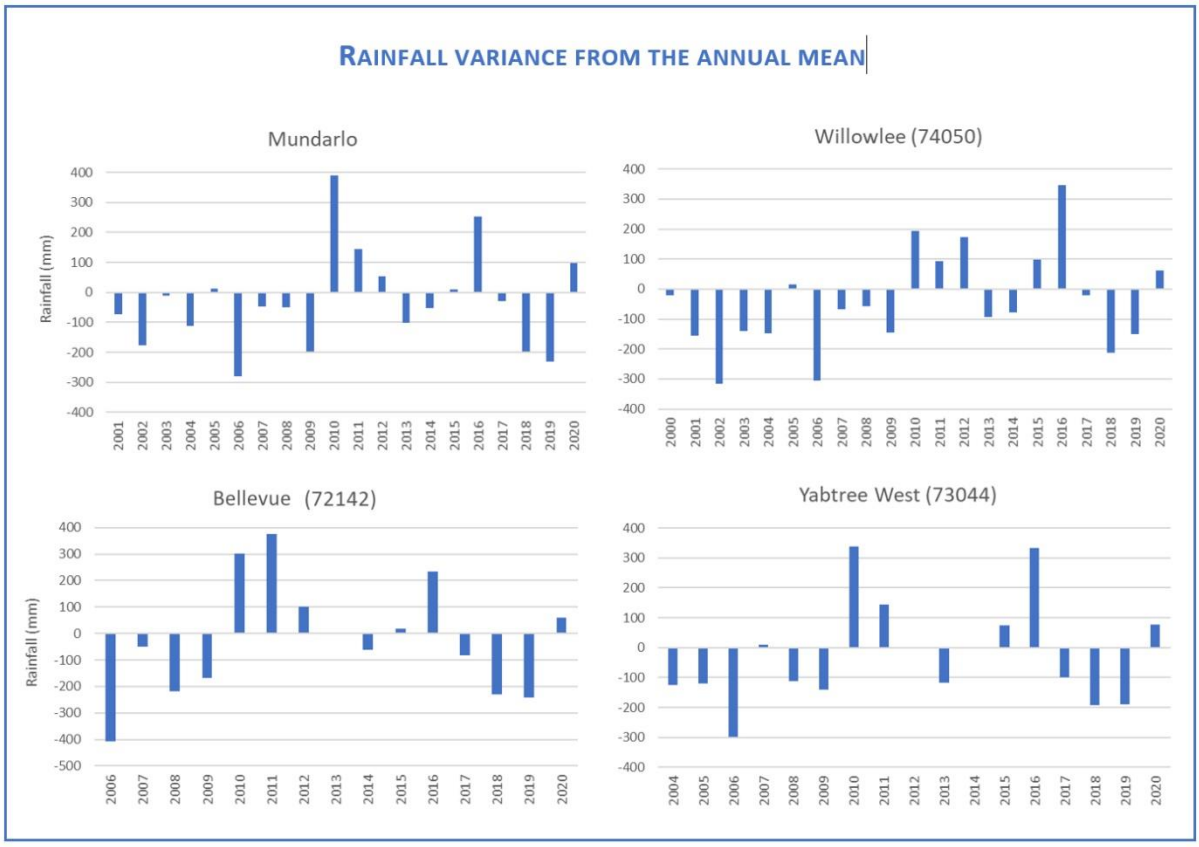

Figure 8: Rainfall variance from the mean for the four focus farms and BOM weather stations in parentheses. Mundarlo rainfall data supplied by producer. Annual average rainfall amount; Mundarlo -570 mm; Willowlee – 457.1 mm; Bellevue – 539.4; and Yabtree West – 570 mm. Rainfall data taken from corresponding BOM weather stations.

Monitoring

To be able to reflect on ecological and other systemic outcomes, the 8 families members have used various methods to monitor their systems. This monitoring has included structured soil monitoring, in-field ecological assessments, laboratory testing and farmer observation. Several members of the group have joined Land to Market which offers annual ecological EOV monitoring. This method assesses ecosystem function using an Ecological Health Index (EHI), where biological indicators for each ecosystem process are measured and scored according to an evaluation matrix that is adapted to each ecological region (eco-region) (Xu et al., 2019).

Ecological Outcomes Monitoring

On Yabtree West, Rebecca has an EOV dataset that spans across multiple years (2018 – 2020) and for the property it is the primary indicator of ecological function. Ecosystem function is scored using the

EOV Ecological Health Index (EHI), which is calibrated to the eco-region and ranges from <0 (Low) to >60 (Very High). Mean EHI values for four consistently monitored paddocks were used below in Figure 9. On Yabtree West, three consecutive years (2017, 2018 and 2019) experienced below average rainfall (
Figure 9) which was reflected in the low EHI scores for years 0 and 1 (2018) and (2019) (
Figure 9a). In year 2 (2020), the EHI index showed an increase from the low EHI range (-15) in 2018 to the high range (+36) in 2020 (
Figure 9a). However, this increase of EHI also corresponds with above annual rainfall experienced within the same year.

Year 2 (2020) also showed landscape function recovery post-drought (
Figure 9b) across all four indices of ecosystem health (water cycle, mineral cycle, energy flow and community dynamics) from baseline (year 0 – 2018) to year 2 (2019). Increases were also seen for three of the four indices from the baseline (year 0 - 2018) (
Figure 9b).

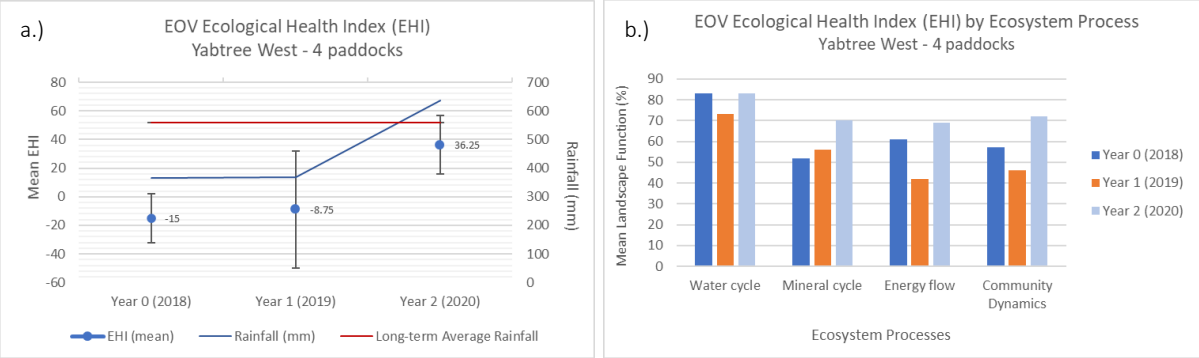

Figure 9: Mean taken across four paddocks on Yabtree West between 2018 (year 0) to 2020 (year 2). Left: Ecological Health Index for Yabtree West. Right: Ecological indicator scores for ecosystem functions (water cycle, mineral cycle, energy flow and community dynamics). Results obtained from Ecological Outcome Verification™ (EOV) provided by Rebecca Gorman. Rainfall data taken from BOM (Wantabadgery station 73044).

Soil monitoring

Other ecological datasets include soil and biological assessments, and include conventional soil chemical and microbial testing for Willowlee (Gooden) and soil chemical tests for Mundarlo (Austin). At Willowlee microbial tests were undertaken in 2020, and the chemical tests were undertaken in 2008 on four paddocks, and in 2020 on another four paddocks. As there were no repeat tests, no time comparison was possible. Further analysis is presented in the soil section below. At Willowlee, Michael has realised the need to have a better focus on what he is measuring. Moving forward Michael plans to use the same laboratory and test.

At Mundarlo, soil chemical tests were undertaken every year from 2012 until 2020. In addition to soil tests and the Baseline EOV monitoring, Nick has been recording photo points every year since 2016 to track change over time (Figure 14). The photos have been taken at the same location at the same time of year (November), this allow for a direct comparison between years. The drought of 2018-2019 is evident in the 2018 and 2019 photos, which indicate lower ground cover with less green growth than the other years.

At Bellevue structured monitoring has not been prioritised.

> *"It's one of my big weaknesses. We've done vague monitoring. I've done soil testing. Just under a conventional program. But I have talked for years about actually doing proper microbial testing and haven't done it. So it's something that I would like to be looking at more. I do a fair bit with a shovel as far as just opening the ground up and seeing what's happening."*
> Sam Pincott (Bellevue)

The solar cycle

The ecological process of photosynthesis can be determined by the amount of ground cover and live canopy abundance that is converting sunlight into sugars via exudates from the plant which feeds the soil microbes and drives nutrient cycling and draw-down of carbon from the atmosphere. Grazing management is a vital tool for maintaining constant ground cover by ensuring the required rest periods, which allow each plant to build energy stores. In addition to grazing management, many of the group have been focusing on increasing perennial species to promote year-round capture of the sun's energy, and building overall pasture diversity to promote and increase nutrient cycling. To complement the observed increases in ground cover, a spatial desktop assessment was completed for the four focus properties. For this report, ground cover was assessed using available data and satellite imagery via the online VegMachine® platform.

Ground cover assessment using VegMachine

Using online mapping software, boundary maps were created for each focus farm along with a 5 km buffer polygon around each property. The online platform VegMachine® was then used to compare ground and fractional cover percentages between a focus farm and its 5 km buffer area. VegMachine® uses local rainfall data and Normalized Difference Vegetation Index (NDVI) imagery to measure the index of plant greenness (photosynthetic activity). Data is derived from the 'fractional cover' product which doesn't distinguish between vegetation layers (i.e., tree canopy to ground cover). Within the 'ground cover' product, the mid and upper layers of vegetation have been removed for the analysis however, the estimate of ground cover is based only on the proportion of ground cover visible from the satellite at that time (Department of Environment and Science, Queensland Government, 2021) The 'ground cover' product was used for three of the four focus farms (Mundarlo, Willowlee and Bellevue). For Yabtree West, the 'Fractional Cover' product was used as it provided a better comparison representation due the land systems found on the property and surrounding area.

Using VegMachine®, the percentage of groundcover was compared between each focus farm and a 5 km buffer area surrounding the property. These comparison products observe total change between two sites simultaneously. Figure 10 presents the mean difference of median ground cover (*Fractional cover for Yabtree West) between the focus farms and 5 km buffer area. Members of the 8 families all have seen visual increases in ground cover since making practice changes on their properties. The spatial mapping results support these observations, showing that all properties maintained higher ground cover than the surrounding 5 km buffer following practice change (Figure 10).

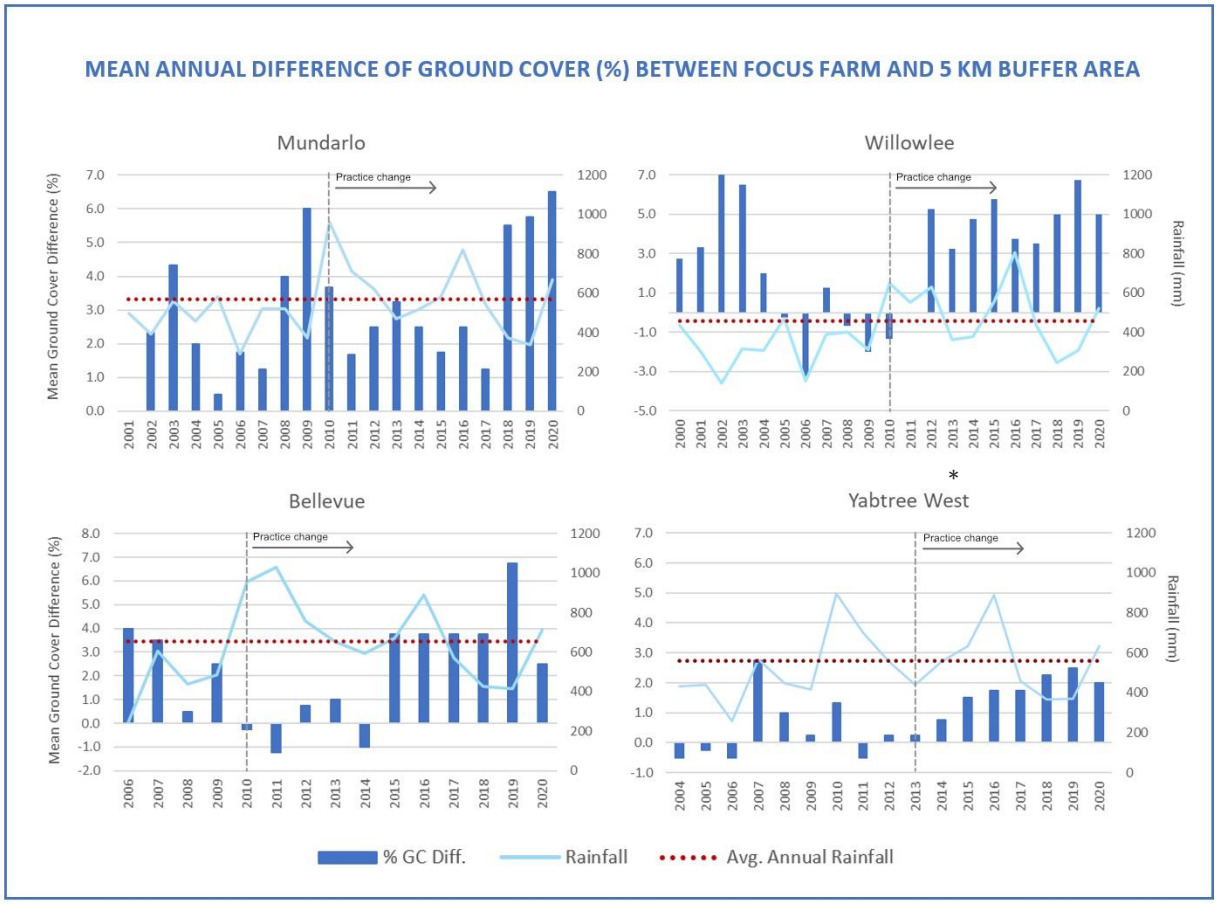

*Figure 10: Median ground cover average difference (*median fractional cover average difference used for Yabtree West), including annual and long-term average rainfall. Mean ground and fractional cover data derived from VegMachine®. Rainfall data taken from corresponding BOM weather stations.*

As climate, land type and management practices are key drivers for ground cover, the comparison tool is a good starting point for comparing management practices between properties where both properties share similar climate and land type. Data presented in
Figure 11 shows a period for each property either 8-10 years before practice change and the same amount of time pre-property acquirement or pre-practice change. Although all focus farms experienced below annual average rainfall throughout the chronological period, all properties maintained a higher greenness index than the 5 km comparison buffer areas since practice change was implemented.

At Willowlee, the vision is "*taking the sunlight through the livestock into the land*". In 2015, Michael began making holistic decisions and since then has maintained more ground cover than the surrounding area regardless of annual rainfall averages (
Figure 11). Satellite imagery data also showed that Willowlee, when compared with the surrounding 5 km buffer, maintained an average of 2.9% more ground cover pre-practice change. This increased to 3.9% more ground cover post-practice change. Willowlee also showed the greatest average difference of ground cover to be highest during the summer period with 6.8% more ground cover than the surrounding area, suggesting the ability to maintain ground cover during the drier periods (
Figure 11). It's expected that the increased ground cover, plant litter and decomposing organic matter would be building topsoil levels and improving soil structure and aeration though root activity and improved soil biology.

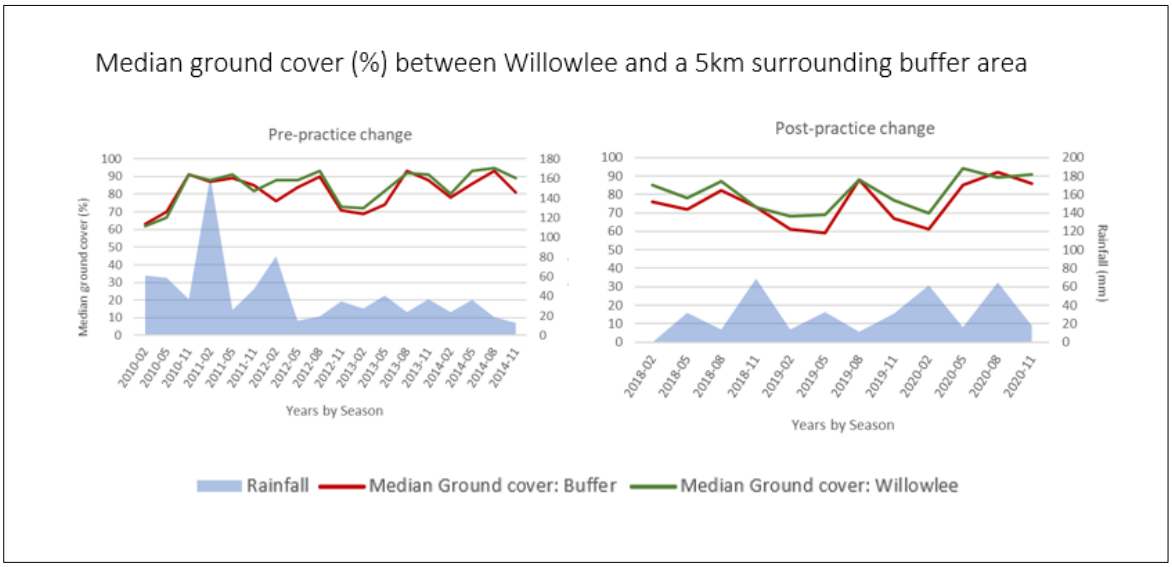

Figure 11: Median ground cover (%) comparisons between Willowlee and the 5 km surrounding area during periods of pre and post-practice change (VegMachine®)

For Mundarlo, ground cover data derived from satellite imagery showed the property had consistently slightly higher ground cover percentages than the surrounding area prior to practice change. Post-practice change, the property maintained a higher percentage of ground cover, especially during periods of rainfall deficit (Figure 12). In addition to satellite imagery, property owner Nick conducted annual biological monitoring between the period 2016-2020. Field data also showed a continual increase in litter cover (Figure 13a) and in 2018, Ecological Outcome Verification (EOV) monitoring data supported Nick's findings, reporting only 2% bare soil with over 62% ground cover and 35% litter cover at the Long-term Monitoring (LTM) site (Figure 13b). In addition, Nick also conducted photo point monitoring to document ground cover each year at a designated point (Figure 14). Images show ground cover between 2016 – 2020. Biological monitoring and photo point data showed a higher amount of bare ground in 2019 which followed three years of below average rainfall. Data suggests Mundarlo also was able to hold on through consecutive dry years, only showing the effects in the third dry year.

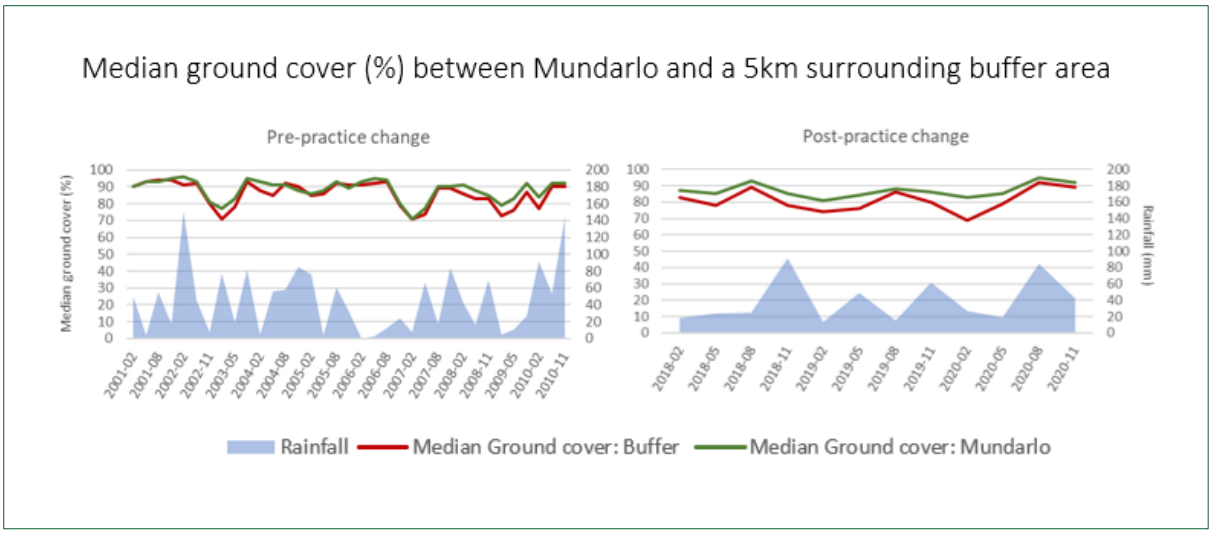

Figure 12: Median ground cover (%) comparisons between Mundarlo and the 5 km surrounding area during periods of pre- and post-practice change (VegMachine®).

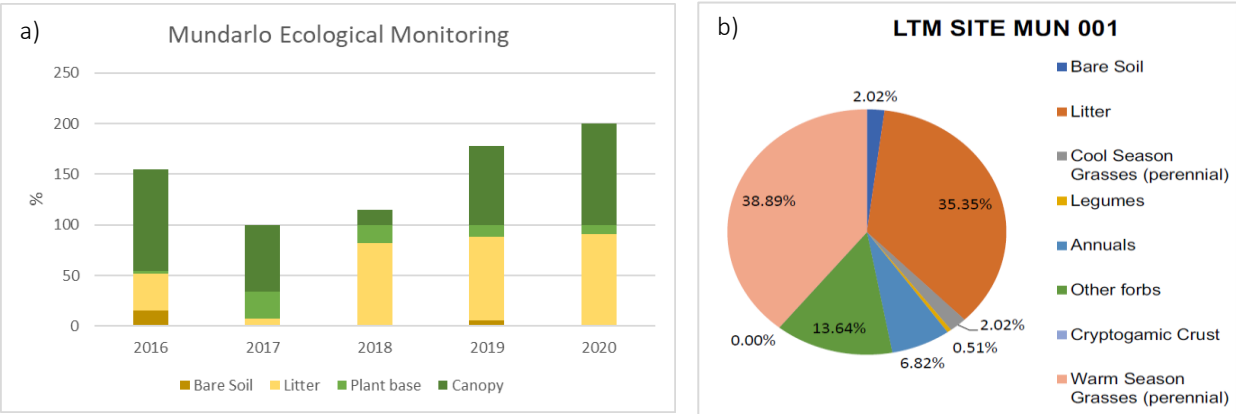

Figure 13: (a) Farmer collected annual biological monitoring data. (b): Ecological Outcomes Verification (EOV) long-term monitoring data from 2018 at site MUN001.

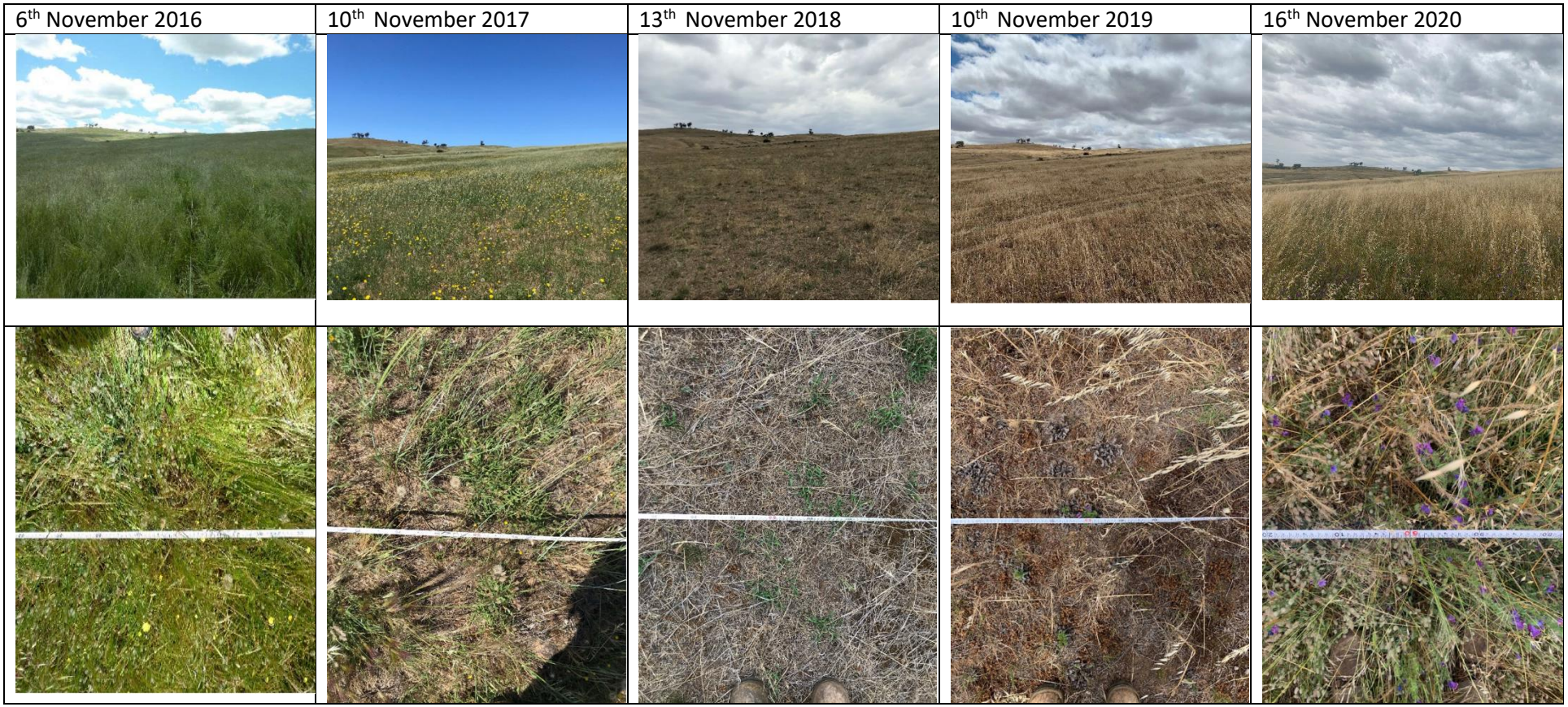

Figure 14: Photo point images taken in November between 2016 - 2020 from Top Hut Paddock on Mundarlo showing (Top) paddock view and (Bottom) ground cover.

For Bellevue, since purchasing the property in 2013 the Pincotts have progressively been increasing ground cover. Within two years of introducing chickens (2015), ground cover increased to higher levels than the surrounding 5 km buffer area despite lower rainfall within this period and the heavy browsing habits of chickens (Figure 15). Interestingly, the difference between Bellevue and the 5 km buffer is at its largest during summer 2019 at the end of three years of rainfall deficit suggesting that management practices have allowed Bellevue to maintain ground cover regardless of dry climatic periods.

> *"The chooks come through and with their scratching habit they till up any dry litter, it's like they're turning the compost. We see a lot of that litter getting tilled up again, we don't get it right all the time.... But if you leave them there too long then it gets bared out. So we try and keep then on the move."* Sam Pincott (Bellevue).

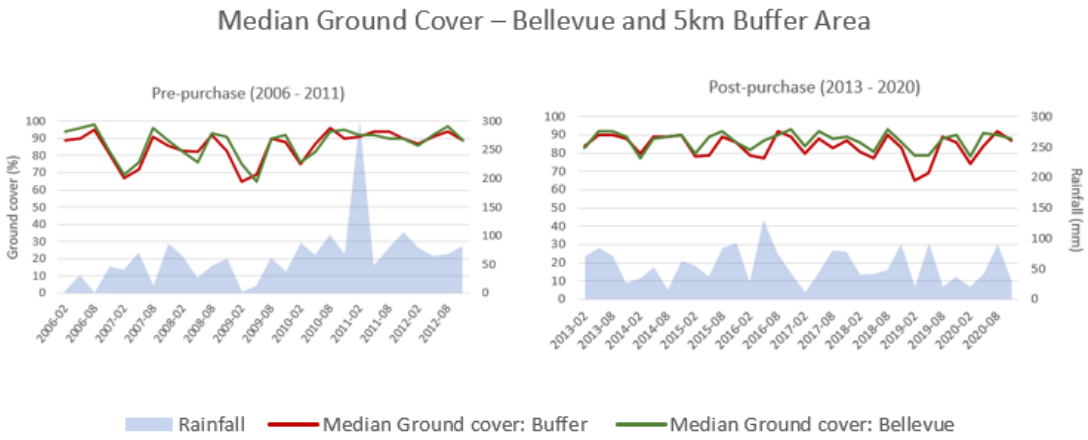

Figure 15: Median ground cover (%) comparisons between Bellevue and the 5 km surrounding area during periods of pre and post-purchase (VegMachine®).

The Fractional Cover analysis tool was used for Yabtree West instead of the Ground Cover tool as it provided a better 'greenness' representation due to the local landscape. Yabtree West sits on the edge of a mountain range, whereas the standard 5km comparison buffer area sits within open alluvial plains. Tree cover on Yabtree West is generally higher than the surrounding area and as ground cover analysis fails to measure canopy cover it may misrepresent total greenness. Since acquirement of the property, fractional cover has consistently remained higher than the surrounding 5 km buffer area (Figure 16).

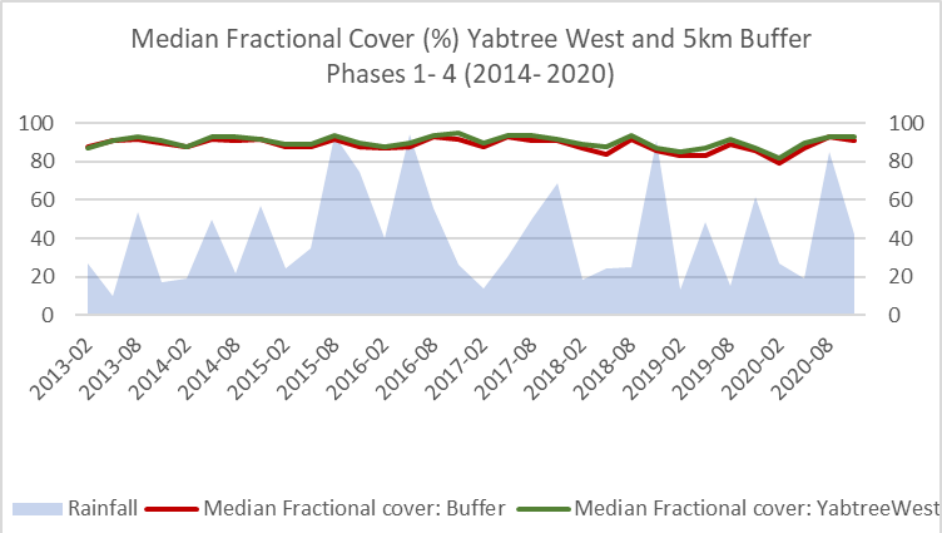

Figure 16: Median Fractional Cover (%) comparisons between Yabtree West and the 5 km surrounding area during periods across all periods (VegMachine®).

As mentioned above, it is important to note that multiple factors such as climate, land type and management practices simultaneously affect levels of ground cover. Spatial data is a useful tool for backdating data, however alone it does not holistically represent the overall health of an ecosystem. For example, ground cover may be showing high percentages, but without knowing actual pasture diversity, there may be inadequate ecosystem function and cycling occurring which will directly relate to nutrient availability, soil compaction rates, erosion etc.

Ground cover resilience during drought and floods

Vegmachine® overlays were also used (Fig. 7) to visualise the ground cover as a timeseries of images for each season since 1990. Overlays were used to provide heat maps of ground cover using a spectrum from Non-Green, Green and Bare (

Figure 17). This allows a seasonal overview of a property, which can isolate ground cover at a paddock scale.

Based on this analysis, one thing that all four producers have in common is greater resilience to drought. This is demonstrated in the heat maps of ground cover during the peak of the recent drought (2018-2019) (Figure 18). As expected, ground cover was reduced on all properties during the drought, however the properties had less bare ground than the surrounding area. At Bellevue the comparison to the surrounding area shows that the Pincotts were able to maintain ground cover even at times when the surrounding area was dominated by bare ground. The heat maps also indicate variability within properties, a result of things such as differing topography, vegetation and grazing management.

Figure 17: These images summarise all ground cover fractions on selected dates. Colours indicate the relative mix of ground cover fractions (Bare, Green (G) and Non-Green (NG) at any point. See this link for a full description. Http://data.auscover.org.au/xwiki/bin/view/Product+pages/Seasonal+Ground+Cover (Source: vegmachine®, 2016)

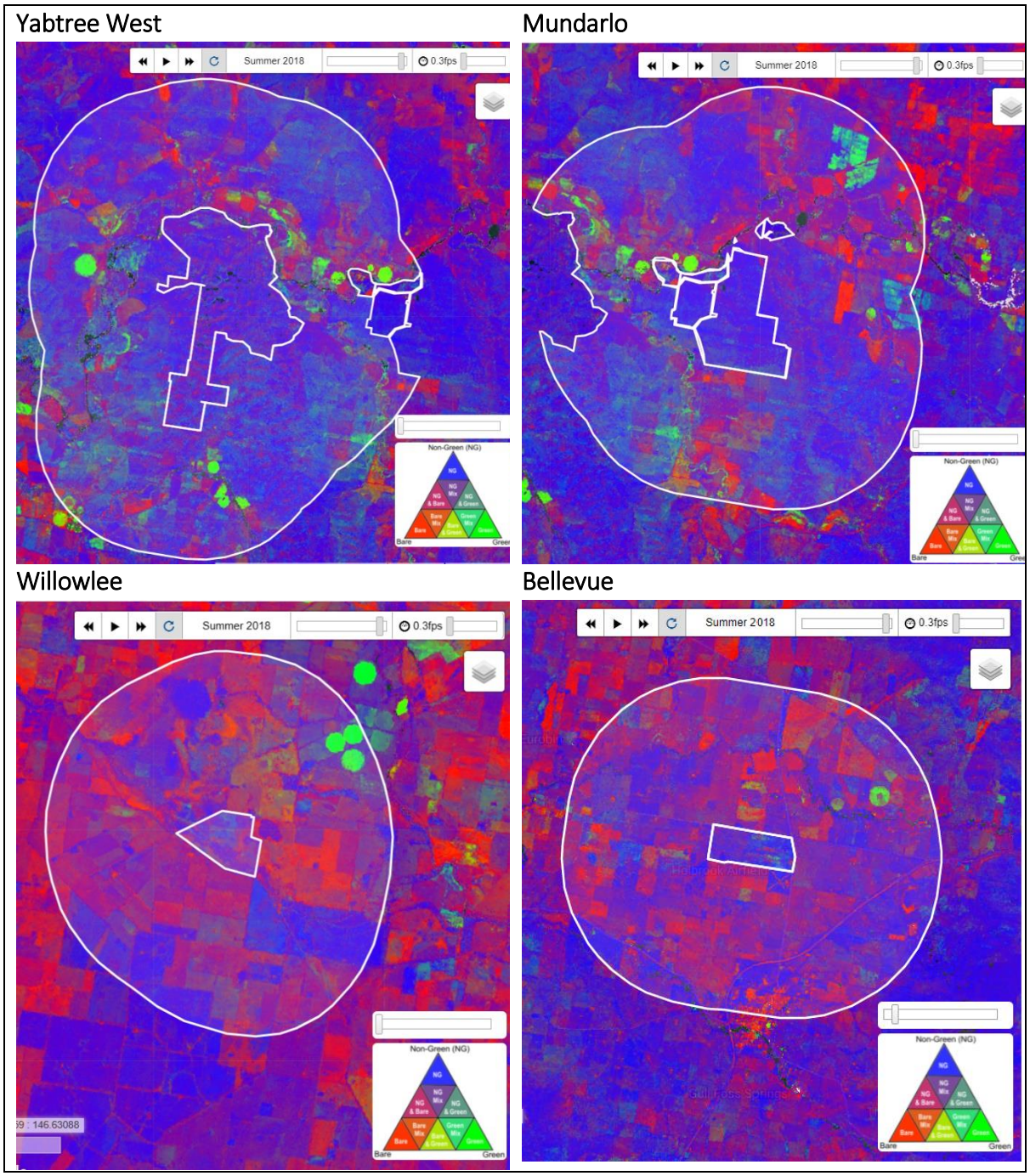

Figure 18: heat map of ground cover over summer 2018- 2019. Ground cover on average was higher during this period than the 5 Km buffer for each property. Created using Vegmachine® 'Ground Cover' layer (CSIRO, Vegmachine®).

The Water cycle

A functioning water cycle requires soils to have the ability to absorb, store and retain rainfall, preventing erosion. Ecological assets which assist the function of the water cycle within a system include maintaining ground cover and litter abundance and decreasing bare soil, soil capping (soil surface hardness) and wind and water erosion. This has been a key focus for members of the 8 families. In particular, the families have focused on slowing water movement across the landscape, preventing soil movement and loss through erosion and increasing the amount of water that can be stored within the soil. Crucial to this is maintaining ground cover, which aids in decompaction and sub-surface health while building the soil's capacity to hold and store water.

> *"You get a summer storm hit…. Every drop of that rain just soaks into our country because we do have that cover, it's just that cover, that top inch is just like a sponge, it just sucks it in" Michael Gooden (Willowlee).*

Slowing the movement of water across the landscape has been important for managing the water cycle at Yabree West. Using a "whole farm planning" system, Rebecca used a combination of Natural Sequence Farming principles such as water contouring and time-controlled rotational grazing cells to improve and maintain groundcover, slow water flow to mediate erosion and manage pasture budgets. In 2020, the EOV monitoring report noted that the water cycle on Yabtree West was improved by the lack of bare soil observed in all but two sites, however across five other sites, evidence of capping and water erosion was present. At Bibbaringa, Gill started implementing Natural Sequence Farming principles in 2014, which included building contours and leaky weirs, and redesigning her dams. This built upon work done in 2007, where waterways were fenced off and over 70,000 trees were planted.

> "*Slowing the flow of water through the landscape. Peter Andrews has taught me a lot. And the results are endless. I see the landscape from a different perspective*" – Gill Sandbrook (Bibbaringa)

At Mundarlo, Nick has also fenced off waterways and planted tree corridors along creek lines and other areas of the property. Nick maintains high ground cover, which has resulted in Nick's observation of improved water quality ("our creeks are running clear"). A large visual difference in water quality can be observed where water from Mundarlo meets water from neighbouring properties, and Nick attributes the difference to his choices and actions (Figure 19).

> *"Humans play an important role in the ecology of the landscape*" – Nick Austin (Mundarlo)

In 2018, Ecological Outcome Verification (EOV) monitoring data reported that the water cycle on Mundarlo was mostly fully functional, and showed little evidence of bare soil or water erosion. Rapid infiltration rates of under 6 minutes demonstrated the soil's fast absorption ability and indicated low soil compaction.

Slowing water in the landscape also can have unintended flow-on implications. As a result of increased ground cover at Mundarlo, Nick is not getting as much runoff into a dam located in a paddock not connected to the water systems. This means that this paddock can only be grazed when water is available. Nick is hoping that, even though there may not be as much runoff, the water stored in the soil will recharge into the creek system and keep the dam filled over a longer period of time. Time will tell if the land system reaches a new equilibrium once the soil has reached maximum moisture.

Figure 19: Garretts creek Junction, left water following form Mundarlo, Right water flowing from neighbouring areas.

The soil-nutrient cycle

The soil-nutrient cycle focuses on the soils ability to move nutrients through the various organisms in the landscape - both above and below ground – via nutrient cycling. A functioning soil-nutrient cycle also unlocks previously bio-unavailable nutrients in the soil, releasing them for plant uptake, growth and health. As with all ecosystem functions, the soil-nutrient cycle is intrinsically linked to the other landscape functions, relying on sunlight, living organisms, water cycles.

Management decisions have been driven by the need to improve soil health, recognising the relationship between the above ground and below ground systems. Many of the farmers within the 8 families have observed changes to their soils under their Holistic Management practices ranging from improved physical soil properties to increases in soil biology such as earthworms. By maintaining ground cover, they are actively rebuilding topsoil, increasing and diversifying root exudates, and increasing the input of organic matter into the system. Furthermore, soil chemical and microbiology laboratory testing has been completed for a few of the focus farms to gain a quantitative understanding of what is happening within the soil.

According to available soils maps, the soils at Willowlee are chromosols, which display a strong texture contrast between surface (A) horizons and subsoil (B) horizons (Figure 2b). A major soil constraint on Willowlee is soil compaction and a heavy clay pan from intense cropping and past management. Current activities on Willowlee that would be assisting in the reduction of soil compaction are increasing the abundance of long rooted perennials and introducing mixed species cover crops with large rhizomes (e.g., tillage radish) that deeply aerate soils.

To better understand the soils at Willowlee, Michael undertook soil sampling and analysis in 2008, 2015, 2018 and 2020. The methods for analysis, timing and the laboratories used have varied over this period, making comparison of the results across years difficult. Further to this, sampling methodology and site selection also varied across sampling periods. The lack of a constant approach to soil testing highlights the gap in knowledge many farmers face when knowing what soil measures are suited to their needs. Michael has recognised the need for consistent monitoring and has made the decision to use the same laboratory to undertake all future soil sampling.

From the available soil tests undertaken at Willowlee, there were only a few measures out of thousands of data points that offered enough data to graph changes over time. Phosphorus and cation exchange capacity (CEC) were the few trend examples that could be explored. From 2008 to 2020 there has been a slight increase in the soil's cation exchange capacity (

Figure 20b). Fertiliser input ceased in 2013 and phosphorous (Colwell) levels in the soil (0-10cm) have declined since 2008 as a result of a reducing phosphorous inputs through fertiliser application (

Figure 20a). Regardless of the decrease in P, Michael has observed strong pasture growth, which is dependent on N and P in the soil and which therefore suggests that natural cycling of phosphorus is occurring. It is important to note that these graphs should be taken with caution because analysis was conducted inconsistently through multiple analytical labs, at different times of the year and at different locations.

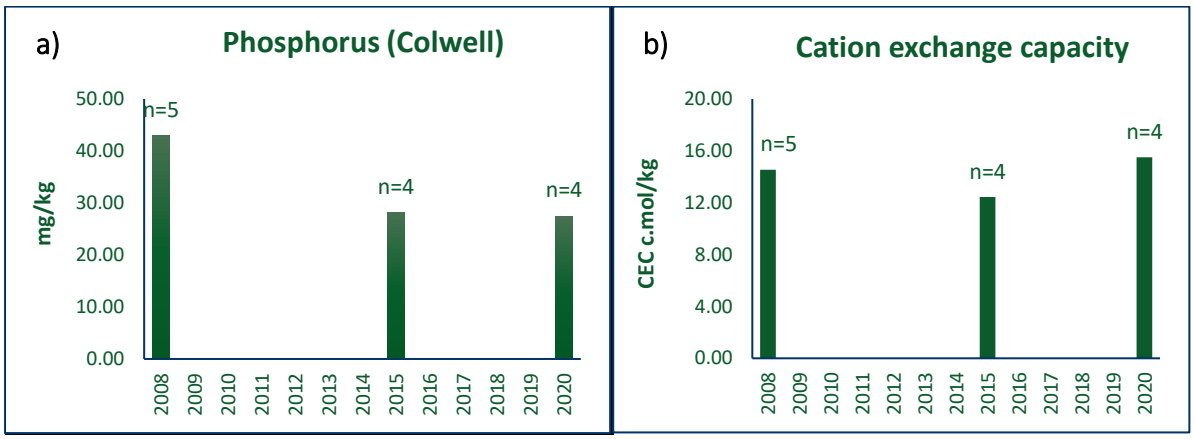

Figure 20: Soil chemical results at Willowlee at three timepoints from 2008 – 2020, n = number of samples per year. a) Phosphorus (Cowell) levels in the top 10cm of the soil at Willowlee b) action exchange capacity in the top 10cm of the soil at Willowlee.

In 2020, Michael started undertaking soil biological monitoring through Microbiology Laboratories Australia. The single point measures must be interpreted with caution, as soil biotic communities can rapidly change in response to environmental conditions such as moisture. Upon observing bacterial groups, Willowlee showed a low bacterial biomass across all groups and a fungal to bacterial ratio which was below optimum levels due to the low bacterial numbers (Figure 21). Results also showed low levels of mycorrhizal fungi.

Michael is using multi species cropping as way to increase above ground diversity to his systems, in the hope that this will also lead to increased soil microbial community diversity, and produce a more balanced F:B ratio. Michael is focusing on getting legumes back into the system, which will increase soil bacterial communities and increase soil nitrogen though the capture of nitrogen from the atmosphere and fixation though bacteria into available nitrogen for plants.

According to Michael, seed sown in the multi species crop at Willowlee is also coated in a biological seed treatment to "*stimulate fungi that growth in the soil".* The way in which the multi species crop is implemented may provide additional benefits for soil biology. Some of the multi species crops have been sown with a Seedhawk machine, which may disturb fungal hyphae. Recognising this, Michael is now exploring broadcast application with no soil disturbance other than the use of cattle to incorporate seed into the soil.

Group	Biomass (mg/kg) Yours	Guide
Total microorganisms	36.4	50.0
Total bacteria	2.5	15.0
Total fungi	33.6	33.8

Microbial indicators	Yours	Guide
Microbial diversity	20.2	80.0
Fungi : Bacteria	13.3	2.3
Bacterial stress	0.3	< 0.5

Key *BDL = Below Detectable Limit (0.001 mg/kg)

Poor Fair Good

Group	Biomass (mg/kg) Yours	Guide
Bacteria		
Pseudomonas	0.343	1.000
Actinomycetes	0.199	1.000
Gram positive	1.240	4.000
Gram negative	1.287	11.000
Methane oxidisers	0.000	0.500
Sulphur reducers	0.000	< 0.005
True anaerobes	0.130	< 0.005
Eukaryotes		
Protozoa	0.188	1.300
Mycorrhizal fungi (including VAM)	2.446	10.000

Figure 21: Biomass of total soil microorganisms, bacteria and fungi in the top 10cm of the soil at Willowlee

Unlike Willowlee, available soil maps for Mundarlo indicated highly variable soil types, including Kandosols, Kurosols, Sodosols, Rudosols and Alluvial Rudosols. Unlike Kandosols, Chromosols and Sodosols, Kurosols lack a strong texture contrast. The difference in soils and the productive capacity of the land has been incorporated into the grazing management of the property. To better understand the soils on Mundarlo, Nick has undertaken annual soil chemical analyses since 2012. Samples have been taken consistently along three transects and the same analytical laboratory has been used each year. Field observations include an increased 'sponginess' of the soil, in other words a softer feel under foot. However, Nick indicated that they have not seen any significant improvements in the soil chemical properties they measure. This does not necessarily mean that there have been no soil health improvements occurring on Mundarlo, but could be indicative that the measures used are not sensitive enough or may not be the best indicator of soil health. From the available soil analysis results, ammonium nitrogen significantly decreased from 2012 to 2014 which corresponds to ceasing nitrogen fertiliser inputs in 2012 (Figure 22a). From 2014, there has been a steady increase in nitrate which indicates that ammonium and nitrite-oxidizing bacteria are present in the soil and are converting ammonia to nitrate (nitrogen cycling) (Figure 22b).

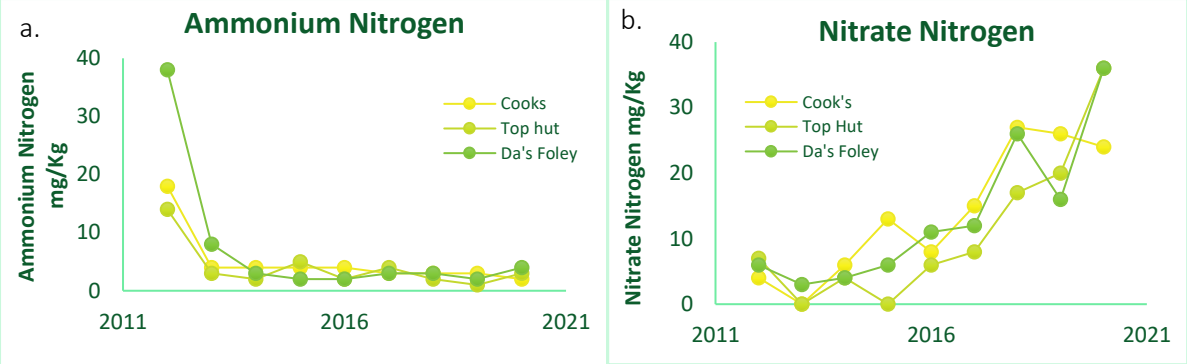

Figure 22: Soil samples taken in the top 0-10 cm at Mundarlo. Left: (a) Ammonium nitorogen mg/kg. Right: (b) Nitrate nitrogen mg/kg.

Soil testing on Mundarlo also included analysis of organic carbon percentages. Data showed that organic carbon levels were declining between 2013 -2015, however since 2016, levels had either increased or remained stable (Figure 23). Since 2019, organic carbon data also showed an increase in variability across the three sampled paddocks. While organic carbon % can provide information on changes in carbon, looking at organic carbon percentages alone may not give a clear indication of soil carbon stores. Conducting bulk density sampling would allow for carbon density or equivalent measures to be calculated, which would provide a better indication of soil organic carbon (SOC) stocks and change over time. As many producers are interested in entering the carbon market to access soil carbon payments, it is important to have a well-designed sampling method over time and to measure bulk density and total carbon levels. In addition, as soil types are variable on Mundarlo, it is important that analysis occurs for each soil type to better understand soil limitations.

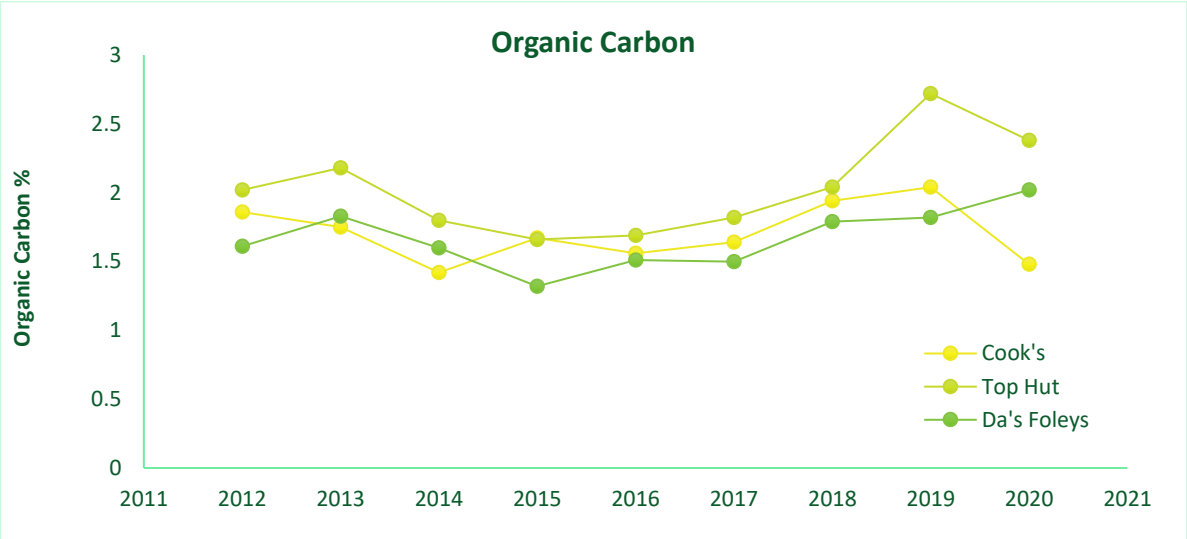

Figure 23: Organic carbon (%) within the top 0-10 cm soil at Mundarlo

In addition to the laboratory soil testing conducted each year, further soil health analysis was completed for Mundarlo though EOV in 2018. A soil health score of 11 was recorded, which was higher than the average (8.2). This soil health score has been calculated based on soil respiration and water extractable carbon and nitrogen. With only a single year of data available, no trends have currently been established, and future testing would need to occur to give an indication of effect of management practices on soil health.

For Yabtree West, available soil maps indicate that the soils are predominantly Kurosols with alluvial rudosols found in the lower areas of the property. Kurosols are soils with strong texture contrasts between A horizons and strongly acid B horizons and many of these soils have some unusual subsoil chemical features (high magnesium, sodium and aluminium). Rudosols are soils with negligible (rudimentary) pedological development, apart from minimal development of a surface (A) horizon (Isbell & the National Committee on Soil and Terrain, 2021). Soil analysis as part of the EOV monitoring provided a higher than average (8.2) reading for the Haney soil health score (Yabtree west 2020 soil health score =14) which is derived from soil respiration and water extractable carbon and nitrogen levels. Long-term soil sampling will increase the ability to demonstrate trends over time and validate management practices such as Natural Sequence Farming and time-controlled rotational grazing management, which will assist nutrient retention by decreasing erosion in the landscape.

On Bellevue, the soils are predominately Sodsols and on the property there has been a long history of management practices which degraded the soil resource. Sodsols are soils with strong texture contrast between A horizons and sodic B horizons which are not strongly acid (Isbell & the National Committee on Soil and Terrain, 2021). Generally, Sodosols have a low-nutrient status and are vulnerable to erosion and dryland salinity if vegetation is removed. This is evident in much of the area around Bellevue, where soil structure is poor as a result of topsoil and organic matter loss through cultivation, or where stock trampling has occurred on wet soils. Localised areas of waterlogging and plough pans are also common on Bellevue (Doughty, 2003).

When the Pincotts purchased Bellevue they knew that the soil was degraded. With the cessation of cropping on the property, soil disturbance was significantly reduced. Then, with the addition of chickens to the system, they saw an instant improvement to the soil health. While chickens' browsing habits disturb the soil, this disturbance is confined to the surface of the soil. The chickens also turn over their own excrement and incorporate this and organic matter into the soil. Sam has observed a large increase in earthworms and other soil macro biota, which not only cycle nutrients, but also improve soil structure and are also a food source for the chickens. To prevent nutrient overload in the soil, the Pincotts use timed rotational practices followed by long recovery periods to manage the chickens' nutrient-dense output.

> "This *allows plants to fully grow and recover and utilize the massive amount of nutrients that we're putting back in the soil*" Sam Pincott (Bellevue).

Community dynamics (Biodiversity)

This section focuses on the biodiversity required for a healthy functioning ecosystem, which includes the inter-dependence of a range of species, including symbiotic relationships and a focus on collaboration rather than competition. Reading the landscape and understanding the ecological parts of a property is vital for maintaining ecosystem function. All of the 8 families members feel that they have been able to improve the biodiversity value of their land and maintain an economically viable enterprise. Increases in the diversity achieved through a range of management practices including revegetation, grazing management and introduction of species on the properties, are having positive impacts on ecosystem heath and assisting in weed management. The following section explores community dynamics by looking at data provided by members of the 8 families.

At Willowlee, managing the different land systems within the property is important to maintain their ecological balance. Paddocks prone to flooding are grazed less intensively with between 110 and 120 day recovery periods. In these areas, Michael has noted an increase in summer active native perennials, wildflowers and orchids, which are now spreading out into other areas of the property and providing a future seed bank. There is also an increase of tree saplings establishing with evident

tree succession occurring along the creek, where there are now trees of multiple ages, including old trees with hollows.

Many of the 8 families members have invested in fencing off waterways and planting trees on their properties. The intention was to improve water conditions within waterways, however this has also provided the additional benefit of increasing floral and faunal biodiversity.

At Bellevue, there have been extensive tree plantings undertaken with support from Bushlinks and Landcare in 2013-2014, which saw a 20-40 m tree and shrub corridor planted along the whole outline of the property (Figure 24). This has not only provided shade for the chickens, but it has also provided an additional food and habitat source for native birds and other faunal species. Wetland areas were also fenced off as part of the 'Bushlinks' project to preserve the wetlands by excluding livestock. This has allowed the grasses and trees a chance to recover and has created a healthier and more resilient ecosystem.

> *"We've done a lot of tree planting through utilising the landcare funding 'Bushlinks program'. That was really good as the property needed it. We want to do that from a biodiversity point of view."* Sam Pincott (Bellevue).

In addition to the active revegetation with the addition of chickens and their manure in the system, there is also a large amount of natural revegetation also occurring (Figure 24).

Figure 24: Regeneration on Bellevue in 2013 (top) and 2019 (bottom) (Source: Livermore H, et al 2019).

Trees are also an important part of the property on Yabtree West. Rebecca's son has collected local seeds and propagates his own plants to plant out across the property. These plantings are seen as something for the future. Rebecca has observed that these plantings and the holistic management practices conducted on Yabtree have led to an increase in biodiversity.

> *"With the long recoveries that we give, the grass is so high that you're now seeing quails nesting in the grasses*." Rebecca Gorman (Yabtree West)

Since changes in the management practices, pasture diversity on Mundarlo has been increasing. Since 2016, Top Hut paddock has shown an increase in pasture species from a single species to four species (Figure 25). While four species doesn't sound like a large increase, it has been enough to maintain a balanced mineral and protein levels so that additional supplements for the sheep and cattle were no longer required. The higher pasture diversity also significantly decreased cases of livestock bloat and dystocia. Dystocia decreases were demonstrated as calving intervention decreased from 50% of the herd to a single heifer per year.

> "*Once we started time-controlled grazing, and allowing plants to recover… we very rarely got bloat. It was just a function of a predominance of lucerne, and not enough choice for the animals to eat, so that they used to get legume bloat, which is a symptom of just too much legume in the pasture*." Nick Austin (Mundarlo).

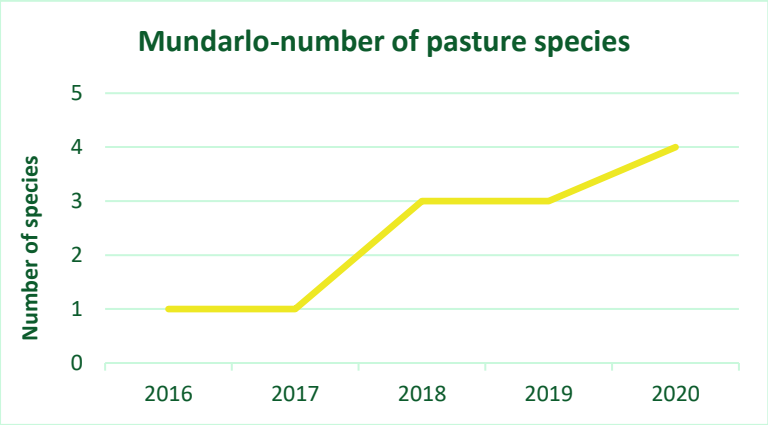

Figure 25: number of pasture species at Mundarlo from 2016 – 2020 in Top Hut paddock.

Through the introduction of chickens on Bellevue, Sam saw a very quick change to the pasture composition. When the property was first purchased there were a lot of weedy species, such as Thistles, Capeweed, Fleabane and Paterson's Curse. By creating the right environment for the desirable grasses, they have now overtaken the weeds and now there is a quality native and sown pasture growing.

> *"Over the first 12 months a lot of the property had fleabane…it's just a short, woody, shrubby weed… Because everything was so neglected and bared out, it grew the first summer. I copped a fair bit of flack behind my back for not spraying it out or doing anything with it. Surprisingly the cattle loved it because at a certain point in its growth cycle, it's really high in protein. So the cattle were busting to get into those paddocks when they could…so very quickly, running chooks over and just leaving those plants there… succession occurred pretty quickly*." Sam Pincott (Bellevue).

Reflecting on the succession from pasture dominated by weeds to biodiverse pasture, Sam indicated that:

> *"If we had our time again, probably there'd be areas we could have just direct drilled some plants into it, to speed up the process that we've gone through. Right now there's just a mess of rye grass, clovers, a lot of Phalarises coming back into the system which is really good, but it's still very annual based. But our Paterson's curse, capeweed, thistles, have all but gone. So we're trending in a really good direction."* Sam Pincott (Bellevue)

On Yabtree West, pasture is slowly diversifying with 5-6 species currently recorded and a gradual decline in weed species. By reducing constant disturbance through time-controlled rotational gazing it allows desirable plants the chance to recover and out compete undesirable species. Grazing management has been a vital tool for speeding up succession.

On Mundarlo, grazing management for weed control has been seen between an area which has been fenced off from grazing and a time-controlled rotationally grazed paddock. Areas that livestock are unable to access have a high density of weeds such as cobblers peg (*Bidens pilosa*) compared with the grazed paddock where grazed cobblers peg is almost non-existent (Figure 26).

Figure 26 cobbles peg (dried sticks) present along fenced off creek. Cobblers peg not present in grazed paddock next to fenced off creek line.

Each of the focus producers have observed flow-on benefits from the grazing decisions in terms of their animal health outcomes and creating nutrient-dense foods. At Bellevue, happy chooks results in high quality eggs, with no hormones or antibiotics used.

> *"The fact that we were moving them and that they had constant access to fresh grass and the bugs and grubs and everything in there, just puts a quality into the egg that we hadn't ever factored in, because it wasn't the key driver to begin with*." Sam Pincott (Bellevue)

Although creating nutrient-dense foods was not initially a driver for Sam, it highlights the interconnected, flow-on and feedback cycles that are associated with many of the decisions made by the 8 families farmers.

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