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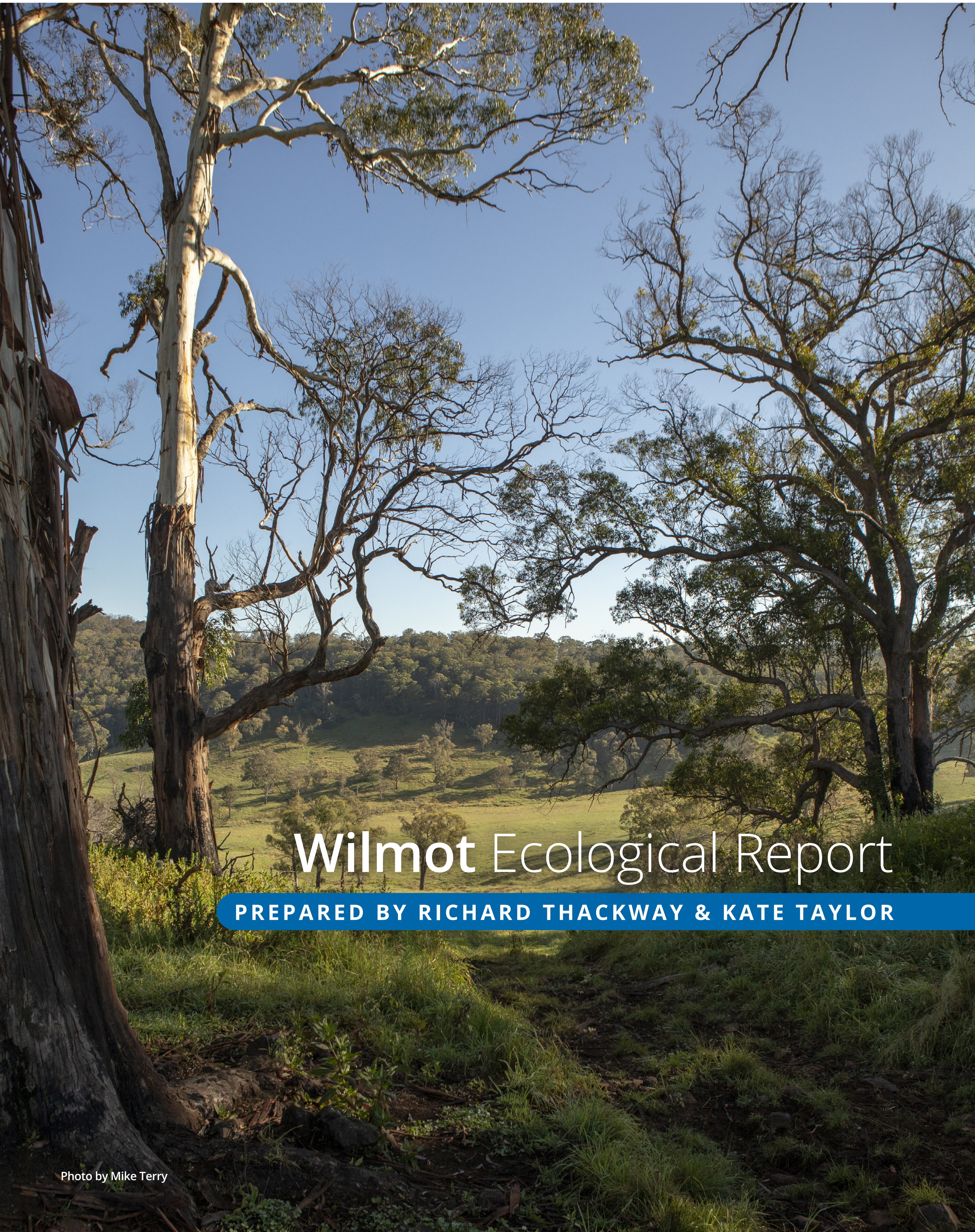

Wilmot Ecological Report

PREPARED BY RICHARD THACKWAY & KATE TAYLOR

Photo by Mike Terry

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Table 1: A chronology of land management practices and qualitative ecological response functions between 2001 – 2020 12

Case Study	Summary		
Enterprise type	Beef Cattle Carbon Farming	**Location**	Approximately 10 km northeast of Ebor, NSW. 30°19'23.92"S, 152°24'13.74"E (Google earth)
Property Size	1854ha	**Annual Rainfall**	1180mm
Soil Type	Uniform earths and loams (Kandosols), texture-contrast non-sodic soils (Chromosols), non-texture contrast structured (Dermosols) and iron-rich (Ferrosols) soils.	**Elevation**	1080m -1270m
Agro-Climatic region	Temperate Cool Season Wet		
Social Structure	Trades as 'Wilmot Cattle Company', with remote owner (Alasdair MacLeod) and on-site General Manager (Stuart Austin).		
Motivation for change	Avoid land degradation associated with rainfall uncertainty and onset of droughts under set stocking or conventional grazing.		
Innovations	Converted from set stocking under conventional grazing practices to holistic management and time controlled rotational grazing practices. Grazed land is now also under carbon farming regime.		

Key findings

- In 2012, the Wilmot Cattle Company began time controlled rotational grazing trials which transformed the ecological outcomes on Wilmot.
- Paddock numbers have almost doubled between 2008 and 2020.
- Cattle run in larger herds, within smaller paddocks for shorter periods and combined with longer recovery times has increased overall ground cover, biomass, plant vigour and Soil Organic Carbon (SOC) while overall cattle production also increased.
- SOC increased from 2011 to 2019 with some paddocks showing an increase of up to 1.5 %.
- Overall landscape resilience to severe climate events such as fires and floods has increased.
- Overall ground cover has increased, even in times of rainfall deficit and is much higher than surrounding area (10 km radius).

[1] A soil landscape is a soil mapping unit that integrates soil and topographic features so the map can be viewed in terms of soil and land qualities and limitations.

Introduction

Wilmot is a 1854 ha cattle property which sits on the Great Dividing Range near the town of Ebor on the Northern Tablelands of New South Wales. Situated at approximately 1200 m on tertiary basalts in the east, and sedimentary argillite in the west, the district has had a long history of grazing dating back to the mid-1800s (Appendix A). Wilmot is situated on the eastern edge of the New England Tableland bioregion, with the gorge of the Guy Fawkes River National Park to the west (Figure 1). The National Park supports both woodlands (characteristic of the central and western sides of the Tablelands) and Dry Sclerophyll Forest. Located on the western edge of the Ebor Plateau, the Wilmot property is within the 'Temperate Cool Season Wet' Agroclimatic region and is contiguous with the Dorrigo plateau. The environment and landscapes of Wilmot and the surrounding Ebor basalts is described by Mitchell (2002) as:

"Hilly benched plateau with deeply dissected margin formed on Tertiary basalt with minor trachyte. General elevation 1200 to 1500m, local relief 150m. Highest and steepest above the Great Escarpment with 2000mm rainfall. Stony profiles on trachyte. Waterlogged clayey peat in some valleys. Snow gum (*Eucalyptus pauciflora*), black sallee (*Eucalyptus stellulata*) woodland with New England peppermint (*Eucalyptus cinerea*), messmate (*Eucalyptus obliqua*), manna gum (*Eucalyptus viminalis*), shining gum (*Eucalyptus nitens*), and brown barrel (*Eucalyptus fastigata*). Sphagnum (*Sphagnum cristatum*) peat, New England mallee ash (*Eucalyptus approximans*) heaths on siliceous soils".

In the late 1990s, Wilmot was run as three separate cattle properties (Maida Vale, Willows and Wilmot), with each managed for beef cattle production using conventional set-stocking practices. In early 2001, the three properties were aggregated into a single property and named 'Wilmot'. In 2008, Wilmot was purchased by the Wilmot Cattle Company. Across the three properties there is a mix of breeding, trading, and 100% natural grass finishing.

Wilmot, like any grazing enterprise relies on rainfall, which is a strong driver of seasonal and annual pasture production. On Wilmot, there is a strong rainfall gradient north to south; 1524 mm in the east, 1270 mm in the centre and 1143 mm in the west. However, Wilmot uses the average annual rainfall records from the central portion of the property (Willows - 1180 mm) and is used for grazing management purposes. The closest Bureau of Meteorology (BOM) weather station is Ebor (The Racecourse) which is approximately 4.3 km from Wilmot and provides a near-complete daily rainfall record from 1928 to 2021 (BOM, n.d.). Average annual rainfall from this weather station is 1243.2 mm which is a difference of 63 mm. Local rainfall data collected on Wilmot (Willows) differs when compared to records from Ebor (The Racecourse) and can be seen in Figure 2. Annual rainfall patterns for Wilmot are strongly summer and early autumn dominated (Figure 3). Additional rainfall information including annual and seasonal anomalies and modelled rainfall (5km x 5km) from 1901 to 2021 are presented in Appendix B, Figures. 1b – 6b. While there are obvious similarities between the actual and modelled rainfall records, differences reflect localised storms and drier periods that have directly affected Wilmot.

Photo by Mike Terry

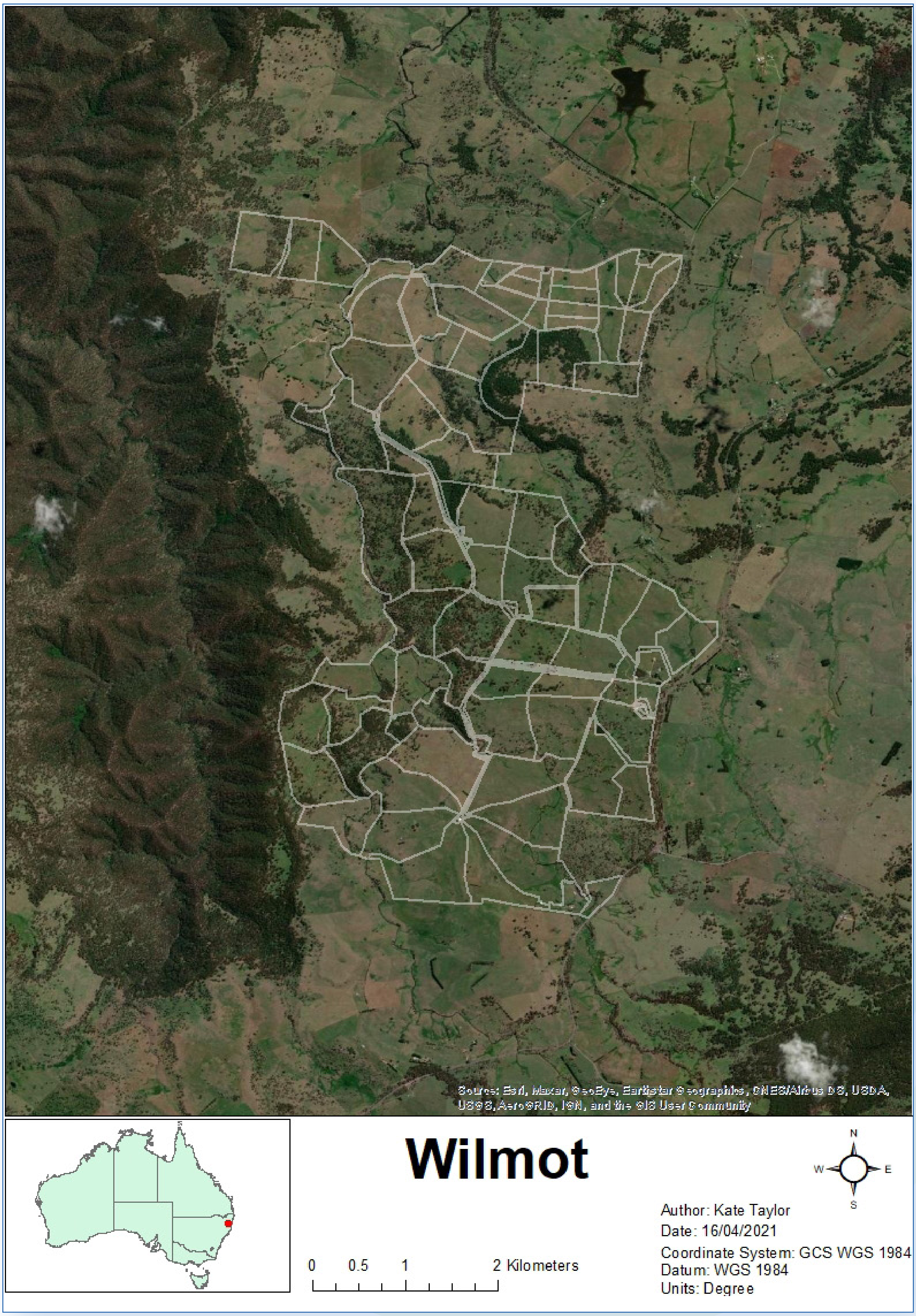

Figure 1: Wilmot is located to the east of Guy Fawkes River National Park on the Ebor Plateau. Map also shows connectivity of forested areas throughout the property.

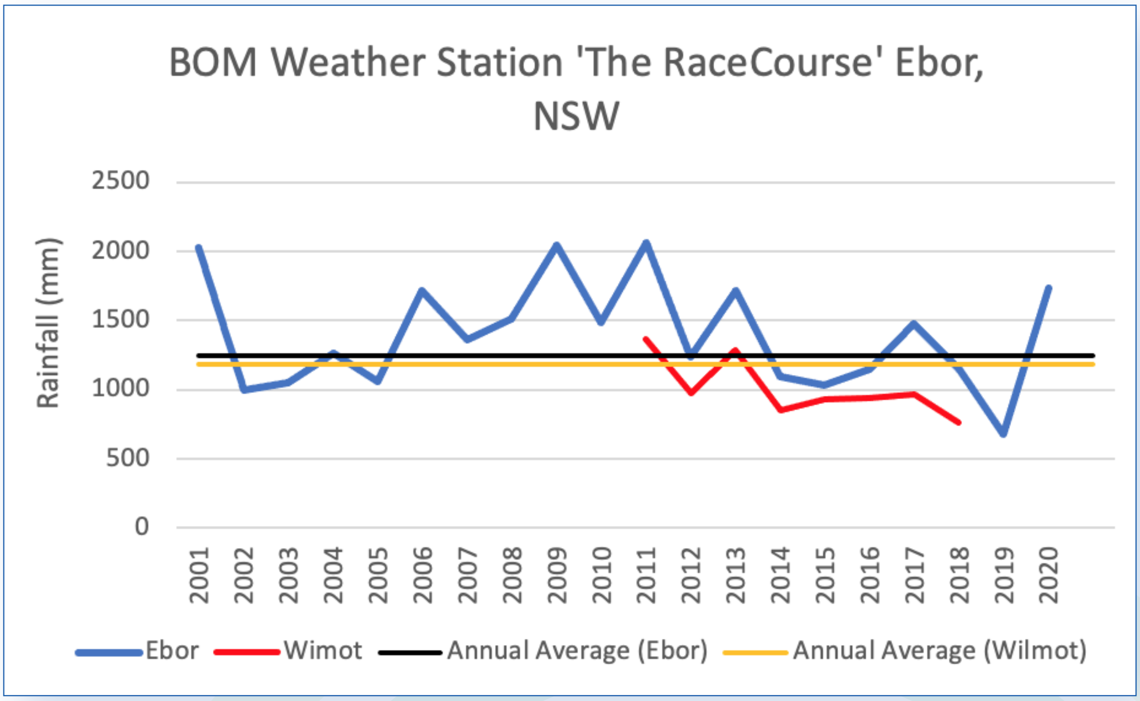

Figure 2: Annual rainfall taken from Bureau of Meteorology (BOM) weather station 59019 Ebor (The Racecourse) located approximately 4.3 km from Wilmot compared to available local rainfall data between 2011 – 2018 from Wilmot (Willows). Red line indicates average annual rainfall for the centre of Wilmot at 1270 mm (Source: Bureau of Meteorology, n.d.; Regen Network, 2020).

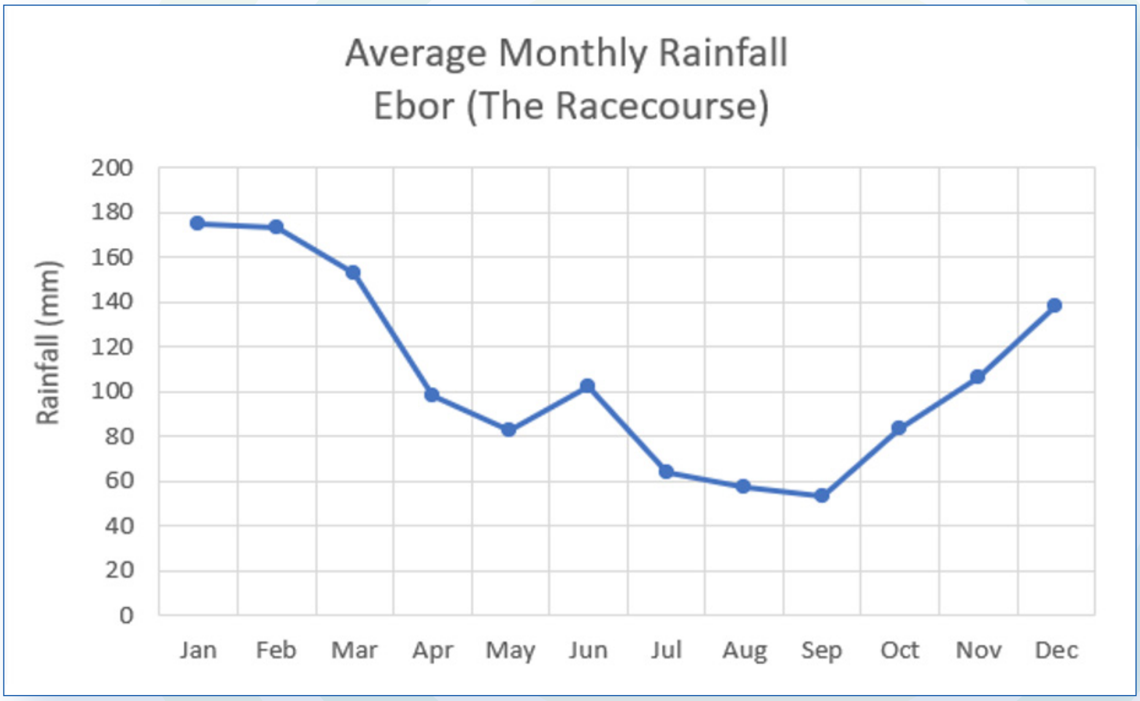

Figure 3: Annual average rainfall data from Bureau of Meteorology (BOM) weather station 59019 Ebor (The Racecourse) located approximately 4.3 km from Wilmot (Source: Bureau of Meteorology).

History of landscape transformation

Most of the original wooded vegetation including open woodlands and forests found on the surrounding Ebor basalts were cleared and converted to native pastures in the late 1800s. Together with non-woody vegetation including grasslands and swamps, these modified grasslands formed the native pastures of the Ebor district until the 1950s. At this time, suitable slopes and soils were ploughed and sown for potato production. Today, Wilmot has good woodland connectivity across the property which is defined as gaps of woody vegetation being <100 m apart (Appendix C). In recent years, revegetation plantings were conducted on Wilmot where 20,000 locally indigenous eucalypt and acacia tree species were added to the property.

Pasture improvement began in the 1960s, which is a process of converting and replacing native pastures with exotic grasses and herbs. Superphosphate was extensively used to establish and maintain these improved pastures. On Wilmot, applications of superphosphate ceased, and since late 2019, no synthetic fertilisers have been applied to pastures. Today most of Wilmot is improved pasture, except for the steeper slopes and ridges where the native pasture ground cover has been retained under the remnant woodland and forest.

When Wilmot was purchased by the Wilmot Cattle Company in 2008, the property was made up of a small number of large sized paddocks (Figure 4). The average paddock size was 46.9 ha (largest paddock size 168.8 ha and the smallest 3.12 ha). Between 2013-20, paddocks were sub-divided and as of 2021, the average paddock size decreased to 25 ha. Current managers, Stuart Austin and Trisha Cowley, have managed Wilmot since 2016 and they both have a wholehearted belief in regenerative landscape management and the benefits it brings to the beef industry. At Wilmot they are collectively working to heal what had largely become a degraded landscape (Regen Network, n.d).

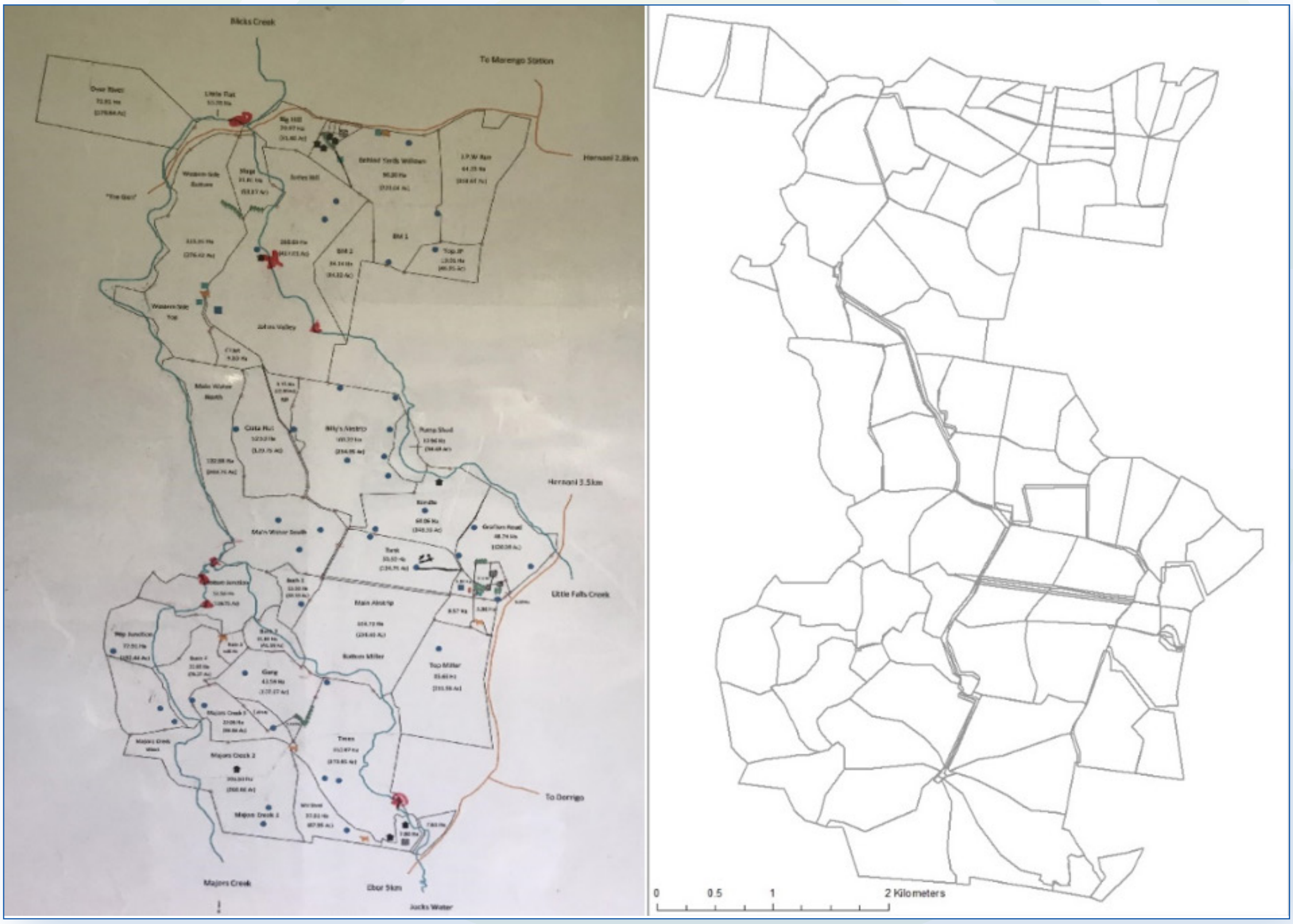

Figure 4: Paddock map for Wilmot circa 2009 (left) and 2020 (right) showing paddocks subdivisions.

Holistic management & time controlled rotational grazing

Between 2001-2009 and within the period of the Millennium Drought, the current Wilmot landowner Alasdair MacLeod had concerns over the effects of overgrazing in south-eastern Australia and began exploring ideas on his family property near Yass around regenerative agriculture based around time controlled rotational grazing. This grazing method is based on mirroring natural herding behaviours of herbivorous species (i.e., livestock) and matches stock numbers to pasture availability and allows short, high density periods of grazing per paddock followed by long rest periods allowing pasture time to recover (Regen Network, 2020). When implemented successfully, the ecological responses include increases in groundcover, biomass, plant diversity, animal and plant nutrition, soil health, water infiltration and SOC. In 2012, a small-scale trial was initiated on Wilmot involving the subdivision of large-sized paddocks, increasing stock densities and intensively grazing for time controlled periods followed with the required period of rest. The positive outcomes from this trial became the catalyst for changes to management practices on Wilmot with the objective of building greater resilience for future climatic variations. The difference to pasture and ground cover between set-stocking and time controlled holistic rotational grazing can be seen in Figure 5 below.

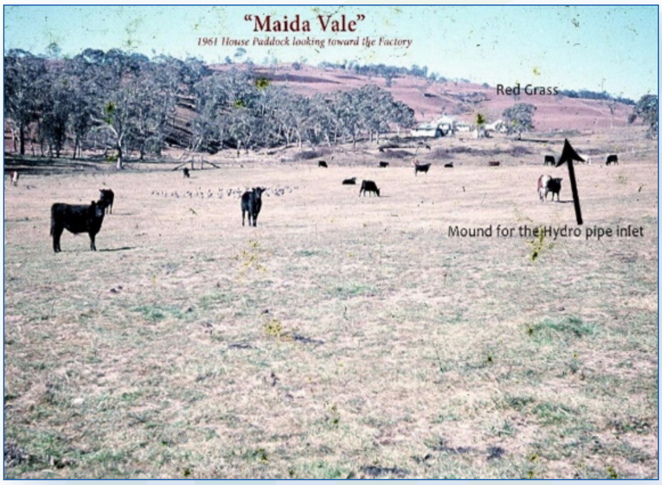

Figure 5: Left: House Paddock (now called 'Trees 1') looking toward the old [potato] factory. Pastures in the foreground are set stocked (Photograph courtesy of Graham MacDougall dated 8 April 1961) Right: same location with pastures in the foreground managed using time controlled rotational grazing. Photograph courtesy of Stuart Austin dated 30 July 2020.

Fundamental to holistic management and time controlled rotational grazing was the development of a planned and regenerative approach to cattle grazing. Initially in 2011-15, hardcopy grazing charts were used to assist the land manager to plan stocking rates based on paddock feed availability several months in advance using the 12 month rolling rainfall data. This approach focuses on soil health and pastures being the land managers assets as opposed to the livestock in conventional thinking. Late 2013 saw conventional set stocking practices cease and the transition to time controlled rotational grazing practices were well underway by late 2014. The process of converting to time controlled rotational grazing involved decreasing paddock sizes to enable effective grazing at a controllable density, establishing reticulated water points, aggregating small herds into larger herds and integrated monitoring of the condition of the pastures, soil and livestock.

In 2016, Wilmot converted from using hardcopy grazing charts to electronic versions via MaiaGrazing as their key grazing management tool after being involved in system testing for the developers Maia Technology and Resource Consulting Services in previous years. The MaiaGrazing software integrates the land managers current observations with other ancillary data, including monthly and seasonal rainfall patterns and pasture information to match grazing intensity with rainfall and pasture growth. MaiaGrazing enables the land manager to ensure that the stocking rate does not exceed carrying capacity by carrying seasonal data forward and setting an annual farm budget for livestock and grass.

MaiaGrazing is a sophisticated stock management system with a suite of best practice grazing techniques designed to make grazing businesses more profitable, resilient and therefore, less prone to drought. A screenshot of Wilmot's grazing chart showing rainfall, rolling rainfall, stocking rates and forecast stocking rates can be seen below in Figure 6.

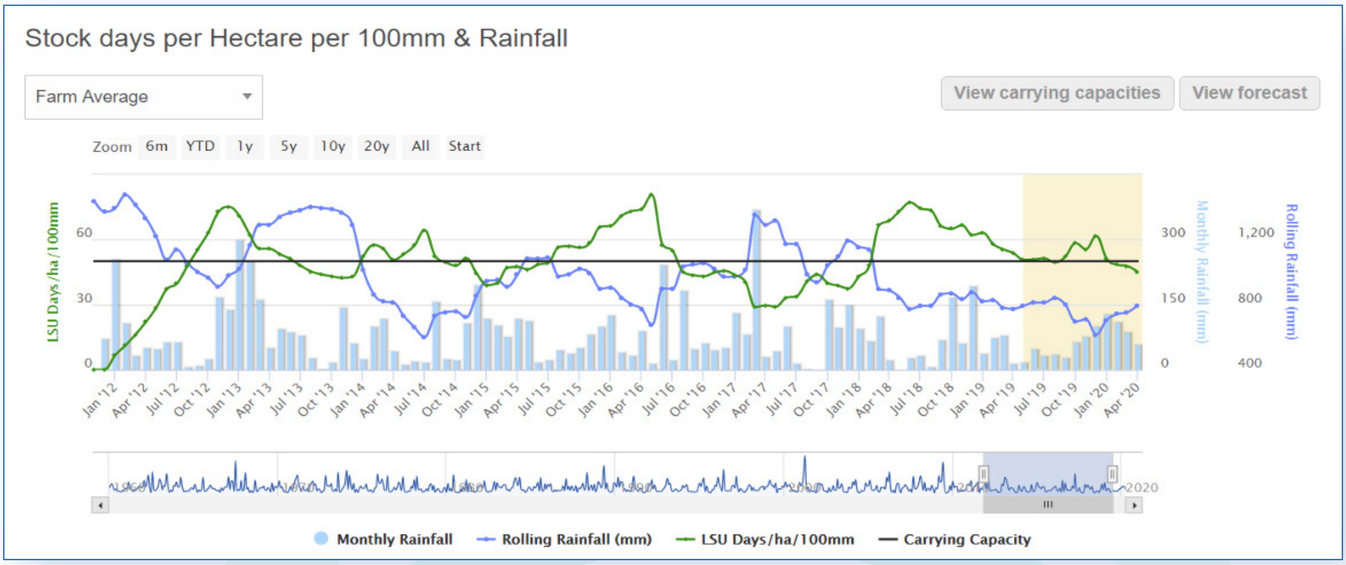

Figure 6: Graph generated from MaiaGrazing showing the actual monthly rainfall recorded on Wilmot, the 12-month rolling rainfall data generating the predicted Large Stock Unit (LSU) days per hectare able to be run in relation to rainfall per 100 mm. Carrying capacity is also provided (Source: MaiaGrazing)

Soil Testing

Historic soil test records taken from the Ebor district in 1960 recorded Soil Organic Carbon (SOC) levels to be at 6%. In 2011, baseline soil testing sites were created on Wilmot to assess change and trend in macro-nutrients and SOC over time. During the reported monitoring period (2011 and 2019), the number of sites ranged between 2 – 9 with a minimum of 3 sub-samples collected per site. Only two sites were sampled in 2011, therefore due to data insufficiency, 2011 was not included within this report. A standardised method was used to collect the topsoil samples at each site to a depth of 15 cm and soil laboratory analyses were independently provided by Southern Cross University (NATA and ASPAC accredited). Over time, SOC levels improved from baseline levels (Figure 7) and it was with these reported changes and trends in SOC which assisted the Wilmot Cattle Company to sell carbon credits to Microsoft Corporation Pty. Ltd. Further to the measures initial measures of SOC collected by Wilmot Cattle Company, Wilmot Cattle Company joined the private carbon market through 'Carbon Link' who added an additional 150 soil testing monitoring sites to Wilmot's existing nine sites. Core samples have now been taken from 159 sites using the Carbon Link SOC monitoring method which saw the monitoring depth increase from 15 cm to ~ 1 m depth. Continuing surveys will provide ongoing evidence of carbon sequestration on Wilmot.

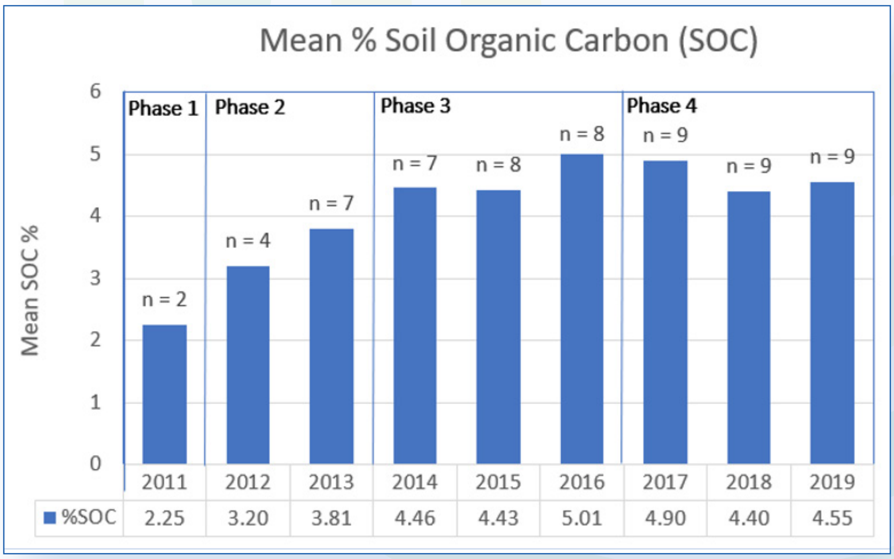

Figure 7: Mean percent of Soil Organic Carbon (SOC) from 2012 – 2019 showing the number of sites sampled per year (n) in each phase. As soil testing only commenced during Phase 1, SOC data during this period was insufficient and not included (data source: data collected by Wilmot Cattle Company and reported in Regen network 2020).

Agricultural Management Practices & Ecological Response Functions

CHRONOLOGY OF LAND MANAGEMENT REGIMES AND NATURAL EVENTS

The generation of a systematic chronology of land management practices, and the ecological responses to those practices, was done using expert elicitation (Thackway and Freudenberger, 2016; Hemming, et al., 2018). This involved the Soils for Life (SFL) Ecologist working with the Wilmot manager, Stuart Austin to collate and compile a chronology of land management regimes and natural events for Wilmot and the effects these had on ecological functions. The chronology summarises how the dominant land types have changed and been managed over time for the key agricultural enterprises (Appendix A) and seeks to document land management regimes before, during and after the adoption of regenerative management regimes and practices. The duration of land management regimes and natural events were recorded either by season, single or multiple year periods. Stuart Austin also recorded observations regarding how these land management regimes, combined with natural events, effected ecological response functions. These observations assisted in generating and interpreting the ecological response functions that were deliberately or inadvertently affected by these land management regimes and natural events.

ECOLOGICAL RESPONSE FUNCTIONS

Landscape responses to land management practices are documented using ten ecological criteria. The process of visually representing these ecological functions elicits the land manager's expert knowledge of changes and trends in ecological function and links this with their land management over time. The land manager is asked to provide a score for the ecological state of the property when it was first acquired, when changes to land management practices commenced and where they are now. The score is given between 0 (no function) and 1 (total or fully effective function). For this report, scoring was provided by Wilmot Manager, Stuart Austin. The 10 ecological criteria are as follows:

A. Resilience of landscape to natural disturbances
B. Status of soil nutrients – including soil carbon
C. Status of soil hydrology
D. Status of soil biology
E. Status of soil physical properties
F. Status of plant reproductive potential
G. Status of tree and shrub structural diversity and health
H. Status of grass and herb structure- Ground cover
I. Status of tree and shrub species richness and functional traits
J. Status of grass and herb species richness and functional traits

Phases of agricultural practice

The land management chronology (Table 1 & Appendix A) and the ten graphically represented qualitative ecological response functions are synthesised and interpreted according to the following guidelines which are based on the conceptual model outlined by Thackway and Gardiner (2019).

Phase 1 – Conventional agriculture production systems

Phase 2 – Initial trialling of regenerative management regimes production systems

Phase 3 – Upscaling of regenerative management production systems

Phase 4 – Whole farm regenerative management production systems

Table 1: A chronology of land management practices and qualitative ecological response functions between 2001 - 2020

Period	Practices
Phase 1: 2001-11	Wilmot was established as an aggregate property from three smaller grazing properties – now known as 'Wilmot' - was purchased by the Wilmot Cattle Company. Conventional grazing practices such as set stocking and regular applications of superphosphate fertiliser were used during this phase. Baseline soil monitoring sites were created and soil testing to 15cm commenced.
Phase 2: 2012-13	Conventional grazing practices continued with set stocking and fertiliser use still occurring across most of the property. Small-scale trials using holistic time controlled rotational grazing practices commenced during this phase. By the end of this phase, the use of superphosphate fertiliser ceased across the entire property, as did other chemical applications except for occasional spraying of blackberries.
Phase 3: 2014-16	Upscaling of holistic time controlled rotational grazing practices across the property. Improvements to water infrastructure and the subdivisions of large paddocks began. Switched to electronic grazing charts (MaiaGrazing) at the end of this phase (2016).
Phase 4: 2017-20	Holistic time controlled rotational grazing practices fully implemented across the whole property. Native revegetation works also occurred during this phase. Wilmot beef marketed as grass-fed. Baseline soil carbon surveys to monitor soil carbon at around ~100 cm commenced. Carbon credits sold to Microsoft on the private market. Wilmot registered with the Commonwealth Government under rules defined in the CFI legislation under the 'Sequestering Carbon in Soils in Grazing Systems' Methodology

[1] *Across Australia, these practices usually led to diminished or degraded function, structure and composition of the landscape.*

Phase 1

Agricultural Practices (2001 - 2011)

Conventional management practices on Wilmot date back to the 1900s. Commercial potato growing occurred on the lower, mid and upper cleared slopes between 1950-1960 and pasture improvements began in the 1960s. A detailed chronology of land management regimes and practices since the late 1800s to 2021 is presented in Appendix A. At the start of phase 1, three properties (Maida Vale, Willows and Wilmot) were aggregated to create 'Wilmot' which was purchased by the Wilmot Cattle Company in 2008, a year prior to the Millennium Drought breaking. By 2008, most of Wilmot was made up of improved exotic pastures, except for the steeper slopes and ridges. Between 2008 – 2010, the main enterprise was finishing steers which were set-stocked in large paddocks and moved between paddocks only if feed insufficiency occurred. Wilmot had a small number of large-sized paddocks which had regular applications of superphosphate fertiliser applied to top dress the pastures to promote plant growth. Effects of overgrazing included areas of bare ground, low pasture height, areas of low ground cover which contributed to low weight gains in livestock.

Ecological Response Outcomes (2008 – 2011)

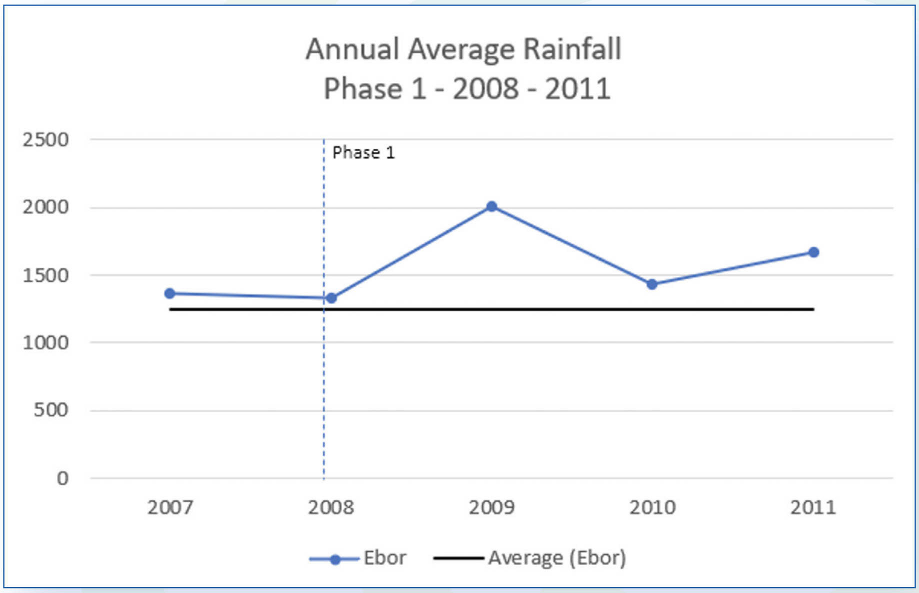

Figure 8: Annual rainfall records for Phase 1 (2008 – 2011) from Bureau of Meteorology (BOM) weather station 59019 Ebor (The Racecourse) located approximately 4.3 km from Wilmot including average annual rainfall.

**Records for 2007 added for reference to previous year. (Source: BOM, n.d.)*

Ecological response outcomes scoring commenced during phase 1 in 2008, reflecting Wilmot's acquisition by Wilmot Cattle Company. Rainfall during this period as recorded at the Ebor (The Racecourse) weather station was above average (1243.2 mm) (Figure 8). During this phase, baseline scores were provided in response to the ecological status of the property at the time of purchase and when changes to management practices commenced. Soil monitoring commenced in 2011 therefore within this phase, soil data was insufficient (See 'Soil Testing').

A. Resilience of landscape to natural disturbances – flood, drought and frost

During this phase, Wilmot mainly relied on natural rainfed streams for its water supply. The water infrastructure consisted of two tanks and multiple dams as well as the creek system; Jocks Water, Majors Creek, Little Falls Creek and Main Water. The ability of the property to cope with drought and fire events was limited due to the poor water infrastructure. During this phase, a baseline score of 0.4 was given (Appendix D, Figure 1d).

B. Status of soil nutrients – including soil carbon level

During this phase, a baseline score of 0.4 was given (Appendix D, Figure 2d). Insufficient SOC data was available during this phase due to soil tests beginning in 2011.

C. Status of soil hydrology

During this phase, a baseline score of 0.4 was given (Appendix D, Figure 3d).

D. Status of soil biology

During this phase, a baseline score of 0.3 was given (Appendix D, Figure 4d).

E. Status of soil physical properties

Soils were known to be heavily compacted due to many years of management practices such set stocking, potato growing and the use of synthetic fertilisers. Anecdotal evidence during this phase reported times of obvious topsoil loss during severe rainfall events as witnessed by the red colour of overland flows entering creeks. During this phase, a baseline score of 0.3 was given (Appendix D, Figure 5d).

F. Status of plant reproductive potential

During this phase, a baseline score of 0.3 was given (Appendix D, Figure 6d).

G. Status of tree and shrub structural diversity and health

Most of the landscapes on Wilmot had been cleared of open woodland and developed and managed for agricultural production since the early 1900s. From the late 1950s, there has been an obvious decline in mature trees and old paddock trees are stressed and gradual die off is to be expected (Carr, 2020). Within forested areas, a good mix of tree size and ages occurs, including large trees with hollows (Carr 2020). During this phase, a baseline score of 0.3 was given (Appendix D, Figure 7d).

H. Status of grass and herb structure - Ground cover

During this period where set stocking occurred and during periods of rainfall deficit, ground cover was described as low. During this phase, a baseline score of 0.3 was given (Appendix D, Figure 8d).

I. Status of tree and shrub species richness and functional traits

Most of the open woodlands on Wilmot had been cleared for the development and management of agricultural production since the early 1900s. Pastures experienced limited regeneration around paddock trees and isolated patches however within areas of native pastures and forested areas tree regeneration occurs (Carr, 2020). During this phase, a baseline score of 0.3 was given (Appendix D, Figure 9d).

J. Status of grass and herb species richness and functional traits

Pasture improvements began on Wilmot in the 1960s due to the focus on cattle production. Most of the lower, mid and some upper slopes that supported native pastures were replaced with sown exotic pastures. During phases 1 and 2, most pastures were largely summer dominant fescue species. During this phase, a baseline score of 0.3 was given (Appendix D, Figure 10d).

Phase 2

Agricultural Practices (2012 – 2013)

Conventional management practices such as set stocking and the use of chemical fertilisers still occurred across most of the property however, it was during this phase that management methods started to move toward regenerative practices. In 2012, time controlled rotational grazing trials were implemented within a small area of Wilmot. Data from the trial showed a significant increase in stocking rate was allowed using this method. This trial led to the further implementation of time controlled rotational grazing practices across the property and saw the cessation of set stocking by the end of this phase. It was also during this phase (2013) that the use of superphosphate ceased on Wilmot. The transition to more regenerative and holistic management practices resulted in significant gains in the overall ecological health of the farm (Wilmot, 2021). In addition, with baseline soil monitoring occurring during the previous period, this phase saw the first test results to come from the soil monitoring completed in 2011.

Ecological Response Outcomes (2012 – 2013)

Scoring of the ecological response outcomes during phase 2 started to reflect the changes to management practices on Wilmot. During this phase, the following criteria were given a single incremental increase in 2012 from the baseline score; (F) 'plant reproductive potential'; (G) 'tree and shrub structural diversity and health' and (H) 'ground cover (grass and herb structure'). These increases occurred despite 2012 experiencing below average rainfall (Figure 9). The following year (2013) experienced above average rainfall and the following five criteria were given a single incremental increase from the baseline score; (A) 'landscape resilience'; (B) 'soil nutrients'; (C) 'soil hydrology', (D) 'soil biology' and (E) 'soil physical properties'. The only ecological criteria that were not provided a score increase during this phase were regarding the 'species richness and functional traits' for (I) 'tree and shrub species' and (J) 'grass and herb species'.

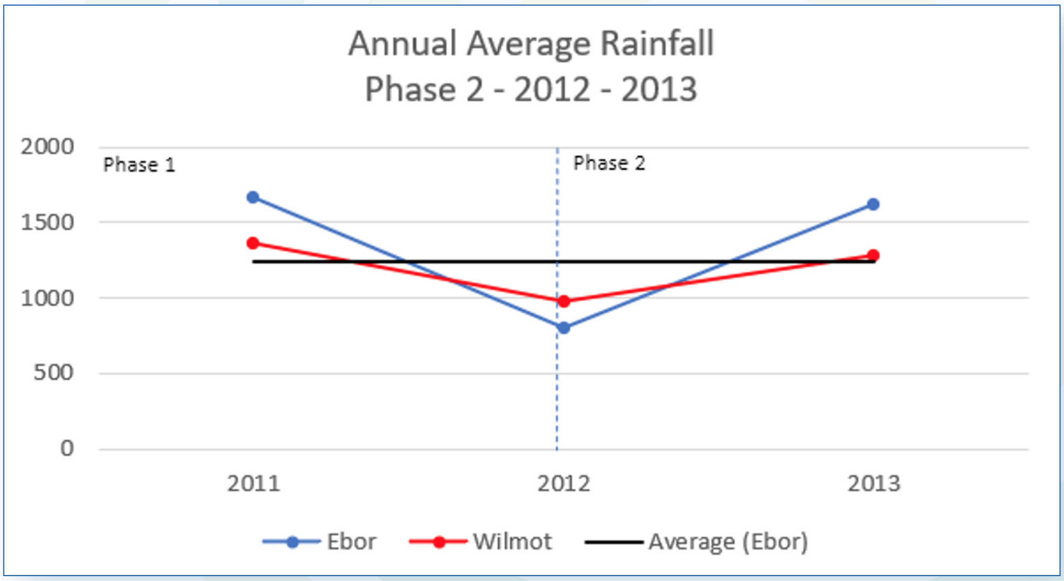

Figure 9: Annual rainfall records for Phase 2 (2012 – 2013) from Bureau of Meteorology (BOM) weather station 59019 Ebor (The Racecourse) located approximately 4.3 km from Wilmot. Local rainfall recorded on Wilmot (Willows) including average annual rainfall

**Records for 2011 added for reference to previous year. (Source: Bureau of Meteorology, n.d.; Regen Network, 2020).*

A. Resilience of landscape to natural disturbances – flood, drought and frost

In 2012, no change from the baseline score was provided. In 2013, this criterion was given the first single incremental score increase from 0.4 to 0.5 (Appendix D, Figure 1d). These changes are attributed to the adoption of regenerative practices such as time controlled rotational grazing and reduced paddock sizes through sub-divisions.

B. Status of soil nutrients – including soil carbon level

The soil condition on Wilmot remained heavily compacted due to the past management regimes and up to 2012, no change from the baseline score was provided. In 2013, this criterion was given the first single incremental score increase from 0.3 to 0.4 (Appendix D, Figure 2d).

SOC results from soil tests carried out in 2011 were reported during this phase. Results showed average SOC levels had decreased from historic levels recorded within the district (6%) to 3.20% and 3.81% across 2012 and 2013 respectively (Figure 7). A positive trend was seen during this phase however it is important to note that the sample size also increased from four to seven during this period. The decrease from historic soil carbon levels would reflect historic management practices such as potato cropping, the many decades of set stocking and the regular application of superphosphate fertiliser.

C. Status of soil hydrology

No change from the baseline was provided for 2012. In 2013, this criterion was given the first single incremental score increase from 0.4 to 0.5 (Appendix D, Figure 3d).

D. Status of soil biology

No change from the baseline was provided for 2012. In 2013, this criterion was given the first single incremental score increase from 0.3 to 0.4 (Appendix D, Figure 4d).

E. Status of soil physical properties – As a medium for plant growth

No change from the baseline was provided for 2012. In 2013, this criterion was given the first single incremental score increase from 0.3 to 0.4 (Appendix D, Figure 5d).

F. Status of plant reproductive potential – Reproductive potential of pastures

In 2012, this criterion was given the first single incremental score increase from 0.3 to 0.4 (Appendix D, Figure 6d). No change was provided for 2013.

G. Status of tree and shrub structural diversity and health

In 2012, this criterion was given the first single incremental score increase from 0.3 to 0.4 (Appendix D, Figure 7d). No change was provided for 2013.

H. Status of grass and herb structure - Ground cover

In 2012, this criterion was given the first single incremental score increase from 0.3 to 0.4 (Appendix D, Figure 8d). No change was provided for 2013.

I. Status of tree and shrub species richness and functional traits

No change was described to this criterion during this phase (Appendix D, Figure 9d) remaining at the baseline score of 0.3.

J. Status of grass and herb species richness and functional traits

No change was described to this criterion during this phase (Appendix D, Figure 10d) remaining at the baseline score of 0.3.

Phase 3

Agricultural Practices (2014 – 2016)

This phase saw the continued practice of time controlled rotational grazing across the entire property. This included more paddock subdivisions and the switch to the electronic grazing management software, MaiaGrazing, which was adopted in 2016. During this phase, pasture composition shifted and due to the introduction of time controlled rotational grazing, Scotch Thistle (*Onopordum acanthium*) and Dandelion (*Taraxacum spp*.) started to become a dominant feature on hill slopes and some paddocks showing a dense cover of Fleabane (*Conyza species*). From a pasture health perspective, these species tend to be first succession plants and their presence is indicative of pastures which have been over-grazed and lacking fertility.

During this phase, improvements to water infrastructure also occurred and a number of water tanks were installed across the property. This enabled the setup of a water reticulation system which pumped water to troughs in most of the paddocks. Effects from these management action should be observed in the soil biology over the coming years.

Ecological Response Outcomes (2014 – 2016)

Below average annual rainfall was recorded across this entire period (Figure 10) however, increases to ecological response were described across nine of the ten ecological criteria. During this phase, the following five criteria were given another incremental score higher than previous phase; (A) 'landscape resilience'; (B) 'soil nutrients'; (C) 'soil hydrology', (D) 'soil biology', (E) 'soil physical properties'. This was the second score increase for these criteria. Criterion (F) 'plant reproductive potential' was given a single score increase which was the third increase from the baseline score. Criteria (G) 'tree and shrub structural diversity and health' and (H) 'status of ground cover (grass and herb structure)' were given two score increases during phase 3, once in 2 014 and again in 2016. Criterion (J) 'grass and herb species richness and functional traits' was given the first score increase from baseline data in 2016 and incremental increases continued each year thereafter (See Appendix D). Criterion (I) 'tree and shrub species richness and functional traits' is the only criterion to remain at baseline score of 0.3.

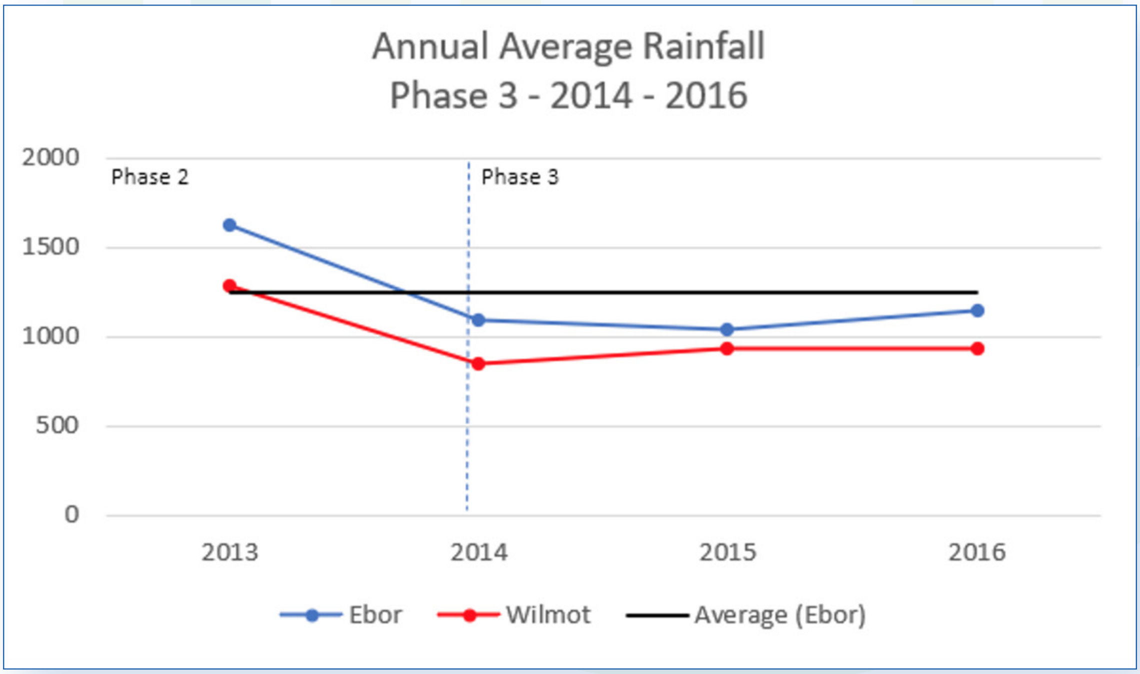

Figure 10: Annual rainfall records for Phase 3 (2014 – 2016) from Bureau of Meteorology (BOM) weather station 59019 Ebor (The Racecourse) located approximately 4.3 km from Wilmot. Local rainfall recorded on Wilmot (Willows) including average annual rainfall

**Records for 2013 added for reference to previous year. (Source: Bureau of Meteorology, n.d.; Regen Network, 2020).*

A. Resilience of landscape to natural disturbances – flood, drought and frost

Landscape resilience was described as showing continual improvements with the qualitative score given a further incremental increase from 0.5 to 0.6 in 2015. This was the second incremental increase for this criterion from the baseline score (Appendix D, Figure 1d).

B. Status of soil nutrients – including soil carbon level

The status of soil nutrients was described as showing continual improvements with the qualitative score given a further incremental increase from 0.5 to 0.6 in 2015 This was the second incremental increase for this criterion from the baseline score (Appendix D, Figure 2d).

The average percentage of SOC levels increased from the previous phase recording 4.46%, 4.43% and 5.1% between 2014 - 2016 respectively. In 2015, the number of sample sites increased from 7 – 8. (Figure 7).

C. Status of soil hydrology

The 'status of soil hydrology' was described as showing continual improvements with the qualitative score given a further incremental increase from 0.5 to 0.6 in 2015. This was the second incremental increase for this criterion from the baseline score (Appendix D, Figure 3d).

D. Status of soil biology

The 'status of soil biology' was described as showing continual improvements with the qualitative score given a further incremental increase from 0.4 to 0.5 in 2015. This was the second incremental increase for this criterion from the baseline score (Appendix D, Figure 4d).

E. Status of soil physical properties – As a medium for plant growth

The 'status of soil physical properties' was described as showing continual improvements with the qualitative score given a further incremental increase from 0.4 to 0.5 in 2015. This was the second incremental increase for this criterion from the baseline score (Appendix D, Figure 5d).

F. Status of plant reproductive potential – Reproductive potential of pastures

The 'status of plant reproductive potential' was described as showing continual improvements with the qualitative score given a further incremental increase from 0.5 to 0.6 in 2015. This was the second incremental increase for this criterion from the baseline score (Appendix D, Figure 6d).

G. Status of tree and shrub structural diversity and health

The 'status of tree and shrub structural diversity and health' was described as showing continual improvements with the qualitative score given a further incremental increase from 0.5 to 0.6 in 2016. This was the third incremental increase for this criterion from the baseline score (Appendix D, Figure 7d).

H. Status of grass and herb structure - Ground cover

The 'status of grass and herb structure' continued to improve as pastures were observed transitioning through succession due to the adoption of time controlled rotational grazing. This criterion was given a further incremental increase from 0.5 to 0.6 in 2016. This was the third incremental increase for this criterion from the baseline score (Appendix D, Figure 8d).

I. Status of tree and shrub species richness and functional traits

No change was given to this criterion during this phase (Appendix D, Figure 9d) remaining at the baseline score of 0.3.

J. Status of grass and herb species richness and functional traits

During this phase, the 'status of grass and herb species richness and functional traits' was given an incremental increase each year from the baseline score of 0.3 (Appendix D, Figure 10d). By the end of phase 3, this criterion's score increased to 0.6.

Phase 4

Agricultural Practices (2017 – 2020)

This phase saw time controlled rotational grazing practices fully implemented across the whole property which resulted in high levels of ground cover and very limited areas showing signs of erosion. Chemical applications across the property ceased during this period other than occasional spraying of blackberries. Due to declining rainfall during this phase, cattle numbers were reduced to reduce grazing pressure.

Revegetation works also occurred during this phase under the National Landcare '20 Million Trees' Program which aimed to assist in re-establishing green corridors and threatened ecological communities. This program funded the planting of 20,000 locally indigenous *Eucalyptus* and *Acacia* species (55 different species across the two genera) consisting of 25 km of 10 m wide tree lines and habitat corridors These plantings increased the ecological resilience and tree and shrub structural diversity, species richness and functional traits on the property. During this phase an initial dung beetle release also occurred.

In 2019, a multi species cover crop trial was sown across 30-hectares which consisted of 11 species (~ 50% annual and 50% perennial). The trial was not successful due to the lack of rainfall in 2019 and a subsequent trial was conducted in February 2020 which had greater success. Exotic pastures recorded on Wilmot were a mix of Fescue (*Festuca arundinacea*), Perennial Ryegrass (*Lolium perenne*), Cocksfoot (*Dactylis glomerata*), Phalaris (*Phalaris aquatica*) and multiple clover species (*Trifolium spp*.).

During 2019, the development of a soil carbon strategy in partnership with Impact Ag also occurred and further soils sampling took place to track changes in SOC. In 2020, Wilmot registered with the Commonwealth Government under the 'Sequestering Carbon in Soils in Grazing Systems' methodology and in 2021, the successful sale of $500,000 of soil carbon credits to Microsoft Pty Ltd occurred. The carbon credits were verified and sold by US-based Regen Network, under their Carbon Plus scheme, as part of the recently announced carbon offset initiatives by Microsoft Pty Ltd. The generation of carbon credits has diversified Wilmot Cattle Company's income stream.

Ecological Response Outcomes (2017 – 2020)

During 2018-19, Wilmot received below average annual rainfall (Figure 11) however 2019 was exceptionally dry with the lowest annual rainfall recorded (674.4 mm) since 1959 (*which is as far as consistent rainfall records date back). Following this period of rainfall deficit, September 2019 saw 50% of the property burnt by intense wildfire which came from the west out of Guy Fawkes River National Park. Much of the litter and coarse woody debris in the forested areas was burnt, along with the revegetation works that occurred in 2017. In 2020 revegetation work recommenced.

Low rainfall and wildfire during this phase would have likely contributed to decreases in the status of; (B) 'soil nutrients', (C) 'soil hydrology', (D) 'soil biology', (E) 'soil physical properties' and (J) 'grass and herb species richness and functional traits' across 2018 - 2019 (Appendix D). SOC also slightly decreased from 2016 figures but did not fall lower than baseline levels (Figure 7). During this phase, the following criteria were either described as stable or increasing; (A) 'landscape resilience', (F) 'plant and pasture reproductive potential', (G) 'tree and shrub structural diversity and health' and (H) 'grass and herb structure (ground cover)'. Criterion (I) 'tree and shrub species richness and functional traits' was given the first and largest increase of all criteria from baseline score of 0.3 – 0.7 in 2017. However, this increase reflects the large tree and shrub planting event which occurred on the property.

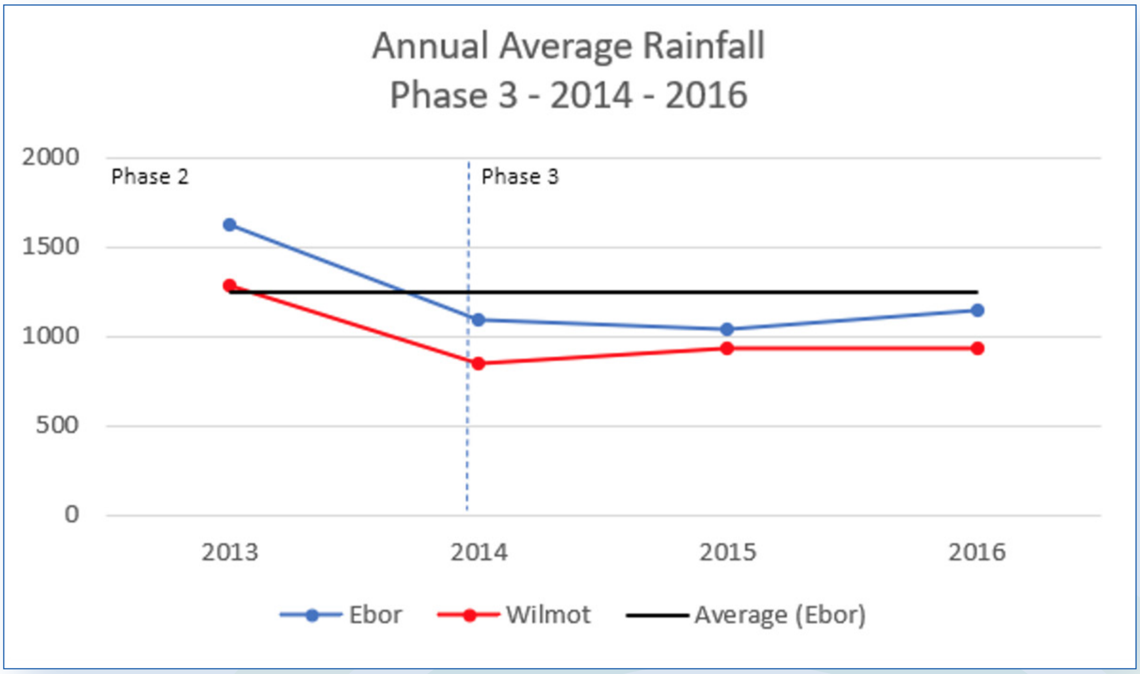

Figure 11: Annual rainfall records for Phase 4 (2017 – 2020) from Bureau of Meteorology (BOM) weather station 59019 Ebor (The Racecourse) located approximately 4.3 km from Wilmot. Local rainfall recorded on Wilmot (Willows) including average annual rainfall

**Records for 2016 added for reference to previous year and local rainfall only available up to 2018. (Source: Bureau of Meteorology, n.d.; Regen Network, 2020).*

In 2019 and 2020, a biodiversity survey was undertaken by 'Stringybark Ecological' using the NSW Government Biodiversity Assessment Method (BAM) of the Biodiversity Conservation Act (2016). Carr (2020) noted obvious epicormic growth occurring on the *Eucalypts* and good recovery of many ground layer species post-fire (Figure 12). Also recorded were several disturbance species such as exotic Inkweed (*Phytolacca octandra*) and the native Clammy Goosefoot (*Dysphania pumilio*). These species grow rapidly after disturbance providing ground cover until more permanent grasses and forbs can recover. Other species such as Weeping Grass (*Microlaena stipoides*), *Solanum* and *Senecio* species were recorded either for the first time on Wilmot post-fire, or in greater number than normally recorded (Carr, 2020).

Figure 12: Eucalypt woodland and native grasses on the steeper upper slopes and ridges recovering from severe wildfire in November 2019. Image shows a fence line comparison and the relative recovery of the trees and pastures between Wilmot (right) and the neighbouring property (left) (Image Source: James Diack).

The BAM survey also reported upon the differences between areas of exotic pastures and forested areas. It was found that areas of exotic pastures were characterised by high ground cover but very low species diversity, with only tussock grasses and legumes present (Carr, 2020). The most common of the sown exotic pasture species were Paspalum (*Paspalum dilitatum*), Cocksfoot (*Dactylis glomerata*), Hop Clover (*Trifolium campestre*) and White Clover (*Trifolium repens*) (Carr, 2020). These exotic pasture species are now not only found in cleared areas but have been found throughout the property, infiltrating forested areas on Wilmot (Carr, 2020). Findings showed that areas dominated by exotic pastures also had low structural diversity compared to forested areas, which in comparison, showed both a higher species richness and greater structural diversity of native ground layer species (Carr, 2020). This is due to the multi-level canopy cover of trees, shrubs and sub-shrubs, grasses, forbs, ferns, epiphytes and climbers found within the forested areas (Carr, 2020). In contrary, areas dominated by exotic species had sparsely scattered trees, very few shrubs and mostly grass species as ground cover (Carr, 2020). Due to the lack of large tress in these areas, the amount of fauna habitat is also much lower compared to the forested area with large trees and hollows (Carr, 2020).

In 2020, a very heavy localised rainfall event occurred, however, due to the ongoing changes to grazing management practices there was no major flooding reported. This could be attributed to positive trajectorial changes to soil compaction levels allowing for increased water infiltration. Further, no erosion was reported due to the increased levels of ground cover. It was also noted that during the rainfall event, streams on Wilmot ran clear demonstrating the lack of soil mobilisation.

A. Resilience of landscape to natural disturbances – flood, drought and frost

During phase 4, Wilmot experienced both severe drought and bushfires between 2018 and 2019. However, positive post-fire recovery was noted in May 2020 during the BAM post-fire survey. Landscape resilience was described as stable in 2017 and increasing incrementally each year thereafter from 0.7 – 0.8. Overall, the scoring process described six incremental increases for this criterion from the baseline score of 0.4 (Appendix D, Figure 1d).

B. Status of soil nutrients – including soil carbon level

The status of soil nutrients was described as showing continual improvements with the qualitative score given two further incremental increase from the end of the previous phase to 0.8 in 2018. This was the highest score given for this criterion. During 2019, the first score decreases were given due to well-below average rainfall recorded. The soil nutrient score decreased to 0.7 and remained stable at this score into 2020. Overall, the scoring process described four incremental increases for this criterion from the baseline score of 0.4 and only one decrease over this time (Appendix D, Figure 2d).

SOC showed slight decreases from 2016 figures. Between 2017 – 2018, SOC levels were 4.90%, 4.40% and 4.55% respectively (Figure 7). This decrease occurred despite the increase to sample sites from 8 –9. However, since 2012, the average percentage of SOC levels ranged between 3.20% (2012) to 5.01% (2016) with an overall increase from baseline levels.

C. Status of soil hydrology

The status of soil hydrology was described as showing continual improvements with the qualitative score given two further incremental increase from the end of the previous phase to 0.8 in 2018. This was the highest score given for this criterion. During 2019, the first score decreases were given due to well-below average rainfall recorded. The soil hydrology score decreased to 0.7 and remained stable at this score into 2020. Overall, the scoring process described four incremental increases for this criterion from the baseline score of 0.4 and only one decrease over this time (Appendix D, Figure 3d).

D. Status of soil biology

From the end of the previous phase, the qualitative score was given two incremental increases to 0.7 by 2018. This was the highest score given for this criterion. During 2019, the first score decreases were given due to well-below average rainfall recorded. The soil biology score decreased to 0.65 in 2019 and increased back to 0.7 by 2020. Overall, the scoring process described five incremental increases for this criterion from the baseline score of 0.3 and only one decrease over this time (Appendix D, Figure 4d).

E. Status of soil physical properties – As a medium for plant growth

From the end of the previous phase, the qualitative score was given two incremental increases to 0.7 by 2018. This was the highest score given for this criterion. During 2019, the first score decreases were given due to well-below average rainfall recorded. The soil physical properties score decreased to 0.65 in 2019 and increased back to 0.7 by 2020. Overall, scoring described five incremental increases for this criterion from the baseline score of 0.3 and only one decrease over this time (Appendix D, Figure 5d).

F. Status of plant reproductive potential – Reproductive potential of pastures

Throughout the severe drought and wildfires experienced in this phase, the reproductive potential of pastures was not affected. This criterion was described as showing continual improvements with the qualitative score given a further two incremental increases from 0.6 to 0.8 during this phase. An overall pattern of gradual improvement was shown for this criterion and scoring described five incremental increases from the baseline score of 0.3 (Appendix D, Figure 6d).

G. Status of tree and shrub structural diversity and health

From the end of the previous phase, the qualitative score was given three incremental increases to 0.8 by 2019 and remained stable in 2020. This was the highest score given for this criterion. Overall, the scoring process described five incremental increases for this criterion from the baseline score of 0.3 (Appendix D, Figure 7d).

H. Status of grass and herb structure - Ground cover

Throughout the severe drought and wildfires experienced in this phase, the status of grass and herb structure was not affected. Time controlled rotational grazing has resulted in a steady increase in ground cover with the continued improvement to the status of grass and herb structure. From the end of the previous phase, the qualitative score was given two incremental increases to 0.8 by 2020. This was the highest score given for this criterion. Overall, the scoring process described five incremental increases for this criterion from the baseline score of 0.3 (Appendix D, Figure 8d).

In validation, between 2017-2019, Sentinel-2 satellite imagery was used by Regen Network to calculate the percentage of bare soil and comparing the difference between the average Bare Soil Index (BSI) value for Wilmot and the surrounding landscape (radius of 10 km) (Regen Network, 2019a). Data showed the percentages of bare ground on Wilmot to be 1.52%, 4.0% and 0.73% from 2017 - 2019 respectively. In comparison, the surrounding landscape had much higher percentages of bare ground showing 7.0%, 7.45% and 7.33% across the same years respectively (Figure 13). Remarkedly, during low rainfall in 2019, Wilmot had ten times less bare soil cover as compared to the reference area, with a difference of 90% (Regen Network, 2019a).

Photo by Mike Terry

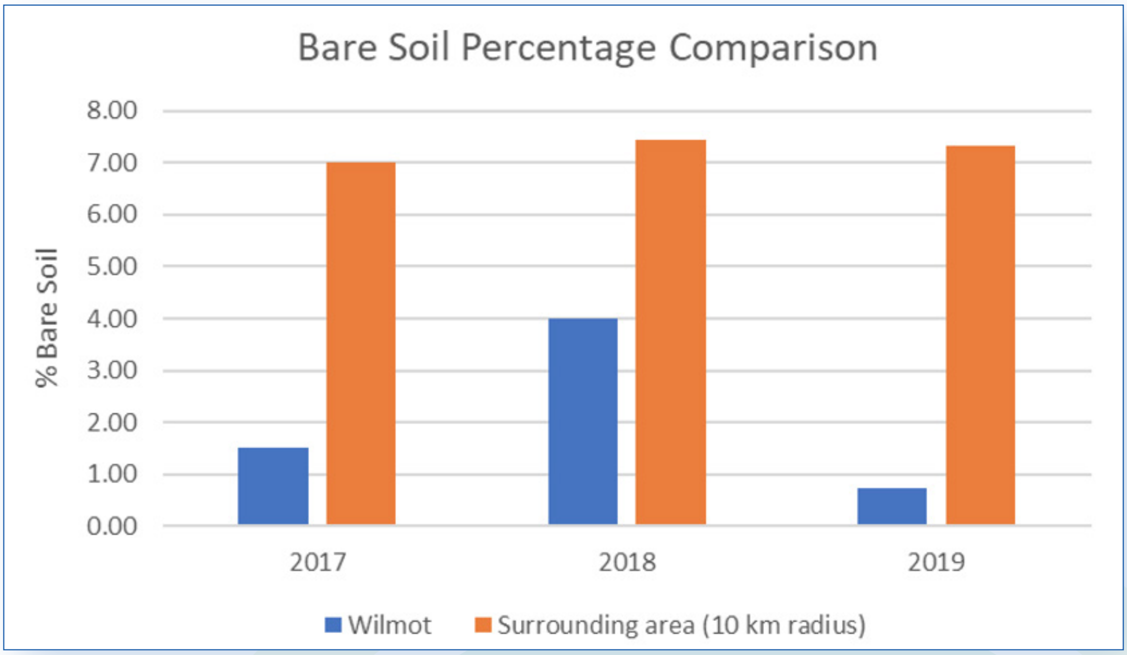

Figure 13: Bare soil comparison between Wilmot and the surrounding area (10 km radius) between 2017 -2019 (Source: Regen Network, 2019a).

I. Status of tree and shrub species richness and functional traits

The 'status of tree and shrub species richness and functional traits' was given a large increase from the baseline score of 0.3 to 0.7 in 2017 (Appendix D, Figure 9d). This increase was in response to the large native planting event that occurred that year as part of the 'Twenty Million Trees' program where 20,000 native trees and shrubs planted on the property. This was the first increase for this criterion from the baseline score provided.

Revegetation work which occurred unfortunately burnt during the wildfires experienced on Wilmot in 2019 and replanting occurred in 2020. Overall, the scoring process described three incremental increases for this criterion from the baseline score of 0.3 to 0.8 (Appendix D, Figure 9d).

J. Status of grass and herb species richness and functional traits

From the end of the previous phase, no further increases to the score was given. Stability through 2018 was followed with the first score decrease in 2019 due to well-below average rainfall recorded during the period. The status of grass and herb species richness and functional traits increased back to 0.7 in 2020. This was the highest score provided for this criterion. Overall, the scoring process described five increases for this criterion from the baseline score of 0.3 and only one decrease over this time (Appendix D, Figure 10d).

Photo by Mike Terry

Independent Scientific Assessment

An independent scientific assessment was conducted by Cibolabs looking at ground cover and woody vegetation and analysing patterns and trends across almost 30 years of Landsat derived land cover metrics of Wilmot and provided comparisons to the surrounding district.

Ground cover

Ground cover was compared between Wilmot and surrounding properties between 1991-2019. Over the period 2008-19, the average ground cover on Wilmot remained around 50% (Figure 14) and ranged between 29.6% in December 2015 and 70% in June 2018.

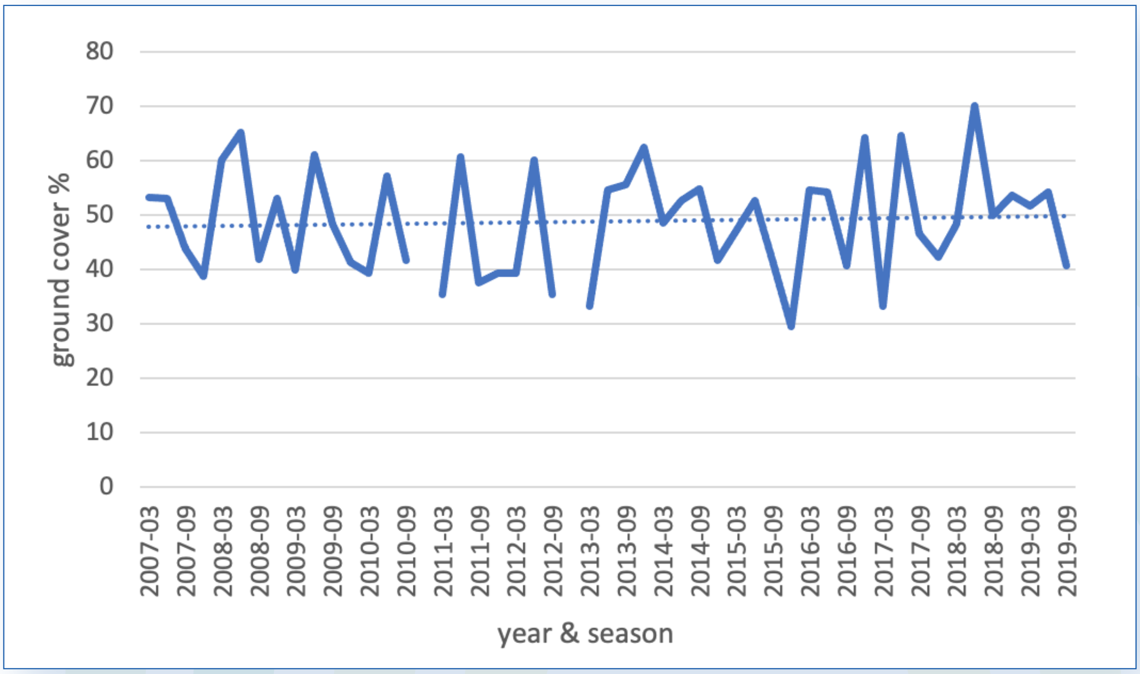

Figure 14. Seasonal ground cover changes on Wilmot over time, measured using remote imaging data (normalised) median ground cover relative to reference area's 25th and 75th percentile.

Woody cover

An independent assessment of the extent of woody plant cover on Wilmot was also assessed. Between 1991 and 2014 the area of woody vegetation on Wilmot averaged around 541 ha. In 2018 and 2019, the area of woody vegetation increased from 450.5ha to 593ha respectively (Figure 15).

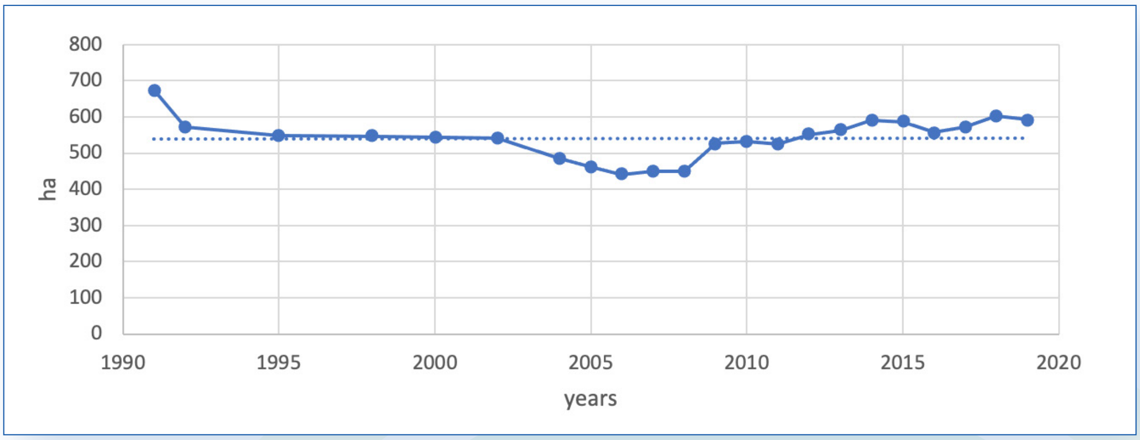

Figure 15: Area of woody vegetation recorded on Wilmot using Landsat imagery.

Conclusions

Landscape responses using the land manager's expert knowledge across the four chronological phases showed an overall increase across all ecological response functions. Between 2008 – 2020, only 2019 documented decreases to soil related criteria and species diversity and richness in grass and herbs. Below average rainfall was recorded locally in 2012 and between 2014-2019 spanning across the last three phases (Phase 2-4). However, with these below average rainfall years this assessment shows that the ecological function continued to be transformed through systematic implementation of time controlled rotational grazing, reduction of herbicide use, the cessation of superphosphate fertilisers and implementing holistic management practices. While these assessments captured some of the driest and most disastrous wildfire years on record, an overall increase of 'landscape resilience' was demonstrated with the property's ability to retain ground cover throughout years of below average rainfall and considerably more than the surrounding area (10 km radius). Wilmot also showed good recovery after the 2019 wildfires. It is important to note that especially during dry periods, the amount of ground cover and its persistence over time has a positive affect to many other of the functional ecological criteria and in particular; (A) 'resilience of landscape to natural disturbances', (B) 'status of soil nutrients – including soil carbon', (C) 'status of soil hydrology', (D) 'soil biology' and (E) "physical properties of the soil'. The analysis of satellite imagery confirms the increase to ground cover and tree cover also recorded by the land manager (Regen Network, 2019). In addition, these increases have been linked to the recorded increase in SOC. Further, independent assessments by Cibolabs showed a common trend with woody cover and the land managers self-assessment in relation to (G) 'tree and shrub structural diversity and health'. Overall, Wilmot's changes to management practices and the introduction of time controlled rotational grazing has shown a positive response over time across all of the ten ecological criteria.

Future enterprise opportunities

Wilmot Cattle Company aims to promote rehabilitation of riparian zones by fencing off these areas to keep livestock out and endeavours to continue subdividing paddocks using electric fencing. Wilmot Cattle Company also plan on investigating multispecies legume plantings to increase sequestration of carbon deeper into the soil profile. Wilmot's goal is to achieve an average of 6% SOC by 2023.

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Appendix A

The chronology of land management practices summarising the agricultural practices and regimes and the outcomes observed by on Wilmot

Year(s)	Practices/regimes	Observed outcome(s) of land management practices and regimes	Other observations
Late 1890s - early 1900s	Much of the Ebor district ringbarked and converted to pasture country for grazing. Native forest and woodland were initially cleared by hand.		
1940s—50s	Clearing continued and development began the district using mechanical and chemical means.		
1950s-1960s	Suitable soil-landscapes with the three separate properties Maida Vale, Willows and Wilmot were used for growing potatoes on the lower, mid and upper slopes. This is likely to have included slopes up to 30 degrees. Potato growing would have occurred on up to 500 ha of the current aggregated 1850 ha that is now Wilmot.	At times there was obvious loss of topsoil during severe rainfall events as witnessed by the red colour of overland flows entering the creeks.	Plough marks from potato growing are still visible in some areas of the current 1854 ha aggregated property Wilmot
1960s - late 1990s	Mechanised pasture improvements widely used across the New England plateau to transform and replace native pasture species with naturalised species, particularly on the flats and the lower slopes.	Phalaris, fescues and clovers replaced the native pastures.	
1960s- early 2000s	Maida Vale, Willows and Wilmot operated as separate cattle grazing properties using conventional management practices such as set stocking, pasture improvement, regular additions of superphosphate and conservation of fodder for periods of feed deficits.	During extended times of low rainfall, ground cover and pasture heights were low.	
Early 1970s	Potato growing ceased on Maida Vale, Willows and Wilmot.		
2001	Maida Vale, Willows and Wilmot was aggregated to form one large property 'Wilmot' (1850 ha).		
2000s-2008	After the aggregation, no changes to management practices and grazing regimes occurred. Conventional methods still used such as set stocking, pasture improvements, regular additions of superphosphate and conservation of fodder for periods of feed deficits.	Low ground cover and pasture height were characteristic of this grazing land management regime.	
2001-09	Local area including aggregated Wilmot experienced generally above average spring rainfall during the Millennium Drought in southeast Australia.		
2007-15	Resource Consulting Services (RCS) and partners commenced developing a methodology for Carbon Credits (Carbon Farming Initiative) (Sequestering Carbon in Soils in Grazing Systems) under the Commonwealth Government's CFI legislation.	SOC increased from 3.2% in 2012 to 4.43% in 2015.	Under this Methodology, graziers can continue to run livestock within project areas using principles which promote an increase in SOC. A detailed property-level project must be registered with the Commonwealth Government under rules defined in the Carbon Farming Initiative (CFI) legislation. The project must adhere to the strict guidelines outlined in the Sequestering Carbon in Soils in Grazing Systems methodology

Appendix A

The chronology of land management practices summarising the agricultural practices and regimes and the outcomes observed by on Wilmot

Year(s)	Practices/regimes	Observed outcome(s) of land management practices and regimes	Other observations
2008	Wilmot (1850 ha) was purchased by Wilmot Cattle Company.		The average paddock size on the Wilmot was 46.9 ha and ranged between 168.8 ha to 3.12 ha.
2008-09	Alasdair MacLeod was the catalyst for changing land management practices due to his increasing concerns about the effects of overgrazing and The Millennium Drought (2001-2009) in southeast Australia. Alasdair MacLeod began exploring ideas around regenerative agriculture and holistic grazing on family property near Yass.	Effects of overgrazing on Wilmot included low ground cover and pasture height. Low weight gain in livestock.	Alasdair MacLeod was motivated to demonstrate investment potential of a well-managed grazing property, underpinned by a drought resilient grazing system and protection of natural values.
2008-10	Conventional set stock grazing continued under initial management (Manager #1) with the focus on growing livestock.		The main enterprise was finishing steers. Steers were set stocked in large paddocks and only moved when the feed was insufficient in the paddock to finish the animals.
2008-12	Water infrastructure consisted of two tanks and many dams as well as the creek systems of Jocks Water, Majors Creek, Little Falls Creek and Main Water.	Soil was heavily compacted due to many years of set stocking regime. Pasture consisted largely of summer dominant fescue species	
2009	Wilmot experienced well-above average autumn rainfall		
2011-12	Soil sampling surveys and testing commenced and baseline measurements of soil health and SOC were collected.	Between 2011 – 12, average percentage baselines of SOC levels were between 2. 25% (n=2) and 3.20% (n=4) respectively.	
2011-12	Manager #2 appointed. Land management decisions were transitioned to hardcopy holistic grazing charts and informed by advice from a local agronomist.		These charts assisted the manager to plan paddock-based stocking rates with feed availability. The focus of this approach is to consider the soil and pastures as the assets, not the livestock. Animals are sold before pasture and soil are degraded. The charts help the land manager to plan several months ahead based on rainfall and feed availability in each paddock
2012	Wilmot experienced well-above average summer rainfall.		
2012	Time controlled rotational grazing trials commenced on Wilmot which involved intensive grazing followed by long periods of rest for each paddock.	Initial improvements to ground cover and soil health began.	Priority switched from growing livestock to growing and preserving pastures.
2012	Alasdair MacLeod was motivated to demonstrate the potential of carbon sequestration on a well-managed livestock enterprise. MaiaGrazing and time controlled grazing principles were seen as a means for achieving that.		

Appendix A

The chronology of land management practices summarising the agricultural practices and regimes and the outcomes observed on Wilmot

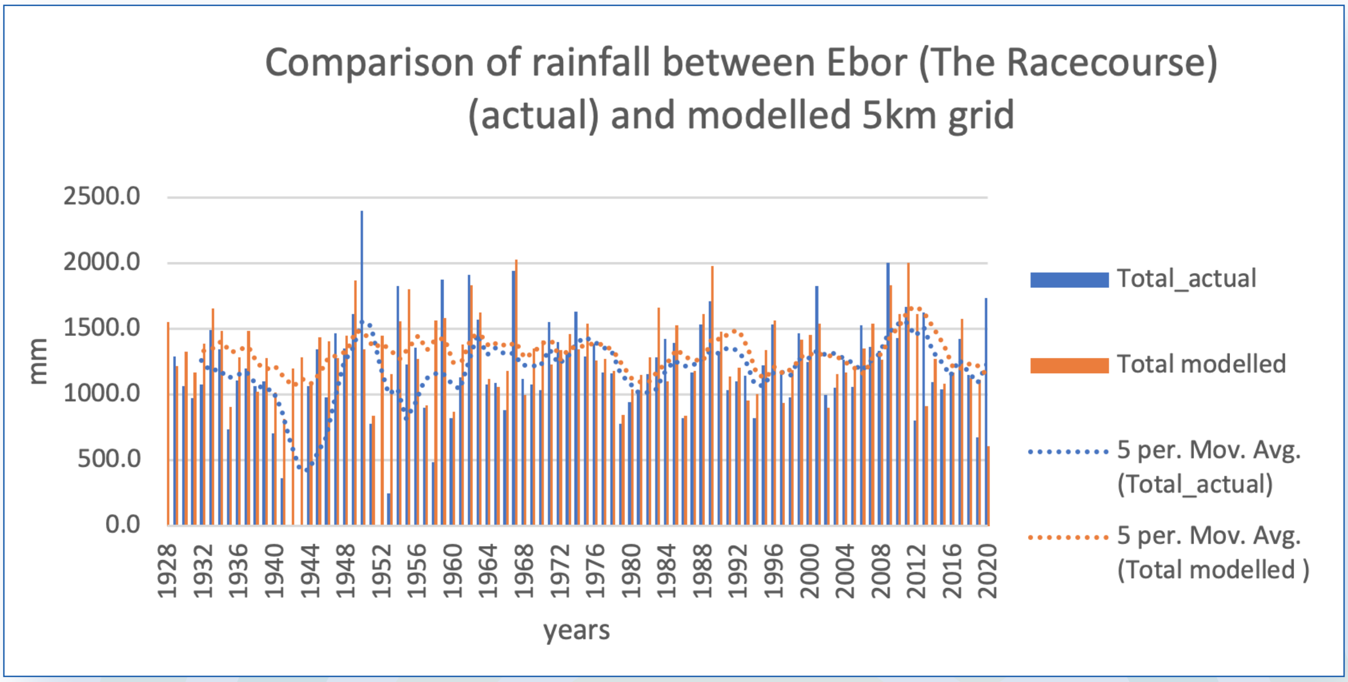
Year(s)	Practices/regimes	Observed outcome(s) of land management practices and regimes	Other observations
2012-13	Development of the MaiaGrazing software system and training modules commenced with Maia Technology and Resource Consulting Services (RCS). Wilmot was used as the "test bed" property. MaiaGrazing software converted and enhanced previous hardcopy grazing charts to electronic format.		MaiaGrazing software was developed as an online tool that can be viewed and managed remotely.
2013	All available property level livestock inventories and rainfall records were entered into the MaiaGrazing software system.		
2013	Applications of superphosphate ceased across Wilmot.		
2013	A time controlled rotational grazing trial was established using the MaiaGrazing software system and holistic grazing principles.	Significant increase to stocking rate in the trial area was achieved.	
2014-15	Upscaling of holistic time controlled rotational grazing practices across the property assisted with the use of MaiaGrazing. Strategically the property aims to run fewer stock that the threshold carry capacity to ensure more pasture/biomass is being generated than is consumed. MaiaGrazing software is used conservatively with respect to rainfall (i.e., only 75% of the average rainfall for a given month is budgeted upon	Scotch thistles and dandelions were a dominant feature of some hill slopes that had been heavily over grazed in some paddocks. Some paddocks had a dense cover of Fleabane (Conyza species)	Threshold cattle numbers were established under the time controlled rotational grazing system based on the 12-month rolling rainfall. Where the rolling rainfall exceeds the threshold carry capacity, the number of cattle on the property is. Where the rolling rainfall decreases and falls below the threshold carry capacity, the stock numbers are reduced prevent grazing pressure degrading pastures and ground cover.
2014-20	As part of the adoption of time controlled rotational grazing, paddocks began to be subdivided to decrease paddock size for management purposed. Paddock numbers increased to a total of 92 by December 2020.		Depending on the forecast results from the MaiaGrazing software the property buys and sells cattle
2014-15	Multiple water tanks installed across the property to enable a water reticulation system to be set up pumping water to troughs in every paddock. Chemical applications across the property ceased other than occasional spraying of blackberries.		
2013 & 2015-19	Wilmot experienced below average summer rainfall		
2016	Manager #3, Stuart Austin appointed.		
2017-19	Revegetation plantings with 20,000 trees of various locally indigenous eucalypt and acacia species		

Year(s)	Practices/regimes	Observed outcome(s) of land management practices and regimes	Other observations
2018-20	Period of declining rainfall. Cattle numbers on Wilmot were reduced in response to decreasing pasture production.	Scotch thistles and dandelions were gradually replaced by pasture grasses.	
2019	Wilmot experienced well-below average spring rainfall		
2019	Time controlled rotational grazing fully implemented across Wilmot.	Between 2018-20 observed ecological outcomes were: • constant ground cover maintained. • pasture quality and quantityimproved • Increased biodiversity • increased soil fertility • increased water infiltration = and soil moisture. Observed production outcomes: • Climate uncertainty resilience increasing for cattle enterprise business	
2019	BAM assessment carried out to provide baseline measurements for a revegetation project being undertaken across the property. Both forest and pasture ecosystems were assessed. Nine plots were surveyed in 2019 and a further six in 2020.		
2019	Half the property was burnt by intense wildfire in September 2019. Fire came out of Guy Fawkes River National Park to the west of Wilmot in September 2019	Observed ecological effects included obvious impacts on 1) grass and herb species richness and functional traits and 2) grass and herb structure - ground cover	May 2020 BAM surveys showed a lot of epicormic growth on the eucalypts and many ground layer species beginning to recover. Much of the litter and coarse woody debris in the forested areas was burnt in these fires.
2019	Soil carbon strategy developed in partnership with Impact Ag. Soil surveys for tracking changes in SOC.		
2019-20	Ecological survey carried out by David Carr of 'Stringybark Ecological' using the Biodiversity Assessment Method (BAM).	Wilmot supports a high level of biodiversity which in turn generates ecosystem services. Post-fire recovery noted and several disturbance species present. Differences in diversity and structure between pastures and forested areas noted. Lack of habitat and regeneration of trees in pasture paddocks.	Some speculative scenarios for Impact Ag to enter into Biodiversity Stewardship Agreements (BSA) over parts of the property occurred. BSAs are used to generate Biodiversity Credits which can then be sold on the open market to entities who are required to purchase and retire credits to account for the impacts of developments. Alternatively, the credits can be sold to the NSW Biodiversity Conservation Trust (BCT) through a number of mechanisms they run such as open tenders.
2020	Below average summer rainfall recorded for both February and December 2020.		

Appendix A

The chronology of land management practices summarising the agricultural practices and regimes and the outcomes observed on Wilmot

Year(s)	Practices/regimes	Observed outcome(s) of land management practices and regimes	Other observations
2020	Wilmot registered with the Commonwealth Government under rules defined in the CFI legislation under the 'Sequestering Carbon in Soils in Grazing Systems' Methodology.	The generation of carbon credits has brought a very welcome additional income stream.	
2020-21	Wilmot operates as a cattle trading enterprise, Wilmot receives cattle from a breeding property owned by Alasdair McLeod, the steers are finished on Wilmot then on sold. The system relies on MaiaGrazing to aid in the process and ensure maximum financial return is gained from each steer.		
2021	Sale of $500K of soil carbon credits to Microsoft Pty Ltd		
2021	Investigating the use of electric fencing to create smaller paddocks		
2021	Investigating planting multispecies legumes to increase sequestration of carbon deeper into the soil profile		


Comparison of rainfall between Ebor (The Racecourse) (actual) and modelled 5km grid
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1500.0
1000.0
500.0
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mm
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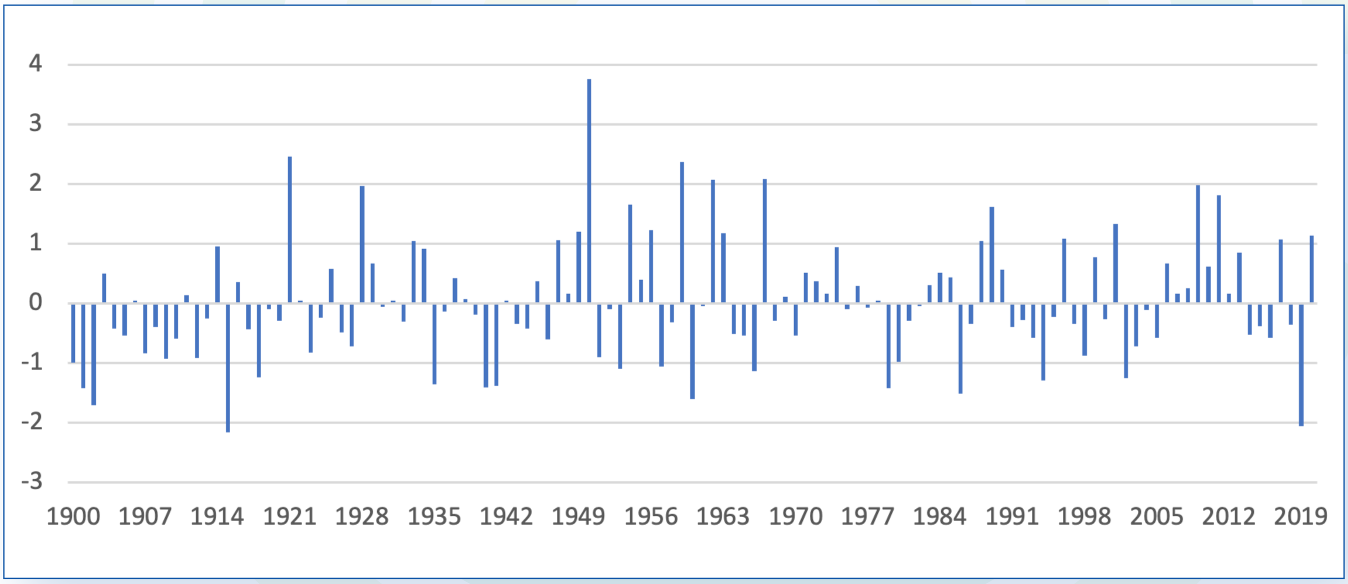
2016
2020
years
Total_actual
Total modelled
5 per. Mov. Avg. (Total_actual)
5 per. Mov. Avg. (Total modelled)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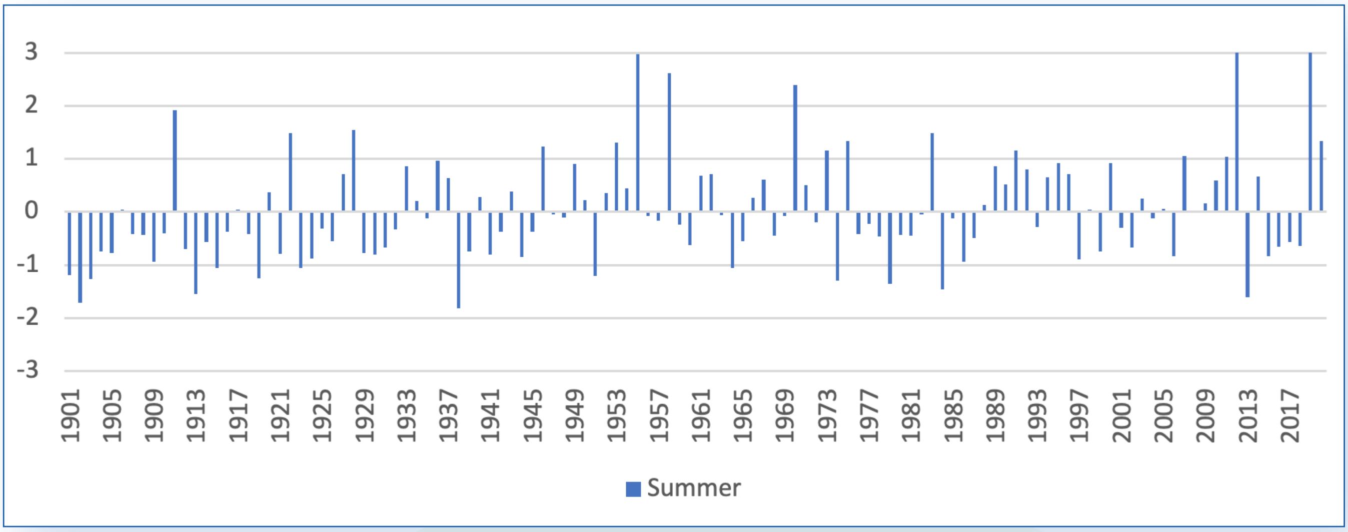
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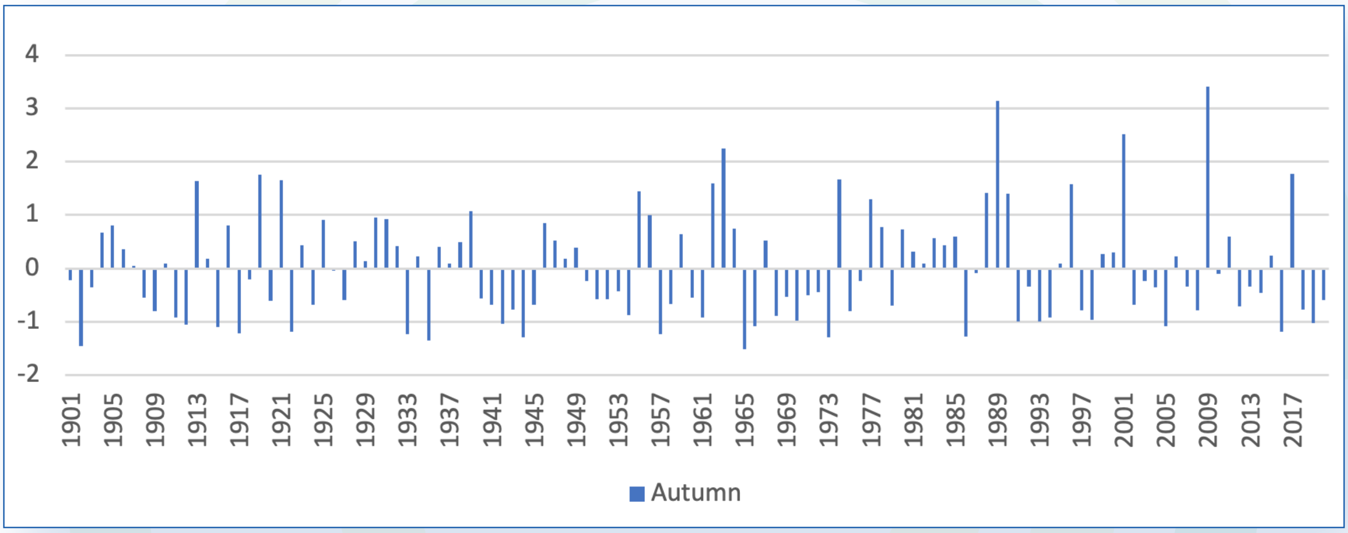
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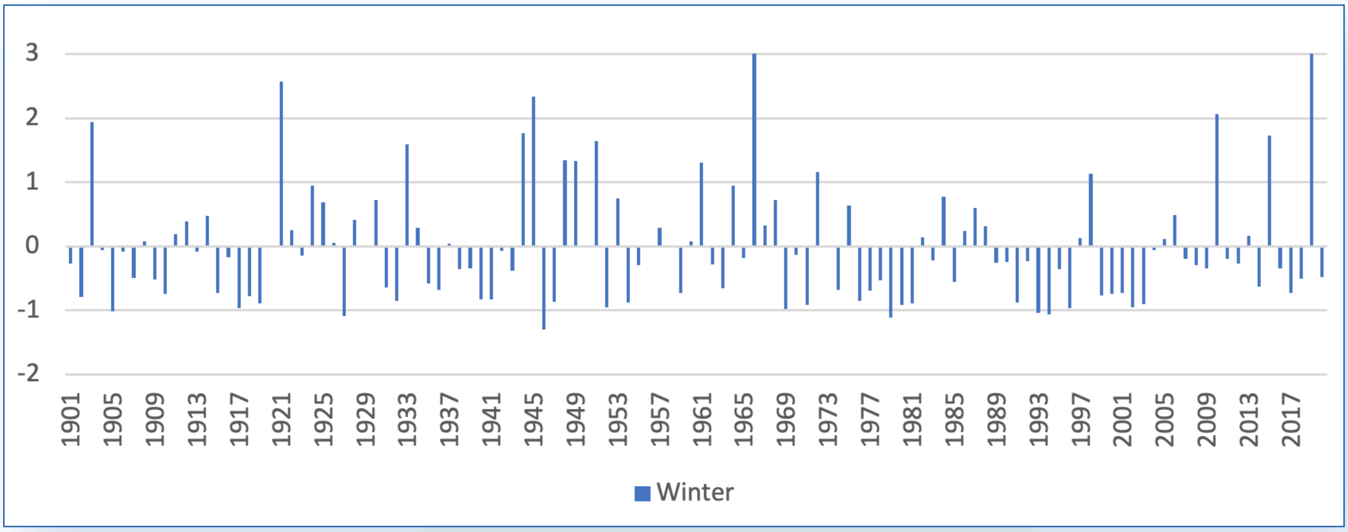
Autumn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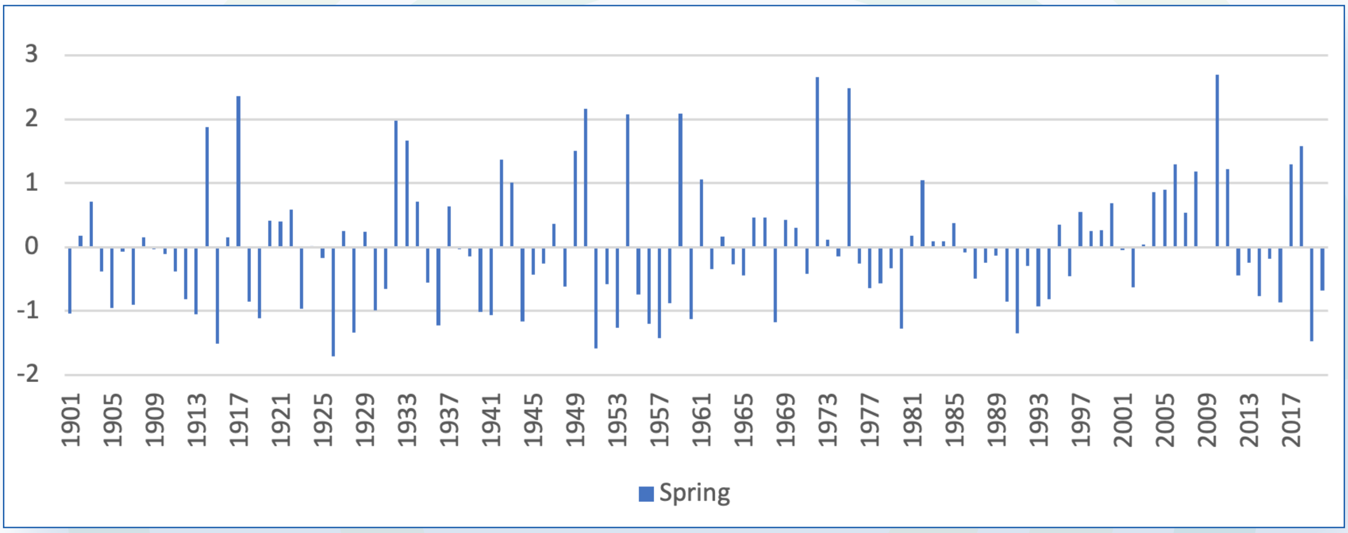
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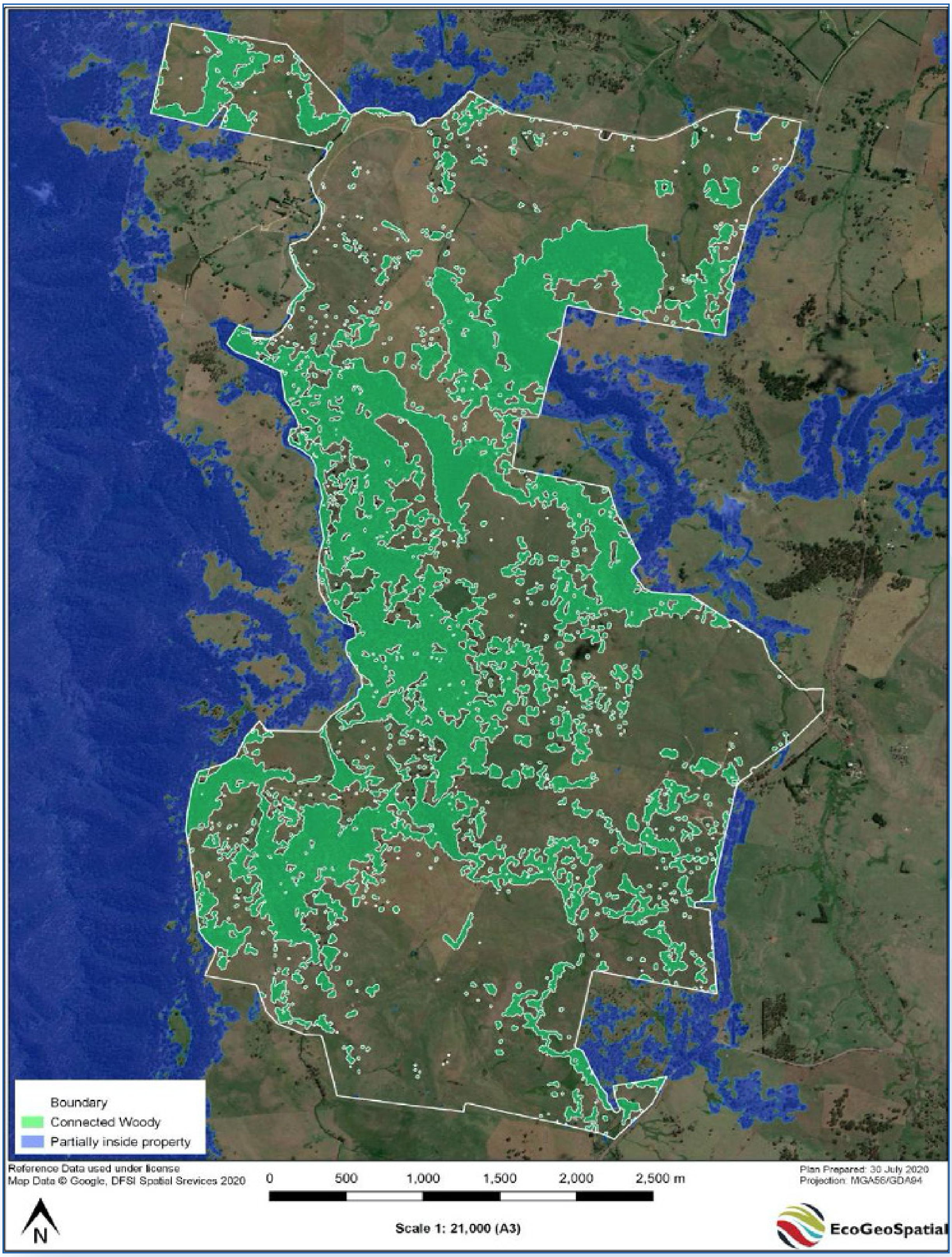
Spring


Boundary
Connected Woody
Partially inside property
Reference Data used under license
Map Data © Google, DFSI Spatial Srevices 2020
0
500
1,000
1,500
2,000
2,500 m
Plan Prepared: 30 July 2020
Projection: MGA56/GDA94
N
Scale 1: 21,000 (A3)
EcoGeoSpatial

Appendix D

A standardised and systematic qualitative assessment scored by Wilmot Manager, Stuart Austin using expert elicitation (Thackway and Freudenberger, 2016; Hemming et al., 2018). These scores are based on the land manager's observations of the ecological responses of the landscape over time due to the land management regimes and practices

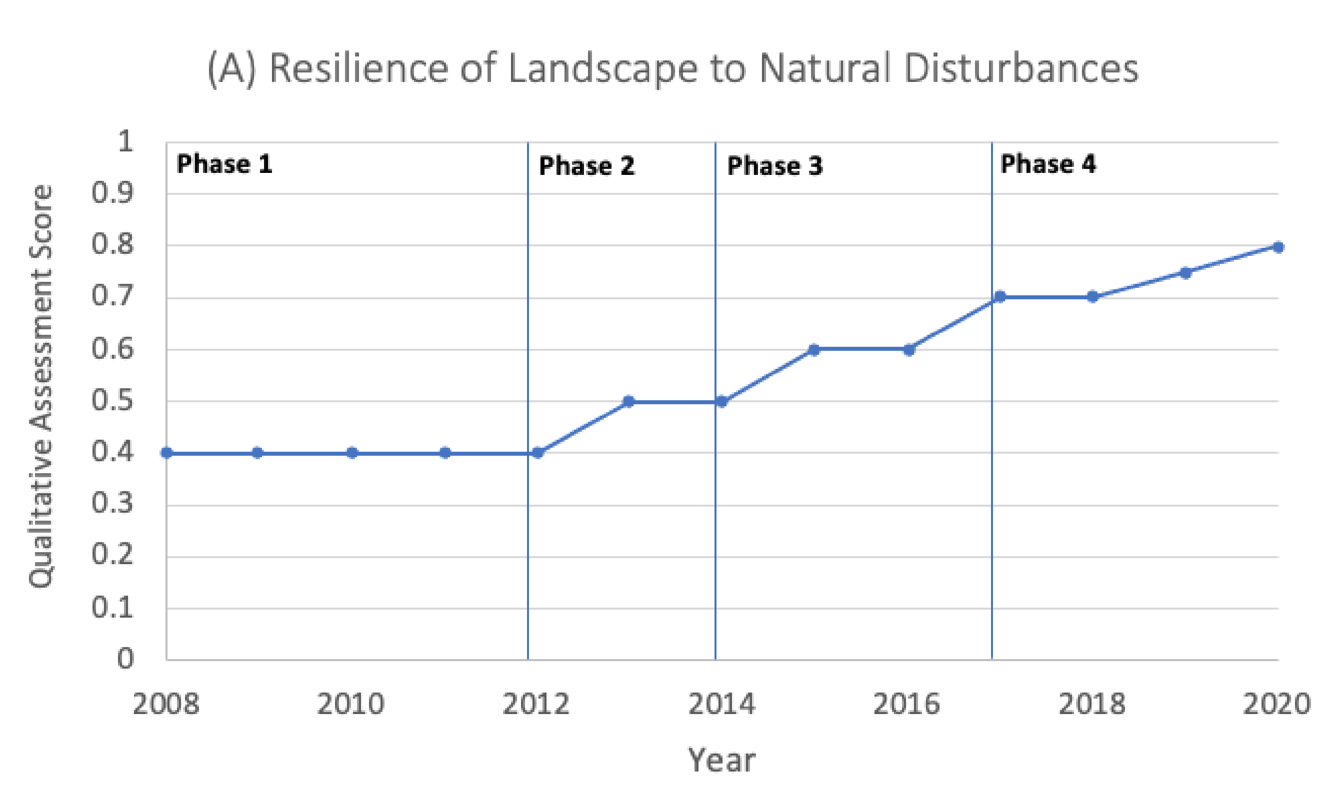


Figure 1d: Status of landscape resilience to disturbance (such as flood, drought and frost)

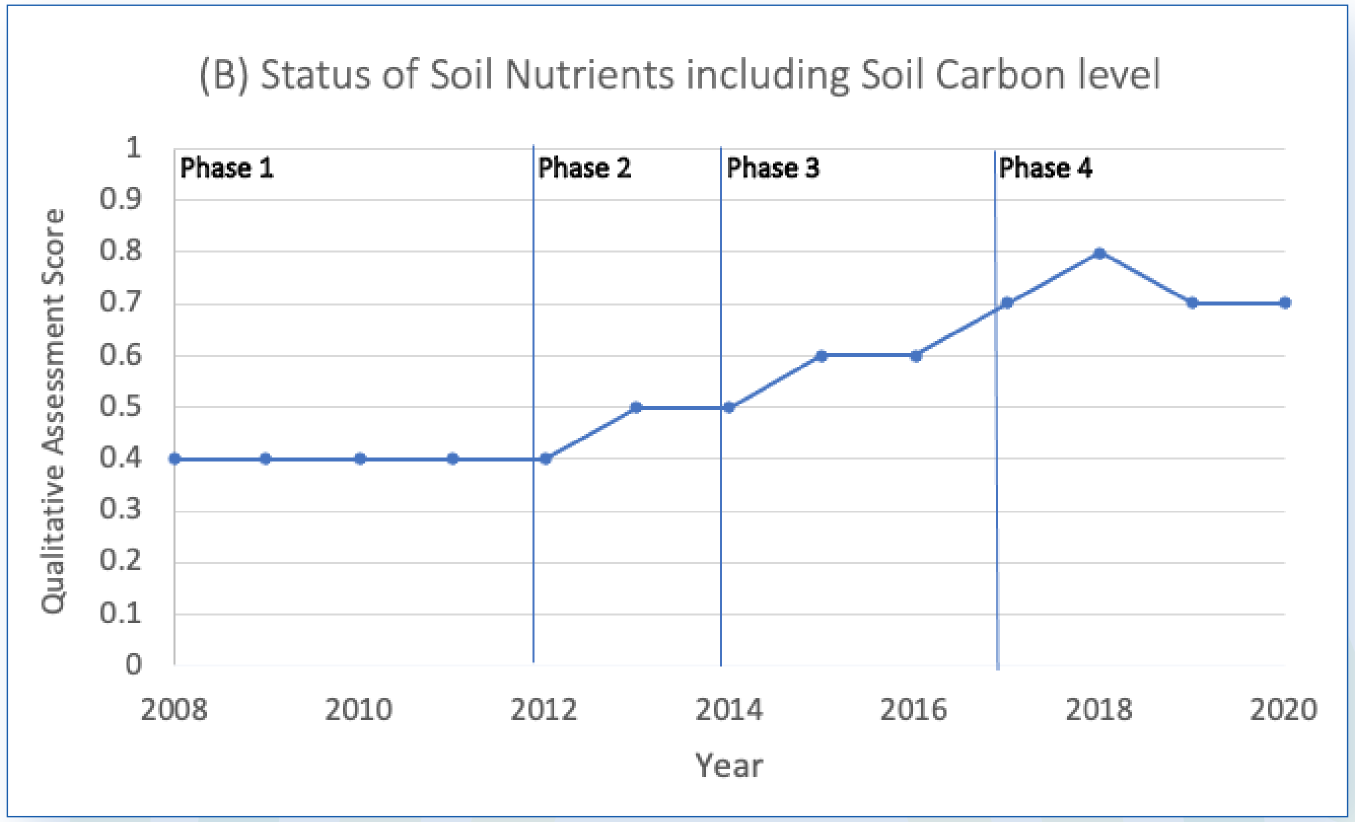


Figure 2d: Status of soil nutrients including soil carbon level.

Appendix D (ctd)

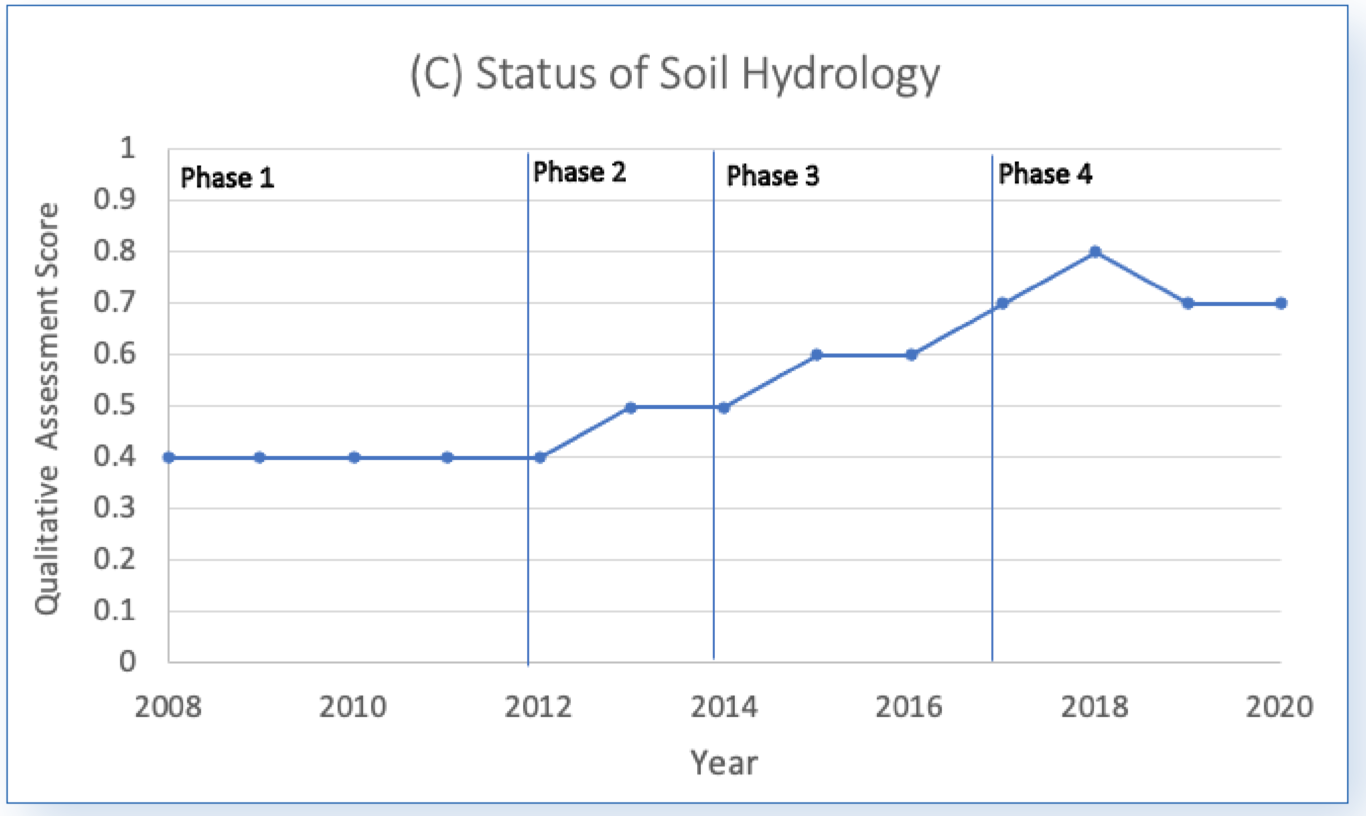


Figure 3d: Status of soil hydrology. Figure 4d: Status of soil biology.

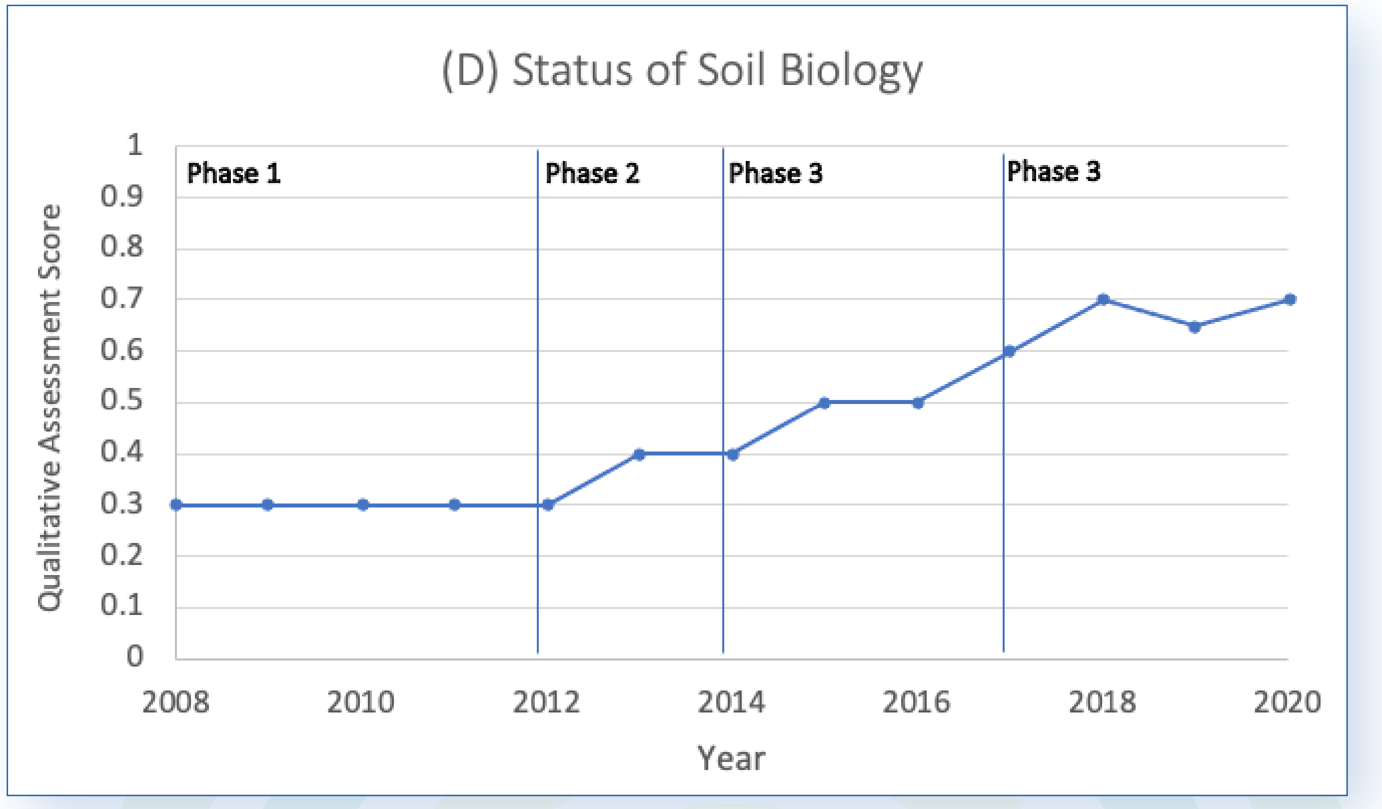


Figure 4d: Status of soil biology.

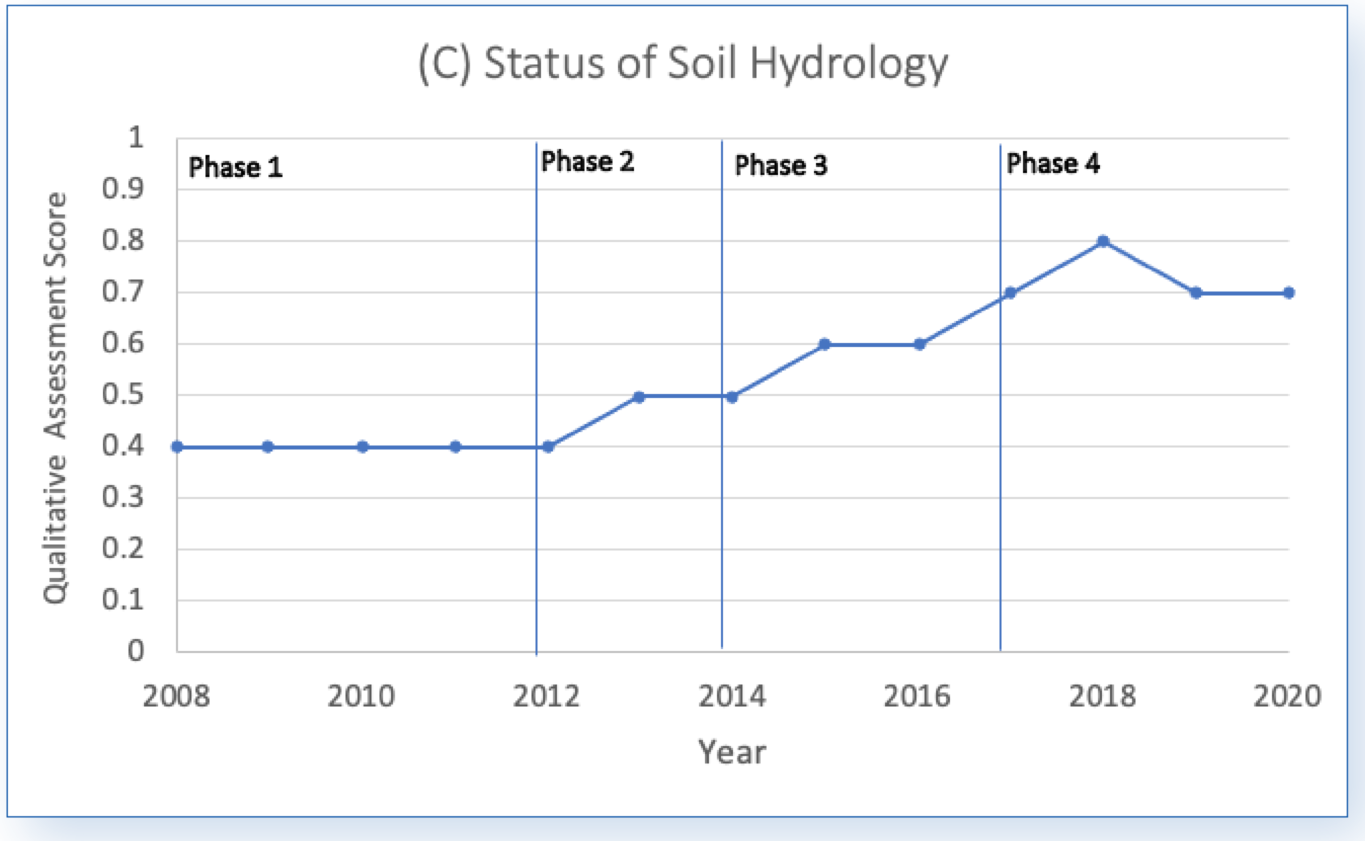


Figure 5d: Status of soil physical properties

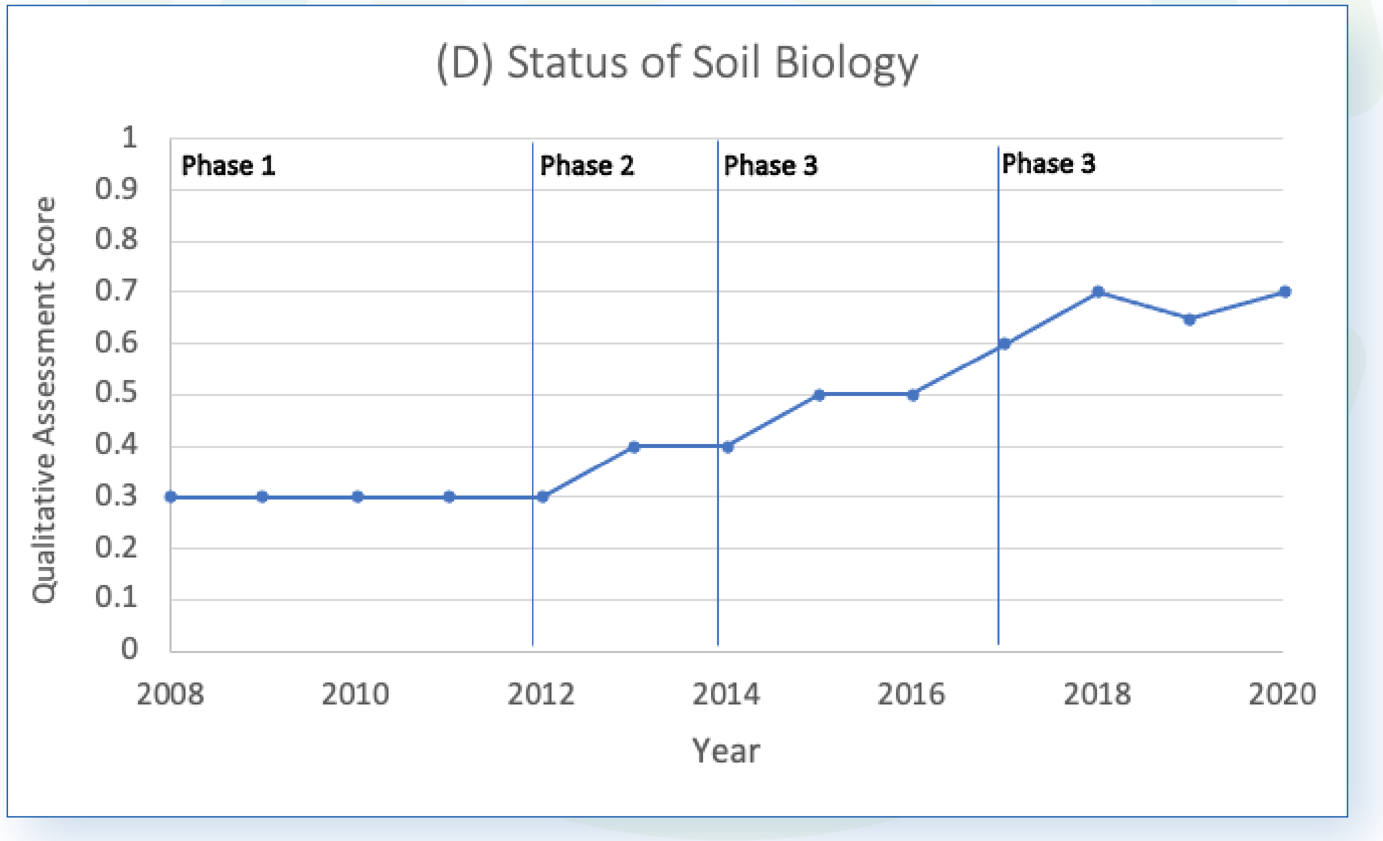


Figure 6d: Status of plant reproductive potential.

Appendix D (ctd)

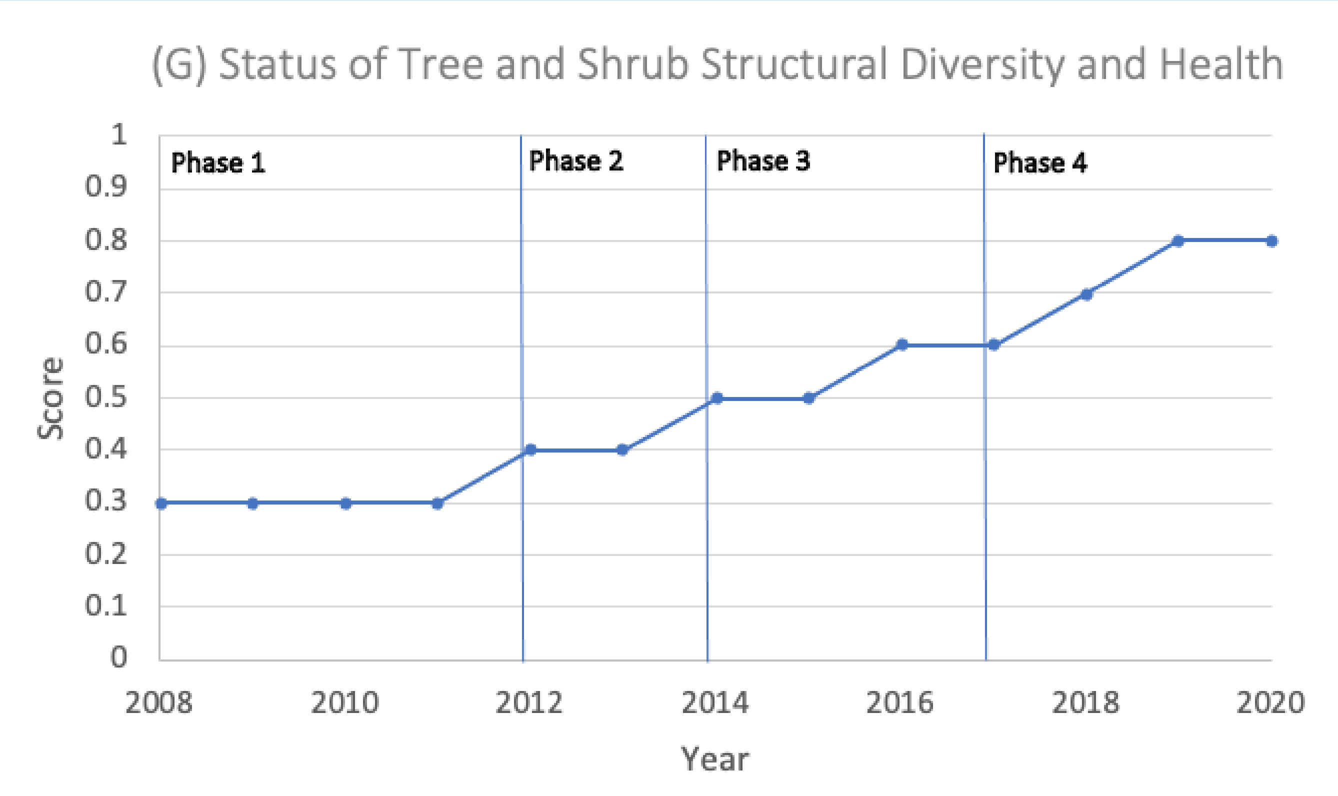


Figure 7d: Status of tree and shrub structural diversity and health.

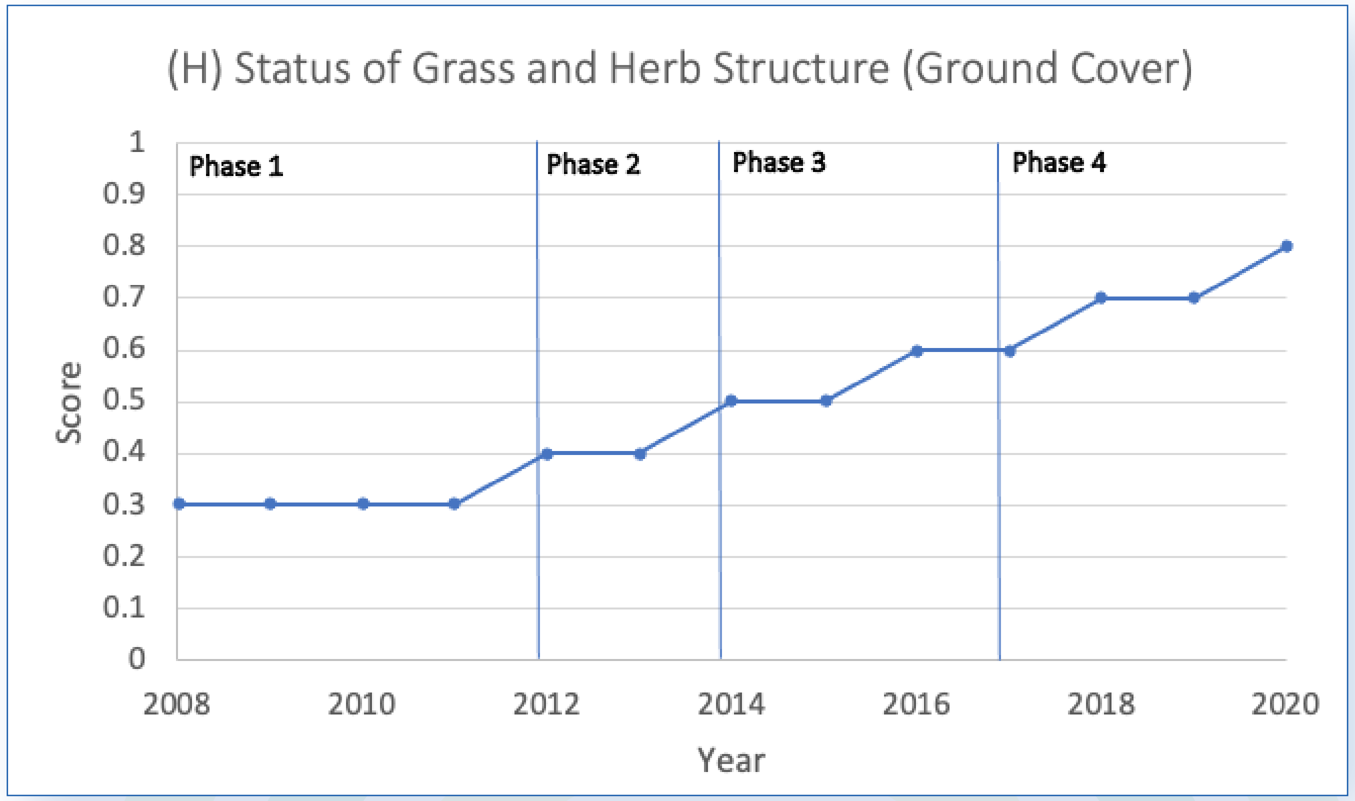


Figure 8d: Status of grass and herb structure (ground cover).

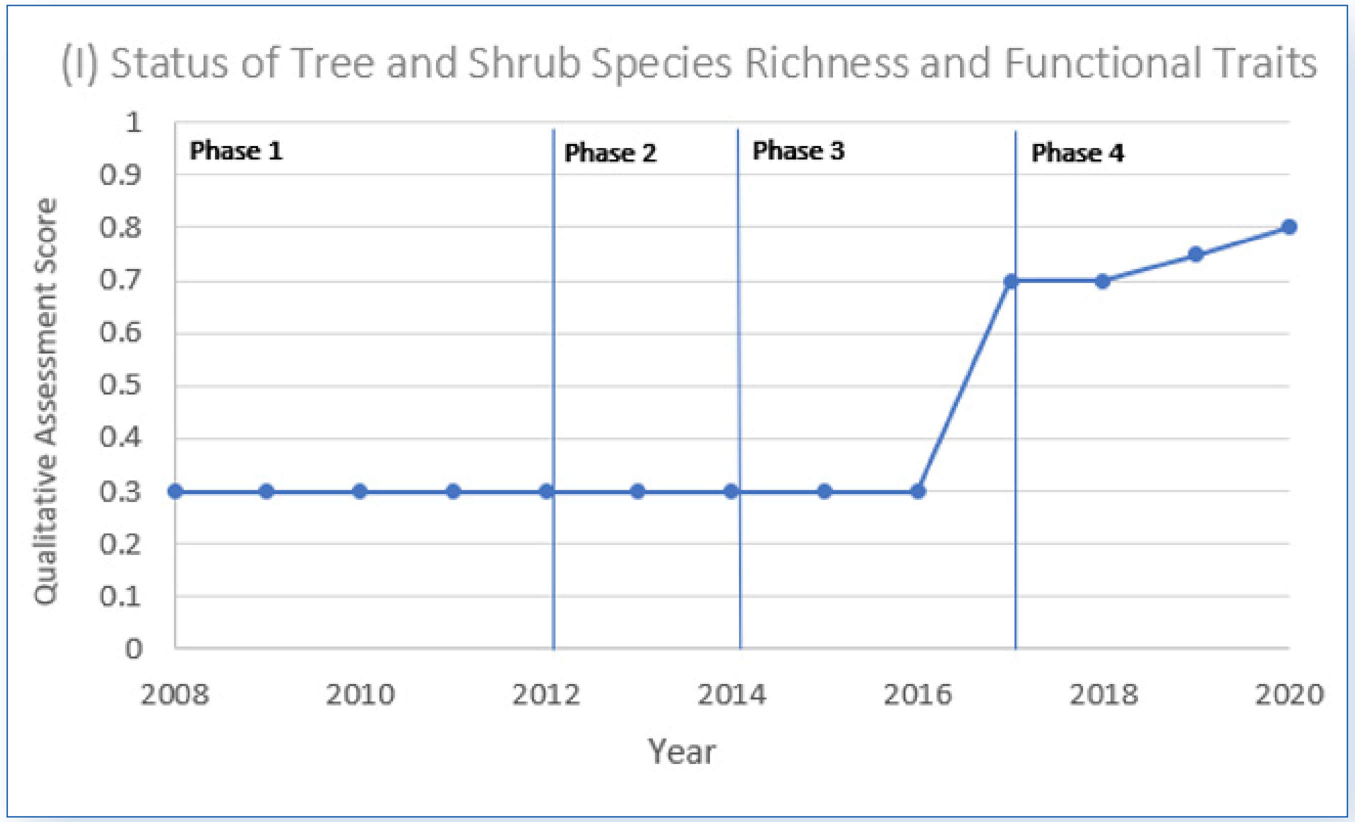


Figure 9d: Status of tree and shrub species richness and functional traits.

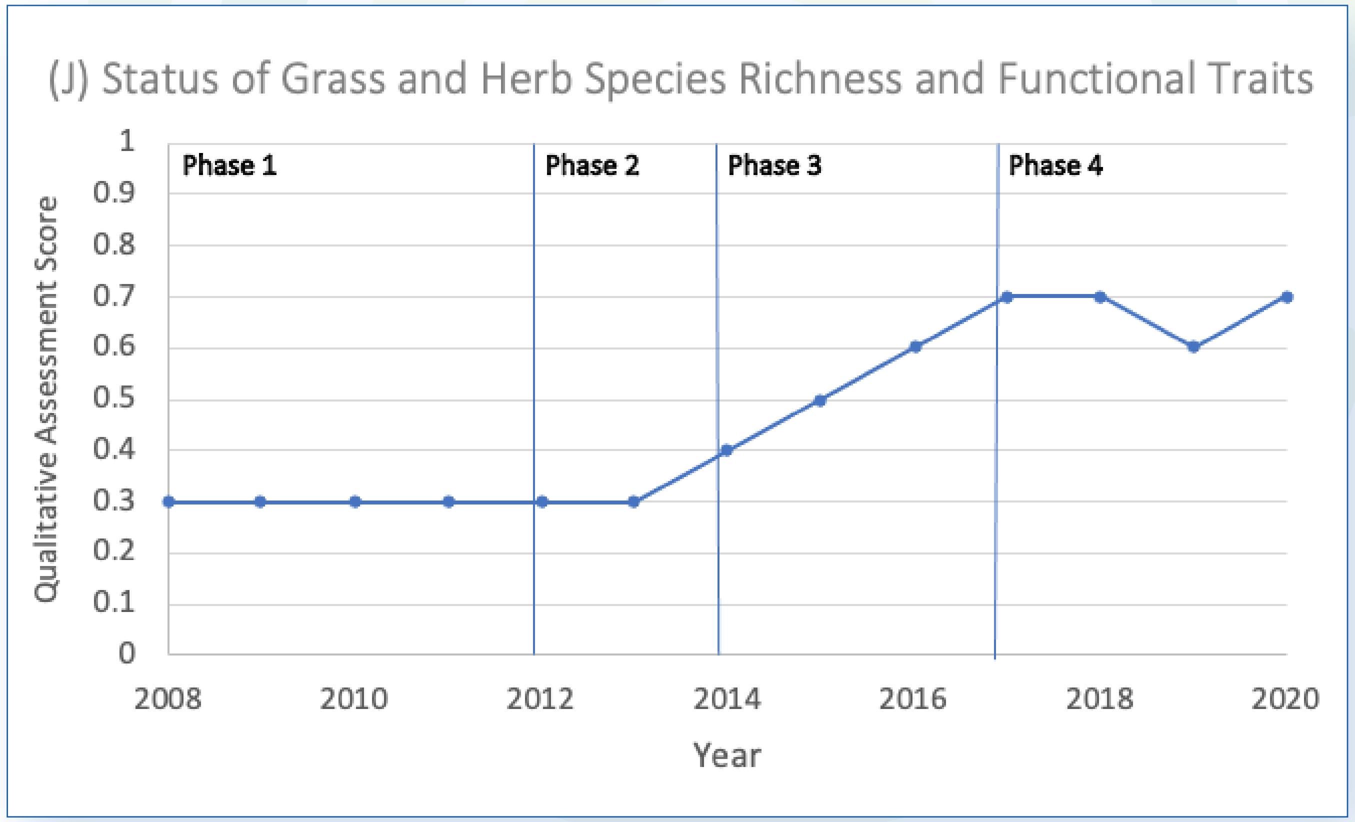


Figure10d: Status of grass and herb species richness and functional traits.