2018

‘JILLAMATONG” CASE STUDY: ECOLOGICAL SUMMARY REPORT

Prepared by

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Key findings

Jillamatong has been managed by one family since 1951. This ecological assessment commences in 1970 - this date reflects the period the land manager, Martin Royds was familiar with land management regimes on Jillamatong.

Martin Royds has been managing Jillamatong since 1985, prior to commencing regenerative landscape management regimes across the whole farm in 2005.

The graphical summaries for each criterion shown in the Supplementary Ecological Report, demonstrate that there is a close relationship between the land manager’s goals/ideals and the ecological outcomes in each of the four phases:

Phase 1: 1972-1984	Conventional non-regenerative regimes and practices
Phase 2:1985-1994	Intensive conventional interventions and small-scale trials
Phase 3: 1995-2004	Transition to broader scale regenerative regimes and associated infrastructure
Phase 4: 2005-2017	Increasing maturity of regenerative regimes and installation of novel water management interventions.

Compared to phases 1-3, in phase 4, most criteria have been assessed as nearly fully achieved or having achieved their reference state (i.e. a scores between 0.8 - 0.9). For example:

- Minimizing effects of extreme climatic events, which considers the whole property and its place in the broader catchment; this includes preparedness for drought and wildfire
- Preventing erosion, restoring eroded areas and maintaining ecological health, productive capacity and water quality of the property and watershed. Ecological changes include: soil nutrients and soil carbon; soil biology; and soil physical properties i.e. soil as a medium for plant growth.
- Managing pastures for production and to maintain ecological health of the property and watershed. Ecological changes include: sustained high levels of reproductive potential of pastures; the maintenance

of consistently high levels of ground cover in summer and in winter;

- Managing trees and shrubs for production and to maintain ecological health of the property and watershed. Ecological changes include: the development of, and maintenance of, tree and shrub species richness and functional traits; as well as grass and herb species richness and functional traits.
- Other criteria have only partially been achieved a partial recovery towards the reference state of 1.0 (i.e. a score of less than 0.8). This includes soil hydrology – infiltration; and the extent of native tree and shrub found on the property.

The land manager's demonstrated capacity to continue to maintain and improve the ecological outcomes of Jillamatong in the face of unreliable seasonal rainfall patterns, during the period 2003-17 (i.e. phases 3 and 4), particularly during the Millennium Drought, late 1996 to mid-2010, is noted.

This ecological assessment shows the importance of ecological learning and literacy, of a willingness to experiment and trial innovations. It also shows that a timescale of decades is required to develop and implement regenerative landscape management regimes on a whole of farm level.

Introduction

The Royds family settled in the Braidwood area in the first half of the 19th century and Martin's maternal grandparents acquired the Jillamatong property in 1952. Martin Royds managed Jillamatong jointly with others in the family from 1985 and took over sole responsibility in 1996.

By the early 1980s there were few trees left for shade and shelter for stock, or pasture and habitat for any other life. The surviving trees were dying. In cold windy weather, stock suffered. Due largely to set stocking and overgrazing, 10 to 15 centimetres of topsoil blew off entire hillsides during the drought of 1982. The only pastures that survived and regrew were the native pastures.

Commencing in the early-1980s much of the landscape consisted of an open grassy woodland with a native pasture of poa species, weeping grass (*Microlaena stipoides*), kangaroo grass (*Themeda triandra*), Danthonia species, and associated forbs and herbs. Manna gum (*Eucalyptus viminalis*) was scattered on the ridges while bogs and a chain of ponds with swamp gums (*Eucalyptus ovata*) and snow gums (*Eucalyptus pauciflora*) were common in the lower areas.

The paddocks were set stocked until the early 1990s. Stock water was from surface dams and free access to ponds in a central major erosion gully running through the axis of the property. Sheet and gully erosion were rampant and salt scalds were appearing. There were no permanent waterways on Jillamatong. This erosion gully was incised a metre at each headwall cut and in places was incised to a depth of over four metres.

An intensive program of pasture development was initiated by Martin, involving ploughing paddocks and sowing three introduced grasses and two clovers after first eliminating previous ground cover with herbicide. In 1991, spraying with various chemicals was intensified to try to establish five introduced grasses, three clovers and two forbs by direct sowing. Monocultures of wheat and oats were used mainly as a break crop to aid the re-sowing of pasture. The survival of rye grass and clovers was used as a bio-assay of when a paddock needed re-sowing.

Martin embarked on a holistic approach to land management at Jillamatong, which was founded on the goal of developing a farming system that is economically, environmentally and socially regenerative. It was important for Martin to acknowledge that management decisions caused the erosion, weeds, and economic problems, and that only by changing these management decisions could regenerative processes be added to achieve the desired positive outcomes.

Assessment of ecological and biodiversity outcomes

Managing soil-landscape types to minimize effects of extreme climatic events

In phases 1-3 (1972-2002) the pastures at Jillamatong were not managed to minimize the effects of extreme climatic events drought and wildfire. In contrast, in phase 4 pastures were developed and managed both to minimize the effects of extreme climatic events drought and wildfire (Figure 1).

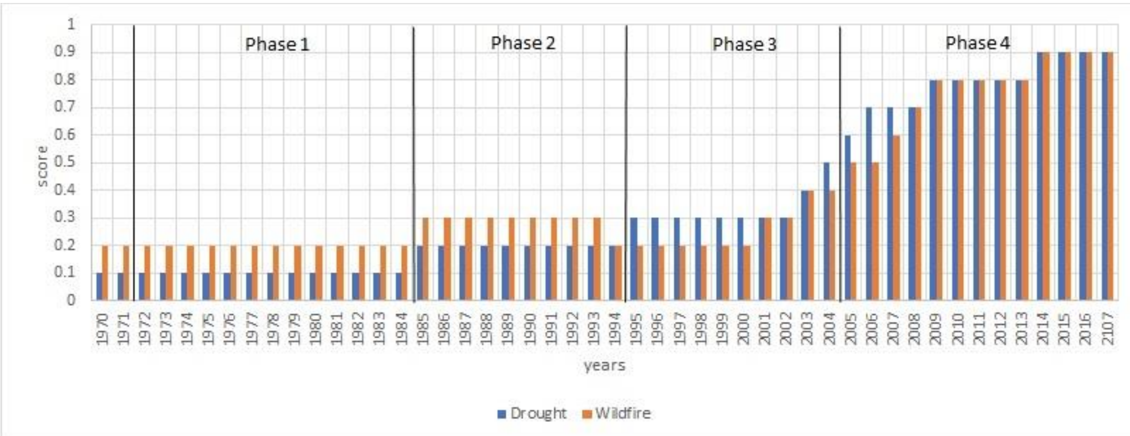


Figure 1. Minimizing the effects of extreme climatic events drought and wildfire in response to changes in land management regimes.

The onset of droughts, particularly 1982-83, saw the land manager retaining high stock numbers on the farm, with declining ground cover, well into drought. This effectively led to over-grazing, (i.e. constant grazing rather than graze/recovery/graze in response to available pasture growth), resulting in considerable bare ground, and exposure of the soil surface to wind and water erosion during periods of intense winds and/or heavy, drought-breaking rain.

During the Millennium Drought in Phase 4, cattle were again agisted or sold. When the dams were low and the floodplain dry, Martin cleaned his dams of clay and installed a series of earthen weirs along the along the central major gully. When the drought broke, this created a chain of ponds. The effect of these leaky weirs is to maintain green forage on the Jillamatong flats. Once the rains began to return, stock was purchased to take advantage of retained pasture and the quick response of the vegetation to in-soil moisture. This management strategy enabled the pasture to survive when rainfall was scant and for groundcover to be maintained. With the implementation of regenerative land management and proactive grazing management, Martin now relies solely on his dense pastures throughout the year rather than bought-in supplementary fodder. By continuing to increase the numbers of paddocks and providing access to water he has reinforced the benefits of graze/recovery/graze in response to available pasture growth.

In Phase 1-3 (1972 -2002) the grazing enterprise was vulnerable to wildfire, particularly in summer because of the inflexible paddock design, which did not enable rapid removal of stock in an emergency and poorly placed water sources for firefighting.

In Phase 4 (2005 to the present) the land manager had made provision for wildfire preparedness including: a greater number of paddocks, improved access to paddocks to enable rapid ingress/egress of stock in an emergency; improved number of, and access to, water points for firefighting; and the planting of fire resistant tree belts. Investment in earthen weirs has enabled the soils across the floodplain to capture, hold and spread water. This has led to improved pasture development allowing for improved water infiltration deeper into the soil profile.

Managing soils to prevent erosion, restore eroded areas and to maintain ecological health, productive capacity and water quality

Soil condition indicators at Jillamatong have all improved over time since 1972, particularly in phase 4 (2003-17).

In phases 1 (1972-84) the condition of the soils at Jillamatong were functioning at a low level compared to a desired reference state (score 1.0) (Figure 2). Changes made in the land management regimes in phase 2 (1985-94) saw a gradual increase in soil nutrients, which was maintained into phase 3 (1995-2002). During that phase, despite changes in land management regimes, there were no observed improvements in other indicators of soil condition i.e. soil hydrology soil biology, and soil physical properties (Figure 2).

Major changes were observed in all indicators of soil condition in phase 4 (2003-17) resulting from further changes in land management including; soil nutrients, soil hydrology soil biology, and soil physical properties (Figure 2).

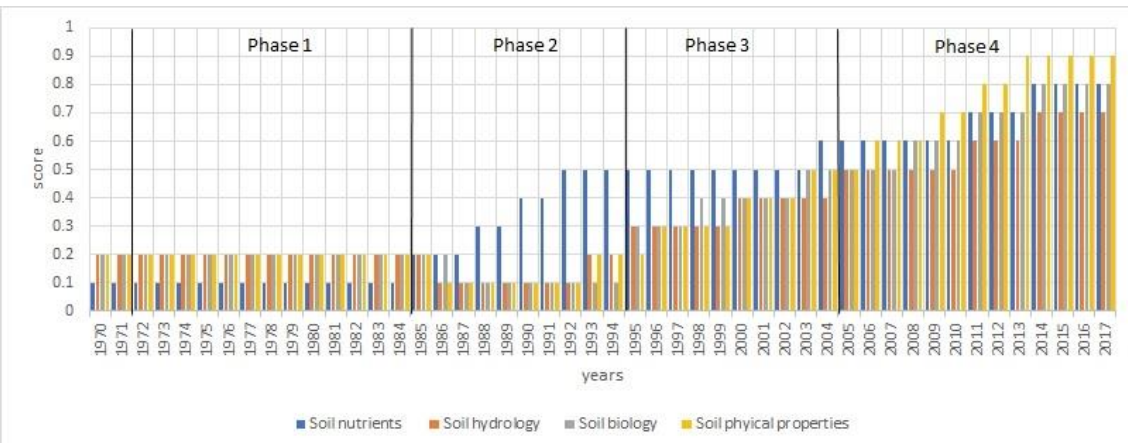


Figure 2. Status of soil indicators over time at Jillamatong.

In Phase 4 soils are becoming more friable and porous with increased soil humus levels. Penetrometers now reach into the soil to one metre at less than 4,000 kPa (kilopascals) pressures.

Recently the paddock design has been converted from the wagon-wheels to narrow paddocks have their fence lines arranged perpendicular to the creek and running upslope to the more elevated country. This allows cattle to graze from the floodplain, via the lower slopes, to the upper slopes thus enabling them to move nutrients from the fertile flats to the upper slopes in their dung. The land manager has observed a steady increase in productivity on his less fertile high country where soils used to dry out quickly or leach during wet seasons.

Deep-rooted forbs such as Chicory (*Cichorium intybus*, Brassicas and Plantain (*Plantago major*) have been established in the pasture on the floodplain to help bring nutrients from deep in the soil up to the root zone of the grasses and to aerate compacted areas.

Available carbon (labile) has also increased from a range of 0.8% to 2.4% in various paddocks in 2007, to a high of 2.9% in 2012. Now, the best sites have measured close to 7.0% for soil organic carbon.

In phase 4 soil are becoming more friable and porous with increased soil humus levels. Penetrometers now reach into the soil to one metre at less than 4,000 kPa (kilopascals) pressures.

The results of Phase 3 management were slow to eventuate, but in Phase 4 the land manager observed obvious improvements in soil biology, especially fungal activity.

Infiltration of rainfall has increased, improving the water cycle and reducing flash floods. With greater water infiltration, there is less surface runoff during rain events. Water now leaks slowly into the floodplain from the surrounding slopes.

Over land flows of rainwater were slowed and dispersed through the system of chain of ponds, diversion banks and contour channels. This system, combined with grazing and pasture management, now prevents rill and gully erosion and replenishes superficial water table, encouraging deep rooting pasture plants and supporting plant growth in dry seasons. Steady sub-surface flows recharge the chain of ponds and have created a healthy, permanent stream in what was previously, in Phases 1-3, a 4m deep, ephemeral watercourse.

Soil structure has improved, becoming more friable, porous and with lower bulk density indicating growing SOM and therefore soil carbon. Stopping the eroding head wall cuts in the former erosion gully using weirs has rehydrated the landscape by enabling water to be held and spread higher in the landscape. As a corollary of raising and maintaining the moisture levels within the soil profile, deep rooted perennials are able to access that moisture, hence mitigating salt rising to the surface. By establishing several contour channels (swales) mid-slope this too has contributed to the rehydration of large areas of the property.

Managing ground layer vegetation for production and to maintain ecological health

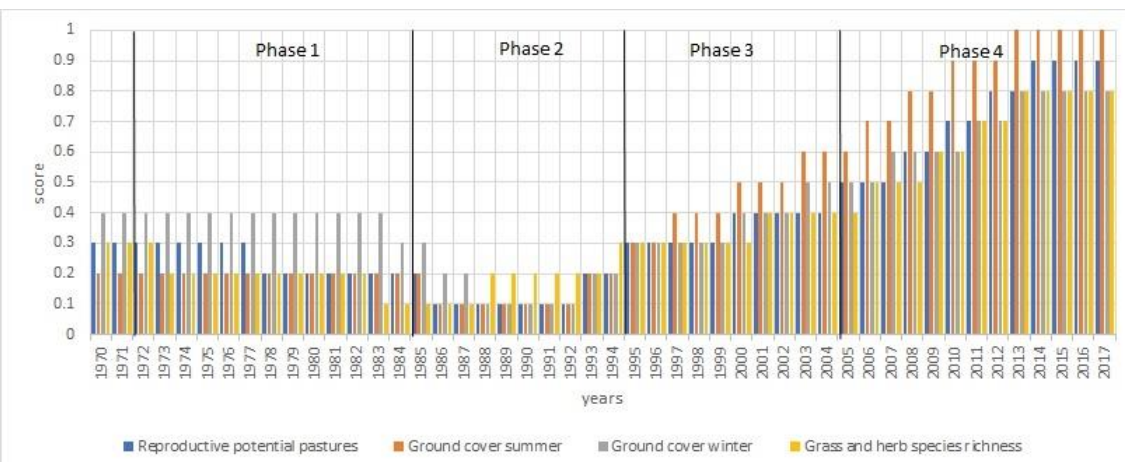


Figure 3. Status of ground layer vegetation for production and to maintain ecological health over time at Jillamatong

The establishment and maintenance of summer and winter active perennial pastures provides year round green grass. When dew condenses on the actively-growing grasses it provides additional moisture that helps sustain healthy pastures.

In Phase 4, with the full implementation of regenerative management practices, soil physical properties began to stabilise at improved levels from 2012 onwards. In such paddocks, the land manager observed his mix of C3 and C4 perennial pastures provided green grass in all seasons beneath which the soil was cooler summer, less frosted in winter, and relatively easily dug with a shovel. The plants had bigger and deeper root systems in keeping with their height.

Managing trees and shrubs for production and to maintain ecological health of the property and watershed

In Phase 1 many of the remaining native trees on the mid and lower slopes, Manna gum (*Eucalyptus mannifera*) and Ribbon Gum (*Eucalyptus Viminalis)*, were isolated and scattered and were over mature/ senescent or dead. High quality timber trees like Yellow Box (*Eucalyptus Melliodora)* had been harvested for fencing nearly a century before.

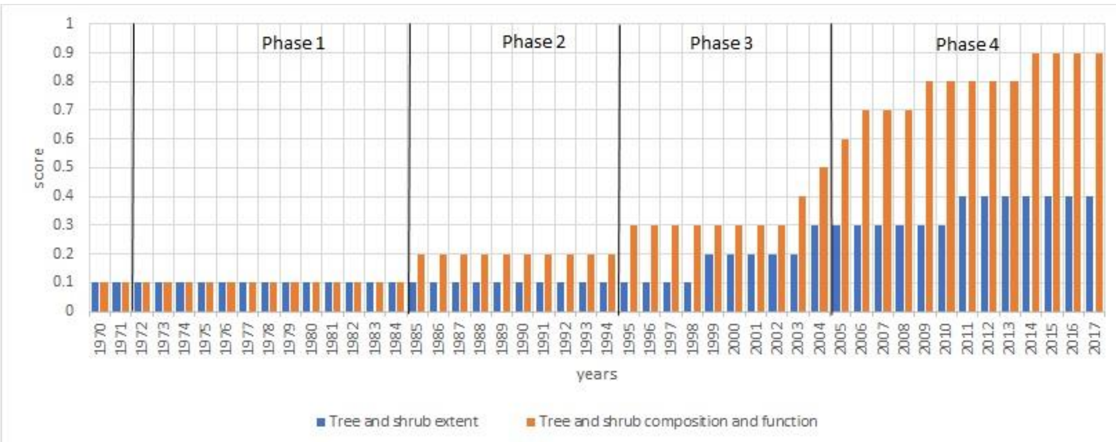


Figure 4. Status of trees and shrubs for production and to maintain ecological health of the property and watershed over time at Jillamatong

In Phase 4 there has been regrowth of black wattles and eucalypts where livestock has been excluded. Extensive tree lane and copse plantings now connect neighbouring forested hills with each other and provide cattle shelter. Tube stock is chosen to best suit the site conditions, particularly to resist frost and wind. Christmas beetles cause problems for several eucalypt species owing to their isolation, so Martin now has a mixture of evergreen exotics as well as beetle-resistant natives. These shelter-belts are reconnecting the habitat areas across the landscape. Most paddocks have trees with an understorey where possible Predatory insects, spiders and birds making their home in these shelter belts have been useful in mitigating pest infestations and the relationship between predator and prey appears to be in balance. Retention and reinstatement of trees on the hill tops also acts as a lure for the cattle seeking shade in hot weather, where they camp and bring fertility up from the flats.

Managing natural watercourses, riparian areas, natural lakes and wetlands, to protect ecosystems that are sensitive to agricultural land management.

Over land flows of rainwater were slowed and dispersed through the system of chain of ponds, diversion banks and contour channels. This system, combined with grazing and pasture management, now prevents rill and gully erosion and replenishes superficial water table, encouraging deep rooting pasture plants and supporting plant growth in dry seasons. Steady sub-surface flows recharge the chain of ponds and have created a healthy, permanent stream in what was previously, in Phases 1-3, a 1-4m deep, erosion gully. Historically, the gully flowed with fast flowing turbid water after heavy rains and only for a short period. Now, there is a perennial flow of water through the ponds, which is continuous, clear and potable.

Rainwater moving through the landscape has been slowed down. There is less surface runoff and the pastures now provide year-long green perennial grasses. When dew condenses on the green perennial grasses this provides additional water that helps sustain soil moisture and healthy pasture growth.

The system of a “chain of ponds” has provided habitat for reeds, sedges and rushes in which water birds and reptiles have become breeding residents. Other migratory bird species are being observed for the first time at Jillamatong, to take advantage of the extensive surface water, the feed source and the reinstated habitat.

2018

“JILLAMATONG” CASE STUDY: SUPPLEMENTARY ECOLOGICAL REPORT

Prepared by

ADJ.Assoc. Prof Richard Thackway BSc. NSc

Ecological Assessment

Key findings

- The land holder has a reputation for early adoption of regenerative landscape management regimes, comprising 14 years of knowledge and experience of broad scale implementation and practice.
- Jillamatong has been managed by one family since 1951 and a single land manager from 1985 to the present.
- This assessment shows the importance of ecological learning and literacy, of a willingness to experiment and trial innovations, and to upscale and implement on a whole farm scale regenerative landscape management regimes and practices. This progression takes time and resources.
- The graphical summaries for each criterion show there is a close relationship between the land manager’s goals/ideals and the ecological outcomes in each of the four phases.
- 10 ecological criteria have been assessed, with all 10 showing differential responses to land management regimes over the four phases.
- Phase 4 shows obvious change in all ecological criteria, relative to phases 1-3.
    - Most criteria have been assessed as nearly fully achieved or having achieved their reference state (i.e. a scores between 0.8 - 0.9): for example, A) Resilience of landscape to natural disturbances (Drought, Wildfire and Flood preparedness A1) and A2) respectively; B) Soil nutrients soil carbon; D) Soil biology; E) soil physical properties (Soil as a medium for plant growth); F) Reproductive potential of pastures; H1) Ground cover in summer; H2) Ground cover in winter; I) Tree and shrub species richness and functional traits; J) Grass and herb species richness and functional traits.
    - Other criteria have only partially been achieved (i.e. a score of less than 0.8): C) Soil hydrology – infiltration (score of 0.7); and G) Native tree and shrub cover (score of 0.4).
    - The land manager’s demonstrated capacity to continue to maintain and improve the ecological outcomes of Jillamatong in the face of unreliable seasonal rainfall patterns (Attachment C), over the long term (phases 4), particularly during the Millennium Drought, is noted.

Assessing responses to land management regimes according to the ecological criteria

This Supplementary Report is underpinned by a Conceptual Model (Annex Figure 1) and Assessment Framework (Attachment A Table 1 and 2). This ecological assessment comprises 9 of the possible 10 response criteria corresponding to ecosystem function, composition and structure (Attachment A Table 2).

Prior to undertaking a field visit to Jillamatong in July 2017, the landowner, Martin Royds, was asked to document the land management regimes or production systems associated with the four phases of management (Annex Figure 1). This included a collation of all available published and unpublished ecological relevant data and information about the farm and how it was managed. It also included paddock-based photographs, fertiliser history, paddock-based management histories, as well as grazing charts, bird surveys and names of interested parties who had visited the farm over time (Attachment B). This 2017 assessment has incorporated information which was compiled in September 2012 as part of the Soils for Life (SFL) Innovations for Regenerative Landscape Management Project.

This section describes how Jillamatong has been managed over the four phases 1972-2017:

Phase 1: 1972-1984	Conventional non-regenerative regimes and practices
Phase 2:1985-1994	Intensive conventional interventions and small-scale trials
Phase 3: 1995-2004	Transition to broader scale regenerative regimes - and associated infrastructure
Phase 4: 2005-2017	Increasing maturity of regenerative regimes and installation of novel water management interventions.

Where quantitative data had been collected over time by the land manager, these were used to populate the respective response criteria i.e. this Ecological Assessment. Because of a paucity of quantitative data, expert elicitation was used to assess the ecological effects of implementing production systems on ecological criteria associated with ecosystem function, structure and composition over time. This was done by asking the land manager to self-assess how his goals or lifestyle intents affected his landscape management regimes (i.e. production systems) and what effects he observed on the scale of ecological response criteria. Change was assessed graphically relative to the baseline which was defined by the land manager as conventional non-regenerative land management.

In the following section, the ten ecological response criteria (Attachment A Table 2) are assessed and shown graphically over four phases (i.e. landscape management regimes). Each phase is described by an aggregate of land management practices, which correspond to the goals or ideals of the land manager (Attachment B).

This ecological assessment acknowledges that climate variability plays a major role in influencing the land manager’s decision-making process and his capacity to implement his plans for production. In turn, the effects of climate variability have major impacts on ecological, economic and social wellbeing. We, like most agricultural land managers use rainfall to as a gauge of climate variability. A summary of the seasonal rainfall from 1900 to 2015 for Jillamatong is presented in Attachment C.

The following 10 ecological response criteria listed in ((Attachment A Table 2) are assessed below:

A. Resilience to natural major disturbance/s (e.g. drought, fire, flood);
B. Status of soil nutrients including soil carbon, major and minor elements;
C. Status of soil hydrology including infiltration, percolation and water availability to plants;
D. Status of soil biology including bioturbators i.e. nutrient recyclers, fungi and bacteria ratios and soil organic matter;
E. Status of soil physical properties including bulk density and soil as a medium for plant development and growth;
F. Status of the reproductive potential of the plant species and plant community;
G. Status of tree and shrub structure;
H. Status of ground layer/ground cover/grass and herb structure;
I. Status of tree and shrub species richness and functional traits; and
J. Status of the ground layer/grass and herb species richness and functional traits

In two cases, because of the familiarity of the land manager with the criteria, more than one indicator was used to assess one criterion e.g.

- natural disturbances – drought preparedness and flood mitigation, and wildfire preparedness
- grass and herb vegetation structure – summer and winter ground cover

To evaluate and validate the land manager's self-assessment, Soils for Life has engaged Farmmap4D, in a partnership agreement, whereby Farmmap4D will provide a satellite-based validation of two measures:

1. the observed responses of paddocks within Jillamatong over time
2. the observed responses of Jillamatong compared with the surrounding properties, i.e. within a 2-kilometre radius of Jillamatong over the study period.

These two measures are expected to show varying levels of correlation within Jillamatong to several response criteria including:

D. Status of soil biology - Soil surface condition

E. Status of soil physical properties – Landscape function

G. Status of tree and shrub structure - Extent of tree cover

H. Status of grass and herb structure – Year-round ground cover

J Status of grass and herb functional diversity - Grass and herb species richness

Assessment of Response Criteria

A1. Resilience of landscape to natural disturbances - Drought Preparedness and Flood Mitigation

Why track changes and trends in resilience to major natural disturbance/s?

Resilience to major disturbance/s includes the following factors depending on the agro-climatic region (wildfire, drought, cyclone, dust storm, flood).

A major natural disaster or natural disturbance event can occur at any time. Some disturbances give a warning, such as a wind storm or electrical storm preceding a wildfire or a flood. Once a disaster happens, the time to prepare is gone. Lack of preparation can have enormous consequences including, social, ecological, economic and production.

Assumptions and definitions

Drought preparedness is an aggregate score across all paddocks within Jillamatong. In the case of Jillamatong the major disturbance is drought. Appropriate drought management dictates dynamic monitoring of stock numbers and available pasture to avoid groundcover loss and expensive fodder purchases. In extreme cases, destocking of all but core breeding females is necessary together with the use of a “sacrificial” paddock where fodder reserves in the form of hay or bought-in pellets can be fed out until the rains come.

Results and Interpretation

Phases 1 and 2

During phases 1 to 2 (1972-1994) this assessment shows the land managers (Captain Helms 1972 to 1985 and Martin Royds, -his grandson- from 1985 to 1995) exhibited minimal capacity to manage for drought using the resources of the farm. During these two phases, the focus was predominantly on livestock production. The onset of droughts, particularly 1982-83, saw the land manager retaining high stock numbers on the farm, with declining ground cover, well into drought. This effectively led to over-grazing, (i.e. constant grazing rather than graze/recovery/graze in response to available pasture growth), resulting in considerable bare ground, and exposure of the soil surface to wind and water erosion during periods of intense winds and/or heavy, drought-breaking rain (Attachment B).

Going into a dry spell or a drought, the land manager would have a feed deficit which generally required supplementary feeding with pasture hay made during the summer or stock pellets. During dry times the animals were sent on agistment and sometimes the land manager drove sheep along roadside verges and travelling stock reserves.

In the 1982-83 drought (Attachment C), Martin Royds watched as tonnes of topsoil blow off hillsides, burying some fences. Gully erosion was rampant, and when the rains eventually did come, much of remaining topsoil and organic matter was stripped and washed away.

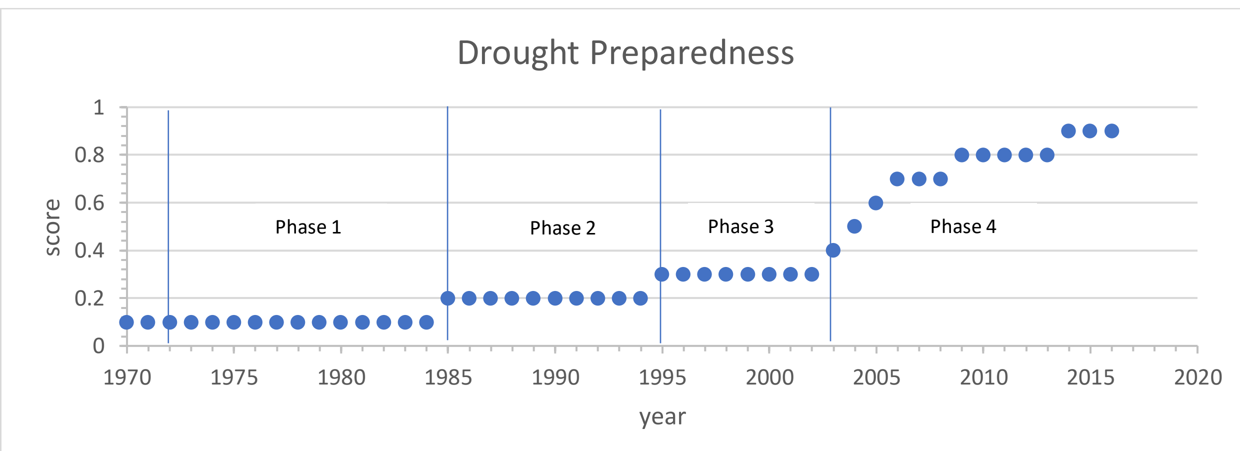
Phase 3 (1995 to 2005), saw the commencement of transition to holistic management across the property. The focus was now transferred to grazing management, to enhance grass growth and the lifecycles of pasture species. By switching the focus from livestock production to maintaining and improving the farm’s resource condition - soil and vegetation - drought was now a manageable issue. Soils and vegetation became the assets rather than the livestock. Agistment and travelling stock reserves remained back-up strategies if selling stock was not an option owing to depressed markets or the need to maintain the breeders. By increasing the numbers of paddocks and providing drinking troughs, Martin saw the benefits of graze/recovery/graze in response to available pasture growth (Attachment B).

During the Millennium Drought in phase 4, the animals were again agisted or sold. When the dams were low and the floodplain dry, Martin cleaned his dams of clay and installed NSF structures along his degraded watercourse. These leaky weirs filled as the drought broke and continue to maintain green forage on the Jillamatong creek flats. Once the rains began to return, stock was purchased to take advantage of retained pasture and the quick response of the vegetation to in-soil moisture. This management strategy enabled the pasture to survive when rainfall was scant and for groundcover to be maintained. With the implementation of regenerative land management and proactive grazing management, Martin now relies solely on his dense pastures throughout the year rather than bought-in supplementary fodder. By continuing to increase the numbers of paddocks and providing access to water he has reinforced the benefits of graze/recovery/graze in response to available pasture growth (Attachment B).

The creek at Jillamatong is man-made, having been created to drain the boggy low country. Prior to 2007, it rarely ran, but when it did, it ran fast, scouring the banks and eroding the bed. The leaky weirs not only remediated the erosion and provided reliable water, but also avoided the risk of fencing loss during floods by slowing the high flows. Martin can now direct the water by a matrix of pipes and contour channels to avoid inundation and to irrigate the entire valley naturally.

Animal management is focussed on weight gain and reproductive efficiency. During the Millennium Drought Jillamatong carried low stock numbers. The priorities were:

- learning how to maintain and protect soil condition;
- managing base level stream flows to water the floodplain;
- enhancing biological activity;
- capturing and holding rain water in new contour channels;
- spreading moisture within the soil profile; and
- maintaining and improving vigorous, high-quality pastures.



A2. Resilience of landscape to natural disturbances - Wildfire Preparedness

Why track changes and trends in resilience to major natural disturbance/s?

Refer to text presented in A1 - Drought preparedness. After Drought preparedness, Wildfire Preparedness is the next major disturbance that the land manager identified that needs to be managed for.

Assumptions and definitions

Wildfire preparedness is an aggregate score across all paddocks within Jillamatong. At Jillamatong the predominant wind direction, which brings with it the threat of wildfire, particularly in summer, is from the west and northwest. In managing for wildfire threat, it is important to prepare strategically, which includes: paddock design, particularly access to paddocks; access to water for firefighting; and planting fire resistant tree belts.

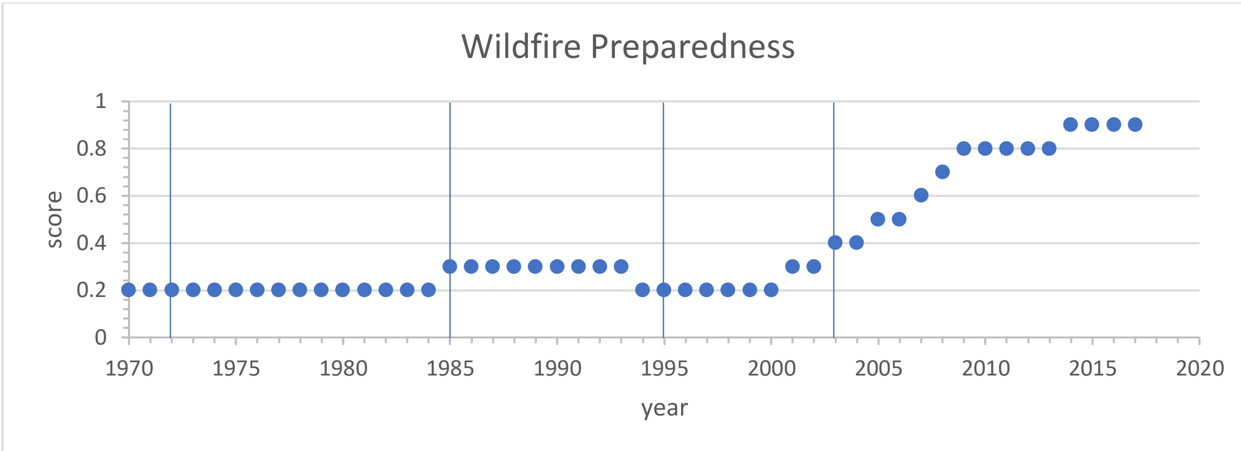
Results and Interpretation

In phase 1 (1972 -1984) the grazing enterprise was vulnerable to wildfire, particularly in summer because of the inflexible paddock design, which did not enable rapid ingress/egress of stock in an emergency and poorly placed water sources for firefighting.

In phase 2 (1985 – 1995) the land manager indicated that there had been some improvements in wildfire preparedness. This was because the composition of the pastures was changed from native to mixed native and exotic species. These modified pastures were considered less likely to carry a fire than pastures dominated by native species.

In phase 3 (1996-2005) the land manager indicated that there were mixed outcomes for wildfire preparedness. This was in part due to implementing a new wagon-wheel design for paddocks, but still carrying too many animals into the summer fire season. The short grass therefore offered less fuel for fires, but was very dry.

In phase 4 (2005 to the present) the land manager had by now developed a sound farm management plan which included provision for: wildfire preparedness, a greater number of paddocks, improved access to paddocks to enable rapid ingress/egress of stock in an emergency; improved number of, and access to, water points for firefighting; and the planting of fire resistant tree belts. The NSF investment in 2007 has enabled him to capture, hold and spread water across the floodplain. Contour channels fed by the leaky weirs along the lower slopes have resulted in improved plant-based systems allowing for improved water infiltration deeper into the soil profile. The result is green, fire-resistant vegetation during dry periods


Wildfire Preparedness
score
year
1
0.8
0.6
0.4
0.2
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

B. Status of soil nutrients – including soil carbon

Why track changes and trends in soil nutrients – including soil carbon?

Soil organic matter (SOM) is the basis of soil fertility. As a general rule-of-thumb, for every tonne of carbon in SOM about 100 kilograms (kg) of nitrogen, 15kg of phosphorus and 15kg of sulphur become available to plants as the organic matter is broken down. Thus, SOM releases nutrients for plant growth, promotes the structure, biological and physical health of soil, and is a buffer against harmful substances.

Assumptions and definitions

This is an aggregate score of the soil nutrients of all paddocks found in Jillamatong. This includes SOM, soil carbon, and a range of major and trace elements.

Soil organic carbon accounts for less than 5% on average of the mass of upper soil layers, and diminishes with depth. According to the CSIRO, in rainforests or good soils, soil organic carbon can be greater than 10%, while in poorer or heavily exploited soils, levels are likely to be less than 1%. Under conventional agriculture, heavy applications of inorganic fertilisers (inputs) are used to drive higher production outputs whereas under regenerative landscape management regimes the emphasis is on organic fertilisers and innovative nutrient distribution via foliar sprays and use of the cattle dung. Regenerative landscape management regimes may be described as low input, but high quality/lower quantity output systems.

A good layer of humus within the root zone is indicative of higher levels of stable soil carbon in the soil profile.

Results and Interpretation

In phase 1 superphosphate was added to the soil to drive higher production outputs, but this production system did not build soil carbon. Because of the high stocking rates minimal levels of SOM were observed in the “A” horizon of the soil during this phase. Heavy applications of superphosphate and biocides enhanced the oxidation of any residual and new organic matter making the podosol soils highly dependent on regular inputs and vulnerable to water stress during dry spells.

In this phase, associated with the 1982-83 drought, it is estimated that wind erosion removed up to 90 tonnes of topsoil per hectare exposing highly leached mineral subsoils with often less than 0.5% soil organic matter. Loss of topsoil meant loss of plant available soil nutrients, including organic carbon.

In phase 2 while the land manager widened his fertiliser spectrum from single super to NPK blends when establishing new pasture, he was seeking alternative methods to boost fertility. This included adding 400 tonnes of ‘agriash’ to the pasture obtained from the Molonglo (Canberra’s) tertiary sewage treatment works to assist in raising pH and to gain trace elements.

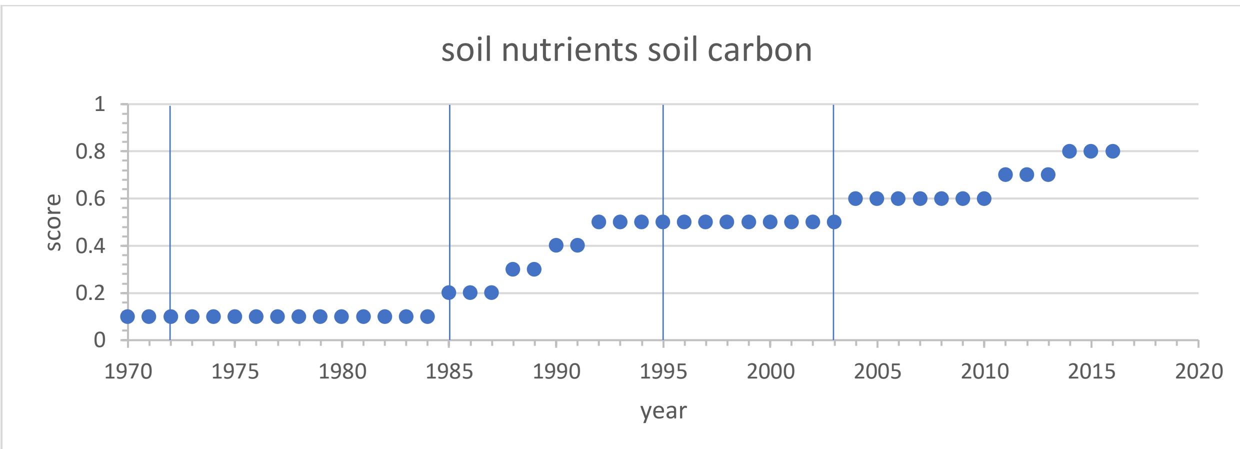
In phase 3 the land manager ceased applying inorganic fertilisers completely. He began to concentrate on building healthy soil, pastures and water cycles. This started with trials of organic fertilisers to enhance soil carbon and microbial activity, followed by biological solutions and compost teas sprayed directly onto the pasture.

In phase 4 Martin has continued the biological, foliar sprays and has initiated in-paddock compost heaps placed within flow lines. These methods appear to have improved the soil and pasture nutrient balances and have stimulated the operation of the soil food web.

The paddock design has been converted from the wagon-wheels to a new layout where narrow paddocks have their fence lines arranged perpendicular to the creek and running upslope to the high country. This allows cattle to graze from the floodplain, via the lower slopes, to the hill tops thus enabling them to move nutrients from the fertile flats to the upper slopes in their dung. The land manager has observed a steady increase in productivity on his less fertile high country where soils used to dry out quickly or leach during wet seasons.

Deep-rooted forbs such as Chicory (*Cichorium intybus*, Brassicas and Plantain (*Plantago major*) have been established in the pasture to help bring nutrients from deep in the soil up to the root zone of the grasses and to aerate compacted areas.

Available carbon (labile) has increased from a range of 0.8% to 2.4% in various paddocks ten years ago, to a high of 2.9% five years ago. Now, the best sites have measured close to 7.0% for soil organic carbon.



C. Status of soil hydrology - Soil surface water infiltration

Why track changes and trends in soil surface water infiltration?

Soil physical properties have a direct relationship to soil moisture. Soil texture and structure greatly influence water infiltration, permeability and water-holding capacity. Of the water entering a soil profile, some will be stored within the root zone for plant use, some will evaporate, and some will drain away. In agro-ecological settings, by increasing water infiltration, permeability and water-holding capacity this will usually act as a stimulus to ecological function.

Assumptions and definitions

Plant available water is the difference between field capacity (the maximum amount of water the soil can hold) and the wilting point (where the plant can no longer extract water from the soil) measured over 100 cm or maximum rooting depth.

This is an aggregate score of the soil surface water infiltration and water holding capacity across all paddocks found in Jillamatong.

Soil water infiltration was observed as rainwater and surface flows resulting from intense rainfall events being absorbed into the soil rather than surface water flows running-off a given soil area.

Results and Interpretation

During the 1960s, the NSW Soil Conservation Service worked at Jillamatong to address extensive gully erosion forming a series of headwall cuts travelling up the central drainage line to a depth of over four metres. There were incisions at each headwall cut down to a metre.

Throughout phase 1 the soil structure was poor. A shovel only penetrated the soil a few millimetres and even tractor drawn ploughs did not easily break the surface. Heavy or intense rainfall events resulted in concentrated surface flows causing sheet and gully erosion. Salt scalds were appearing. The NSW Soil Conservation Service established a series of contour drains leading to dams the overflow from which was then piped to the bottom of the erosion gully. Surface water flows were regarded as a problem, with excess to be drained away as quickly as possible.

In phase 2 the land manager was concerned that erosion controls previously installed were not correcting the gullying associated with heavy or intense rainfall events. In 1986, this ephemeral erosion gully bisected the property.

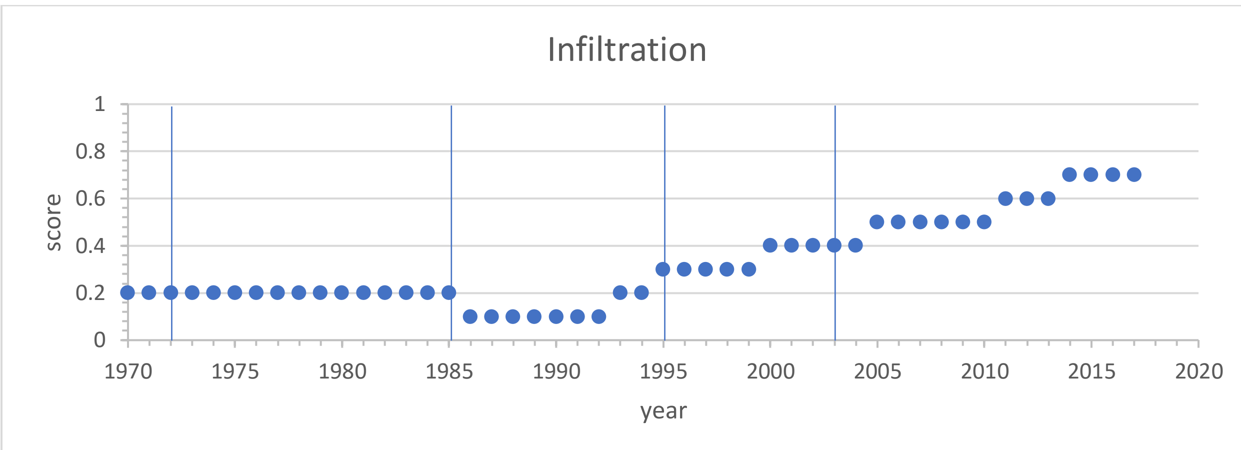
In phase 3 soil penetrometers only pierced the topsoil a few millimetres and at maximum pressure. Soil erosion continued unabated. Sheet water flows during major rainfall events were associated with low ground cover levels.

In phase 4 holistic management and natural sequence techniques were implemented across the farm. Soil health has now improved, becoming more friable and porous with increased soil humus levels. Penetrometers now reach into the soil to one metre at less than 4,000 kPa (kilopascals) pressures.

Commencing in 2005 the land manager began a focus on water cycle management with the support of Peter Andrews. This involved rehabilitating the erosion gully and turning it into a permanent, meandering stream. Eroding head wall cuts were stabilized with earthen weirs. These practices also involved rehydrating the valley by holding and spreading surface water higher in the landscape. It also involved holding water for longer periods on the flood plains.

Over land flows of rainwater were slowed and dispersed through the system of chain of ponds, diversion banks and contour channels. This system, combined with grazing and pasture management, now prevents rill and gully erosion and replenishes superficial water table, encouraging deep rooting pasture plants and supporting plant growth in dry seasons. Steady sub-surface flows recharge the chain of ponds and have created a healthy, permanent stream in what was previously, in phases 1-3, a 1-4m deep, erosion gully. Where historically, the gully flowed with fast flowing turbid water after heavy rains and only for a short period; now days there is a perennial flow of water through the pods, which is continuous, clear and potable water..

The establishment and maintenance of summer and winter active perennial pastures provides year round green grass. When dew condenses on the actively-growing grasses it provides additional moisture that helps sustain healthy pastures.



D. Status of soil biology - Soil biology

Why track changes and trends in soil biological activity?

Soil biology affects plant (and animal) production by modifying the soil physical, chemical and biological environment within which plants grow and persist. The ratio of fungi to bacteria is important for land managers to understand - too many bacteria can indicate an unhealthy and unproductive soil. Soil fungi contribute to:

- natural processes (litter transformation, micro-food web participation and soil engineering);
- the decomposition of organic material resulting from compost applications and disturbance from cattle grazing; and
- enhancing nutrient distribution for plant health and productivity.

In healthy soils, invertebrates including arthropods and worms, also form a vital part of a soil food web.

Declining soil surface condition involves the depletion of nutrients, soil organic matter and of key elements of the soil biology from the soils. Soil degradation is the result of high levels of bare ground, water erosion, wind erosion, chemical and physical deterioration. It is often associated with unsuitable land management regimes.

Assumptions and definitions

This is an aggregate score of the soil surface condition properties of all paddocks found in Jillamatong.

Soil degradation can be defined as a process by which one or more of the potential ecological functions of the soil are harmed. This process lowers the current and/or future capacity of the soil to produce goods and services.

Indicators of this criterion focus primarily on the cover of plants, organic material (including dung) and plant litter retained on the soil surface. Condition may be defined as the extent and size of vegetation "patches", where resources accumulate, and bare soil areas ("inter-patches"), where resources may be mobilised and lost. By observing changes and trends in groundcover and organic matter over time, land managers are able to assess their success in implementing regenerative landscape management principles and practices.

Decomposition of plant and animal residues is a dynamic process involving trophic levels. While some of the residues are being broken down for the first time by the litter transformers (detritivores), other residues have already been sequestered by soil microflora, which are in turn consumed by microfauna predators. The process of converting plant and animal residues into humus is facilitated by enzymes, either contained within the soil organisms or secreted by either living or dead soil organisms into the soil matrix. Each of these process makes soil nutrients available for plant production and contributes to soil carbon.

Results and Interpretation

In phase 1 pastures were intensively managed to promote available fodder for livestock production including spraying with biocides to control red-legged earth mite, scarabs, grasshoppers and fungal diseases. High levels of superphosphate fertiliser were also added to increase pasture productivity. It is likely that superphosphate combined with biocides enhanced the oxidation of any residual and new organic matter making the podosol soils highly dependent of regular inputs and vulnerable to stress during dry spells.

In phase 2 the land manager was carrying a higher stocking rate than in phase 1. He continued to observe relatively high levels of bare ground erosion, compacted soil and landscape desiccation in summer. He also realised that he was poisoning himself and the landscape via the fungicides, herbicides and insecticides. At the same time the land manager continued to apply NPK when establishing new pastures or renovating existing ones. However, he began to seek alternatives to NPK, to build the soil carbon and improve soil structure.

In 1990 Martin trialled pasture mixes including phalaris, fescue, ryegrass, markoo lotus and two clovers.

In 1991, pastures were intensively sprayed out with various chemicals to reduce competition when trying to establish five introduced grasses, three clovers and two forbs by direct drilling. Winter wheat and oats were used mainly as break or cover crops to aid the re-sowing of pasture. The survival of rye grass and clovers was used as a bio-assay to determine when a paddock needed re-sowing.

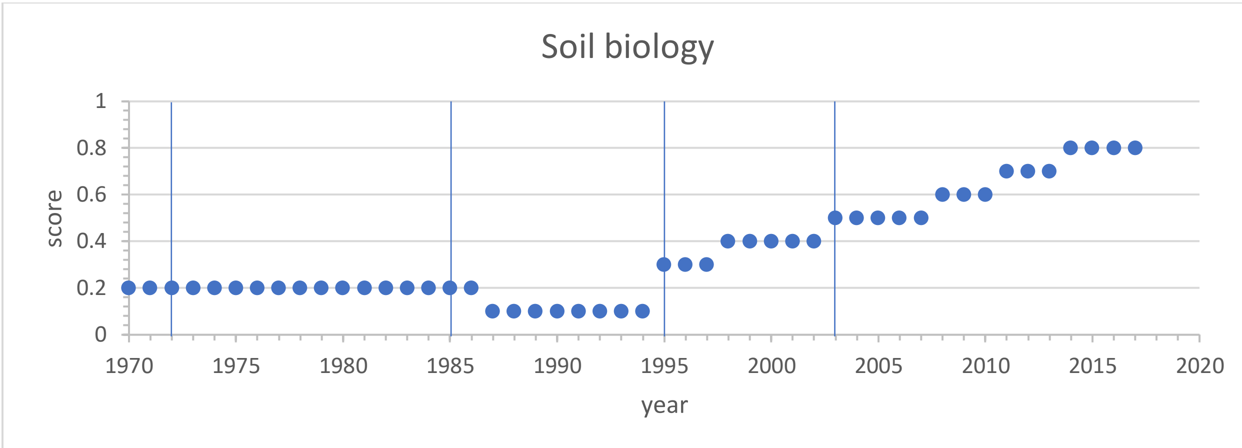
Flat weeds and thistles were sprayed with MCPA and Amicide. Paddocks were poisoned at each re-sowing between 1990 and 1995 with Roundup. Most fallen dead paddock timbers were pushed up and burnt to reduce rabbit infestation and to increase the area for pasture. The rabbits were trapped or poisoned.

In 1994, the land manager constructed the first wagon-wheel fencing design and increased the number of paddocks from 10 traditional paddocks to 25 triangle shaped paddocks. These smaller paddocks met at the hub of the wheel, with a shared central water trough. Using this paddock design the land manager began to evaluate the outcomes of rotational grazing; he observed that those paddocks that were rested showed improvements in the regeneration of pastures, soil biology and soil structure, ground cover in summer and winter and higher levels of soil moisture.

In phase 3 the land manager began scaling-up time-controlled cell grazing to the whole farm. The small-scale benefits observed in phase 2 began to impact the entire property. Exotic perennial pastures were established, maintained and enhanced. This phase saw the cessation of superphosphate applications, the spraying of insecticides, pesticides and herbicides (including Roundup) and ploughing. Stopping these practices enabled the biology to gradually recover.

In phase 4, with the full implementation of holistic planned grazing across all paddocks increased cover and density of perennial grass species were observed, both native and exotic. Animal management is now focussed on weight gain at all times. If the stock are not “doing” well (as can be evidenced by their dung) they are moved to a new, rested paddock. This strategy enables the vacated paddock to regenerate before the stock are reintroduced.

The results of phase 3 management were slow to eventuate, but with the introduction of phase 4 the improvements have accelerated with significant increases in soil biology, especially fungal activity.


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

Why track changes and trends in soil physical properties?

Soil provides all necessary things for the plant growth, except light and solar radiation, hence that is why soil is called the natural medium of plant growth. Where land management regimes are too intense e.g. too much cultivation and/or too intensive total grazing pressure, this can lead to poor soil condition. This will have consequences on production, economic, other ecological criteria and it turn have social consequences.

Assumptions and definitions

This is an aggregate score of the soil physical properties of all paddocks found in Jillamatong. This includes effective rooting depth of the soil profile and bulk density of the soil through changes to soil structure or soil removal.

The rooting depth of plants was observed by the landholder over time when the soil was ploughed or dug with a shovel. Under more intensive management, involving continuous grazing, grass tussocks were observed to be low in height and relatively shallow rooted.

Indicators of landscape function over time include: soil surface rain-splash protection, cryptogam cover, soil surface erosion type and severity, washed/deposited materials, physical features on the soil surface to retain resources during surface flows, and ground cover complexity which influences permeability.

Results and Interpretation

In phase 1 (1972-1984), under continuous grazing and conventional agriculture, grass tussocks were observed to be low in height and shallow-rooted. Relatively large areas of bare ground were observed over summer, particularly in drier months, where annual plant species soon completed their cycle, exposing the soil. Soil temperature was also observed to be over-heated in summer. Under this management regime, the soil was hard, compacted and highly resistant to penetration with a shovel when fencing.

In conjunction with the 1982-83 drought, it is estimated that wind erosion removed between 10 and 15 centimetres of topsoil off entire hillsides leaving highly leached mineral subsoils with often less than 0.5% soil organic matter. The only pastures that survived and regrew were low order natives, barley grass and vulpia. A shovel only penetrated the soil a few millimetres and tractor drawn ploughs had difficulty breaking the soil. Heavy rainfall events resulted in high energy surface flows causing sheet and gully erosion and salt mobilisation. Earlier in this phase the NSW Soil Conservation Service established a series of contour drains leading to dams the overflow from which was then piped to the bottom of the erosion gully. Surface water flows were regarded as a problem, with excess to be drained away as quickly as possible.

In phase 2 (1985 to 1995) the land manager began seeking alternatives to build the organic matter and improve soil structure rather than using superphosphate. He decided to raise the plough so that it was just skimming the surface to provide a strip of tilth for direct seeding of improved pastures. This direct drilling technique was developed for renovating pastures.

In 1994 the first wagon-wheel paddock system was installed and the number of paddocks rose from 10 traditional paddocks to 25 triangle shaped paddocks. This experimentation was confined to a small area of Jillamatong. Sheep and cattle were grouped into one mob and rotated around the paddocks so that soil and vegetation could be rested.

In phase 3 (1995-2005), with experimentation and scaling up of regenerative land management practices, gradual improvement in soil physical properties were observed. The outcomes of rotational grazing trials began to take effect with those paddocks that were rested showing less compaction, higher levels of year round groundcover and soil moisture.

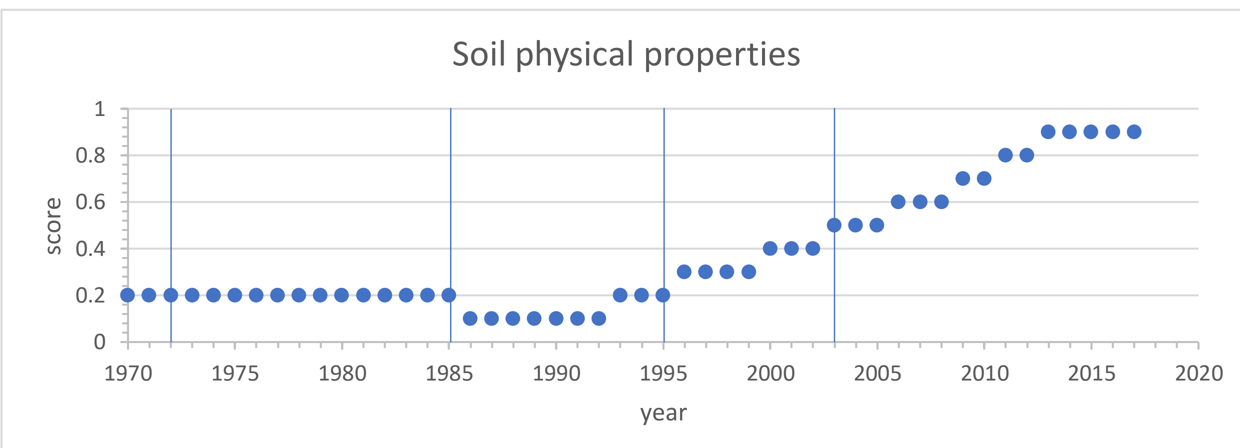
In this phase soil penetrometers only pierced the topsoil a few millimetres and at maximum pressures and erosion remained a problem.

In phase 4, with the full implementation of regenerative management practices, soil physical properties began to stabilise at improved levels from 2012 onwards. In such paddocks, the land manager observed his mix of C3 and C4 perennial pastures provided green grass in all seasons beneath which the soil was cooler summer, less frosted in winter, and relatively easily dug with a shovel. The plants had bigger and deeper root systems in keeping with their height.

Soil structure has improved, becoming more friable, porous and with lower bulk density indicating growing SOM and therefore soil carbon. Penetrometers now reach a depth of one metre at less than 4,000 kPa (kilopascals) pressures. Infiltration of rainfall has increased, improving the water cycle and reducing flash floods. With greater water infiltration, there is less surface runoff during rain events. Water now leaks slowly into the floodplain from the surrounding slopes.

Stopping the eroding head wall cuts in the former erosion gully using weirs has rehydrated the landscape by enabling water to be held and spread higher in the landscape. Raising the water table has kept the floodplain moist and removed the saline outbreaks. By establishing a number of contour channels (swales) mid-slope this too has contributed to the rehydration of large areas of the property.

Implementing holistic management has transformed the soil physical properties into a spongy, aerobic medium for plant growth.



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

Why track changes and trends in reproductive potential of pastures?

An understanding of successful reproduction, germination, establishment and development of plant life cycles is important in managing agri-ecological ecosystems. This understanding of successful plant reproduction is vital in the manipulation of planned production outcomes - e.g. grazing regimes can prevent seed-setting by undesirable or invasive plants.

Assumptions and definitions

Reproductive potential is the relative capacity of a species to reproduce itself under optimum conditions. In the context of land management regimes this is an aggregate score assigned across all pastures found on Jillamatong.

Too much cultivation and relatively high stocking rates managed under continuous grazing, was leading to poor soil structure and farming was reducing the amount of organic carbon causing "weediness."

With the advent of smaller paddocks, the infrastructure permitting regular stock movement and a program that allowed the perennials to set seed, germinate and grow, the pastures thickened and became more resilient to climatic extremes.

Results and Interpretation

In phase 1 pastures were intensively managed to promote available fodder for livestock production including spraying with bio-cides for pest and disease control. High levels of superphosphate fertiliser were applied making the land dependent on regular inputs and vulnerable to stress during dry spells.

When Martin assumed control in phase 2, he purchased a Kaldo seeder, wick wiper and spray rig and began spray grazing with small amounts of Roundup followed by a crash grazing with 1200 wethers. When groundcover had been removed, he used the seeder to plant new pastures which were subsequently set-stocked with wethers.

The land manager ploughed and harrowed the lower slopes and flats and sowed exotic pasture species Phalaris (*P. tuberosa)*, Tall Fescue (*Festuca arundinacea)* and Perennial Rye (*Lolium perenne)* as well as two clovers (Haifa White and Subterranean) after first eliminating with herbicide the previous pasture that was dominated by native poa tussocks.

Close monitoring of the species mix in the pastures helped the land manager understand how to determine what and when and how to graze a paddock. Martin was carrying a higher stocking rate than had been the case in phase 1. In 1987 the improved pasture was well-established however, phalaris did not thrive. Over the short term the pasture became dominated by 90% fescue. The same year the land manager observed that no Poa tussocks regenerated. In 1988 – 89 grazing management failed to reduce fescue dominance. In 1990 the land manager trialled several different seeding programs but used the same mixes.

In 1991, the paddocks were intensively treated with selective herbicides to try to give the introduced species a competitive advantage. Flat weeds were sprayed with MCPA and 2-4D amine and when the pastures had thinned, they were poisoned with Roundup prior to re-sowing. Fallen timber was pushed up and burnt to reduce rabbit harbour, warrens were ripped and the rabbits were poisoned or trapped.

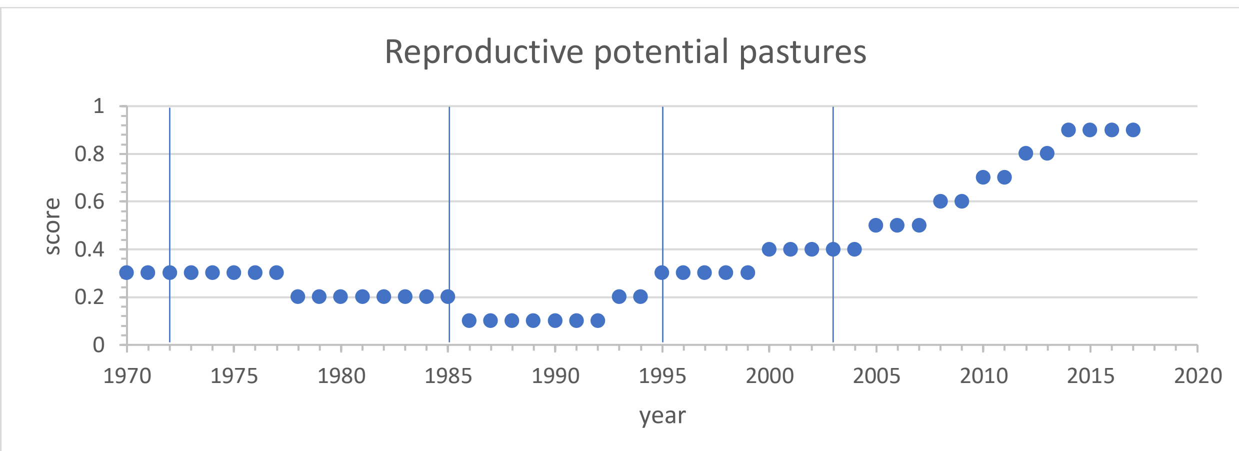
In phase 3 the focus was on managing plant species within the pasture using grazing animals. The land manager was skilled in identifying and managing grass growth stages including the energy available at the milky stage of kernel development. He used that knowledge and the relationship between grazing pressure to manipulate pasture composition to control weeds, for example eliminating Vulpia (Silver Grass), an annual low quality grass from the pastures. He also learnt that by always having green plants growing, the sugary root exudates would feed the soil biota which in turn would mobilise the minerals for the plants

In phase 4 during the Millennium Drought there was an obvious increase in soil surface condition resulting from low to very low stocking rates. Where pastures were insufficiently nutritious to promote weight gain in the livestock, those paddocks were spelled until they recovered. This strategy enabled plant species to complete a life cycle (go to seed, drop the seed, shoot and mature) before the stock were reintroduced.

As soil structure improved, perennial grass species were observed to develop larger and deeper root systems. This ensured greater plant resilience in hot dry summers or cold wet winters as well as a greater capacity to seed, thus covering any bare soil

Martin observes closely the grazing behaviour of his livestock – once they have selectively eaten (but not decimated) the more palatable plants, it is time for a move. The less digestible grasses will have been trampled allowing ground space for the nutritious plants to regrow or seed. Using strategic livestock grazing he has changed pasture composition and is on a pathway to reduced fescue dominance and a wider diversity of more palatable species across all paddocks.

Biodiversity assessments along transects, recording all grasses, forbs and weeds has revealed some pastures support 80 species per transect, comprising both native and exotic grasses, legumes, brassicas, herbs, forbs, medics and some useful weeds.



G. Status of tree and shrub structure - Extent of tree cover

Why track changes and trends in extent of tree cover?

Tree cover in working landscapes provides important ecosystem benefits including: mitigation of soil erosion, shelter for pastures, improved animal welfare; enabling added revenue from stacked enterprises; habitat and breeding sites for pollinators and predatory insects, birds and animals; improved salinity management; improved interception of rainfall and improved aquifer recharge management.

Assumptions and definitions

By gradually increasing the area and connectivity of tree cover on Jillamatong, in the form of shelter belts and corridors, the landholder expected this would lead to improvements in stock health, pasture productivity, improved habitat, and breeding sites and food for native wildlife. This would also lead to improved visual amenity of the formerly over-cleared flats and gently rolling hills.

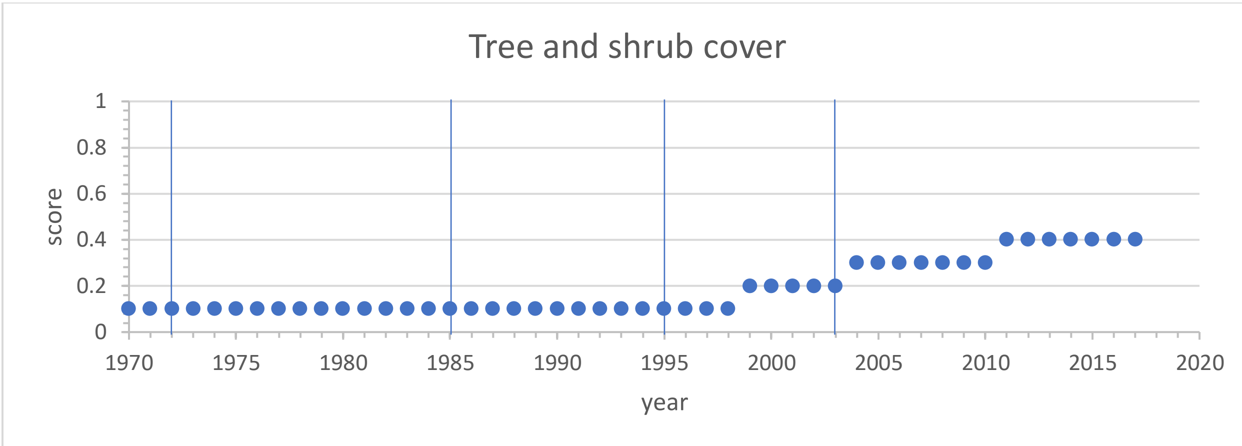
Results and Interpretation

In phase 1 many of the remaining native trees on the mid and lower slopes, Manna gum (*Eucalyptus mannifera*) and Ribbon Gum (*Eucalyptus Viminalis)*, were isolated and scattered and were over mature/ senescent or dead. High quality timber trees like Yellow Box (*Eucalyptus Melliodora)* had been harvested for fencing nearly a century before.

In phase 2 many of the remaining native Manna gums were over-mature/ senescent or dead. Most dead and fallen paddock timbers were pushed up and burnt to reduce harbour for rabbits. Where trees once grew, these areas were ploughed and sown to pasture to increase the productive area. At the same time rabbits were killed by poisoning and trapping.

In phase 3 the land manager commenced tree plantings, changed fencing designs, fenced-out the areas with young trees, established off-stream water points, commenced soil biology enhancement and changed to organic fertilisers. This last strategy is important for the success of growing native trees and shrubs because such vegetation will not thrive under high phosphorus conditions. These initiatives were assisted by grants from Landcare and the CMA.

In phase 4 there has been regrowth of black wattles and eucalypts where livestock has been excluded. Extensive tree lane and copse plantings now connect neighbouring forested hills with each other and provide cattle shelter. Tube stock is chosen to best suit the site conditions, particularly to resist frost and wind. Christmas beetles cause problems for several eucalypt species owing to their isolation, so Martin now has a mixture of evergreen exotics as well as beetle-resistant natives. These shelter-belts are reconnecting the habitat areas across the landscape. Most paddocks have trees with an understorey where possible Predatory insects, spiders and birds making their home in these shelter belts have been useful in mitigating pest infestations and the relationship between predator and prey appears to be in balance. Retention and reinstatement of trees on the hill tops also acts as a lure for the cattle seeking shade in hot weather, where they camp and bring fertility up from the flats.



Tree and shrub cover
score
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0.6
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H1. Status of grass and herb structure - Ground cover in summer

Why track changes and trends in ground cover in summer?

The quality of ground cover in summer is important for cattle production when calves are still suckling. It also provides essential protection to keep the soil cool against direct, searing summer heat by reducing evaporation, protecting bare soil against raindrop splash and wind erosion. Good summer pastures also slow overland flows during the storm season and assist with infiltration of intense rainfall events, thus mitigating water erosion and replenishing soil moisture.

Definitions and Assumptions

Ground cover is an aggregate score across the total area of Jillamatong and is estimated in summer (Dec-Feb). The aerial extent of ground cover is measured within an area of 25 m x 25 m and is a relative area defined as a per cent. These relative estimates are scaled up to the paddock level and then scaled up to the whole farm.

Ground cover is defined as green and brown (dead) grasses and herbs as well as other organic matter including leaf litter from grasses, herbs, shrubs and trees as well as coarse, woody debris.

Results and Interpretation

In phase 1, under continuous grazing and conventional agriculture, native poa grass tussocks dominated the floodplain and provided little nutrition to the animals. Relatively large areas of bare ground appeared in the summer months when annual plant species had hayed-off at the completion of their life-cycle and prior to germination at the autumn break. The soil temperature was also observed to be hot, the surface dusty and the topsoil hard, compacted and prone to deep cracking.

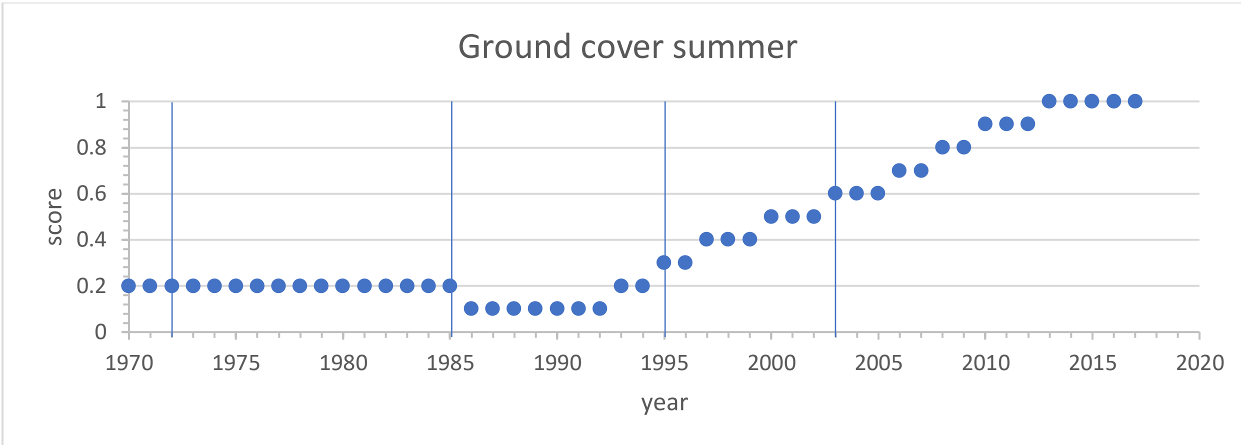
In phase 2 the land manager was carrying more stock than in phase 1 and observed bare patches from late spring until autumn. The soil loss during the 1982 drought was a direct result of exposed soil on the slopes and hills, while the gully erosion inhibited growth of anything but poa tussock on the flats. Stock water was even in short supply.

In phase 3 the focus had been redirected towards grazing management, grass growth and pasture life-cycles using the animals as a management tool. Martin learnt that by keeping green plants growing, he was feeding the soil biology and therefore ensuring year-round healthy, fully-covered soil.

In phase 4, with the implementation of regenerative land management regimes the land manager developed a flexible cattle management system comprising cattle trading/breeding/agistment. Key to developing this system was having a focus on having 100 % ground cover 100 % of the time, so that soil is always protected and building humus.

The land manager greatly reduced total grazing pressure on Jillamatong during the Millenium Drought. It was in that period that there was an obvious increase in soil surface condition resulting from low to very low stocking rates. Where pastures on rehydrated land were not supporting grazing stock that were continuously gaining weight, numbers in these paddocks were reduced, if necessary to nil. This strategy enabled new plant species in these pastures to develop, set seed, re-establish and mature before the stock were reintroduced.

As groundcover has thickened, morning dew often lasts until late morning, even in summer, adding moisture and maintaining high photosynthetic levels.


Ground cover summer
score
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year

H2. Status of grass and herb structure - Ground cover in winter

Why track changes and trends in ground cover in winter?

Year-round grazing is an important management consideration in landscapes that are managed for livestock production. With proper pasture management and licks to supplement protein and mineral intake, livestock can be successfully grazed on dormant winter forage without the need to invest in high inputs of harvested feeds (grains and hays).

Conserving pasture for use during winter months is both ecologically and economically sensible. Additionally, if precipitation is adequate, and the temperatures suitable for growth, slow recovery of pastures that were grazed earlier in the year will occur.

Definitions and Assumptions

This is an aggregate score across all paddocks in Jillamatong

The commonly espoused practice of continuous or set stocking throughout the year means that the height i.e. the biomass of pastures in winter is low to very low. During this critical period land managers have a feed deficit which generally requires supplementary feeding with pasture hay made during the summer. Alternatively, planting crops of winter cereals (oats, triticale, barley or feed wheat) for green forage is also common. Feeding out grain when the season stalls, is also widely practised. Each of these mechanisms over time were used on Jillamatong.

Results and Interpretation

In phases 1 and 2, continuous or set stocking was the system used throughout the year at Jillamatong, meaning that biomass and the productivity of pastures was generally low to very low. Going into winter, if there had not been timely rain over summer and autumn to stimulate pasture growth, the land manager would have a feed deficit at the exact time when the stock required energy to maintain their body heat. Such a deficit required supplementary feeding with pasture hay stock pellets or grain. When winters were really challenging, the animals were sent on agistment or taken out on the road and into travelling stock reserves to find better feed.

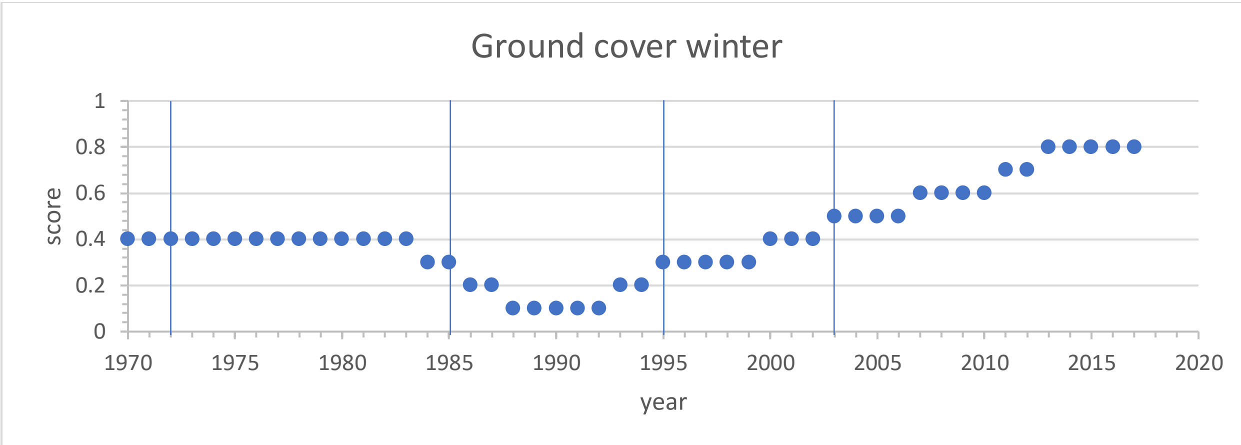
In phase 2 winter forage was often too short for the cattle to access, but the sheep were able to cause real damage. The legacy of low grazing by sheep was stunted pastures, removal of high order grasses and invasion by weeds and unpalatable species.

The land manager realised he was driving his land too hard. Hoping to address what he believed to be a growing problem, he constructed the first wagon-wheel fencing design and increased the number of paddocks from 10 traditional paddocks to 25 triangle shaped paddocks. Sheep and cattle were grouped into one mob and rotated around the paddocks so that soil and vegetation could be rested. This experimentation was confined to a small area of Jillamatong but failed to correct the winter feed deficits.

In phase 3 the land manager began scaling-up time-controlled, cell grazing to the whole farm. The small-scale benefits observed in phase 2 began to become more widespread. Exotic perennial-based pastures were established, being maintained and enhanced

In phase 4, with the implementation of regenerative land management regimes the land manager developed a flexible cattle management system comprising cattle trading/breeding/agistment and largely abandoned sheep production save for some fat lambs for meat. Key to developing this system was having a focus on having 100 % ground cover 100 % of the time, so that pastures could protect the soil and build humus. soil is always protected and building humus.

Martin’s cattle are now continuously gaining weight throughout the year. This is contrary to the old saying “you don’t have cattle feed till the second week of October”. He can fatten cattle right through the winter when other farmers are destocking because of short, dormant pastures lacking nutrition.



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

Why track changes and trends in the status of tree and shrub species richness and functional traits?

Definitions and Assumptions

This is an aggregate score across all paddocks in Jillamatong.

Results and Interpretation

In phase 1 many of the remaining paddock trees on the mid and lower slopes, Manna gum (*Eucalyptus viminalis*), Snow Gum (*Eucalyptus pauciflora),* Candlebark (*Eucalyptus rubida*) and Black Sal-lee (*E. stellulata)* were isolated and scattered, over mature, senescent or dead.

There were few heathy trees left for shade and shelter for stock or pasture and habitat for any other wildlife. In cold windy weather, stock suffered.

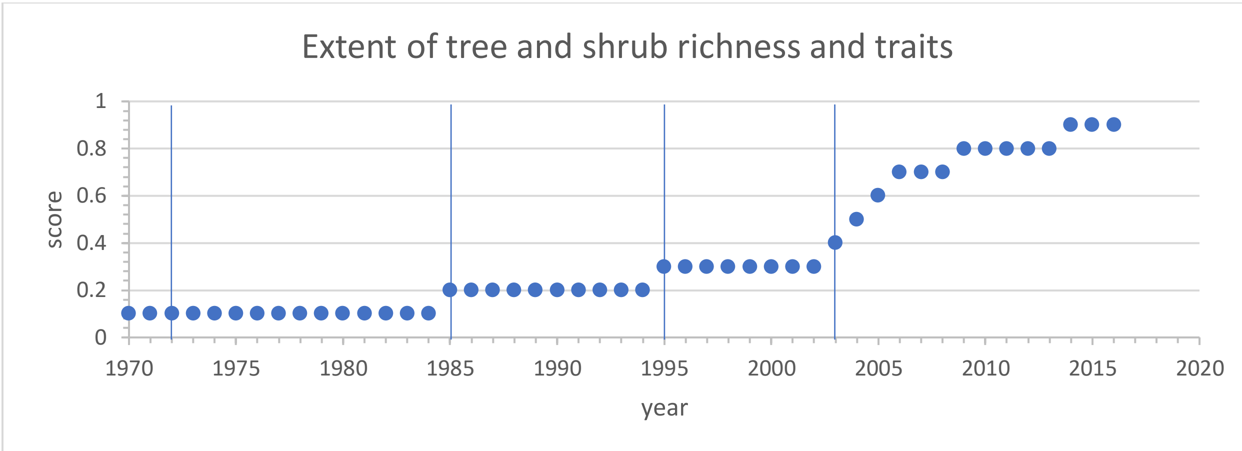
Phase 2 saw no real improvement in tree and shrub numbers with any regrowth eaten by livestock or wildlife. Spraying, ploughing and fertilising were considered to be a better use of financial resources and labour than tree planting.

In phase 3 the land manager commenced tree plantings, changed fencing designs, fenced-off areas with tree plantings, fenced out the stream and established off-stream water points, commenced soil biology enhancement and fertiliser techniques. These initiatives were assisted by grants from Landcare and the CMA.

Cessation of fertilising with inorganic chemicals allowed native trees, shrubs and wetland plants to re-establish – as none of them tolerate high levels of phosphorus or nitrogen.

In phase 4 Black wattles and some eucalypts have regrown naturally because of changed grazing management. Extensive tree lane and copse plantings have been established, reconnecting the surrounding forested hills and providing shade for the cattle and shelter against the wind. Martin continues to get expert advice as to species choice and planting methods from the Local Land Services and Landcare, together with physical help from the Green Army. He has achieved good survival rates using tube stock sourced locally in Braidwood and is now seeing the benefit resulting from flora and fauna diversity.

The system of a “chain of ponds” has provided wooded habitat for trees, shrubs, reeds, sedges and rushes in which water birds and reptiles are now breeding residents. Other migratory bird species are being observed for the first time at Jillamatong, to take advantage of the extensive surface water, the feed source and the reinstated habitat.



Extent of tree and shrub richness and traits
score
1
0.8
0.6
0.4
0.2
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
year

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

Why track changes and trends in grass species diversity?

Functional richness refers to the number of species inhabiting a place and what is/are their roles in that place and functional diversity reveals how evenly the species are distributed in an area. Decrease in functional richness and evenness decreases an ecosystem's productivity and stability. How an ecosystem is managed in a production setting will determine its productivity and stability.

In many farming and grazing situations, perennial pastures (plants that live for more than two years) such as lucerne, warm season grasses and fodder shrubs can improve production, protect natural resources (soil and water) and build the capacity of farming systems to adapt to future production and environmental challenges. The intensity of the grazing management system will determine the health and vitality of pastures and their longevity.

The selection of which perennial pasture species, on which to base a grazing production system, should be based on considerations of climate, soil conditions and performance of pasture species under different management regimes. Legumes, pulses and medics in particular are valued for their high-quality feeding value and ability to improve soil fertility through the natural fixation of nitrogen.

Assumptions and definitions

This is an aggregate score across all pasture species found on Jillamatong.

Under conventional agriculture in this agri-climate zone, pastures dominated by annual species are common. Familiar southern tablelands grasslands might comprise barley grass, wimmera rye, vulpia, pattersons curse, crowfoot, black thistle, Illyrian thistle and saffron thistle plus some persistent perennials like couch, paspalum, Yorkshire fog grass, subterranean clover and tall fescue.

Where regenerative land management practices have been implemented perennial pasture species include Wallaby Grass (Danthonia, Kangaroo Grass, *(themeda*) Weeping Rice Grass (*Microlaena)*, Armgrass millet, Austrostipa, Couch, Paspalum, prairie grass (*Soft Brome)* and the forbs plantain and chickory have all increased markedly and spontaneously since 2010. Exotic perennial grasses include Cocksfoot, Phalaris, perennial rye and tall fescue. Legumes such as lucerne, white, red and strawberry clovers, lotus and medics (snail and burr) complete a balanced pasture mix.

Results and Interpretation

In phase 1, during the drought of 1982-83 between 10 to 15 centimetres of topsoil blew off entire hillsides due largely to set stocking and overgrazing. The only pastures that survived and regrew were low order annuals and unpalatable native grasses and heaths.

The land manager sprayed the native poa tussock with herbicide to eliminate it from the lower slopes and flats. This was followed by ploughing, harrowing and sowing exotic pasture species Phalaris (*P. tuberosa)*, Fescue (*Festuca arundinacea***)** and Ryegrass (*Lolium perenne)* as well as two clovers. Some NPK blends were applied when establishing this new pasture.

In phase 2 the land manager continued replacing native pasture species with exotics using the same method described in phase 1. In 1987 improved pasture was well-established however, phalaris did not persist. Over the short term the pasture became dominated by 90% fescue. In that year, the land manager observed that no Poa tussocks regenerated. In 1988 – 89 grazing management failed to reduce the fescue dominance. In 1990 the land manager trialled different seeding mixes with Phalaris, brome, cocksfoot, ryegrass, markoo lotus, and two clovers.

In 1991, pastures were intensively sprayed with various chemicals to try to establish the introduced grasses and clovers by direct drilling. Wheat and oats were used mainly as a break or cover crop to aid the re-sowing of pasture. The survival of rye grass and clovers was used as a bio-assay of when a paddock needed re-sowing.

Flat weeds were sprayed with MCPA and 2-4D amine. Paddocks were poisoned at each re-sowing between 1990 and 1995 with Roundup

In phase 3 the focus turned to grazing management using the animals as a tool to improve the pastures. The land manager was now skilled in identifying and managing grass growth stages to determine when grazing should take place. He used that knowledge and the relationship between grazing pressure to manipulate pasture composition to control weeds, for example eliminating Vulpia, an annual weed from the pastures. He also learnt that by always having a green plant growing, it is feeding the soil biology thus keeping a year-round healthy soil and growing pasture.

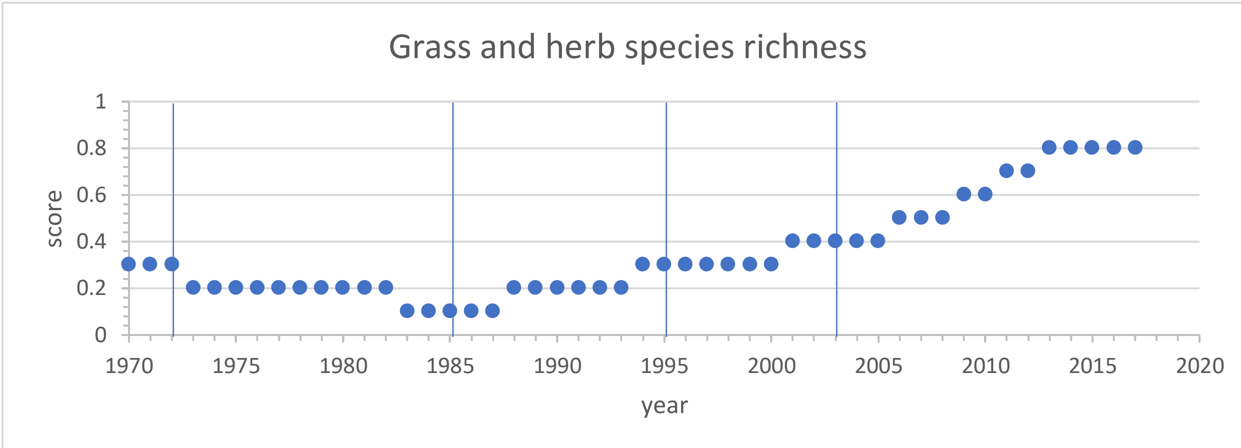
In phase 4 with the advent of full implementation of holistic grazing management the land manager had developed a flexible cattle management system comprising cattle trading/breeding/agistment. He began to take an interest in the more productive native perennials such as Microlaena, Themeda, Danthonia and Red Grass. Some of these appeared when conditions were suitable from a seed bank in the soil and others he encouraged by finding or purchasing seeds. The mixture of winter and summer active species meant that he no longer had gaps in his pastures, provided he managed the livestock in keeping with pasture growth.

In the mid and upper slopes biodiversity assessments are taken along transects noting all the different grasses, forbs and weeds. In addition, species were grouped into annual and perennial life forms. To date 80 species of native and exotic plants have been recorded.

Thistles and carrot weed, were observed to have very deep tap roots which bring nutrients up from deeper down in the soil profiles than the shallow rooted rye grasses and clovers. More beneficial fodder species, Chicory (*Cichorium intybus*) and Plantain (*Plantago major*), have been established in the pasture to perform the same function as thistles and carrot weed.

Where occasional undesirable plants (weeds) become established these are slashed to prevent seeding and serrated tussock is chipped out.

While cattle are given unrestricted access to the unfenced water’s edge of the chains of ponds, their herding and foraging patterns involves them spending less time near the water, and most of their time away from these moist environs; grazing on the lower, mid and upper slopes.



Grass and herb species richness
score
1
0.8
0.6
0.4
0.2
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
year

Attachment A

Conceptual model and assessment framework

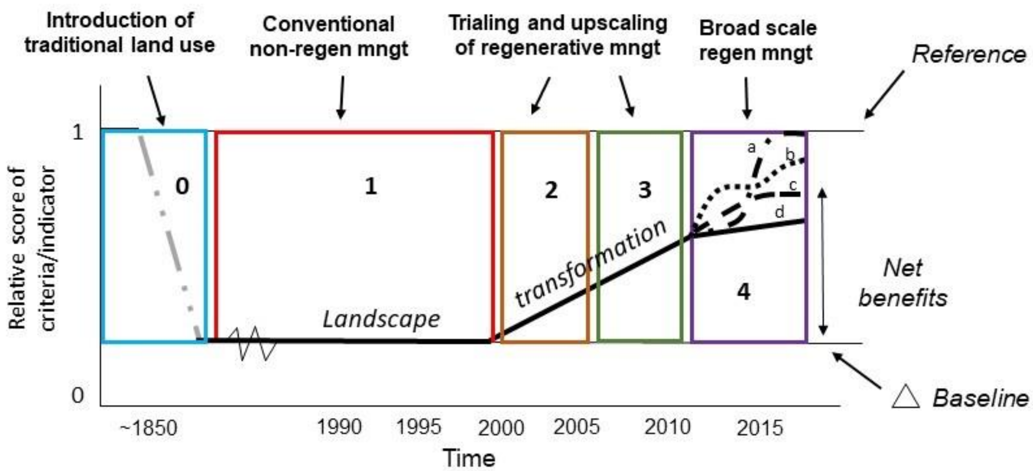


Fig 1. Conceptual model illustrating four potential landscape transformation trajectories in response to implementing regenerative landscape management regimes; where a) represents a very high response, b) represents a moderate to high response, c) represents a moderate response, and d) represents a low-moderate response. Numbers 0-4 depict phases or broad production systems. NB: phase 0 is only given cursory attention to provide an historic context.

Assessment of change and trends relative to a fully natural reference state (phase 0), based on a knowledge of pre-European settlement ecosystems, is not the focus of the Soils for Life case studies. We acknowledge that in some agro-climatic and bioregions e.g. production from rangelands and some small areas for conservation and production; rehabilitation, restoration and regenerative initiatives may involve reinstating a modified pre-European goal /ideal or target however, phase 0 is not the focus of the Soils for Life case studies, many of which are in intensively managed landscapes. phase 0 is included here to provide an ecological context.

Assessment Framework

			Quadrants Science and qualitative/ quantitative data /info			
Phase	**Years**	**Landscape management regimes**	**Production**	**Ecological**	**Economic**	**Social**
0	From x_i to x_{ii}	Introduction of traditional land use				
1	From x_1 to x_2	Conventional non-regenerative mangt				
2	From x_3 to x_4	Experiments (small scale) mainly non-regen				
3	From x_5 to x_6	Transitioning to broad scale - mainly regen				
4	From x_7 to x_8	Broad scale regenerative management				

Table 1. Assessment framework comprising phases with corresponding periods (years). Each phases is assessed using four quadrants: production, ecological, economic and social criteria.

Table 2. This Assessment Framework (matrix) assumes that the SFL Team will be given access to quantitative/qualitative observations and estimates for each of the phases (Fig. 1), to enable the criteria and indicators to be populated across the four quadrants: Production, Ecological/environmental, Economic and Social. It is acknowledged that due to information constraints, not all cells in the matrix will be able to be filled for each of the four phases in Figure 1.

Production	**Ecological /Environment** [1]	**Economics**	**Social**
1. Yield (head per ha / DSE per ha) / planting densities (plants / ha or m2) per FY	A. Resilience of the soil-landscape unit/s in the face of natural major disturbance/s (wildfire, drought, cyclone, dust storm, flood)	i. Profit (Industry Standard (Holmes/Sackett AgInsights or ABARES)	a. Access to, and use of, NRM services available for your enterprise (CMAs, Landcare, other)
2. Yield (kg/t) produced per ha without added fertilizer per FY	B. Status of soil nutrients including soil carbon and major and minor elements ad organic matter	ii. Profit Efficiency	b. Barriers to enhancing, maintaining, and improving measures of Productivity, Ecological/environmental, Economic/ financial and Social/ Community
3. Yield (kg/t/ha produced per (kg/t) of P added, per FY	C. Status of soil hydrology including infiltration, percolation and water availability to plants.	iii. Cost Efficiency (for 4-5 key expense categories)	c. Community participation, engagement, social cohesiveness and connectedness
4. Yield (kg/t/ ha produced per (kg/t) of N added, over a FY	D. Status of soil biology including bioturbators i.e. nutrient recyclers, fungi and bacteria ratios and soil organic matter eg soil carbon	iv. Financial costs (Bank/lease)	d. Financial control and independence
5. Yield (kg/t/ha produced per (ml) of irrigation water, per FY	E. Status of soil physical properties including bulk density and soil as a medium for plant development and growth.	v. Farm Profit; Operating profit, EBIT, and total profit.	e. Health and well-being
6. Yield (kg/t) produced per ha per units of rainfall, per FY	F. Status of the reproductive potential of the plant species and plant community.	vi. Level of Farm Debt/Equity	f. Access to, and use of, public-private services including medical, financial, technology, other
7. Quality of product produced against	G. Status of tree and shrub structure	vii. DSE/labour unit	g. Goals for the future across 24 key criteria

[1] Where relevant to the goals of agricultural production and maintenance of biodiversity.

regional/industry benchmarks per FY			
8. Total Farm DSE per FY	H. Status of ground layer/ground cover/grass and herb structure	viii. Machinery: income ratio	h. Family satisfaction across 12 key criteria.
	I. Status of tree and shrub species richness and functional traits	ix. EBIT efficiency (earnings before interest and tax); EBIT per ha over time; EBIT/gross Margin; EBIT/assets	
	J. Status of the ground layer/grass and herb species richness and functional traits		

Subsidiary information that may also be compiled:

Biota: Flora & fauna

Number of taxa recorded at a site at fixed time intervals using a standardized survey method; noting numbers exotic and native species. Taxa to be considered, where lists are readily available include: birds, frogs, reptiles, fish, mammals, insects/ arthropods. Subsets of these taxa may include: lizards, passerines, ants, bats, small mammals

Attachment B

Landscape Management Regimes – Production systems

The Royds family settled in the Braidwood area in the first half of the 19th century and Martin's maternal grandparents acquired the Jillamatong property in 1952. Martin managed Jillamatong jointly with others in the family from 1985 and took over sole responsibility in 1996.

Information below describing land management regimes or production systems comes from two field visits and interviews with Martin Royds at Jillamatong, conducted during July 2017 and September 2012. The 2012 interview was written up as a case study report as part of the Soils for Life Innovations for Regenerative Landscape Management Project.

Martin Royds, Jillamatong, Braidwood

This section describes how Jillamatong has been managed over the period 1972-2017. The report groups management regimes and four phases: 1) phase 1 1972-1984; 2) phase 2 1985-1994; phase 3 1995-2002; and phase 4 2003-2017. Each phase is described by an aggregate of land management practices, which correspond to the goals or ideals of the land manager.

Phase 1

Years:

1972-1984

Land area:

453 ha

Management ideals:

- Martin Royds in the early 1980s set out with the goal to question the ways that his family had farmed at Jillamatong and had goal of trialling different ways of managing the land.
- Focus was on 'production of livestock' rather than on 'pasture production-based grazing'.

Production system

Prior to clearing of the native woodland and conversion to cultivation (early 1800s), the landscape consisted of an open grassy woodland with a native pasture of weeping grass (*Microlaena stipoides*), kangaroo grass (*Themeda triandra*), Danthonia species, and associated forbs and herbs. Manna gum (*Eucalyptus mannifera*) was scattered on the ridges and mid and lower slopes, while bogs and a chain of ponds with Ribbon gums (*Eucalyptus viminalis*) and snow gums (*Eucalyptus pauciflora*) were common in the wetter areas.

In the 1960s the NSW Soil Conservation Service were involved at Jillamatong in establishing a series of contour drains leading to dams the overflow from which was then piped to the bottom of the erosion gully. Water at that time was seen as a problem to be drained away as quickly as possible.

- Commencing in the early-1980s much of the landscape consisted of an open grassy woodland with a native pasture of poa species, weeping grass (*Microlaena stipoides*), kangaroo grass (*Themeda triandra*), Danthonia species, and associated forbs and herbs. Manna gum (*Eucalyptus viminalis*) was scattered on the ridges while bogs and a chain of ponds with swamp gums (*Eucalyptus ovata*) and snow gums (*Eucalyptus pauciflora*) were common in the lower areas.
- Management of the lower slopes and flats management involved ploughing paddocks and sowing

Phalaris (*P. tuberosa)*, Fescue (*Festuca arundinacea*) and Ryegrass (*Lolium perenne)* as well as two clovers after first eliminating previous ground cover with herbicide.

- Stock were watered from surface dams and free access to ponds located in the erosion gully running the length of the property. There were no permanent waterways on Jillamatong.
- Ploughed and harrowed the lower slopes and flats and sowed exotic pasture species into soils that were dominated previously by native poa tussocks. Grandparents had concerns that this would cause erosion.
- Martin bought a Kaldo seeder, wick wiper and spray rig and began spray grazing with small amounts of Roundup followed by a crash grazing with 1200 weathers.
- Newly established pasture was managed by set stocking with wethers.
- Pastures were also sprayed with bio-cides to control red-legged earth mite, scarabs, grasshoppers and fungal diseases.

Observations and monitoring

- Many of the remaining native trees on the mid and lower slopes, Manna gum (*Eucalyptus mannifera*), were isolated and scattered and were over mature/ senescent or dead.
- The number of paddocks was 10.
- There was extensive erosion with a series of headwall cuts working their way up the central erosion gully to a depth of over four metres.
- Pastures lasted five to seven years, much less than the ten to twelve years needed to recoup the cost of establishment.
- Sheet and gully erosion were rampant and salt scalds were appearing. The major erosion gully was incised a metre at each headwall cut.
- There were few trees left for shade and shelter for stock or pasture and habitat for any other wildlife. The surviving trees were dying. In cold windy weather stock suffered.
- 1982-83 drought was followed by good rains in spring and summer (Attachment C).
- In 1982 Jillamatong was run-down because of:
    - applications of superphosphate
    - set stocking with 160 cattle and 200 sheep including rams
- 1987 pasture was well-established. Phalaris did not persist. Became 90% fescue.
- 1987 observed that no Poa tussocks regenerated.
- 1988 – 89 grazing management failed to reduce fescue dominance.
- Low rainfall followed by a sharp fall in the price of sheep, led Martin to graze sheep on the poa tussocks.
- Close monitoring of the species mix in the pastures helped to determine what and when and how to graze a paddock.
- Soil structure was poor. Soils were observed not to be very friable or porous and soil humus levels were low. A shovel only penetrated the soil a few millimetres and tractor drawn ploughs did not easily penetrate the soil.
- It is estimated that soil and wind erosion removed up to 90 tonnes of carbon per hectare leaving highly leached mineral subsoils with often less than 0.5% soil organic matter.

Evaluation

- There was a seemingly endless battle with weeds, serrated tussock in particular, was becoming a major problem. Many paddocks were so thick with thistle that he had to slash tracks to find and get stock out of paddocks. Wool quality was also affected.
- During the drought of 1982 between 10 to 15 centimetres of topsoil blew off entire hillsides due largely to set stocking and overgrazing. The only pastures that survived and regrew were the native pastures.

- High additions of superphosphate fertiliser and bio-cides enhanced the oxidation of any residual and new organic matter making the podosol soils highly dependent of regular inputs and vulnerable to stress (drought).

Phase 2

Years:

1985 – 1994

Land area:

- No change from phase 1

Management ideals:

- Focus during this period was on maintaining and improving soil structure.
- 1985 commenced managing Jillamatong as a grazing property. Martin took over from his grandparents, who had managed the property using set stocked for many years.

Production system

- The paddocks were set stocked until the early 1990s.
- Sheep were drenched every six weeks with a constant watch for fly outbreaks and other problems. Cattle were also drenched regularly.
- The number of paddocks was 10.
- Continued set stocking running Dorset Horn fat lambs and rams and an Angus cross herd, sold as vealers.
- Seeding new pasture with applications of some NPK to assist germination.
- 1990 trialled differential seeding systems with Phalaris, fescue, ryegrass, markoo lotus and two clovers
- Flat weeds were sprayed with MCPA and 2-4D amine. Paddocks were poisoned at each re-sowing between 1990 and 1995 with Roundup.
- Most dead and fallen paddock timbers were pushed up and burnt to reduce rabbit warrens and increase the area for pasture, while rabbits were poisoned and trapped.
- In 1991, spraying pastures with various chemicals was intensified to try to establish five introduced grasses, three clovers and two forbs by direct sowing. Monocultures of wheat and oats were used mainly as a break or cover crop to aid the re-sowing of pasture. The survival of rye grass and clovers was used as a bio-assay of when a paddock needed re-sowing.
- In 1994 constructed the first wagon-wheel fencing design and increased the number of paddocks from 10 traditional paddocks to 25 triangle shaped paddocks. These smaller paddocks met at their points, with a shared central watering point.
- Sheep and cattle were grouped into one mob and rotated around the paddocks so that pastures could be rested.
- Spread 400 tons of ‘agriash’ to the pasture from the Molonglo (Canberra’s) tertiary sewage treatment works.
- Sprayed pastures to control red legged earth mite, scarabs, grasshoppers and fungal diseases.
- Instead of ploughing and sowing pastures, ploughing was replaced with shallow soil-surface cultivation and direct seeding.

Observations and monitoring

- Key people that provided advice during this period were:
    - Stan Parsons and Bruce Ward in 1991
    - Drs Stan Parsons and Terry McCosker in 1994

- In 1986, an ephemeral erosion gully ran through the middle of most of the property. Water in this gully stopped flowing most summers.

Evaluation

- 1994 Martin knew he could not continue to allow Jillamatong to deteriorate. Nearly every strategy he had employed was either too expensive or not giving the desired results or both. The major catalyst for changing the way Jillamatong was managed was when he attended a talk on holistic management in 1994. That seminar showed him that he had been focusing on stock numbers, fighting weeds and pests and ignoring the fundamental imperatives of groundcover and carrying capacity dictated by pasture availability.
- As a result of Martin continuing to attend courses on soils, pasture species identification and farm management systems, he gradually changed the way he managed his animals so as to work with nature, not against it.
- Martin realised he was also poisoning himself and the landscape with chemicals – the fertilisers, insecticides, herbicides and fungicides.

Phase 3

Years:

1995 – 2004

Land area:

- No change from phase 1

Management ideals:

- Having attended the seminar on holistic management in 1994, Martin put those decision-making ideas into practice. He now concentrated on building healthy soil, pasture and water cycles.
- Martin commenced the transition to holistic management across the property. The focus was on grazing management, grass growth and lifecycles of grasses by managing plant species within the pasture using grazing animals.
- To improve ground cover and connect areas using shelter belts.
- Martin started setting goals that incorporated the triple bottom line. Whole farm management for him meant including the bank managers, knowledgeable farmers and ecologists as advisers to his business. He engaged with Landcare, CMAs (now LLS), government agencies, and political decision makers, together with innovative thinkers in the agricultural, environmental and educational fields.

Production system

- Maintained wagon-wheel fencing design and increased the number of paddocks from 25 paddocks to 35 triangle shaped paddocks. These smaller paddocks met at their points, with a shared central watering point.
- Commenced laying several kilometres of polythene pipe to provide water to troughs away from the gully.
- Ceased applying inorganic fertilisers.
- Ceased spraying chemicals to control weeds, insect pests and fungal diseases.
- Ceased ploughing and spraying out with Roundup.
- Martin began identifying and managing grass growth stages from first tiller to seed set. He used that knowledge and the relationship between grazing pressure to manipulate pasture composition to control weeds, for example eliminating Vulpia, an undesirable annual from the pastures.
- Commenced tree plantings, expanded the wagon wheels, off stream water points, soil biology enhancement and fertiliser techniques, assisted by grants from Landcare and the CMA.

- Sheep and cattle were combined into one flock/mob.

Observations and monitoring

- Detailed financials are available for 1995 onwards.
- Soil penetrometer testing showed the soil remained unyielding
- Salt scalds were beginning to appear in the 1990s.

Evaluation

- 1999 Martin Royds recognised the need to develop a plan of management.
- Learnt that by always having a green plant growing, it is feeding the soil biology thus keeping a year-round healthy soil and growing pasture.

Phase 4

Years:

2005 - 2017

Land area:

- No change from phase 1

Management ideals:

- Martin completed a holistic management course in 2003. His focus changed to managing plant species within the pasture by managing grazing animals to achieve desired outcomes of promoting grass growth and the full lifecycles of grasses.
- To improve ground cover and connect patches of woody vegetation using shelter belts.
- To manage water with contour channels, swales and leaky weirs.
- Broad scale implementation of the holistic approach to land management that commenced in 2003.
- One goal was to get grass to grow earlier at the end of winter and continue to grow longer into the summer.
- Begin to understand and then to develop a soil food web.
- To become more aware of biodiversity including insects and birds.
- To develop a farming system that is economically, environmentally and socially regenerative.
- T to acknowledge that management regimes and practices are responsible for soil erosion, weeds, and economic problems and that it is only by changing these management decisions that regenerative processes will follow.

Production system

- In 2003 the number of paddocks at the start of phase 4 was 35 paddocks, 2017 there are now 54 paddocks.
- 2003 to 2004 Martin Royds was involved in droving agisting and selling stock, which coincided with the early stages of Millennium Drought.
- Ceased running sheep.
- Change from wagon wheel fencing design for paddock initiated in 1981 and adopted a new design where narrow paddocks have their fence lines arranged perpendicular to the creek and running upslope from the creek. This allows cattle to graze from the flats and lower slopes to the upper slopes thus enabling cattle to feed on green rich pasture on the lower slopes and allowing the cattle to fertilise the pastures on the upper slopes with their dung.

- Promoting more fodder through grazing palatable and more nutritious grasses on the lower slopes and flats and allowing the less palatable grasses to be trampled or left. The aim is for the pasture composition to progress towards a predominance of more palatable species.
- Cattle are given free access to mineral supplements and are much healthier than previously as a result.
- Animal management is focussed on weight gain at all times. Where pastures are not yielding stock that are continuously gaining weight, then stock numbers are reduced, if necessary to nil.
- Developed a flexible cattle management system comprising cattle trading/breeding/agistment. Key to developing this system is having a focus on having 100 % ground cover 100 % of the time so that soil is always protected and building humus.
- 2005 began water cycle management with Peter Andrews by implementing 'natural sequence farming' as a process to fix the erosion gully and turn it into a permanent stream. Eroding head wall cuts were stabilized with earthen weirs. These practices involve rehydrating the landscape by holding and spreading surface water higher in the landscape. It also involves holding water for longer on the flood plains.
- After fixing the erosion gully, a number of contour channels and diversion banks were established mid-slope to rehydrate large areas of the property.
- 2007 established a chain of ponds upon what starts on Jillamatong as a second order stream and leaves the boundary as a third order stream. This continued until 2009. Level contour channels were constructed, crossing the floodplain to divert water across the paddocks of the flats before joining the stream at a weir lower down the system.
- Yabbies and fish have been added to most of the weirs and dams to assist in recycling of nutrients and to continue to build biodiversity. Wetland plant species were manually established in all watercourses and weirs.
- 2004 – 2009 no addition of chemical/industrial fertilisers the only soil additives were bio-stimulants (compost teas) and mulch piles placed in the flow lines comprising clay, crusher dust, green waste and worm castings.
- 2010 - 2017 had established a flexible grazing plan that can be readily adjusted to match changing weather and climate patterns.
- Stock are watered via a trough system connected by 3.5km of 50mm polythene pipe from one end of the property to the other, mainly gravity fed from dams high in the catchment.
- Cattle were combined into one mob.
- Cattle are accustomed to frequent movement between paddocks, so that they congregate around the gate when the grass has been eaten down. Cattle are moved by opening the gate into a new pasture and closing it behind them when they have left the eaten down pasture.
- Where occasional undesirable plants (weeds) become established these are slashed to prevent seeding and serrated tussock is chipped out.
- Chicory (*Cichorium intybus*) and Plantain (*Plantago major*) are established in the pasture to help bring up nutrients deeper in the soil profile and to recycle nutrients.
- Grazing management, weed trampling, combined with pasture rest and high levels of ground cover are the main tools now used for suppressing and managing weeds.

Observations and monitoring

- Using rotational grazing, 90% of the property in rest and recovery stage at any one time.
- Biodiversity assessments are taken along transects noting all the different grasses, forbs and weeds. Martin has a goal to exceed the present 80 species per transect and increase the proportion of perennial species.
- Litter levels, ground cover, growth/recovery of plants and insect activity are also monitored.
- Thistles and carrot weed, were observed to have very deep tap roots which bring nutrients up from deeper down in the soil profiles than the shallow rooted rye and fescue.
- Black wattles and some eucalypts have regrown naturally because of changed grazing management. Extensive tree lane and copse plantings now connect neighbouring forested hills

across the property and provide cattle shade and shelter. Seedling trees are chosen to best suit the conditions. Because Christmas beetles attack the native Manna gum (*Eucalyptus Mannifera*), it struggles to survive in this intensively managed landscape. By planting many different tree and shrub species, including exotic conifers and Holly Oaks as host for the truffles, landscape function has been enhanced.

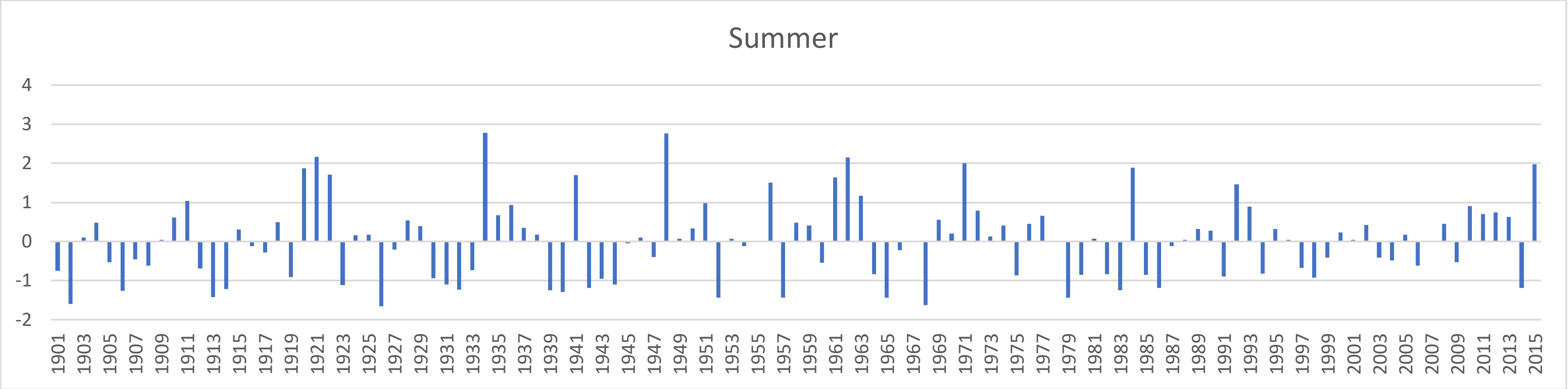
- Most paddocks now have trees with an understorey where possible. Tree plantings are designed to encourage stock and birds to move to the top of the hills and to process and recycle nutrients that can then infiltrate the soil and build natural fertility across the property.
- The in-paddock compost heaps and spraying of biological fertilisers appears to have improved the soil and pasture nutrient balances.
- Salt scalds have disappeared due to the increased ground cover and the creation of fresh water lenses that float on top of the saline groundwater within the shallow aquifers.
- Rainwater moving through the landscape has been slowed down. There is less surface runoff and the pastures now provide year-long green perennial grasses. When dew condenses on the green perennial grasses this provides additional water that helps sustain soil moisture and healthy pasture growth.
- Reduced costs of weed, bio-cides, fertiliser, vet and machinery inputs and labour, and increased income from being able to sustain weight gain on healthier cattle for longer due to improved and sustained pasture growth.

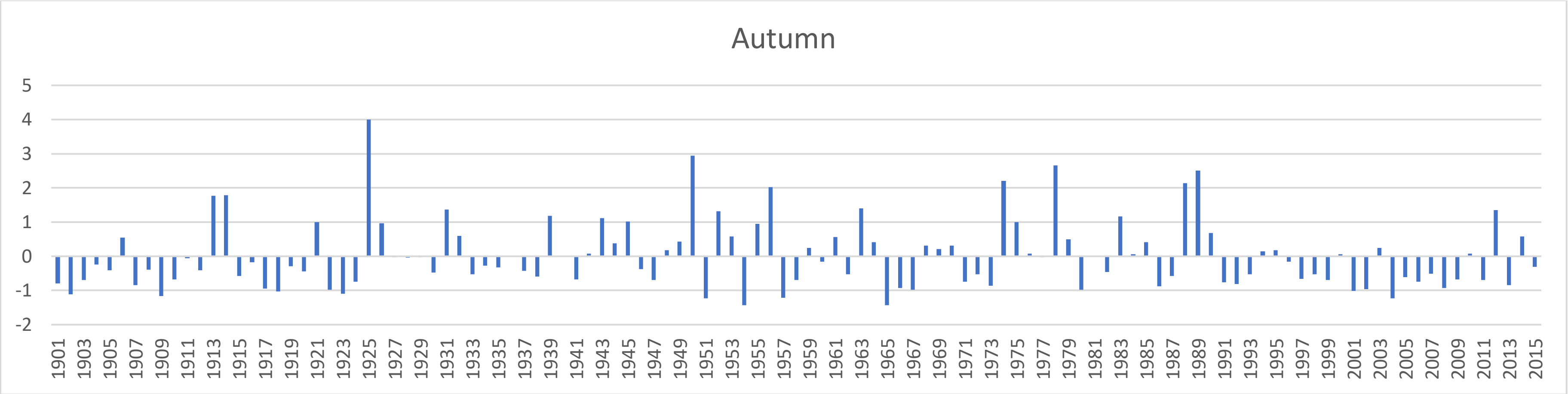
Evaluation

- Since adopting this pattern of pasture management, Martin has been self-sufficient in organic fertilisers, producing his own compost teas and mulches.
- As a result of his flexible grazing plan, Martin is confident that he can easily adjust the number of grazing animals according to changing weather and climate.
- Mortgage on the property under control.
- The realisation that the diversity of pasture grasses and herbs is beneficial and that this contributed to animal health. The realisation the need to establish, maintain and encourage plant species that continue to grow in the pasture whatever the seasons
- 2010 - 2017 grazing land management and production of cattle is now a stable, reliable and profitable enterprise
- Over land flows of rainwater are slowed and dispersed through the system of chain of ponds, spreader banks and contour banks (swales). This system, combined with grazing and pasture management, prevents rill and gully erosion and replenishes the sub-surface soil water that encourages deep rooting of the pasture plants and promotes plant growth in dry seasons. Steady sub-surface flows recharge the chain of ponds and have created a healthy permanent stream.
- With the broad scale implementation of rotational grazing and better management of pastures, any major weed problem has disappeared over the last 10 years. Weeds are regarded as part of the soil and landscape repair process where land has been overgrazed, poisoned or degraded. Stands of thistles are seen as indicators of earlier land management regimes or production systems.
- As a result of the holistic management techniques, soils have dramatically improved to be much more friable and porous with increased soil humus levels. Penetrometers now require less than 4,000 kPa (kilopascals) pressures to reach a metre in depth.
- Available soil phosphate levels have doubled without the addition of any superphosphate.
- Martin's cattle are now continuously gaining weight throughout the year. This is contrary to the old saying "you don't have cattle feed till the second week of October". Martin is also fattening cattle right through the winter.
- Available carbon (labile & stable) has increased from a range of 0.8% to 2.4% in various paddocks ten years ago, to a high of 2.9% five years ago. Now, best sites have measured close to 7.0% soil organic carbon.
- As evidenced by the now -permanent central watercourse, infiltration of water across the property has increased with enhanced soil structure, improving the water cycle and "smoothing" peak flows. With greater water infiltration, there is less surface runoff.
- During the Millennium Drought in the past decade there were periods where Martin's neighbours were unable to run any stock for up to 11 months due to lack of feed and water and yet cattle on Jillamatong were still gaining weight.

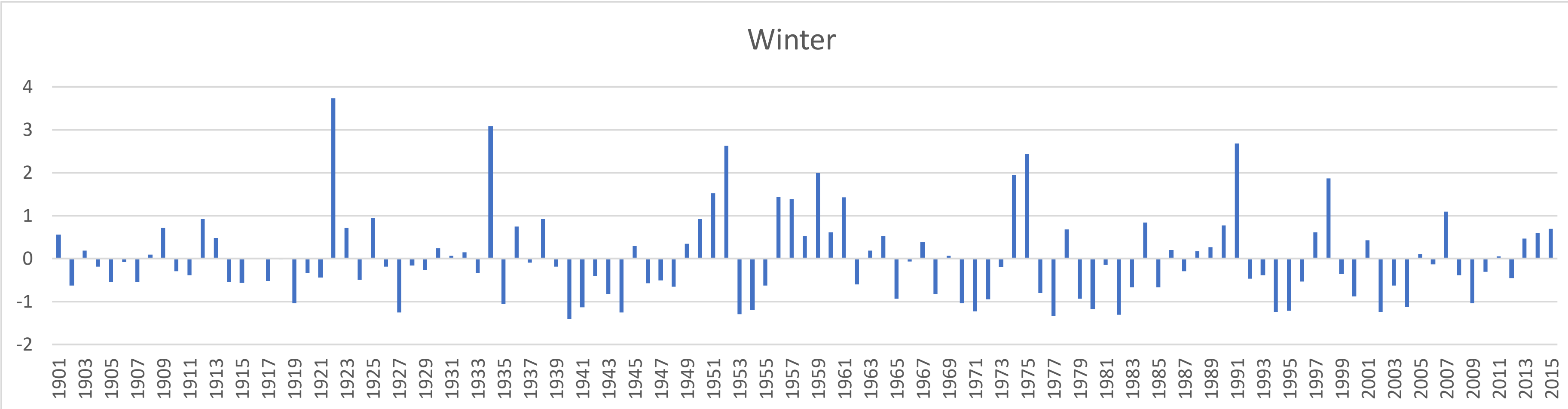
Attachment C

Patterns of seasonal rainfall derive from modelled monthly rainfall data for Jillamatong[2]showing variants around the mean.





[2] Source: Bureau of Meteorology modelled 5-kilometre resolution rainfall data. Seasons are defined as the standard 3 monthly intervals e.g. summer comprising December, January and February


Winter
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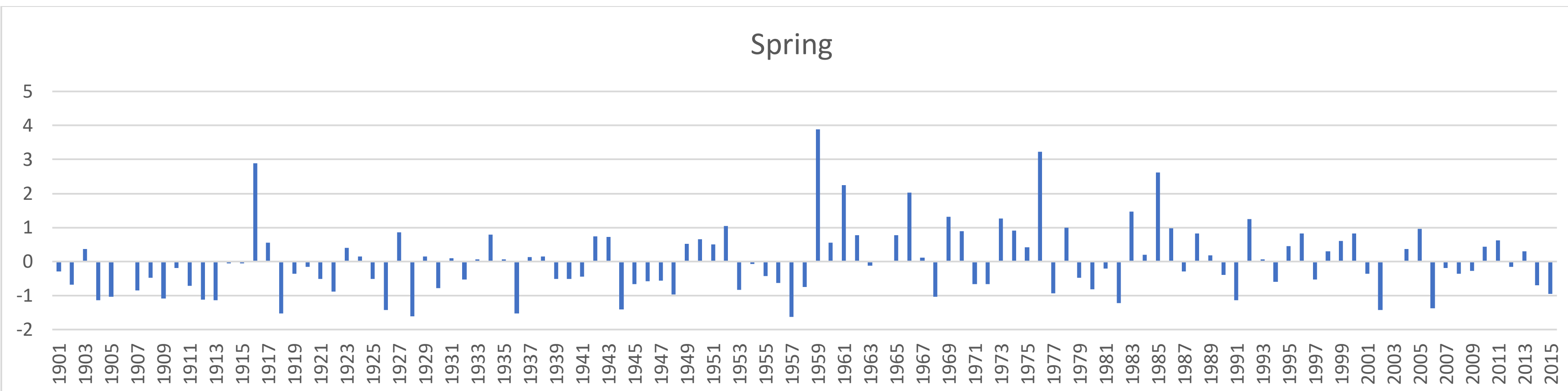
Spring
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1901
2015

Acknowledgements

Martin Royds revised the detailed narrative for Jillamatong documented in the Round 1 Case Study report #7 (Soils for Life 2012). That narrative was complemented with additional interview notes, written records, paddock histories and photo archives to create the *Landscape Management Regimes – Production systems* (Attachment B). Martin also prepared created the draft response criteria graphs which are presented in the section - *Assessment of Response Criteria*.

Julia Mackay provided comments and edits on an earlier version of this report. Julia also added the *Glossary* of terms.

John Leggett and Mark Gardner participated in, and contributed to the write-up of the July 2017 interview with Martin Royds.

Shane Cridland provided the seasonal rainfall record from modelled monthly rainfall data for Jillamatong (Attachment C).

Glossary

C3 and C4 Grasses - As a generalisation, C3 plants are more temperate, preferring cooler, moister conditions — winter active. C4 plants grow better in warmer, dryer conditions. Their mix in the paddock ensures productive growth year-round.

Chain of Ponds – sometimes called pool and riffle systems. Chains of ponds are a discontinuous river type found in Australia and are part of a spectrum of rivers found in a laterally unconfined valley setting. This range of discontinuous rivers includes intact valley fills and swamps, marshy meadows and chains of ponds. Chains of ponds are typically set into broad, low-gradient valleys containing swampy, alluvial valley fill. They are characterised by irregularly spaced ponds that are separated by multiple preferential flow paths that do not carry flow under low-flow (baseline) conditions.

A chain of ponds naturally occurred in the valley of Jillamatong however, in the mid-1880s draft horses dragging soil scoops were used to drain the ponds and create a linear drainage line. That linear feature persists to this day (Martin Royds pers comm). The purpose for draining the ponds was to gain access to the rich organic black soils in the valley flats to provide a rich soil for growing vegetables for the town of Braidwood.

Compost Tea – is produced by mixing a number of organic ingredients with water and “brewing” the resulting solution over a period of days or weeks This process requires the production of a mature compost, itself the result of the aggregation and subsequent decomposition of feed stocks that may include green waste, manure, wood chip or shavings, worm castings or worm juice, lactobacilli (from sour, raw milk), rice water, lime or dolomite, molasses and animal carcasses. The aim is to achieve a blend of ingredients that has a ratio of carbon to nitrogen of approximately 25:1. The compost itself will require up to six months to mature and to develop the desirable pH, beneficial bacteria and humic (derived from humus) compounds that will feed both the plants and the soil. This process can be accelerated by regular turning, watering and temperature monitoring – too hot and the biology can be destroyed and too cold causing cessation of decomposition and growth of bacteria. Once the compost has been successfully produced and mixed with the water (together with an energy source such as molasses or corn syrup) it is stirred and aerated during the brewing process. Seaweed extract or fish emulsion is often added at this point.

It is then strained to remove particulates (still useful for return to the compost heap) and the resulting liquid applied as a foliar spray directly onto pasture, vegetables, vines or orchards.

Forb – a non-woody plant that is not a grass, a legume, a sedge (rush or reed), nor a fern. All forbs have a relatively deep tap-root rather than the fibrous diffuse root ball of grasses. Most herbs and brassicas are forbs.

Holistic Management – A grazing system developed by Allan Savory formerly a Zimbabwean wildlife ranger who developed holistic management to mimic the function of wild herbivores in the African savannas. The philosophy is based on managing a property like a game reserve, moving the animals to reproduce the migrations of large herds following the rainfall. Hence, the concept requires numerous small paddocks and large herds or mobs of livestock being permitted to eat what they like and trample what they don't like. The management of the livestock is based on a decision-making framework prepared by the land holder taking into account water availability, ease of moving the herd around the property and providing sufficient time for the eaten and trampled pasture to recover prior to the next grazing. The term, holistic management is often used interchangeably with "cell grazing" or "time-controlled grazing", although these regimes might not involve the same decision-making processes. Cell grazing is more closely linked to rotational grazing while time-controlled grazing could be a more rigid movement of stock according to a pattern of a certain number of days per paddock or a predetermined grazing pattern.

Humus - the dark brown or black organic material in soils containing a high proportion of organic carbon, that forms in the soil when plant and animal matter decays. Humus contains many useful nutrients for healthy soil, nitrogen being the most important of all. Humus significantly influences the bulk density of soil and contributes to moisture and nutrient retention. In agriculture, humus is also used to describe mature, or natural compost or a topsoil horizon that contains large quantities of organic matter.

Leaky Weirs – A style of stream, watercourse or gully intervention that is distinct from a dam or impoundment. Leaky weirs mimic a chain of ponds. Weirs are not designed specifically to store water but rather to allow the gradual infiltration of water into the surrounding land. This is achieved by ensuring that the weir has permeable sides and also involves a bywash or overflow system (a pipe through the wall) that permits the continued trickle flow of water down the water course. In major rain events, the overflow is managed by the creation of de-energising water patterns that meet each other over rock rills, with the assistance of pipes, via the bywash or after being slowed in level diversion contour channels. The resultant turbulence in the main channel leaves the water downstream stilled and lacking destructive power.

Leaky weirs are always constructed from natural materials obtained locally – rock, fallen timber, clay and topsoil and do not rely on concrete or geofabrics. The leaky weir system was developed by Peter Andrews as the hydrological element of Natural Sequence Farming (see below).

Natural Sequence Farming (NSF) – An agri-environmental system of water and fertility management that depends upon reinstatement of the chain of ponds morphology and "invented" by Peter Andrews in the Hunter Valley in the 1970s. It incorporates the use of many types of vegetation, both native and exotic (even blackberry, thistles and willow trees), to stablilise eroded areas. Given that all land slopes, either steeply or gradually, Andrews uses gravity to shift water, not pumps. Earthen contour banks, paddock design and the feeding of livestock near the top of hills ensures the movement of water-soluble nutrients throughout the landscape.

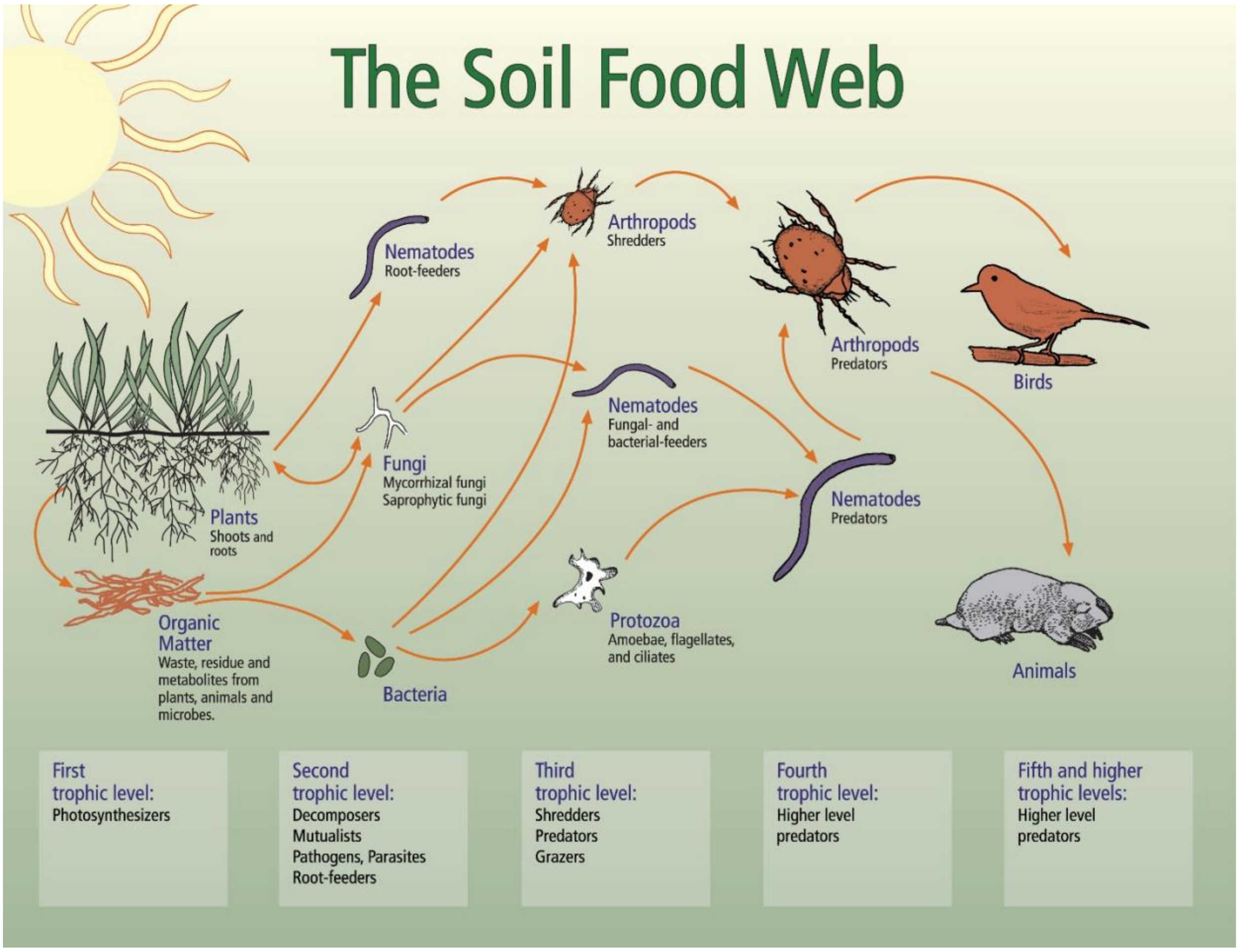
NPK – (sometimes includes S) – Nitrogen (N), Phosphorus (P), Potassium (K) and Sulphur (S) are essential elements for pasture growth. They are usually supplied under the generic names "Urea" for nitrogen, Superphosphate for Phosphorus, Calcium and Sulphur, Muriate of Potash for Potassium. Blends can be acquired like MAP (mono ammonium phosphate) that provides both P and N and smaller amounts of K and S, DAP (Di-ammonium phosphate provides larger amounts of N & P, K and S. These are the major nutrients but secondary and trace elements like Magnesium (Mg), Zinc (ZN), Copper (Cu), Boron (B) and Molybdenum (Mo) may be added to the blend if deficiencies are detected from soil tests. All these products are inorganic and result from industrial (including petrochemical) processes.

Rotational Grazing – A system whereby animals are "rotated" around a property in quest of fresh pastures. This may be achieved by "strip grazing" using electric fencing, allowing the livestock a long, thin portion of the paddock containing fresh pasture for grazing over a few hours or up to a day. The fence is then moved overnight and the following day a new strip is provided to the animals. Alternatively, rotational grazing can be achieved within a property containing numerous small paddocks with fixed fencing. The livestock may remain in the small paddock depending on numbers, paddock size, pasture quality and quantity, for up to a week prior to being introduced to a new paddock.

Set-Stocking – Usually involves relatively large paddocks in which a pre-determined number of animals are generally continuously grazed. Depending on the amount of feed available, the animals might remain in the same paddock until they are sold or until the pasture is completely exhausted whichever comes first. The practice of set-stocking usually requires the land manager to feed supplementary hay, grain or pellets if all paddocks are grazed-out.

In the area surrounding Jillamatong this pattern of management is most often associated with dry summers and cold, windy winters.

Soil Food-Web – the fertility cycle created by the synergistic relationship between plants, soil, soil biota, fungi sunlight and water. Food webs describe the transfer of energy between species in an ecosystem. Diagrammatically the Soil-Food-Web is shown below.



Source: http://www.groundgrocer.com/the-soil-foodweb/

Plants use the sun's energy to convert inorganic compounds into energy-rich, organic compounds, turning carbon dioxide and minerals into plant material by photosynthesis. Plant flowers exude energy-rich nectar above ground and plant roots exude acids, sugars, and ectoenzymes into the rhizosphere, adjusting the pH and feeding the food web underground.

Plants are called autotrophs because they make their own energy; they are also called producers because they produce energy available for other organisms to eat. Heterotrophs are consumers that cannot make their own food. In order to obtain energy, they eat plants or other heterotrophs.

In above ground food webs, energy moves from producers (plants) to primary consumers (herbivores) and then to secondary consumers (predators). The phrase, trophic level, refers to the different levels or steps in the energy pathway. In other words, the producers, consumers, and decomposers are the main trophic levels. This chain of energy transferring from one species to another can continue several more times, but eventually ends. At the end of the food chain, decomposers such as bacteria and fungi break down dead plant and animal material into simple nutrients.

Wagon Wheel Paddock Design – a fencing pattern that has a central, circular hub in which a drinking trough is placed and a number of paddocks radiate from that central hub. The trough services all the paddocks within the wagon wheel. These paddocks are triangular with all their points meeting at the hub, like the spokes of a wheel radiating from the centre to the rim.

Case Study