Natural Capital Accounting

Measuring On-Farm Natural Capital in Western Australia

GOVERNMENT OF WESTERN AUSTRALIA

natural resource management program

Perth NRM

Acknowledgements

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This project was delivered in partnership with Integrated Futures and is supported by funding from the Western Australian Government's State NRM Program, and Commonland. This project was also made possible thanks to the support and encouragement from our industry partners.

The methods used to collect and compile the data in this report has leveraged extensive work undertaken by La Trobe University as part of their Farm-scale Natural Capital Accounting project. This support has been invaluable.

Acknowledgement of Country

Perth NRM acknowledges the traditional custodians throughout Western Australia and their continuing connection to the land, waters, and community. We pay our respects to all members of the Aboriginal communities and their cultures; and to Elders past and present. We appreciate the important and ongoing contributions by Noongar people in caring for Country, Noongar Boodja, where this project took place; Amangu, Yuat, Whadjuk, Balardong, Wiilman, Nyakinyaki, Kaniyang, Wardandi, Bibbulman and Minang.

Reference

Tuckett I, Jupp B, & O'Brien D, (2024) Natural Capital Accounting: Measuring On-Farm Natural Capital in Western Australia, Perth NRM Inc.

Cover Image Credit: Project participant

Disclaimer

This report has been prepared by Perth NRM for the purpose of demonstrating how measuring on-farm Natural Capital (NC) and Natural Capital Accounting (NCA) may be beneficial to farmers and relevant stakeholders when it comes to decision making and communicating agricultural environmental performance. The purpose of measuring on-farm NC was to contribute findings to developing a measurement and verification framework for determining the change in the condition of NC and the economic contribution of NC to farming systems. NCA is aligned to the United Nations System of Environmental-Economic accounting used by governments for economic analysis and policy design. The information in this report is general and it does not constitute and should be not relied on as expert advice. Perth NRM recommends seeking advice from a qualified subject matter expert or consultant. While Perth NRM tries to ensure that the content of this report is accurate, adequate or complete, it does not represent or warrant its accuracy, adequacy or completeness. Perth NRM is not responsible for any loss suffered as a result of or in relation to the use of this report. To the extent permitted by law, Perth NRM excludes any liability, including any liability for negligence, for any loss, including indirect or consequential damages arising from or in relation to the use of this report.

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"For over two centuries, Australian landholders have invested in and managed properties for production and sale of agricultural commodities within various market arrangements that have ultimately focused on production with less consideration of the value of natural capital used in producing those goods, and, unfortunately, this natural capital has depreciated over time"

- National Farmers' Federation

Project Snapshot

28*	**Number of farms**
50	**Number of days in the field**
150	**Number of coffees consumed**
645	**Number of site assessments**
979	**Recorded revegetation work (ha)**
2,326	**Area of high ecological integrity (ha)**
6,500	**Engagement reach (# people)**
11,028	**Total cropping area (ha)**
12,000	**Total area sown to pastures (ha)**
15,000	**Km travelled (not including on-farm)**
30,968	**Total hectares surveyed**

*20 farms were part of Perth NRM's NCA project, 8 farms were part of the Farming for the Future NCA project

Key Outcomes

This project has met the funding requirements of the Western Australian Government's State NRM Program and is progressing towards the broader outcomes outlined below. It provides strong evidence for further investment in Natural Capital Accounting (NCA). These efforts demonstrate the project's potential and support for the necessary investments for the widespread adoption of NCA. Ultimately, this will ensure that future generations have access to land that is at least as productive as it is today, thereby promoting effective land stewardship.

1) Participating farmers have a comprehensive NCA report which they can use as a baseline for on-going measuring, monitoring, and managing of on-farm natural resources. Farmers have the data to begin the process of verifying and demonstrating their land stewardship credentials with Natural Capital (NC) condition considered.
2) Government and other public investors have increased their capacity and capability to guide, measure and evaluate the impact of their investment in NCA in Western Australia (WA) through the data and feedback collected through this project.
3) An interactive database platform has been developed which will be a tool for farmers to evaluate and manage their NC, making it easier to monitor and measure NC condition changes over time.
4) Increased capacity of industry to understand what NC and NCA is, how it can influence farm performance, and the co-benefits NC provides.
5) This project has highlighted the need for WA-specific datasets due to its unique agro-ecological systems and farming enterprises and therefore on-going research and development is required.

Project Outputs

1) Successfully produced 20 NCA reports for all 20 participating farms;
2) Developed a database platform for participating farms to interact and share (optional) their NC information;
3) Increased knowledge, confidence, and skills in NCA and the co-benefits of regenerating on-farm NC for staff and farmers;
4) Improved understanding and feedback of -
   a) what data is missing or needs more research;
   b) what activities are required to develop an agreed-to NCA framework;
   c) the misalignment between WA datasets and those of the Eastern States; and
   d) what NC assessments consist of.
5) Deepened relationships with industry partners; and
6) Increased awareness and interest in NC and NCA from non-participants through our extension engagements and presentations.

Key Learnings

1) More WA farm-scale NC data is needed to provide a better contextual representation for each rainfall zone or bioregion. For example:
   a. Future funding of NCA work is required to expand the dataset and conduct more baseline accounts to support farmers measuring changes to their NC and increase relevance to the agricultural sector;
   b. For improved and appropriate State and Transition Models for WA, local reference condition datasets are needed for accurate condition scoring; and
   c. More data is needed to identify and quantify the ecosystem services provided by different landscapes in WA, such as carbon sequestration, water filtration, and biodiversity conservation to be able to demonstrate clear links to community/shared benefits.
2) Further research is required to highlight the economic value of NC and ecosystem services to raise awareness of their importance for long-term prosperity and well-being, both locally and globally.

3) The industry has a role to empower land managers and stakeholders with tools and information to better manage and protect NC, enhancing land stewardship practices across various enterprises.
4) Engaging with diverse stakeholders, including Indigenous communities, farmers, and industry stakeholders in the NCA process will ensure that multiple perspectives are considered and integrated into decision-making processes. There will be ongoing engagement with other stakeholders developing alternative auditing methodologies to ensure consistency and options for the end user.
5) Farmers involved in the research project were open to learning about NCA and how NC may affect their farm performance. It was a pleasure to work with open-minded, innovative, patient, and generous farmers who gave us the opportunity to explore these methodologies in WA.
6) The project highlighted the need for collaborative efforts from industry to leverage off existing data, technology, skills and knowledge to develop accurate, affordable, efficient and effective NCA in WA giving it the ability to have data that is globally recognised and referenceable.

"You can't manage what you don't measure."

- Peter Druker, renowned business management consultant

Executive Summary

Perth NRM is a highly regarded for-purpose organisation in the Natural Resource Management (NRM) sector. Perth NRM collaborates with government (federal, state and local), community, academics and the corporate sector to deliver solutions to environmental issues. Perth NRM achieves economic, environmental, public health and social outcomes that align with the goals of our stakeholders, underpinned by evidence-based research.

With our strategic approach to managing natural resources, Perth NRM is an essential contributor to the long-term sustainability of Perth (and WA's) agriculture, supply chain and environment. This is the value that we offer our partners and the community.

Perth NRM's '*Measuring On-Farm Natural Capital in Western Australia*' Project began in 2020 to assist WA farmers by developing a clear method for assessing and managing NC on their farms.

"Natural capital underpins our economy but is largely invisible in our accounting systems."

- Farming for the Future

Building on from the pilot project, *NCA Learning Case Studies (NCALCS)*, this project's aim was to provide a framework for farmers to measure and track changes in their NC over time, ultimately improving environmental performance and promoting sustainable land stewardship.

Detailed NCA reports and a database platform have been developed for each participating farmer so they can make informed future management decisions and enhance communication of their environmental performance to stakeholders.

Our farming practices draw-down on (deplete) the finite NC that generate ecosystem services, like food and fibre production. This draw-down of NC is inextricably linked with land degradation, declining productivity, and land-stewardship.

Our food production is dependent on natural assets and ecosystem services, thus our food security depends on our farm management being sustainable. As managers of a large proportion of the Australian continent, farmers can have a big impact on our carbon draw down and NC restoration.

Perth NRM was successful in receiving funds from State NRM to lead the **first on-ground NCA project that focused on farming systems in Western Australia**, in partnership with Integrated Futures.

The outcomes of this project will contribute significantly to the development of a broader robust measurement and verification framework, crucial for assessing changes in NC condition and the economic contributions of NC to farming systems specifically in WA agro-ecological regions.

Introduction

What is Natural Capital?

Natural Capital (NC) is the stock of living, natural (renewable & non-renewable) assets or resources and services on a farm that provide benefits and value to people, the economy, and the broader environment (Figure 1).

These natural assets are things like vegetation, soil and microbes, water (above & below surface), wildlife and livestock, crops, pastures, riparian areas, and biodiversity corridors. This includes the NC we bring onto and export from the farm e.g. plant and animal products, fertilisers, water, and sediment runoff.

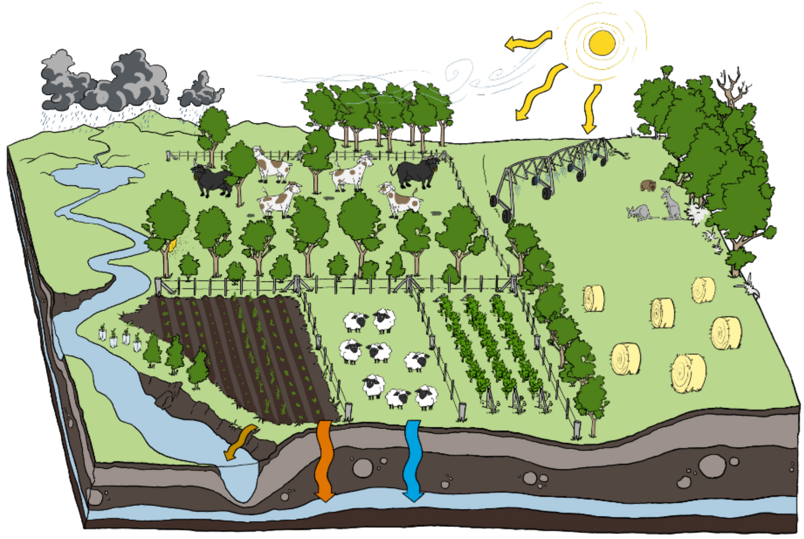


Figure 1. Ecological and biological assets on farm. Source: Farming for the Future.

Why is Natural Capital Important?

Globally and nationally, our economy relies on our natural assets. In 2018, the Australian Bureau of Statistics did research on the economic value of Australia's natural assets and found that it was worth $6.5 trillion.

Approximately 55% of Australian land mass is owned by farmers, so the management of farmland is key to restoring NC, building climate resilience and maintaining viable food production.

NC can provide **ecosystem services** which are the outputs, conditions or processes derived from natural assets that directly or indirectly benefit producers (private benefit) and society (public benefit). These are not limited to, but can consist of the following services and provisioning:

- Carbon sequestration or storage;
- Biodiversity conservation;
- Habitat for predatory insects and pollinators;
- Fodder for livestock and sale;
- Soil regulation services;
- Composting functionality;
- Shade and shelter;
- Reduction of erosion and nutrient leaching/runoff; and
- Quality water cycling.

Additionally, people can undertake activities to protect, manage, restore or improve NC and ecosystem services. These are often referred to as **environmental services** and include things like:

- Revegetation and protection of riparian zones (erosion control);
- Fencing to exclude stock;
- Protection of culturally significant sites;
- Pest and weed control;
- Holistic grazing management; and
- Protection of critical habitat.

What is Natural Capital Accounting?

The measuring of on-farm NC, commonly referred to as Natural Capital Accounting (NCA), has quickly moved from an emerging concept to a hot topic in the agricultural sector.

> *"Farmers quite often rely on technology to 'stay in the game'. To ignore your natural capital and to not account for maintaining its integrity, especially ecosystem health, will see those dreams turn to dust."*
>
> *- Project participant*

NCA is an approach that assesses the condition of NC on a farm and tracks changes over time. Depending on what NC elements are measured and the purpose of the accounts, NCA can yield benefits such as competitive advantage (through better decision making on farm), positive environmental outcomes, and improved well-being for humans and other life forms.

Farming businesses can gain environmental, economic, and social benefits from these ecosystem and environmental services, highlighting NCA's potential to deliver essential public benefits as well. In addition to understanding on-farm NC management, there is increasing pressure from organisations in the supply chain, the financial services industry, and governments to understand the environmental impact of their operations.

Although global standards for NC reporting exist, an agreed-upon standard for on-farm NCA benchmarking is still developing, with several methodologies in development. This is why Perth NRM initiated this research project to develop an approach and methodology for on-farm NCA in Western Australia.

> *"[Dirty Clean Food] are so excited about this Perth NRM NCA project because it is a way of monitoring and measuring the natural capital on a farmer's farm so they can make management decisions based on what changes they're seeing happen over time."*
>
> *- Project partner Christie Stewart, Dirty Clean Food*

Project Background

Phase One – Natural Capital Accounting Learning Case Studies (NCALCS)

As sumarised in the NCALCS phase 1 report, (*https://www.perthnrm.com/project/measuring-on-farm-natural-capital/*), the project began with engaging 5 farmers who could co-design and provide on-ground knowledge into developing an appropriate method to measure NC at farm-level. These farmers were recognised as trusted sources through the RegenWA Ltd network and had substantial WA regenerative farming experience. From these encounters, we learnt about what NC means to them and how they would measure it (considering future practicalities).

Buntine farmer and RegenWA Chair, Stuart McAlpine said he was "keen to see a framework in place that enables him and his bank to measure the land's true asset value." Other farmers and RegenWA committee members also expressed their enthusiasm in the hope of seeing a NCA measurement and verification framework as being useful in identifying next best-practices, and its capability to demonstrate stewardship credentials.

This constructive feedback and advice was key as the project's phase 2 objective was to equip farmers with the ability to utilise that information in their mangement decisions and when communicating their environmental performance to their stakeholders.

While aligning the project with the United Nations System of Environmental Economic Accounting (UN SEEA EEA) and the structure described by the Natural Capital Protocol (NCP), the NCA team were able to 'test-drive' the emerging methodologies specifically designed for ecological assessments and farmer-centric approach.

Phase Two – Measuring On-Farm Natural Capital in Western Australia

Through a combination of processes such as an online expression of interest (EOI) form, engagement with pre-inclined farmers, and logisitcal considerations relating to travel and budget, we were able to identify 20 willing participants from across the Southwest of Western Australia. We selected farms from a diverse range of enterprises and bioregions to ensure the protocols and methods were tested, applicable and beneficial to as many stakeholders as possible (Figure 2). There were 3 viticulture properties, 3 horticulture, 9 cropping and/or mixed (sheep and crop), and 5 livestock (cattle, sheep and/or chickens) properties signed onto the project.

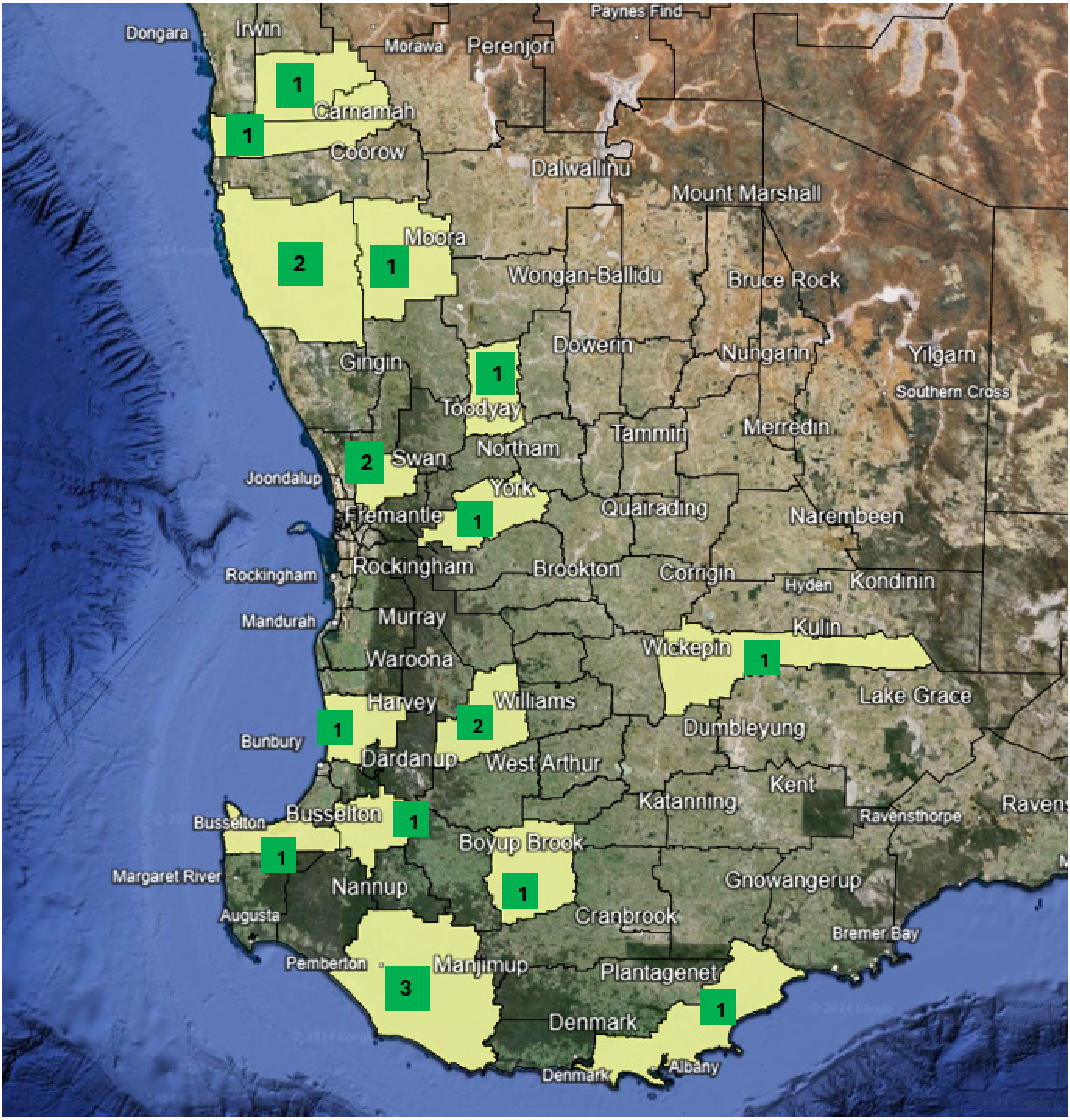


Figure 2. A visual representation of the participating farms per local government area in WA.

The NCA reporting followed the process shown in Figure 3. A summary of the core elements of each step are provided in the methodology section.

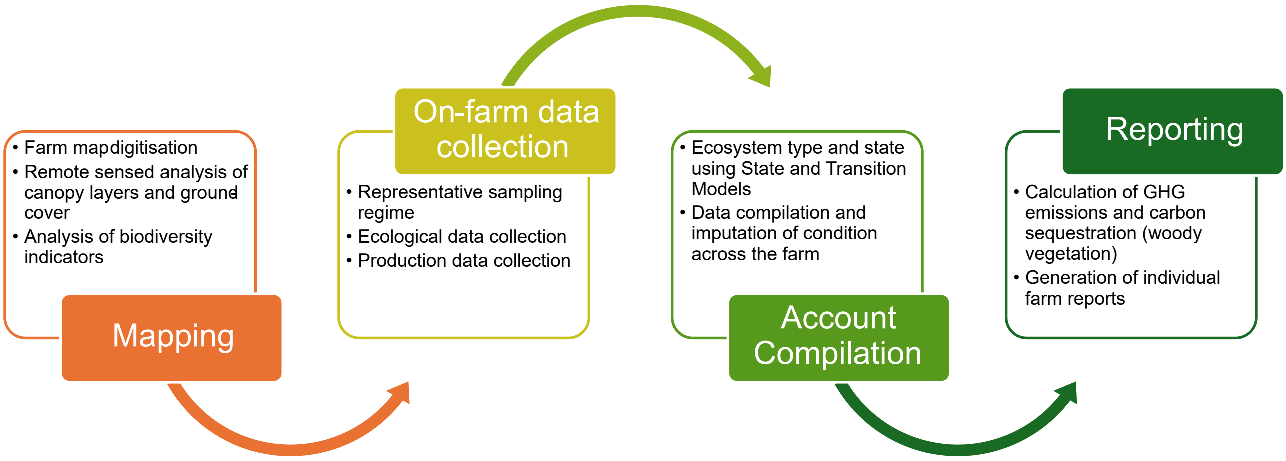


Figure 3. NCA reporting process

> ***"I found the Natural Capital Accounting process very user-friendly and rewarding by gathering data and providing substance to the importance of incorporating ecological values into future farm systems. Natural Capital Accounting helps enable land managers to quantify their greater community stewardship actions and environmental services including positioning around achieving net zero emission operations."***
>
> *- Project participant*

A key consideration of the project design was to ensure that the work was continuing the collaborative approach to the development of farm-level NCA methods that were emerging around Australia. Rather than creating a competing approach to farm-level NCA measurement, the collaboration ensured that WA farmers were benefitting from work already underway in this emerging space, and avoiding the confusion that can arise with different, competing solutions.

Building on the learnings from phase 1 and in parallel with phase 2, the Perth NRM NCA team collaborated with La Trobe University via their Farm-scale Natural Capital Accounting (FSNCA) project (through joint partner Integrated Futures) to leverage the methodologies and tool sets that had been developed in that program. Perth NRM were key partners in the update of the methodology to cover Western Australian landscapes, and to test the tools and processes as part of that development. Details of the FSNCA methods are available from the FSNCA project page (Blueprint-Farm-scale-Natural-Capital-Accounting-methods.pdf (latrobe.edu.au))

The Perth NRM project team also collaborated on the Farming for the Future (FFTF) Livestock Pilot Program (fftf.org.au) to further develop and test the data collection tools, and it was this final toolset that was used for the ecological data collection in this program. The methods and protocols used by FFTF for their NCA program are publicly available from the FFTF website (https://farmingforthefuture.org.au/resources/natural-capital-methods/).

Methodology

Overview

The methods used to collect and compile the data in this report has leveraged extensive work undertaken by La Trobe University as part of their Farm-scale Natural Capital Accounting project. The methods are expected to evolve as they are used in future projects across various agricultural landscapes. It should also be noted that in this project, NC data is collected at a single point in time and therefore, does not provide accounts of change to NC over time.

Farmer Engagement & Methodology Design	Engaged with 5 farmers from Phase 1 for co-design and knowledge input. Gather feedback on NC measurement and future practicalities.
Methodology Testing & Refinement	Align project with UN SEEA-EA** and NCP***. Test methodologies for ecological assessments. Refine methodologies based on feedback.
Farm Selection & Data Collection	Extend Phase 2 EOIs through RegenWA network. Select 20 farms across diverse enterprises and bioregions. Collect property maps and management data.
GIS Mapping & Management Unit Identification	Digitise property maps using GIS software. Define ecosystem units and ecosystem states. Classify ecosystems based on remote sensing data.
On-Farm Assessments	Identify survey sites based on ecosystem representation. Navigate using Avenza app and conduct field surveys. Record data using SafetyCulture app for ecological assessments.
Soil Condition Assessment	Conduct rapid visual soil assessments. Evaluate soil attributes based on standardised criteria. Determine soil health scores for each site.
Soil Sampling & Analysis	Perform soil sampling post-fertiliser application. Process and analyse samples for chemical composition. Interpret analysis results for management insights.
Ecological Asset Register Compilation	Compile survey data into Ecological Asset Register. Assign ecological integrity scores to ecosystem unit based on state & transition models. Impute scores to similar ecosystem units for comprehensive assessment.
Production Data Collection	Gather operational data on inputs and outputs. Record resource use efficiency for analysis. Collect data on greenhouse gas emissions and pollution.
Threatened Species Assessment	Evaluate presence of threatened species through data from Department of Biodiversity, Conservation and Attractions (DBCA).
Report Generation	Develop NCA reports for farmers. Quantify farm's NC at the time of assessment. Provide baseline for future management decisions.

**United Nations System of Environmental Economic Accounting (UN SEEA-EA)
***Natural Capital Protocol (NCP)

Mapping

The first step in compiling the natural capital accounts was to map out the farm elements and construct a stratified model of the farm.

Property maps were produced by Integrated Futures and provided to the Perth NRM NCA team for upload into GIS software. Once digitalised, these maps were manually divided into different management units (riparian areas, paddocks, bushland).

The collection of management data from each farmer provided valuable information to complement and/or verify the remote mapping and ensured the pre-fieldwork information was relevant and reliable. This data included things like tree plantings, sown crops or pastures, paddock rotations, fertiliser use and conservation areas.

Spatial analysis of remote sensed datasets (canopy cover and density, ground cover) was then combined with the farm management data to develop a stratified model of the farm (based on pre-1750 vegetation type, ground cover and canopy cover).

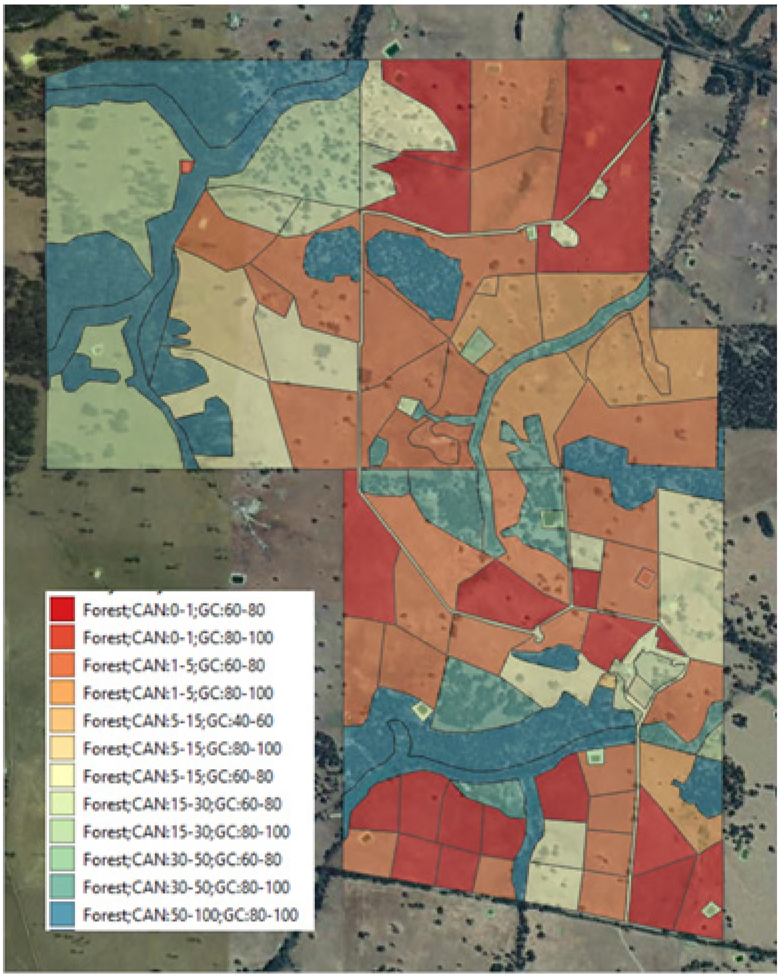


Figure 4. An example of combined classification of ecosystem units (EUs) for a farm.

On-farm Data Collection

Ecological Assessments

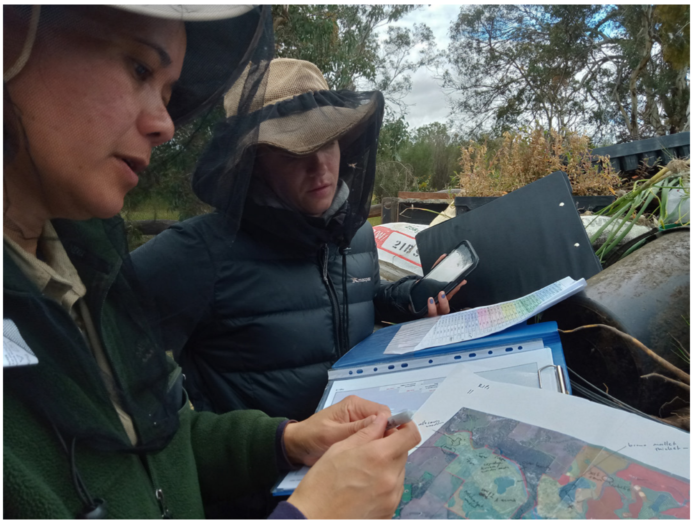


Figure 5. Perth NRM staff out on-farm conducting ecological assessments.

Using the information from the remote vegetation classifications, approximately 30 site assessments were identified across each farm. This number of sites and their locations were chosen based on access and appropriate representation for each Ecosystem State (ES) (its ratio across the farm's total area). Each site consisted of 1 to 4 assessments depending on species diversity and to ensure ecological integrity.

A number of mapping technologies were used to facilitate data collection whilst on farm. This included loading geo-coded maps of the stratified farm model into the Avenza app to provide real-time views of the data. The GPS tracking feature of the app aided on-farm navigation, and ensured traceability of the site assessments undertaken.

While in the field, SafetyCulture (previously called iAuditor) was used to record the site assessment data. This data was collected following a protocol co-designed with Integrated Futures and influenced by NCALCS participants. Parameters included metrics such as land use, vegetation type and extent, species diversity and health, habitat, weeds, and groundcover condition.

A simplified methodology was developed for the viticulture sites in order to collect information specific to the land use, such as assessing the inter-row ground layer and under-row groundcover.

Rapid Soil Assessments

The rapid soil assessments were designed to provide the farmer with information to track long-term trends in soil condition and thus, the capacity of the EMU (Ecosystem Management Unit) to support agricultural production over time.

These assessments were designed to be quick and simple so the farmer could do them themselves and were not intended to replace or inform agronomic assessments of inputs required for short-term production outcomes (e.g., fertiliser, lime, micro-nutrient, organic amendments).

These assessments looked at several attributes including soil pH, topsoil depth, compaction, porosity, texture, slaking and dispersion, as outlined in Table 2. Based on the North Central Victoria Soil Health Guide, these measures focused on topsoil characteristics, meaning management that aims to improve the condition of the whole soil profile (e.g., deep ripping organic amendments) may not be captured in these assessments.

At the start of the project, these assessments were conducted at all farm sites. However, due to time and budget constraints of getting quality data at each site within the allocated timeframe, it was agreed that only one soil condition assessment was conducted per ES.

Figure 6. Screenshots of the various assessments on SafetyCulture.

Table 1. Tests (indicators) to include in Visual Soil Condition Assessment.

Test	Method	Poor Score = 1	Fair Score = 2	Good Score = 3
1. Groundcover	3 X 1 m^2 visual estimates	Less than 50% groundcover (plants dead or alive; stubble)	50% to 70% groundcover (plants dead or alive; stubble)	More than 75% groundcover (plants dead or alive; stubble)
2. Soil pH	Soil pH probe	pH 5.0 or lower; greater than pH 8.5	pH 5.0 - 6.0; pH 7.5 - 8.5	pH 6 to pH 7.5
3. Soil texture	Profile uniformity test	Soil texture abruptly changes from the topsoil (e.g. sandy loam) to the subsoil (e.g. clay)	Soil texture is the same throughout the profile	Soil texture gradually becomes heavier down the profile
4. Topsoil depth	Observe change in colour within the soil profile	Topsoil depth 0-5cm	Topsoil depth 5-10cm	Topsoil depth >10cm
5. Soil compaction	Penetrometer	Soil is hard; penetrometer will not penetrate the soil	Penetrometer penetrates with difficulty to less than 15 cm	Penetrometer easily penetrates beyond 15 cm
6. Soil porosity	Soil pit (50 cm X 50 cm)	No soil macropores and coarse micropores are visually apparent within compact, massive structureless clods. The clod surface is smooth with few or no cracks or holes.	Soil macropores and coarse micropores between and within aggregates have declined significantly but are present in parts of the soil on close examination.	Soils have many macropores and coarse micropores between and within aggregates associated with good soil structure
7. Slaking & Dispersion	Emersion test (takes ~20 mins so set up first)	Unstable structure; aggregates break down and disperse; milkiness of water	Evidence of slaking; aggregates break down; no milkiness of water	Maintains structure; aggregates remain intact. No swelling of clay particles

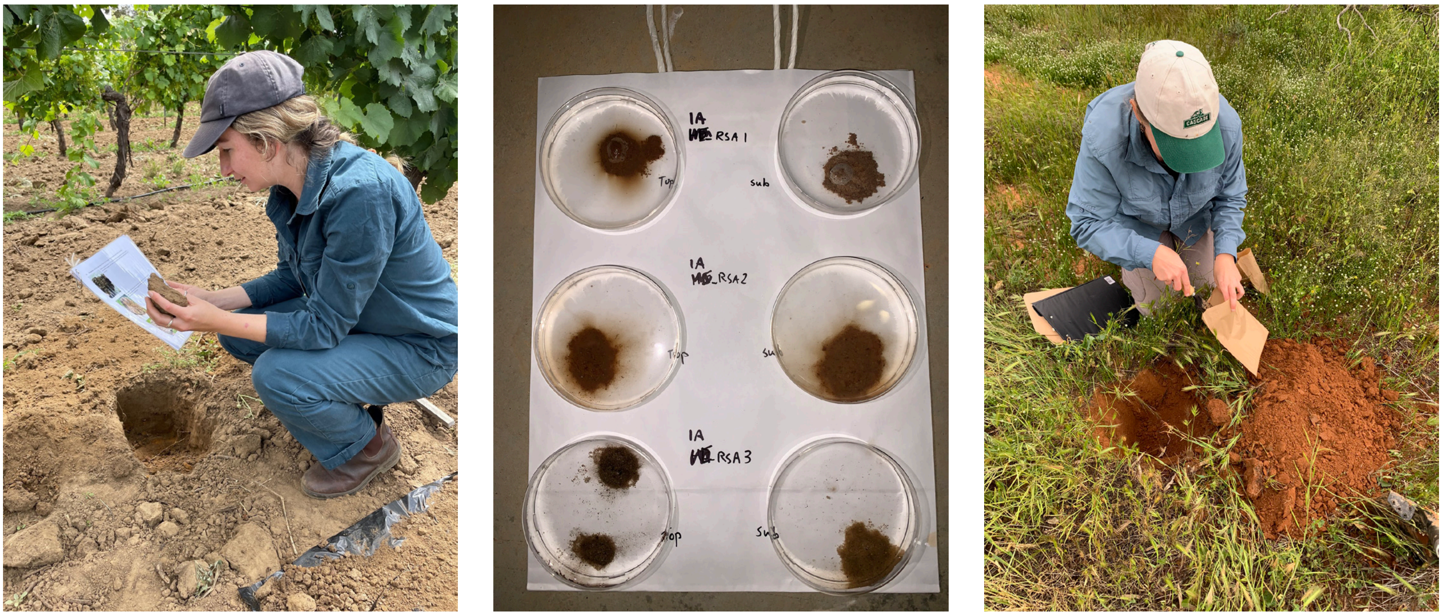


Figure 7-9. Left-right: Bonnie assessing the soil porosity under a vine, assessing soil slaking and dispersion, Bronwyn collecting soil samples.

Soil Sampling for Lab Analysis

Following discussions with agronomists and in alignment with the budget, it was determined that soil sampling for chemical analysis was to take place three months after any fertiliser use, lime, or gypsum application (November-March, before seeding). Depending on soil types and enterprise, slightly different protocols were used. Aside from time of year and enterprise, there were many other factors to consider including appropriate sampling area, number of samples, depths, processing, and storage of samples.

The sampling protocol was made in consultation with analytical chemistry facility WA ChemCentre, with additional advice from CSBP Ltd. The recommended soil sampling strategies sourced from the Department of Primary Industries and Regional Development (DPIRD), Department of Primary Industries (NSW) and Department of Jobs, Precincts and Regions (VIC) were also consistent with the soil sampling strategy used.

Produce and Petiole Sampling

Produce Sampling

Several participating farmers had produce sampled for lab analysis. These samples were collected and transported in an esky with ice bricks to maintain optimal temperature conditions. Upon arrival at the farm, most farmers provided random samples for analysis. For cereal crops, a representative sample consisting of an ice cream container filled with grain harvested from a specific paddock was delivered to ChemCentre. Likewise, for horticulture properties, a diverse selection of recently harvested produce was collected in a bucket, ensuring randomness by sampling from various trees or plants.

Petiole Sampling

The Perth NRM NCA team collected the petiole samples following the protocol set by the WA ChemCentre. Sampling for plant sample assessment in the vineyard was best performed just prior to vine budburst, in the early morning when leaf turgor is optimal. Approximately 100g of the youngest fully emerged petioles across several vines were collected to provide a sufficient representative sample. They were then placed into paper bags, chilled at 4°C and sent to the laboratory for analysis. Plant tissue testing is the preferred method for diagnosing trace element toxicities, deficiencies, and imbalances for plant nutrients.

Production Data Collection

A key step of data collection for this project was the gathering of production (operational) data. These indicators provided important information about the environmental performance of the farm businesses. This data provided insights into the sources of greenhouse gas (GHG) emissions, how effectively resources are used in production, as well as estimates of pollution generated.

Depending on enterprise, this included data on inputs such as fuel use and fertiliser levels, production outputs (wool, meat, grain), and efficiency use for resources like water and power. Figure 10 provides an insight to just how much data was collected and analysed in this project. Note the data in Figure 10 is faux and not that of a participating farm.

Integrated FUTURES

FLOCK 1 stock numbers - by class and season

INSTRUCTIONS: The data below is required to estimate the greenhouse gas emissions (methane, carbon dioxide, nitrous oxide) associated with your sheep production. This includes enteric emissions, manure emissions and leaching of nutriuent. The numbers for a particular class of sheep will be average over a season. The data below is for sheep agisted on your property

NUMBER OF ANIMALS		WINTER			SPRING			SUMMER			AUTUMN				Lambing rate (%)	81%
Year	Class of animal	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Greasy wool yield (kg/hd/year)	Sheep purchased (head)	0
2017-18	Breeding ewes	1,537	1,545	1,553	1,561	1,569	1,578	1,586	1,594	1,602	1,610	1,618	1,634	5.0	Total LWT of purchased sheep	0
	Maiden ewes	952	967	982	997	1,012	1,027	1,042	1,057	1,072	1,087	1,102	1,132	5.0	Purchase $	$0.00
	Other ewes	-	-	-	-	-	-	-	-	-	-	-	-	6.0	Sheep sold (head)	2226
	Lambs	1,197	1,208	1,219	1,230	1,241	1,252	1,264	1,275	1,286	1,297	1,308	1,330	2.0	Total LWT of sold sheep	122430
	Hoggets	-	-	-	-	-	-	-	-	-	-	-	-	4.0	Sale $	$318,660.00
	Wethers	-	-	-	-	-	-	-	-	-	-	-	-	6.0	Greasy Wool produced (kg)	17659
	Rams	54	54	54	54	54	54	54	54	54	54	54	54	6.0	Clean wool yield (%)	70%
	TOTAL	3,740	3,774	3,808	3,842	3,876	3,911	3,946	3,980	4,014	4,048	4,082	4,150		Agistment income ($)	$0.00

NUMBER OF ANIMALS		WINTER			SPRING			SUMMER			AUTUMN				Lambing rate (%)	48%
Year	Class of animal	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Greasy wool yield (kg/hd/year)	Sheep purchased (head)	8
2018-19	Breeding ewes	1,810	1,804	1,798	1,792	1,786	1,780	1,775	1,769	1,763	1,757	1,751	1,739	5.0	Total LWT of purchased sheep	560
	Maiden ewes	761	786	811	835	860	885	910	934	959	984	1,009	1,058	5.0	Purchase $	$6,400.00
	Other ewes	-	-	-	-	-	-	-	-	-	-	-	-	6.0	Sheep sold (head)	2070
	Lambs	2,079	2,064	2,049	2,035	2,020	2,005	1,990	1,975	1,960	1,946	1,931	1,901	2.0	Total LWT of sold sheep	113850
	Hoggets	-	-	-	-	-	-	-	-	-	-	-	-	4.0	Sale $	$316,702.00
	Wethers	-	-	-	-	-	-	-	-	-	-	-	-	6.0	Greasy Wool produced (kg)	15437
	Rams	92	89	86	83	80	77	74	70	67	64	61	55	6.0	Clean wool yield (%)	70%
	TOTAL	4,742	4,743	4,744	4,745	4,746	4,747	4,749	4,748	4,749	4,751	4,752	4,753		Agistment income ($)	$0.00

NUMBER OF ANIMALS		WINTER			SPRING			SUMMER			AUTUMN				Lambing rate (%)	68%
Year	Class of animal	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Greasy wool yield (kg/hd/year)	Sheep purchased (head)	9
2019-20	Breeding ewes	1,634	1,615	1,597	1,578	1,560	1,541	1,523	1,504	1,485	1,467	1,448	1,411	5.0	Total LWT of purchased sheep	630
	Maiden ewes	1,132	1,151	1,170	1,189	1,208	1,227	1,247	1,266	1,285	1,304	1,323	1,361	5.0	Purchase $	$11,100.00
	Other ewes	-	-	-	-	-	-	-	-	-	-	-	-	6.0	Sheep sold (head)	2984
	Lambs	1,330	1,311	1,291	1,272	1,252	1,233	1,213	1,194	1,174	1,155	1,135	1,096	2.0	Total LWT of sold sheep	164120
	Hoggets	-	-	-	-	-	-	-	-	-	-	-	-	4.0	Sale $	$467,281.00
	Wethers	-	-	-	-	-	-	-	-	-	-	-	-	6.0	Greasy Wool produced (kg)	17659
	Rams	54	53	53	52	51	50	50	49	48	47	47	45	6.0	Clean wool yield (%)	70%
	TOTAL	4,150	4,130	4,111	4,091	4,071	4,051	4,033	4,013	3,992	3,973	3,953	3,913		Agistment income ($)	$0.00

NUMBER OF ANIMALS		WINTER			SPRING			SUMMER			AUTUMN				Lambing rate (%)	0%
Year	Class of animal	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Greasy wool yield (kg/hd/year)	Sheep purchased (head)	0
	Breeding ewes	-	-	-	-	-	-	-	-	-	-	-	-	5.0	Total LWT of purchased sheep	

1. Flock 1 | 1. Flock 2 | 1. Flock 3 | 2. Herd 1 | 2. Herd 2 | 3. Purchased Feed | 4. Crops | 5A. Inputs - Detailed | 6. Fuel and Electricity | 7. Water | Meta Sheep | Meta Cattle | M

Figure 10. An example of the various production data collected for assessing a farm's environmental performance.

Significant Species

To enhance our understanding of the ecological landscape on and around the farm, data was obtained via a desktop search through the Department of Biodiversity, Conservation and Attractions (DBCA) of threatened, specially protected, and priority fauna within each farm boundary and a buffering circumference. This enabled the project team to compile a list of significant species that had previously been recorded in the area and include that information in the NCA reports.

Additionally, Perth NRM facilitated one-on-one online meetings with each farmer to discuss the list of significant species and any observations the farmer may have had on their property. The purpose of this engagement was to inform them about the diverse range of species that may potentially reside on their property (depending on habitat present) and raise awareness of their influence and contribution to biodiversity protection.

Account Compilation

An Ecological Asset Register (EAR) is a core component of the overall NC accounts and reports. It reviews the site assessment data, calculated ecological type, and condition state.

The NC site assessments were designed to collect ecological information from representative areas of the farm with differing ecological characteristics. For EUs that were not visited or assessed, ecological condition was imputed from the visited sites based on the original stratification model of the farm.

This imputation process is manual and utilises the assessor's knowledge of the landscape from time on-farm, as well as information from management data and conversations with the farmer. If there was evidence suggesting that an alternative ES was more accurate—such as data provided by the farmer or spatial imagery—the assessor could adjust the imputed state accordingly. Each EU was given an ecological integrity score based on the State and Transition category (see Appendix 1: State and Transition Models).

Reporting

The final activity was to produce NCA reports for each participating farm. The purpose of these reports was to demonstrate the ability to quantify the NC on-farm at the time of assessment and to produce a baseline that the farmer could refer to when considering future management practices. Additionally, this report could help identify any issues and opportunities related to NC and assist in tracking changes over time.

The design of the reports took into consideration the complexity of information being presented and the variety of audience learning styles and preferences. The Perth NRM team and Integrated Futures worked very closely to develop the NCA reports and received some valuable feedback for future templates and NCA work.

> *"We are grateful for the experience and resulting report. We appreciate this NCA report because it reminds us where we have achieved good things; this kind of thing could be a good baseline to measure condition over time; it shows us our weaknesses and potential for where future work can be done; and done well, it could be a helpful summary to explain to stakeholders what work we've done, and why we're planning what we're planning."*
>
> *- Project participant*

Results

Being the first on-ground farm-scale NCA project of its kind in WA, Perth NRM signed a non-disclosure consent form with each participating farmer to acknowledge their private information and value that asset. This means that the NCA reports, and information collected throughout the project are private property of the farmers and are not publicly available. Therefore, the following results offer a summary of the data, and an overview of the content provided to each farmer in their report.

Ecological Statistics

Across the life of this project, 645 site assessments were conducted across 20 farms, with ecological site assessments contributing to just over 60% of these (Figure 11). Spanning a total of 30,968 hectares (ha), we assessed a range of properties and enterprises where the smallest farm was 3ha and the largest was 5,688ha (Table 3).

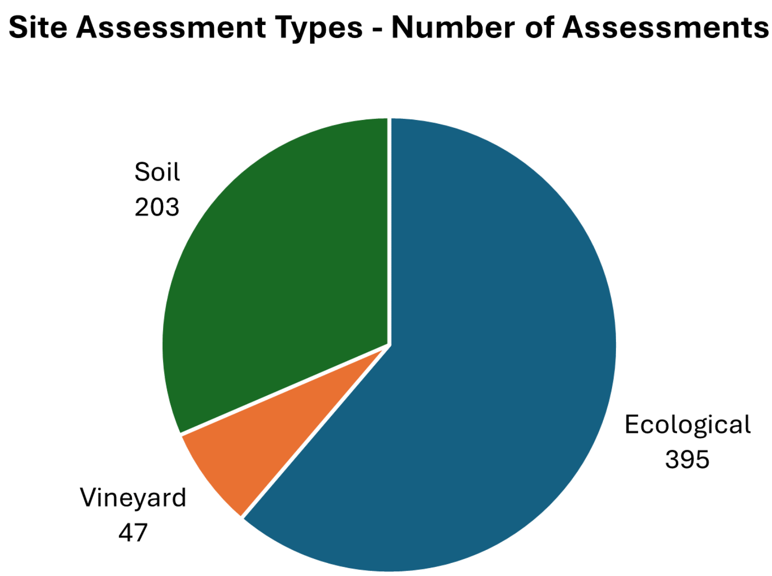


Figure 11. Percentage of site assessment types conducted during the project.

Table 3. Farm area (ha) statistics

Farm area	Hectares (ha)
Total	30,968
Average farm Size	1,475
Maximum farm size	5,688
Minimum farm size	3

High Ecological Integrity

The overall project data shows a noteworthy sum of Ecosystem Units (EUs) as having high ecological integrity. High ecological integrity refers to the ecosystem's potential to persist at a top-quality condition.

Ecological data revealed that ecosystems with high ecological integrity closely resemble reference conditions, such as a pristine native forest with high canopy cover and minimal disturbance. The data indicated that a total of 2,326 hectares across the farms were identified as having high ecological integrity, including native grasslands, pastures, woodlands, shrublands, and forests.

Agricultural Landscapes

The project found that a significant portion of participants allocated nearly 12,000 hectares to sown pastures, surpassing the 11,028 hectares designated for crop cultivation.

An additional observation was that of ET Exotic Woody Vegetation. This ET only accounted for a total of 42ha across all farms, indicating that perhaps most farmers prefer to plant native vegetation when undertaking any revegetation work, with 979ha recorded across the group of participating farms.

Soil and Produce Analysis

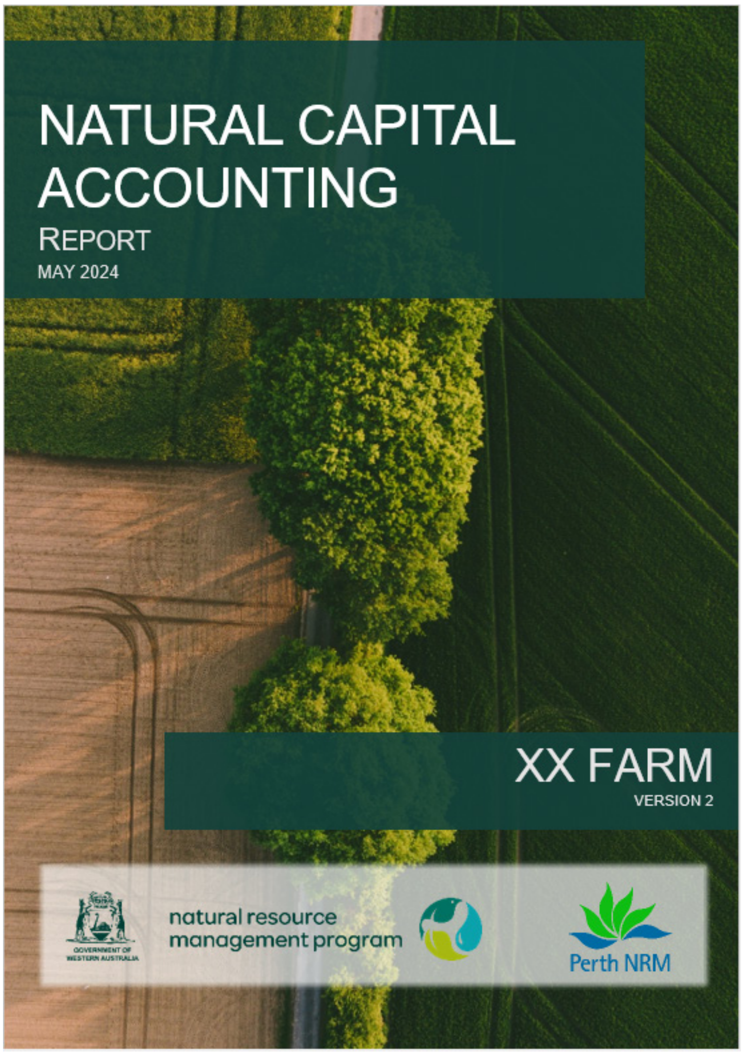
Soil tests provide valuable information about soil properties (mostly chemical properties) that affect plant growth. ChemCentre analysed samples from ten farms, and reports were issued in the form of National Association of Testing Authorities (NATA) endorsed certificates (where applicable) and electronic spreadsheets. These reports included analysis on elements such as oil content, macro nutrients, and trace elements.

The results were interpreted by Sage Consultancy and developed into a final report for each of the farms assessed. These reports included soil physical, chemical, and microbial assessments and recommendations for the farmer.

Similarly with the produce assessments, ChemCentre analysed the samples and Sage Consultancy interpretation the results, reporting on the nutritional findings. These reports included information on a range of macro nutrients and trace elements.

Reports

An NCA report was produced as a resource for each of the 20 participating farmers. The aim of these reports was to present information about NC in a form that is useful to people that make decisions about the farm's management and to use as a reference tool when tracking changes over time.



These reports have been prepared for research purposes including the development of NC measurement and accounting methods. Alongside the NC accounts is a narrative description that interprets the accounts and explains how they have been developed.

The reports were structured in the following manner:

- **Natural Capital Dashboard**

This summary page provides some key metrics relating to the management of the NC for each farm. It includes soil protection, potential habitat maintained for significant species, rapid soil assessment results and a summary of the averaged carbon emissions and sequestration over a 5-year period.

- **Natural Capital Type & Condition Extent**

This provides more detailed information about the different types of NC assets that comprise the farm. There was a combination of measurement approaches and techniques was used during the project's ecological surveying, to ensure integrity and reliability.

- **Biodiversity and Habitat Services**

This highlights Significant Species and Threatened Ecological Communities (TEC) on or near the farm. It is to be noted that the biodiversity data was predominately conducted using remote information provided through the Department of Biodiversity, Conservation and Attractions (DBCA), and not via on-farm site assessments. As an ecosystem service, habitat for biodiversity was estimated based on this information, however the results in this section of the report are an indication of the potential for these species to be found on the farms and are there to provide management guidance only. This data is something the research is looking into extending and developing further in the future.

- **Groundcover Analysis**

This section provides information about the historical trends of groundcover metrics of the past 5-year period. The levels of groundcover maintained across the property has a direct impact on the susceptibility of the landscape to wind and water erosion during significant weather events. A combination of in-field data and remote imagery was used to generate the groundcover results.

- **Environmental Performance Indicators**

This section provides information about the Greenhouse Gas (GHG) emissions and sequestration, as well as the resource use intensity and pollution generated by the farming operation. It looks at whole of farm Scope 1, 2 and 3 emissions, input use and efficiency. It's important to understand the estimation methods behind each environmental performance indicator. For detailed calculations and scientific references, see the publication, 'A natural capital accounting framework to communicate the environmental credentials of individual wool-producing businesses' at https://www.emerald.com/insight/content/doi/10.1108/SAMPJ-06-2021-0191/full/html.

Database Platform

The development of an online platform was a priority to ensure that the participating farmers had the relevant attributes from their audit available in an interactive format that facilitates the interrogation of the data to better understand the NC that underpins their farm business.

The participating farmers have secure access to their data superimposed over imagery of their farms. Their data is underpinned by fully attributed shape files (including meta data) that the farmers can export and use in other platforms of their choosing. The different elements of NC presented on this platform include the ecosystems and their different classifications, groundcover attributes, how the ecosystem unit was scored (visited in-person or imputed), area of each EU and more.

The NCA platform has been built using the ArcGIS Online Platform (Esri) and presents users with a personalized portal that integrates the presentation of their NCA reports along with an interactive map of the NCA data. The portal allows users to extend the NCA data by importing other spatial data sets (Living Atlas, ArcGIS Online maps, and other web-based data sources) to assist with farm management and planning. Each farm dataset is secure with only the participating farmer and the platform administrators having access to the data. The administrators have signed a non-disclosure agreement to protect the data owners and their data.

A significant co-benefit of digitizing their data is the ongoing legacy of the investment well beyond the life of the project. Support was provided by Esri Australia by granting subsidised software licenses through their not-for-profit organisations program. The template setup and data curation was conducted by Integrated Futures Pty Ltd with support from Cibo Labs Pty Ltd.

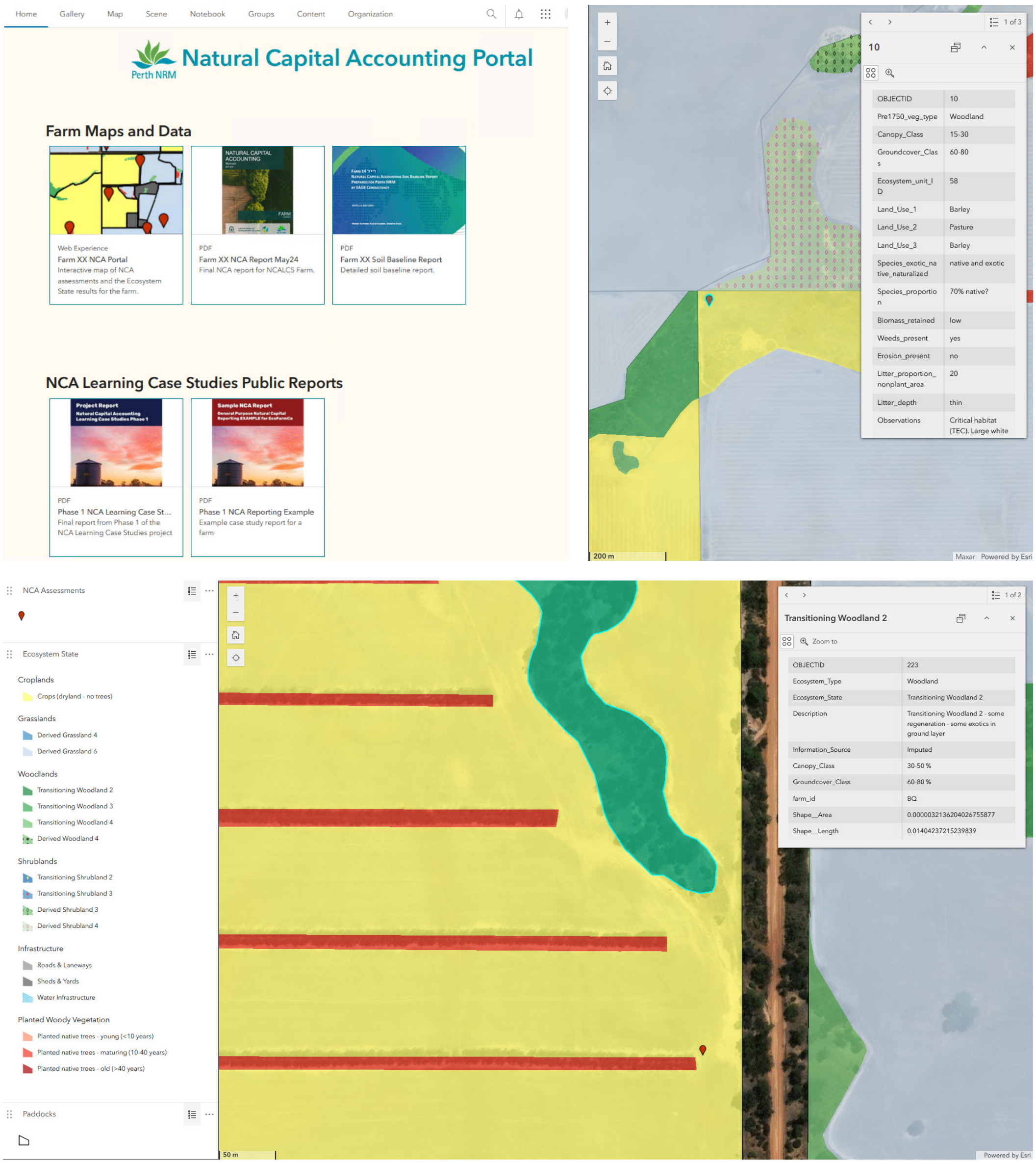


Figure 12. A screenshot of ArcGIS showing the ecosystem states across a property map. The pop-up box is highlighting an area of the map that has been classed as a Transitioning Woodland 2.

Extension Activities

A significant aspect of the project was engagement and education with the public and community around NC and NCA. We curated an array of online resources, presented at events and workshops, facilitated webinars, and hosted stalls at field days. Extension outputs are summarised in Figure 13 below. Whether they were one-on-one conversations, university guest lectures, or a presentation to an industry group, all these activities and engagements have contributed to an overall increase in awareness amongst industry, community and landholders on NCA and the importance of restoring NC in our farming landscapes.

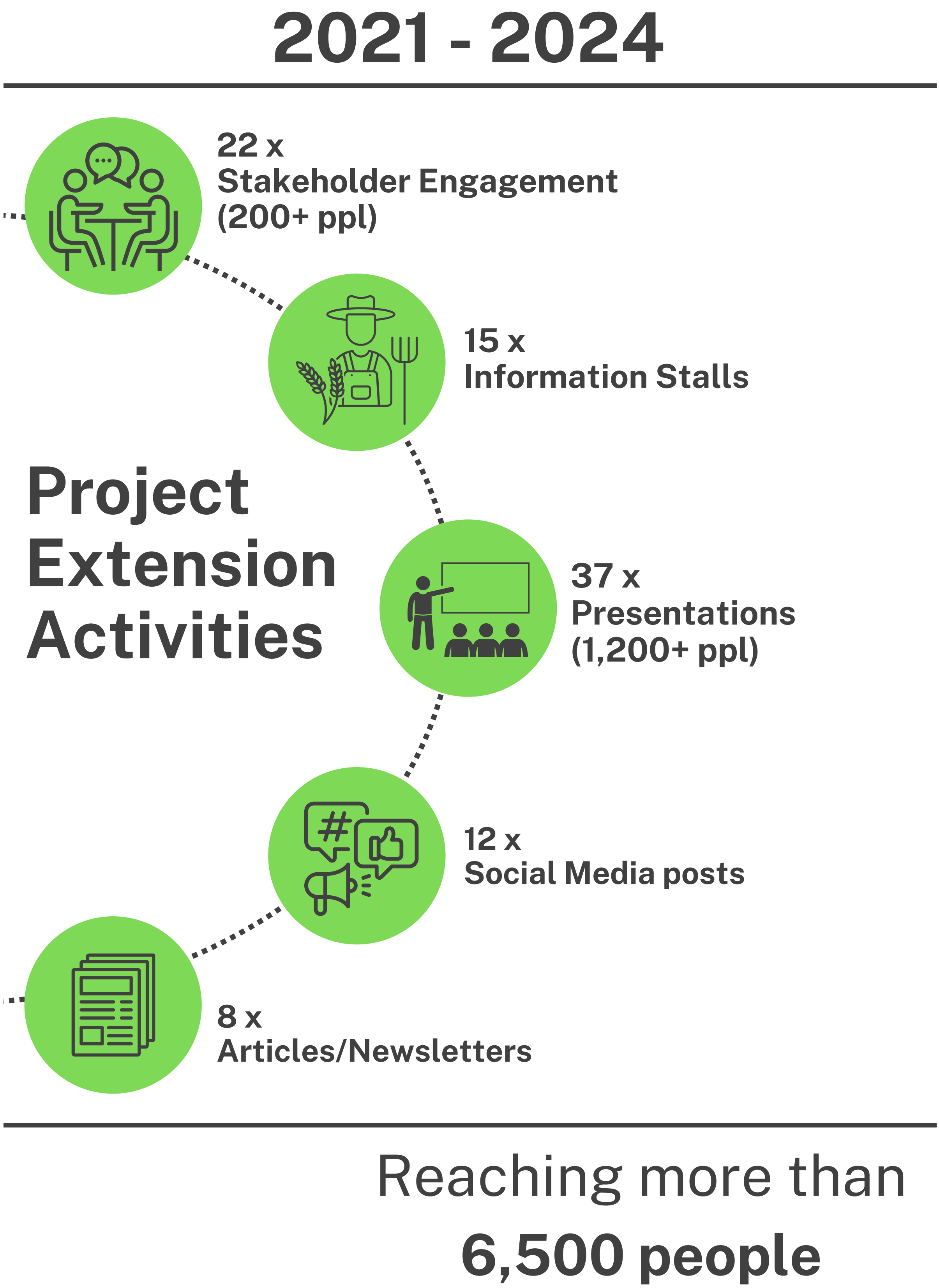


Figure 13. NCA project extension activity statistics

Figure 14 & 15. Bonnie Jupp presenting on NCA at the WA Regenerative Livestock Production (WARLP) Field Day, 2023.

Discussion

Interpretations of Results

Data Collection & Assessments

The Perth NRM NCA team spent many hours out on farms collecting ecological and soil data. Travelling as far North as Carnamah and down South to Albany, the diversity of species, soil types and management styles meant the team was facing new experiences, unknown challenges and constantly adapting key learnings. This developed the team's confidence and efficiency in site assessments, and their skill in assessing the landscape. Though there was a relatively high level of staff turnover, core staff retention ensured continuity in data collection procedures and project management.

The project highlighted the importance of assessing deep soil carbon over topsoil carbon, given that topsoil carbon levels can fluctuate significantly with rainfall. There is a pressing need to update State and Transition (S&T) Models to better reflect the conditions specific to Western Australia. This includes incorporating more accurate local reference conditions, accounting for factors such as soil compaction, which varies between WA and Eastern States, and understanding the impact of livestock numbers on soil condition.

Despite the recognised importance of soil in assessing NC, the project faced constraints due to limited funding, which meant soil sampling could only be conducted on ten out of twenty farms. This also meant interpretation of the lab analysis was restricted. Due to being a research project, the project team had limited capacity to visit the farms at appropriate times for both soil and ecological assessments. The project also identified gaps in soil measurement methodologies, noting that soil condition assessments are complex and costly, and may not always be relevant depending on agricultural practices, soil types and time of year.

Although there were gaps in the soil component of the project, it did reveal significant areas of native grasslands and sown pastures across the participating farms. In particular, sown pastures covered nearly 12,000 hectares, which was more than the 11,028 hectares of cropped farmland. It was interesting to note this as WA's dominate enterprise is broadacre grain production, however, due to our climate and bioregions, many WA farmers still run mixed crop and livestock operations.

The integration of livestock can bring both challenges and benefits to a farming operation, however they can regenerate the landscape if managed by matching the stocking rate to the carrying capacity, maximising their (positive) impact on the land.

NCA Reports

The development of the NCA reports achieved the project's objective of quantifying a farm's NC at the time of assessment and establishing a baseline for a farmer to refer to for future management decisions. With a complex production data collection spreadsheet, some farmers excluded their operational information (resource efficiency use, inputs, and outputs) from their final NCA reports. However, they were given a second opportunity to provide this information when interim reports were issued.

Feedback indicated some challenges with the clarity of the reports. Distinguishing between generic and specific information was not always clear, which impacted farmers' understanding and interpretation of the findings. Some data provided by the farmers was not utilised in the final reports, possibly due to issues with relevance, suitability, or the project's capacity to analyse it. However, A few participating farmers were also involved in the FFTF NCA Program and this information may have been used in that project instead, thus not wasted.

Though information capturing social, political efforts, and investment details was not fully integrated, many project participants offered words of appreciation and support for this field of work. The long-term view would be that farm advisors and/or accountants would be the ones generating these types of reports in conjunction with an NRM/Landcare/land services/ecological partner.

Engagement & Extension

Farmer engagement was a notable success, with many farmers showing strong interest in the project and expressing a desire for future participation. This feedback highlighted the growing interest in NC and the importance of speaking engagements in enhancing farmers' understanding of NC and its potential impacts on farm performance. The project also demonstrated the value of engaging with diverse stakeholders, including Indigenous communities and industry professionals, to ensure multiple perspectives are integrated into decision-making processes. This engagement is crucial for developing and refining auditing methodologies and ensuring consistency and relevance for end users.

To enhance sustainability and improve land stewardship, the following strategies were recommended to farmers during these engagement activities:

- **Reduce soil disturbance:** Minimise activities that disrupt the biological, physical and chemical functions of soil.
- **Maintain year-round ground cover:** Ensure that soil is covered throughout the year to prevent erosion and degradation.
- **Increase biodiversity:** Incorporate a variety of plant species to improve ecosystem resilience.
- **Use alternative land uses for degraded areas:** Repurpose degraded land for uses such as salt land pastures to restore productivity.
- **Integrate animals into farming systems:** Incorporate livestock in a way that benefits both the land and the animals.
- **Implement precision agriculture technologies:** Use advanced technologies to manage resources more effectively.

Project Limitations - Lessons and Gaps

Farmer Feedback

Farmers involved in the research project demonstrated a willingness to learn about NCA and its potential impact on farm performance. Their openness, innovation, patience, and generosity provided valuable opportunities for exploring methodologies in WA. There was a genuine interest and passion shown by some farmers when they shared their observations and efforts in caring for NC. This demonstrated to the NCA team the value proposition of the ecological assets on the farms.

Farmers provided valuable feedback on the project, noting several benefits:

- **Recognition of achievements:** The NC assessments helped farmers identify where they had made significant improvements.
- **Baseline measurement:** NC data served as a useful baseline for tracking changes in farm conditions over time.
- **Identifying weaknesses:** The data highlighted areas for improvement and opportunities for future work.
- **Summary for stakeholders:** The reports provided a helpful summary for explaining their conservation efforts and future plans to stakeholders.

Key Lessons

Reflecting on the project, several key lessons have been identified:

- **Context:** Consideration of scale and relativity is crucial in environmental assessments. Definitions of the same feature may vary between regions; for instance, a creek in WA might present differently to one in NSW. This underscores the need for localised understanding and tailored approaches to data analysis and interpretation. There is a lack of consistent and accessible date in WA, along with ecological condition agreement across the industry.
- **Model suitability:** There is a need to update S&T Models to better reflect local conditions in WA and use region-specific models and methodologies. The Queensland grazing model may not be appropriate for WA due to differences in pasture species and environmental conditions i.e. WA pastures are dominated by improved annual grass species and our mixed enterprises means less paddock trees and grazing of some woodlands.
- **Importance of deep soil carbon:** Deep soil carbon is more crucial for understanding soil health than topsoil carbon, which is more variable with rainfall.
- **Limiting datasets:** More data is needed to identify and quantify the ecosystem services provided by different landscapes in WA, such as carbon sequestration, water filtration, and biodiversity conservation to be able to demonstrate clear links to community and the shared benefits of preserving NC.
- **Engaging diverse stakeholders:** Engaging with a broad range of stakeholders, including Indigenous communities, farmers, and industry professionals, is crucial. This ensures that multiple perspectives are considered and integrated into decision-making processes. Ongoing engagement with stakeholders developing alternative auditing methodologies will help ensure consistency and provide options for end users.
- **Collaborative efforts for NCA:** The project underscored the need for collaborative efforts within the industry to leverage existing data, technology, skills, and knowledge. Developing accurate, affordable, efficient, and effective NCA methods in WA will help ensure that the data is globally recognised and referenceable.
- **Data collection:** The collection of diverse data types presented difficulties, particularly when farmers did not have the information readily accessible. Additionally, the complex layout of the data collection spreadsheet required a significant time commitment, complicating the process of receiving complete and accurate data. A better approach would be more appropriate for future NCA work.

Methodology Gaps

Several current methodoloy gaps were identified, these present opportunities for further development:

- **Water Sampling:** Water quality, infiltration tests and salinity were not included in this project's methodologies, highlighting the need for more comprehensive monitoring.
- **Cultural aspects:** There was limited incorporation of cultural aspects such as Traditional Ecological Knowledge, which could enhance assessments and value-add to NCA.
- **Connectivity models:** The absence of specific connectivity models for Western Australia indicates a need for improved biodiversity measurement tools.
- **Cropping systems data:** There is a need for better data and clarity regarding cropping systems in the region.
- **Soil Analysis:** Soil condition assessments are complex and costly, and may not always be practical depending on time of year, farm management and soil types. The project team had restricted capacity to visit the farms at appropriate times for both soil and ecological assessments.
- **Additional on-farm achievements:** This project did not include the impactful social and political efforts already undertaken by the farmers. This information would've value-added to this work and is something worth considering in future iterations.

Recommendations

To address the identified gaps and improve future projects, the following recommendations are made:

- **Expand datasets:** Increase the size of datasets and streamline data collection processes across Western Australia. We need better collaboration across government and industry to house and access data. There needs to be consistency in data collection, storage, and agreement on what the data tells us (i.e. what would be considered good or bad)
- **Establish procedures:** Develop agreed procedures for NC data collection and processing so the data owner can move between different accounting systems.
- **Secure further funding:** Future funding is essential to expand the dataset and conduct more baseline accounts. This will support farmers in measuring changes to their NC and increase the relevance of NC data to the agricultural sector. Obtaining further funding for extension activities and capacity building will accelerate the collective knowledge and skillset in NC and NCA.
- **Link NC to production:** Connect NC elements with production impacts to provide actionable insights.
- **Enhance soil assessments:** Include detailed measurements of biological activity, nutrient availability, and organic matter quality in soil health assessments.
- **Conduct comprehensive surveys:** Fund more thorough flora and fauna surveys.
- **Curate data effectively:** Ensure that collected data can serve multiple purposes and be used to its full potential.
- **Empowering land managers and stakeholders:** The industry should focus on empowering land managers and stakeholders by providing them with tools and information to better manage and protect natural capital. This will enhance land stewardship practices across various enterprises.
- **Economic value of NC and ecosystem services:** Further research is necessary to highlight the economic value of natural capital and ecosystem services. This research will raise awareness of their importance for long-term prosperity and well-being, both locally and globally.

Conclusion

This project, alongside initiatives such as those by La Trobe and FFTF, has significantly advanced the concept of NC assessments on farms, and NCA. It has played a key role in testing, validating, and refining the protocols used to measure and report on-farm NC.

With continued research, development, and extension, farmers will gain access to a robust NCA framework that enables them to accurately measure the stock of NC on their land. This will enhance their ability to understand and manage practices that either deplete or build NC, ultimately increasing the productive capacity of their land, but also supporting a resilient, prosperous ecosystem that not only provides beneficial services to the public, but plants, animals and microorganisms in the landscape.

The trialling of new methods and technologies for on-farm NC measurement has led to a more systematic and efficient assessment process. This will reduce the costs of data collection and compilation over time, as methodologies and protocols continue to evolve.

Farming communities stand to benefit greatly from an NCA framework that allows them to measure, manage, and improve their land, and to effectively demonstrate the impact of their practices. By investing in NC management, farmers are enhancing the sustainability, resilience, and productivity of their farming systems. This in turn supports the broader community by increasing their capacity to feed a growing population.

By fulfilling the State NRM Office’s outputs, this project has laid a solid foundation for further investment in NCA. Such investment is essential for the wider adoption of NCA, ensuring that future generations inherit land that remains productive and well-managed, thereby promoting sustainable land stewardship.

Appendix 1: State and Transition Models

State and Transition Models

For the purposes of natural capital accounting, it is necessary to assign a 'State' (or identity) to an area that summarised characteristics of that particular area of land. The condition of this area can then be considered in the context of the purpose for which that area of land is managed, as well as alternative ecosystem services such as protection of soil, capacity to filter and purify water, potential for carbon storage and sequestration. Other primary and secondary purposes of an area of land may include livestock grazing, timber production, honey production or conservation. Thus, a particular area of land may have multiple purposes. For example: scattered trees among native grasslands have livestock production, conservation of biodiversity, carbon storage/sequestration and honey production potential and also regulate climate, water quality, and protect soil; a timber plantation where plantings are less dense can be used for livestock grazing, shelter, timber production and carbon storage/sequestration.

Identity states are well established for many native ecosystems in Australia. The frameworks that describe these identity 'states', and the transitions between states, are referred to as 'State and Transition' models (STMs). As outlined above, generally, in areas modified for agriculture, there has been a move towards lower tree cover and conversion of the ground layer vegetation from native species to exotic improved pastures and/or crops.

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

The Farm-scale NCA project team have worked with other project partners (Farming for the Future program and Perth NRM) to build upon published 'state' and 'transition' identity classes for the temperate grassy woodland biome as outlined in Whitten et al., (2010). We apply these identity states to areas on a farm that retain general characteristics of the original native ecosystem such as remnant trees and some native herbaceous species. In some areas the original vegetation might have been a native grassland and the STM model used also applies to grasslands. In some places the original vegetation may have been more dense and scrubby forest but, for the purposes of this project, the basic principles in the simplified STM apply also. In the context of this project, determining the 'state' or 'transition' identity of an area enables a determination of the potential for provision of a range of ecosystem services. For the purposes of this project, we also created an extended State and Transition model to account for modified ecosystems that are common where land is managed for agriculture. This approach has been extended to produce STM for generic Forest, Grassland and Shrubland biomes.

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

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

Forest State and Transition Model

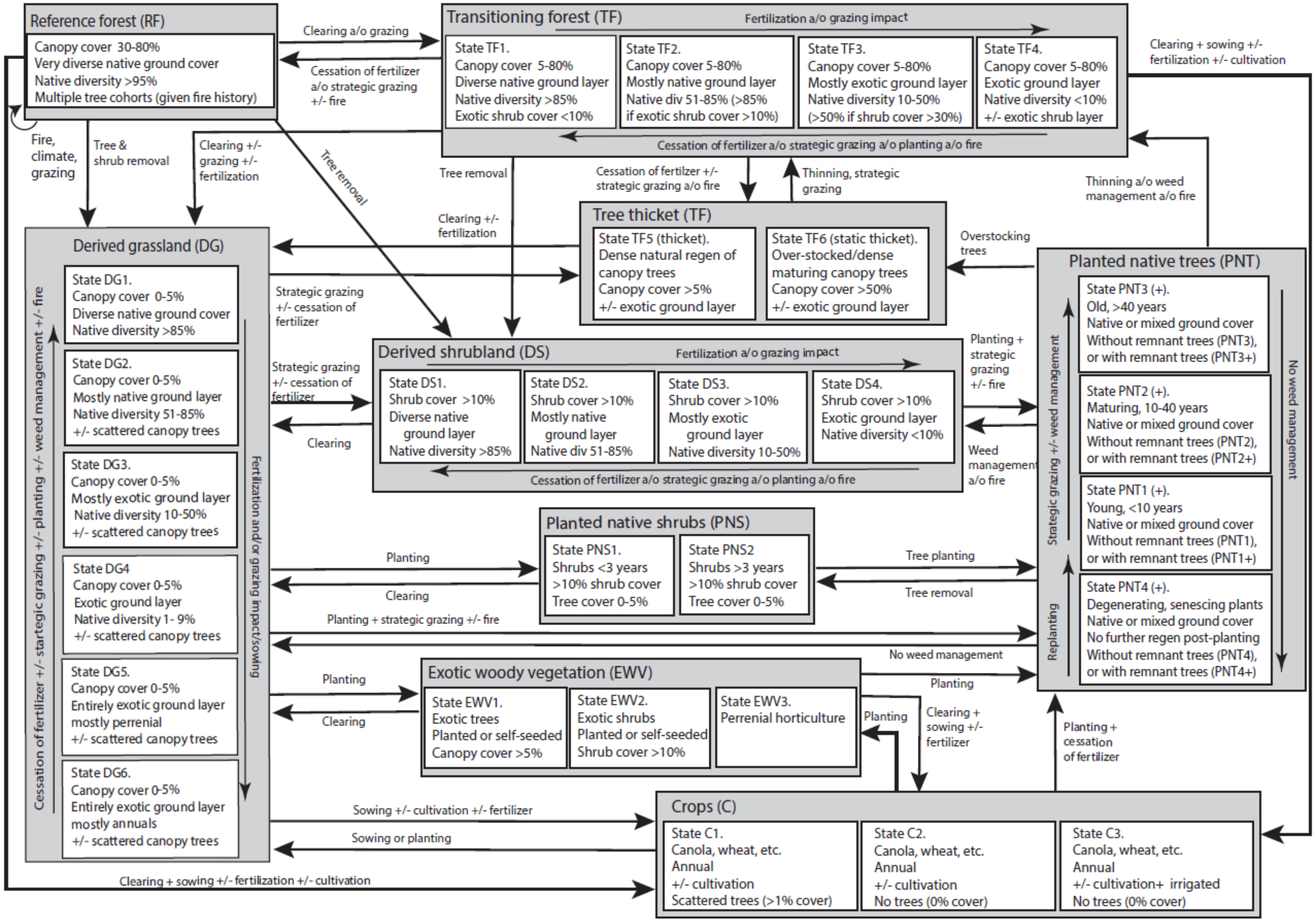


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Table 1. Thresholds for forest state and transition model

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
RF	Reference forest	15-80	0-100	>90	>50	Species richness >85% relative to local benchmark. A 'stable state' maintained by fire and/or grazing and/or drought climate processes. Very high diversity relative to benchmark. Evidence of regeneration, multiple age cohorts of canopy trees. Very little, if any, exotic species. Represents 'best available' condition.
TF1	Transitioning forest 1	15-80	0-100	71-90	>50	Relatively intact forests with high native diversity. Some degradation of canopy layer and understorey diversity relative to reference condition.
TF2	Transitioning forest 2	15-80	0-100	41-70 (>70 if exotic shrub cover >10)	>30	Mostly native understorey with potentially degradation of the canopy layer and understorey diversity. There may be exotic shrubs present.
TF3	Transitioning forest 3	5-80	0-100	11-40 (>40 if exotic shrub cover >30)	>10	Mostly exotic ground layer with few native species present. Some evidence of canopy regeneration – potentially more in mesic areas.
TF4	Transitioning forest 4	5-80	0-100	0-10	n/a	Ground layer vegetation almost entirely exotic. Some evidence of canopy regeneration – potentially more in mesic areas.
TF5	Transitioning forest 5	>5	<10	n/a	>10	Dense thicket of regenerating canopy trees, often occurring in patches.
TF6	Transitioning forest 6	>5	<10	n/a	>10	'Static' thicket. High density of sub-mature canopy trees. Tree height is less than the maximum expected for the vegetation type.
DG1(t)	Derived grassland 1(t)	0-5	<10	>70	>50	High diversity of native species in the ground layer. Few, if any, exotic species. If scattered trees present, then DG1t.
DG2(t)	Derived grassland 2(t)	0-5	<10	41-70	>50	Mostly native species in the ground layer. Some exotic species. If scattered trees present, then DG2t.
DG3(t)	Derived grassland 3(t)	0-5	<10	11-40	>30	Mostly exotic species in the ground layer. Few native species. If scattered trees present, then DG3t.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
DG4(t)	Derived grassland 4(t)	0-5	<10	1-10	1-30	Exotic ground layer. Few native species may be present. If scattered trees present, then DG4t.
DG5(t)	Derived grassland 5(t)	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by perennial species. Depending on time of year, may have annual dominance but with a perennial base. If scattered trees present, then DG5t.
DG6(t)	Derived grassland 6(t). Annual sewn pasture.	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by annual species. If scattered trees present, then DG6t. Can be a forage crop, grazed or harvested.
DS1	Derived shrubland 1	0-5	>10	>70	>50	Native shrubs (not planted) with ground layer equivalent to DG1.
DS2	Derived shrubland 2	0-5	>10	41-70 (>70 if exotic shrub cover >10)	>30	Native shrubs (not planted) with ground layer equivalent to DG2.
DS2	Derived shrubland 3	0-5	>10	11-40 (>40 if exotic shrub cover >30)	>10	Native shrubs (not planted) with ground layer equivalent to DG3.
DS3	Derived shrubland 4	0-5	>10	0-10	n/a	Native shrubs (not planted) with ground layer equivalent to DG4.
PNT1(+)	Planted native trees 1	n/a	n/a	n/a	n/a	Young planted native trees (<10 years). If scattered trees present, then PNT1+.
PNT2(+)	Planted native trees 2	>5	n/a	n/a	n/a	Maturing planted native trees (10 – 40 years). If scattered trees present, then PNT1+.
PNT3(+)	Planted native trees 3	>5	n/a	n/a	n/a	Old, planted trees (>40 years). If scattered trees present, then PNT1+.
PNT4(+)	Planted native trees 4	n/a	n/a	n/a	n/a	Senescing planted trees. If scattered trees present, then PNT1+.
PNS1	Planted native shrubs 1	<5	>0	n/a	n/a	Young planted native shrubs (<3 years).
PNS2	Planted native shrubs 2	<5	>0	n/a	n/a	Mature planted native shrubs (>=3 years).

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
EWV1	Exotic woody vegetation 1	>5	n/a	n/a	<70	Exotic trees. May be planted or self-seeded.
EWV2	Exotic woody vegetation 2	0-5	>10	n/a	n/a	Exotic shrubs. May be planted or self-seeded.
EWV3	Exotic woody vegetation 3	n/a	n/a	n/a	n/a	Perennial horticulture.
C1	Crops 1	>0	n/a	n/a	n/a	Annual crops with scattered trees.
C2	Crops 2	0	n/a	n/a	n/a	Annual crops without scattered trees.
C3	Crops 3	0	n/a	n/a	n/a	Irrigated annual crops.

Grassland State and Transition Model

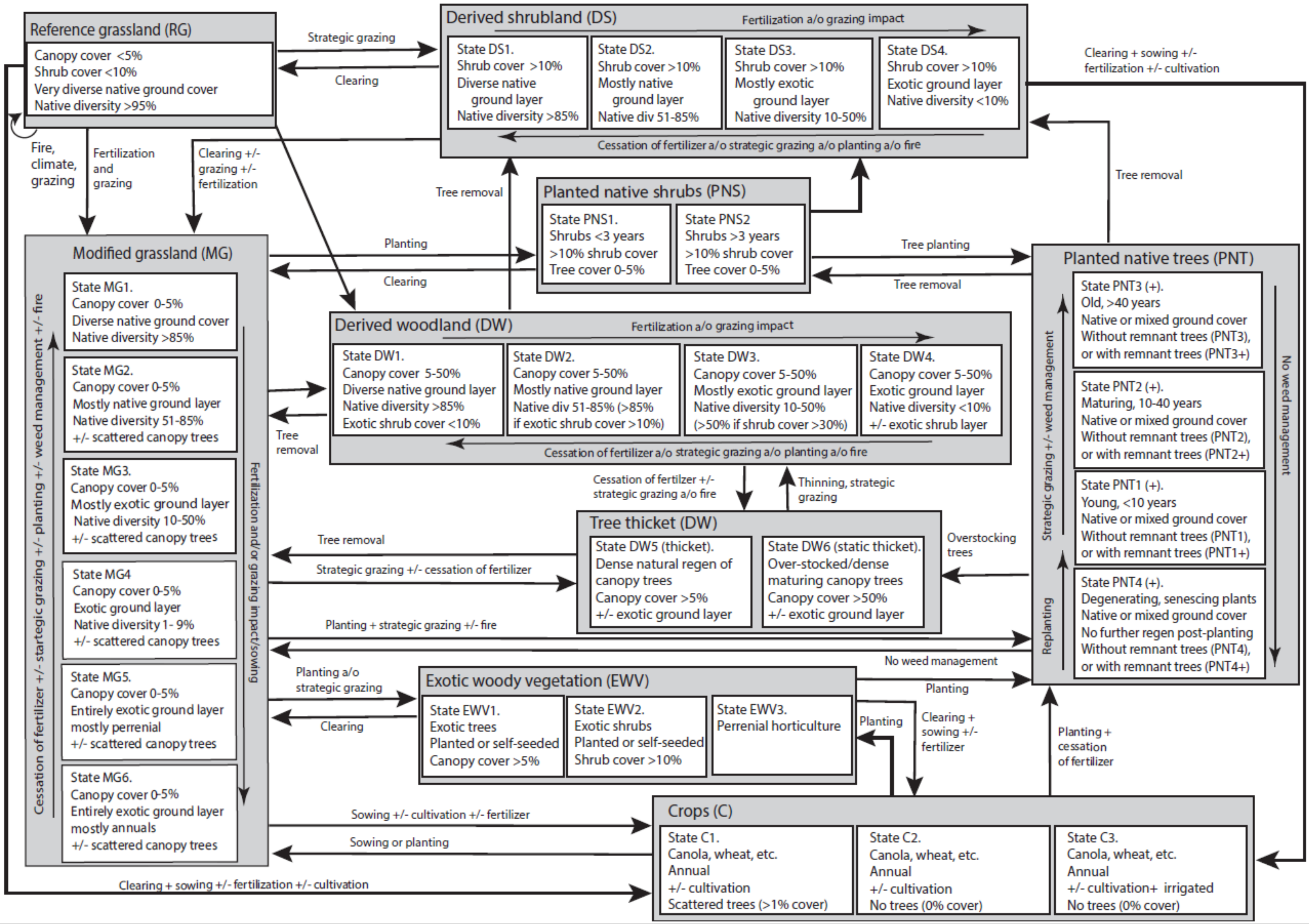

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Table 2. Thresholds for grasslands state and transition model.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
RG	Reference grassland	0-5	<10	>90	>50	Species richness >85% relative to local benchmark. A 'stable state' maintained by fire and/or grazing and/or drought climate processes. Very high diversity relative to benchmark. Evidence of regeneration. Very little, if any, exotic species. Represents 'best available' condition.
MG1(t)	Modified grassland 1(t)	0-5	<10	71-90	>50	High diversity of native species in the ground layer. Few, if any, exotic species. If scattered trees present, then MG1t.
MG2(t)	Modified grassland 2(t)	0-5	<10	41-70	>50	Mostly native species in the ground layer. Some exotic species. If scattered trees present, then MG2t.
MG3(t)	Modified grassland 3(t)	0-5	<10	11-40	>30	Mostly exotic species in the ground layer. Few native species. If scattered trees present, then MG3t.
MG4(t)	Modified grassland 4(t)	0-5	<10	0-10	1-30	Exotic ground layer. Few native species may be present. If scattered trees present, then MG4t.
MG5(t)	Modified grassland 5(t)	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by perennial species. Depending on time of year, may have annual dominance but with a perennial base. If scattered trees present, then DG5t
MG6(t)	Modified grassland 6(t)	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by annual species. If scattered trees present, then DG6t. Can be a forage crop, grazed or harvested.If scattered trees present, then MG5t.
DW1	Derived woodland 1	15-80	0-100	>70	>50	Woodland with high native diversity. Some degradation of canopy layer and understorey diversity relative to reference condition.
DW2	Derived woodland 2	15-80	0-100	41-70 (>70 if exotic shrub cover >10)	>30	Mostly native understorey with potentially degradation of the canopy layer and understorey diversity. There may be exotic shrubs present.
DW3	Derived woodland 3	5-80	0-100	11-40 (>40 if exotic shrub cover >30)	>10	Mostly exotic ground layer with few native species present. Some evidence of canopy regeneration – potentially more in mesic areas.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
DW4	Derived woodland 4	5-80	0-100	0-10	n/a	Ground layer vegetation almost entirely exotic. Some evidence of canopy regeneration – potentially more in mesic areas.
DW5	Derived woodland 5	>5	<10	n/a	>10	Dense thicket of regenerating canopy trees, often occurring in patches.
DW6	Derived woodland 6	>5	<10	n/a	>10	'Static' thicket. High density of sub-mature canopy trees. Tree height is less than the maximum expected for the vegetation type.
DS1	Derived shrubland 1	0-5	>10	>70	>50	Native shrubs (not planted) with ground layer equivalent to DG1.
DS2	Derived shrubland 2	0-5	>10	41-70 (>70 if exotic shrub cover >10)	>30	Native shrubs (not planted) with ground layer equivalent to DG2.
DS2	Derived shrubland 3	0-5	>10	11-40 (>40 if exotic shrub cover >30)	>10	Native shrubs (not planted) with ground layer equivalent to DG3.
DS3	Derived shrubland 4	0-5	>10	0-10	n/a	Native shrubs (not planted) with ground layer equivalent to DG4.
PNT1(+)	Planted native trees 1	n/a	n/a	n/a	n/a	Young planted native trees (<10 years). If scattered trees present, then PNT1+.
PNT2(+)	Planted native trees 2	>5	n/a	n/a	n/a	Maturing planted native trees (10 – 40 years). If scattered trees present, then PNT1+.
PNT3(+)	Planted native trees 3	>5	n/a	n/a	n/a	Old, planted trees (>40 years). If scattered trees present, then PNT1+.
PNT4(+)	Planted native trees 4	n/a	n/a	n/a	n/a	Senescing planted trees. If scattered trees present, then PNT1+.
PNS1	Planted native shrubs 1	<5	>0	n/a	n/a	Young planted native shrubs (<3 years).
PNS2	Planted native shrubs 2	<5	>0	n/a	n/a	Mature planted native shrubs (>=3 years).
EWV1	Exotic woody vegetation 1	>5	n/a	n/a	<70	Exotic trees. May be planted or self-seeded.

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Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
EWV2	Exotic woody vegetation 2	0-5	>10	n/a	n/a	Exotic shrubs. May be planted or self-seeded.
EWV3	Exotic woody vegetation 3	n/a	n/a	n/a	n/a	Perennial horticulture.
C1	Crops 1	>0	n/a	n/a	n/a	Annual crops with scattered trees.
C2	Crops 2	0	n/a	n/a	n/a	Annual crops without scattered trees.
C3	Crops 3	0	n/a	n/a	n/a	Irrigated annual crops.

Shrubland State and Transition Model

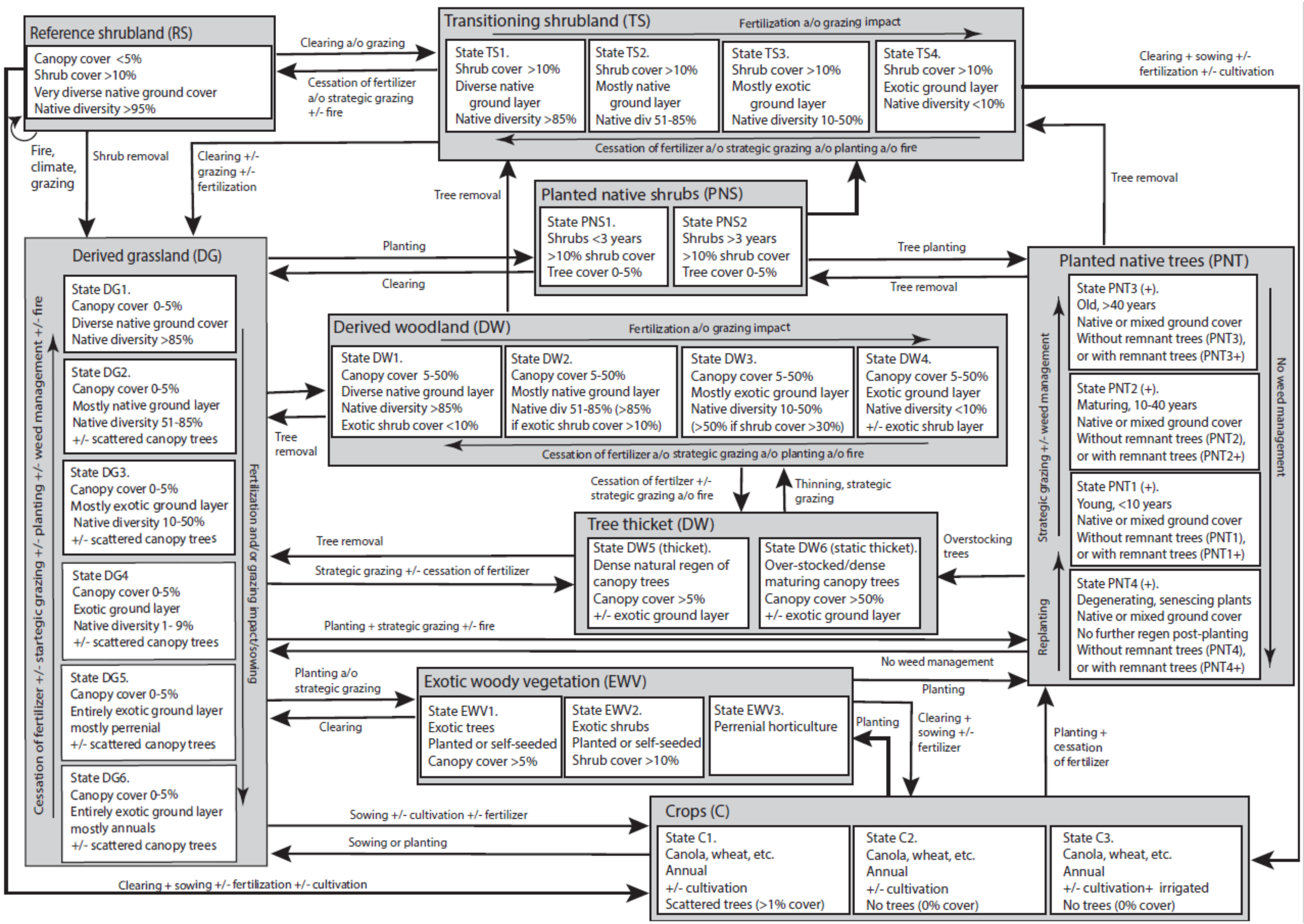

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Table 3. Thresholds for shrubland state and transition model.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
RS	Reference shrubland	0-5	>10	>90	>50	Species richness >85% relative to local benchmark. A ‘stable state’ maintained by fire and/or grazing and/or drought climate processes. Very high diversity relative to benchmark. Evidence of regeneration. Very little, if any, exotic species. Represents ‘best available’ condition.
TS1	Transitioning shrubland 1	0-5	>10	71-90	>50	Native shrubs (not planted) with ground layer equivalent to DG1.
TS2	Transitioning shrubland 2	0-5	>10	41-70 (>70 if exotic shrub cover >10)	>30	Native shrubs (not planted) with ground layer equivalent to DG2.
TS3	Transitioning shrubland 3	0-5	>10	11-40 (>40 if exotic shrub cover >30)	>10	Native shrubs (not planted) with ground layer equivalent to DG3.
TS3	Transitioning shrubland 4	0-5	>10	0-10	n/a	Native shrubs (not planted) with ground layer equivalent to DG4.
DW1	Derived woodland 1	15-80	0-100	>70	>50	Woodland with high native diversity. Some degradation of canopy layer and understorey diversity relative to reference condition.
DW2	Derived woodland 2	15-80	0-100	41-70 (>70 if exotic shrub cover >10)	>30	Mostly native understorey with potentially degradation of the canopy layer and understorey diversity. There may be exotic shrubs present.
DW3	Derived woodland 3	5-80	0-100	11-40 (>40 if exotic shrub cover >30)	>10	Mostly exotic ground layer with few native species present. Some evidence of canopy regeneration – potentially more in mesic areas.
DW4	Derived woodland 4	5-80	0-100	0-10	n/a	Ground layer vegetation almost entirely exotic. Some evidence of canopy regeneration – potentially more in mesic areas.
DW5	Derived woodland 5	>5	<10	0-100	>10	Dense thicket of regenerating canopy trees, often occurring in patches.
DW6	Derived woodland 6	>5	<10	0-100	>10	‘Static’ thicket. High density of sub-mature canopy trees. Tree height is less than the maximum expected for the vegetation type.
DG1(t)	Derived grassland 1(t)	0-5	<10	>70	>50	High diversity of native species in the ground layer. Few, if any, exotic species. If scattered trees present, then DG1t.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
DG2(t)	Derived grassland 2(t)	0-5	<10	41-70	>50	Mostly native species in the ground layer. Some exotic species. If scattered trees present, then DG2t.
DG3(t)	Derived grassland 3(t)	0-5	<10	11-40	>30	Mostly exotic species in the ground layer. Few native species. If scattered trees present, then DG3t.
DG4(t)	Derived grassland 4(t)	0-5	<10	0-10	1-30	Exotic ground layer. Few native species may be present. If scattered trees present, then DG4t.
DG5(t)	Derived grassland 5(t)	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by perennial species. Depending on time of year, may have annual dominance but with a perennial base. If scattered trees present, then DG5t.
DG6(t)	Derived grassland 6(t). Annual sewn pasture.	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by annual species. If scattered trees present, then DG6t. Can be a forage crop, grazed or harvested.
PNT1(+)	Planted native trees 1	n/a	n/a	n/a	n/a	Young planted native trees (<10 years). If scattered trees present, then PNT1+.
PNT2(+)	Planted native trees 2	>5	n/a	n/a	n/a	Maturing planted native trees (10 – 40 years). If scattered trees present, then PNT1+.
PNT3(+)	Planted native trees 3	>5	n/a	n/a	n/a	Old, planted trees (>40 years). If scattered trees present, then PNT1+.
PNT4(+)	Planted native trees 4	n/a	n/a	n/a	n/a	Senescing planted trees. If scattered trees present, then PNT1+.
PNS1	Planted native shrubs 1	<5	>0	n/a	n/a	Young planted native shrubs (<3 years).
PNS2	Planted native shrubs 2	<5	>0	n/a	n/a	Mature planted native shrubs (>=3 years).
EWV1	Exotic woody vegetation 1	>5	n/a	n/a	<70	Exotic trees. May be planted or self-seeded.
EWV2	Exotic woody vegetation 2	0-5	>10	n/a	n/a	Exotic shrubs. May be planted or self-seeded.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
EWV3	Exotic woody vegetation 3	n/a	n/a	n/a	n/a	Perennial horticulture.
C1	Crops 1	>0	n/a	n/a	n/a	Annual crops with scattered trees.
C2	Crops 2	0	n/a	n/a	n/a	Annual crops without scattered trees.
C3	Crops 3	0	n/a	n/a	n/a	Irrigated annual crops.

Woodland State and Transition Model

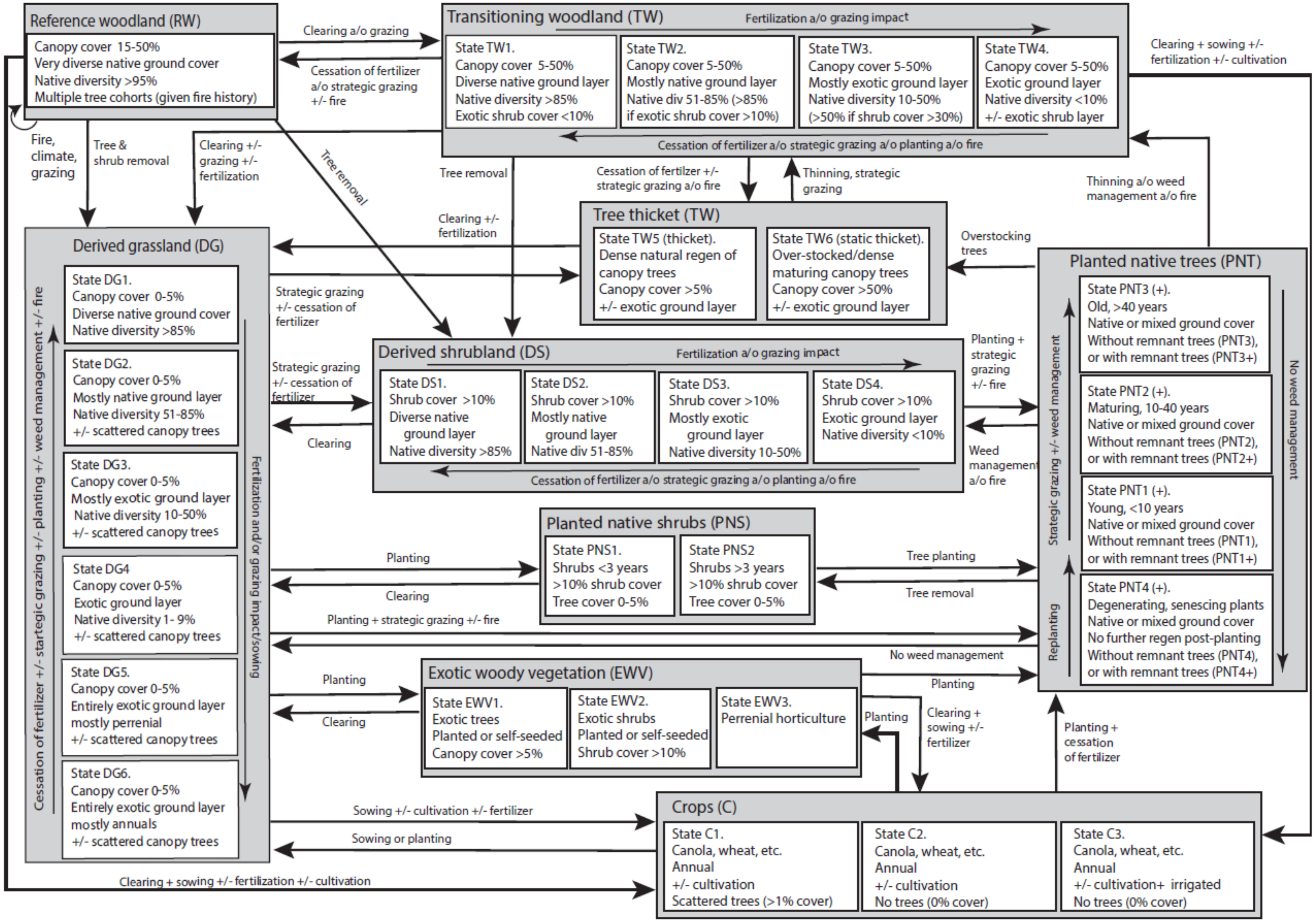

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Table 4. Thresholds for woodland state and transition model

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
RW	Reference woodland	15-50	<50	>90	>50	Species richness >85% relative to local benchmark. A 'stable state' maintained by fire and/or appropriate grazing and/or drought climate processes. Very high diversity relative to benchmark. Evidence of regeneration, multiple age cohorts of canopy trees. Very little, if any, exotic species. Represents 'best available' condition. In some low or very high productivity areas, RW (or TW1/2) states may naturally have canopy cover in the range of 5-15% but this needs to be accompanied by very high native species composition in the shrub and ground layers and the absence of tree clearing for many decades.
TW1	Transitioning woodland 1	15-50	0-100	71-90	>50	Relatively intact woodlands with high native diversity. Some degradation of canopy layer and understorey diversity relative to reference condition.
TW2	Transitioning woodland 2	15-50	0-100	41-70 (>70 if exotic shrub cover >10)	>30	Mostly native understorey with potentially degradation of the canopy layer and understorey diversity. There may be exotic shrubs present.
TW3	Transitioning woodland 3	5-50	0-100	11-40 (>50 if exotic shrub cover >30)	>10	Mostly exotic ground layer with few native species present. Some evidence of canopy regeneration – potentially more in mesic areas.
TW4	Transitioning woodland 4	5-50	0-100	0-10	n/a	Ground layer vegetation almost entirely exotic. Some evidence of canopy regeneration – potentially more in mesic areas.
TW5	Transitioning woodland 5	>5 (but with >50% cover of immature saplings)	<10	n/a	>10	Dense thicket of regenerating canopy trees, often occurring in patches.
TW6	Transitioning woodland 6	>5 (but with >50% cover of	<10	n/a	>10	'Static' thicket. High density of sub-mature canopy trees. Tree height is less than the maximum expected for the vegetation type.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
		sub-canopy trees)				
DG1(t)	Derived grassland 1(t)	0-5	<10	>70	>50	High diversity of native species in the ground layer. Few, if any, exotic species. If scattered trees present, then DG1t.
DG2(t)	Derived grassland 2(t)	0-5	<10	41-70	>50	Mostly native species in the ground layer. Some exotic species. If scattered trees present, then DG2t.
DG3(t)	Derived grassland 3(t)	0-5	<10	11-40	>30	Mostly exotic species in the ground layer. Few native species. If scattered trees present, then DG3t.
DG4(t)	Derived grassland 4(t)	0-5	<10	1-10	1-30	Exotic ground layer. Few native species may be present. If scattered trees present, then DG4t.
DG5(t)	Derived grassland 5(t)	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by perennial species. Depending on time of year, may have annual dominance but with a perennial base. If scattered trees present, then DG5t.
DG6(t)	Derived grassland 6(t). Annual sewn pasture.	0-5	<10	n/a	<1	Entirely exotic ground layer dominated by annual species. If scattered trees present, then DG6t. Can be a forage crop, grazed or harvested.
DS1	Derived shrubland 1	0-5	>10	>60	>50	Native shrubs (not planted) with ground layer equivalent to DG1.
DS2	Derived shrubland 2	0-5	>10	41-60 (>60 if exotic shrub cover >10)	>30	Native shrubs (not planted) with ground layer equivalent to DG2.
DS2	Derived shrubland 3	0-5	>10	11-40 (>50 if exotic shrub cover >30)	>10	Native shrubs (not planted) with ground layer equivalent to DG3.

Condition state code	Condition state name	Canopy cover - mature trees (%)	Shrub cover (%)	Native ground layer (% of composition)	Native ground layer (% cover)	Description
DS3	Derived shrubland 4	0-5	>10	0-10	n/a	Native shrubs (not planted) with ground layer equivalent to DG4.
PNT1(+)	Planted native trees 1	n/a	n/a	n/a	n/a	Young planted native trees (<10 years). If scattered remnant trees present, then PNT1+.
PNT2(+)	Planted native trees 2	>5	n/a	n/a	n/a	Maturing planted native trees (10 – 40 years). If scattered remnant trees present, then PNT1+.
PNT3(+)	Planted native trees 3	>5	n/a	n/a	n/a	Old, planted trees (>40 years). If scattered remnant trees present, then PNT1+.
PNT4(+)	Planted native trees 4	n/a	n/a	n/a	n/a	Senescing planted trees (without regeneration). If scattered remnant trees present, then PNT1+.
PNS1	Planted native shrubs 1	<5	>0	n/a	n/a	Young planted native shrubs (<3 years).
PNS2	Planted native shrubs 2	<5	>0	n/a	n/a	Mature planted native shrubs (>=3 years).
EWV1	Exotic woody vegetation 1	>5	n/a	0-100	0-100	Exotic trees. May be planted or self-seeded.
EWV2	Exotic woody vegetation 2	0-5	>10	0-100	0-100	Exotic shrubs. May be planted or self-seeded.
EWV3	Exotic woody vegetation 3	n/a	n/a	0-100	0-100	Perennial (woody) horticulture.
C1	Crops 1	>0	n/a	n/a	n/a	Dryland annual crops with scattered trees.
C2	Crops 2	0	n/a	n/a	n/a	Dryland annual crops without scattered trees.
C3	Crops 3	0	n/a	n/a	n/a	Irrigated annual crops.

Appendix 2: NCA Glossary

- **Benchmark:** A standard against which the value of a particular indicator may be compared. In this account, the benchmark often represents the average value of the indicator across multiple farms based on empirical research. The benchmark is not necessarily the best or most desirable value but the average of the farms studied.
- **Carbon Sequestration:** Carbon sequestration is the process by which carbon dioxide (CO2) is captured from the atmosphere and stored in natural or artificial reservoirs. It can occur through biological processes, such as photosynthesis in plants and trees, or through technological methods like carbon capture and storage (CCS). Carbon sequestration helps reduce the concentration of greenhouse gases in the atmosphere and mitigate climate change.
- **Carbon Stock:** Carbon stock refers to the amount of carbon stored in a particular ecosystem or natural resource. It includes carbon stored in vegetation, soils, biomass, and other dead and living organic matter (excluding geological storages like fossil fuel reserves).
- **Condition:** In the context of natural capital, condition refers to the quality of an ecosystem state or natural resource. It assesses the health, and resilience of the ecosystem, considering factors such as biodiversity, habitat quality, and water quality.
- **Ecosystem Asset (EA):** A single, contiguous area of the same ES.
- **Ecosystem Services:** The outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or enhance social welfare. They can benefit people in many ways, either directly or as inputs into the production of other goods and services. (e.g. pollination of crops provided by bees and other organisms contributes to food production).
- **Ecosystem State (ES):** Secondary categorisation defined by a combination of general characteristics (such as canopy cover, groundcover, and pre-1750 vegetation classification). They align with the 'condition states' in the relevant State and Transition Model (e.g., Transitioning Woodland 1, Derived Grassland 1, etc.).
- **Ecosystem Type (ET):** Primary categorisation of land cover type defined by the primary land use and general characteristics such as canopy cover (%), groundcover (%), and classification of the ecosystem (vegetation) prior to modification for agriculture (pre-1750). These align with the ecosystem State and Transition Models. E.g. Reference Woodland, Transitioning Woodland, Derived Grassland, planted native trees, perennial pasture, exotic vegetation, crops, wetland, riparian).
- **Ecosystem Unit (EU):** The smallest unit on the farm map. An EU is a single area/continuous MU that has similar ecological characteristics (e.g. grassland or pasture paddock) within an EA. Thus, a single EA can be subdivided into multiple EUs by paddocks, or a single paddock can be split into more than one EU if more than one EA occurs in the same paddock. For example, it can have pasture amongst unfenced remnant bush patches. The bush and pasture areas equate to two different EUs.
- **Environmental Performance Indicators:** These are supplementary indicators used to evaluate the environmental performance of an organization or project beyond natural capital indicators. They may include measures of energy efficiency, waste management, greenhouse gas emissions, pollution levels, and other environmental factors.
- **Extent:** Refers to the spatial coverage or size of an ecosystem or natural resource. It measures the physical area or volume occupied by a particular habitat, landscape, or natural feature. Evaluating the extent helps understand the distribution and availability of natural capital and assess its vulnerability to degradation or loss.
- **Management Unit (MU):** A single area (typically a paddock, defined by fencing) that is subject to common management regime e.g. cropped paddock, fenced riparian area or an area with infrastructure like sheds and yards. A MU can be a single EU or multiple EUs if the paddock has two or more different EU classes within it
- **Natural Capital Accounting (NCA):** A method of measuring and quantifying the value of natural resources and ecosystems. This can be done in physical units and / or monetary values. It involves assessing the stock, condition (i.e., quality), and flow of natural capital to inform decision-making.

- **Natural Capital (NC):** All natural resources (living and non-living) that producers manage for the benefit of their businesses, their families and society via ecosystem and environmental services. It includes soils, remnant native vegetation, pasture and croplands, riparian areas, water resources, agroforestry, environmental plantings, and animals.
- **Reference State:** Represents the original or unmodified pre-development condition of a particular ecosystem or natural resource. It serves as a baseline against which the current condition can be measured. The reference state helps determine the impact of human activities and the extent to which natural capital has been altered.
- **Scope 1:** Direct greenhouse gas emissions (GHGE) from sources that are owned or controlled by an organisation. This includes emissions from activities like burning fossil fuels for heating, operating vehicles, or manufacturing processes.
- **Scope 2:** Indirect GHGE associated with the consumption of purchased electricity, heat, or steam by an organisation. These emissions occur during the production of the energy consumed by the organization.
- **Scope 3:** Indirect GHGE that occur throughout an organisation's value chain, including both upstream and downstream activities. This includes emissions from purchased goods and services, transportation, waste disposal, employee commuting, and other activities not directly owned or controlled by the organization.
- **Significant Species:** Threatened, specially protected and priority species that are at risk of extinction. Threatened species are allocated to different wildlife classes depending on the degree of risk of their extinction, such as vulnerable, endangered, or critically endangered.
- **State and Transition Model (STM):** Conceptual models of ecosystem dynamics that represent alternative condition states for a particular ecosystem and the processes or disturbances that trigger and drive changes (transitions) between states. STMs can be used to summarise relationships between land management and disturbances, and the ecological state (or condition) of a site.
- **Threatened Ecological Communities (TEC):** Ecosystems that are in danger of being lost and are listed under national, state and territory legislation.