Department of
Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

We're working for Western Australia.

Western Australian Soil Health Strategy 2021-2031

Sustaining Western Australia's Agricultural, Horticultural and Pastoral Soils

Soil and Land Conservation Council
of Western Australia

Acknowledgments

The Soil and Land Conservation Council (SLCC) consulted widely and engaged grower, industry, research, community, and government sectors. A series of workshops and surveys to support the preparation of the draft strategy were undertaken, before seeking general public comment. Together with many written submissions, more than 400 people were involved in several focus group discussions, all of which have formed the basis for the key goals presented in this document. A summary report comprising all consultation submissions can be found at: https://www.agric.wa.gov.au/soil-and-land-conservation-council.

DPIRD acknowledges the Traditional Owners of Country, the Aboriginal people of the many lands that we work on and their language groups throughout Western Australia and recognise their continuing connection to the land and waters.

We respect their continuing culture and the contribution they make to the life of our regions and we pay our respects to their Elders past, present and emerging.

Recommended reference:

Department of Primary Industries and Regional Development (2021) State Soil Health Strategy, Western Australia. Department of Primary Industries and Regional Development, Perth.

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Minister's Foreword

Western Australia's agrifood industry derives production worth nearly $11 billion every year from the state's soils, which support highly diverse land uses, ranging from high-rainfall and tropical agriculture and horticulture to near arid pastoral enterprises.

Healthy soils are critical to our future. As well as our agrifood industry, soil supports a range of ecosystem services including climate, clean air and water, supporting our unique biodiversity and providing infrastructure stability.

We have an opportunity to position Western Australia to lead the way in meeting the community's growing expectation and the change in many markets seeking provenance tracing and sustainable production of agrifood and fibre.

Developed in consultation with industry and the community, the WA Soil Health Strategy sets the strategic direction that will guide policy, research, and investment to support the management, protection, and improvement of soil functions including carbon sequestration, for the next 10 years.

This Strategy supports the science, innovation and adaptations that farmers can use to improve their climate resilience. It embraces new ideas and perspectives that can build on existing practices, to ensure sustainable soil management into the future. There is also acknowledgement that these new ideas may become accepted future practice, after rigorous scientific and economic assessment.

I look forward to working with farmers, industry and the community on the implementation of the Western Australian Soil Health Strategy.

Hon Alannah MacTiernan MLC,
Minister for Regional Development;
Agriculture and Food

Introduction

The continued prosperity of Western Australia's natural environment and primary industries depends on the health of our soils and increasingly, on community and market expectations for their sustainable management.

The Western Australian Government recognises that our farmers, pastoralists, and land managers strive for sustainable and profitable land systems and share responsibility for addressing threats to their productive soils. Many diverse approaches and practices are used to achieve productive soils for future generations.

Western Australia's land area covers more than two and a half million square kilometres, almost one-third of the Australian continent. In an area this size, highly diverse land uses occur, ranging from high-rainfall agriculture and horticulture in the south, to tropical and near-arid pastoral rangelands in the north.

Maintaining the security and health of such variable and complex soils poses numerous benefits and challenges for sustainable management. Soil health is the foundation of our food systems – it boosts the resilience of agricultural and pastoral systems to the effects of increased climate variability, and healthy soils are critical in supporting improved soil porosity, water infiltration and storage, nutrient retention, disease resistance, and a wider diversity of soil biota supporting healthy plant growth.

Amongst the challenges in WA, the loss of perennial vegetation, rising groundwater tables, acidifying soils, and salinity are four major issues for both private and public land assets. Competing and incompatible land uses place pressure on highly productive land. Bushfires and the overuse of agricultural chemicals impact both shoot, root, microbial growth and soil condition. Increasing loss of soil through wind and/or water erosion associated with a changing, drying climate is a major threat to soil health.

The Western Australian (WA) Soil Health Strategy (the Strategy) sets the strategic direction that will guide policy, research, investment, and on-ground actions that support the management, protection, improve the partnerships and improvement of soil functions and associated ecosystem services for the next 10 years within WA.

The Strategy reflects the high value that industry, communities, and government place on soil health and aims to:

- support landholders and service providers (researchers, consultants, natural resource management groups, grower groups and associations, government officers) to understand the guiding principles of soil health and to plan and resource their key activities appropriately
- support soil health management practices that provide environmental, economic, and social benefits to WA
- develop community-wide understanding of the overall policy direction and management of the state's agricultural, horticultural, and pastoral soils
- identify the responsibilities of landholders and government in addressing emerging soil health issues and challenges, so as to prioritise future investment in soil health.

Significantly, this Strategy welcomes innovation, adaptation, and changes in farming systems and land management that can improve or sustain soil health. It recognises that different ideas, expertise, and experience will continue to drive innovation (by land managers, agribusiness, and advocates of regenerative agriculture and organic farming), serve the interests of Aboriginal people, and achieve investor-required sustainability standards in corporate agriculture. This Strategy acknowledges that rigorous scientific and economic assessment will support ongoing development and adoption of emerging and new practices.

Scope

The Strategy covers a 10-year period (2021–2031). It outlines soil health principles, goals, objectives and key actions to guide investment in soil research, as well as opportunities for innovation. It supports the development or refinement of matters relating to soil governance and associated policy.

In so doing, the Strategy addresses the management of agricultural, horticultural, and pastoral soils as well as implications for on- and off-site impacts from soil and land degradation.

Although soils support a range of outcomes, including natural capital and social wellbeing, the scope of this Strategy does not specifically address matters relating to soil health interactions covering chemical contamination, animal welfare, food safety, or human health.

Purpose

The purpose of this Strategy is to provide direction for investment that will support the management, protection, and improvement of the functions and associated ecosystem services of soils in WA.

Vision

Western Australian soils will incorporate healthy and diverse soil ecosystems that enhance agricultural production, support a healthy environment, and protect public and private infrastructure for the long-term benefit of the Western Australian community.

Defining soil health

This Strategy defines soil health as:

> *'the capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant, animal and human health.'*
>
> **Doran et al. (1996)**

Soil is a living resource with varying physical, chemical, and biological properties depending on its location, management, seasonal, and environmental conditions. Healthy soils support the exchange of energy and nutrients, which sustains plant and animal life as well as the production and decomposition of organic matter.

Western Australia has many different soil types across its diverse, complex, natural and modified landscapes. The number and type of soil functions vary; some examples are shown in Figure 1. In their natural state, many WA soils are typically nutrient-deficient and highly variable in texture. The various soil types have differing degrees of stability and resilience, and support different soil organisms.

These differing properties of soils influence both potential productivity and the degree to which the soil is susceptible to degradation. Healthy soils increase the capacity of plants to withstand extreme weather events and play a critical role in fuelling the entire terrestrial food chain and aquatic systems.

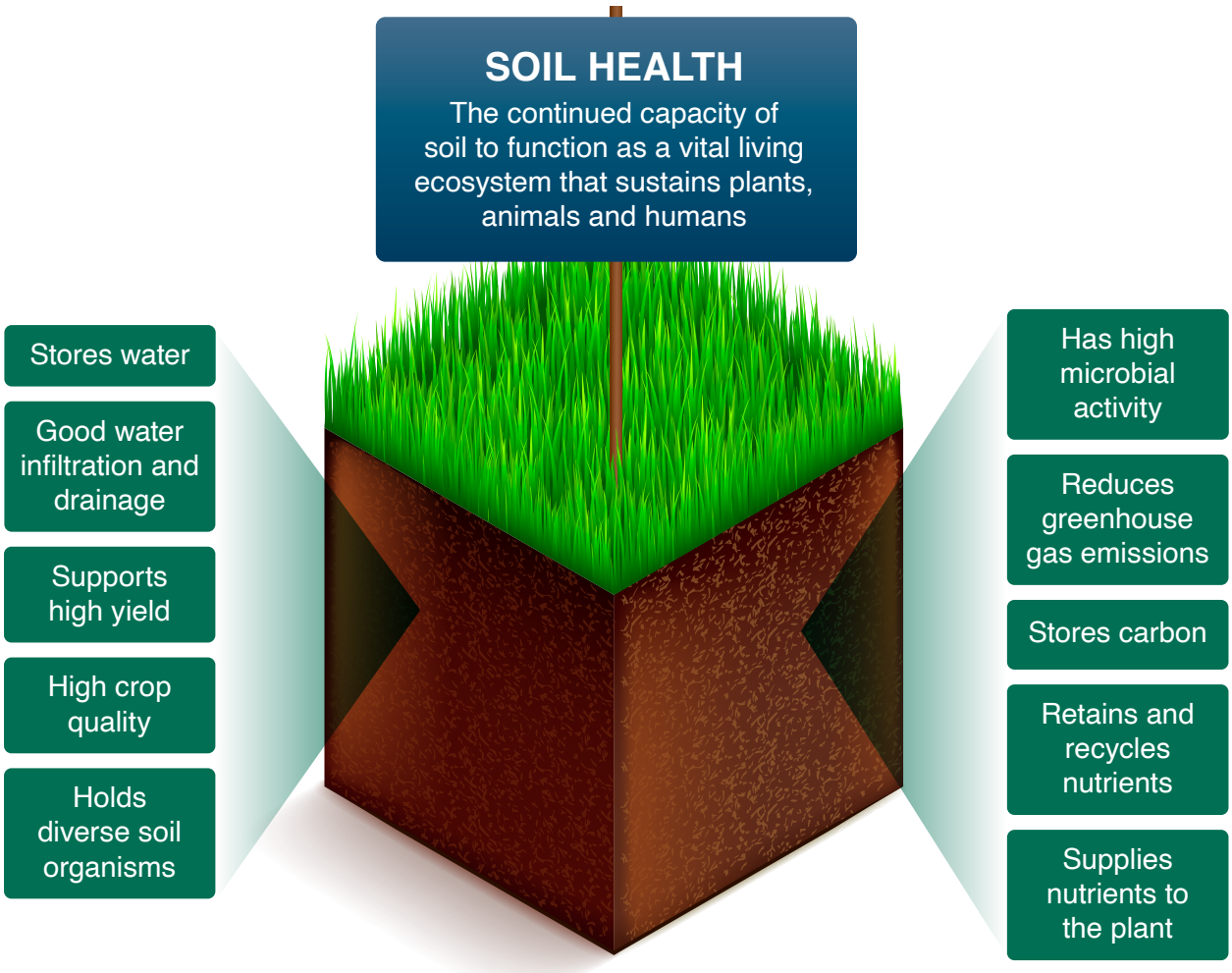


Figure 1. Healthy soils deliver and receive a range of ecosystem functions as appropriate to their environment (adapted from NRCS 2017).

Benefiting from healthy soils

Governments, communities and natural resource managers are taking a broader ecosystem approach to decision making for natural resource management issues that can achieve multiple benefits for land managers and society (Close et al. 2010).

Soil supports a range of ecosystem services including agricultural productivity, climate, clean air and water, and infrastructure stability. These services are provided to humans by transforming resources (natural assets, including land, water, vegetation, and atmosphere) into a flow of essential goods and services.

Improving the health of our soils will provide long-term environmental, economic, and social benefits now and into the future (Figure 2).WA's agrifood industry derives production worth nearly AU$11 billion every year from the state's soils (Figure 3). Australia successfully markets Australian products as green and clean. Healthy soils contribute to this goal. The land resources that sustain WA's agriculture and food sector are critical to our rural and regional communities. In 2016–2017, this sector directly or indirectly employed 188,000 people (Department of Primary Industries and Regional Development [DPIRD] 2018a).

Long-term benefits of soil health improvement

Environmental Benefits	Economic Benefits	Social Benefits
Better water quality as nutrient and sediment run-off is minimised	Improved infrastructure for human liveability (and provision of construction materials)	Contribution to long-term security of food supply chains, locally and beyond
Increased soil organic matter improves nutrient availability, water retention and soil structure	Sustained long-term agricultural productivity	Stable ground and reduced soil erosion maintains landscape aesthetics
Better resilience to climate variability and extreme/ episodic weather events	Improved soil resilience contributes to long-term land management cost savings	Fewer dust storms reduces human health implications and risk issues
Increased soil biodiversity	Access to markets and premiums that reward sustainability and improved natural capital.	Preservation of historical and cultural heritage sites
Improved groundcover density and diversity	Overall plant and animal health	Human health and community wellbeing

Soil ecosystems services (cultural, supporting, provisioning, regulating)

Figure 2. Benefits of long-term and sustained improvements to soil health. Stable ground and reduced soil erosion maintains landscape aesthetics and the natural environment for habitat protection and recreational and tourism assets.

Estimated production from soil (2018-2019)

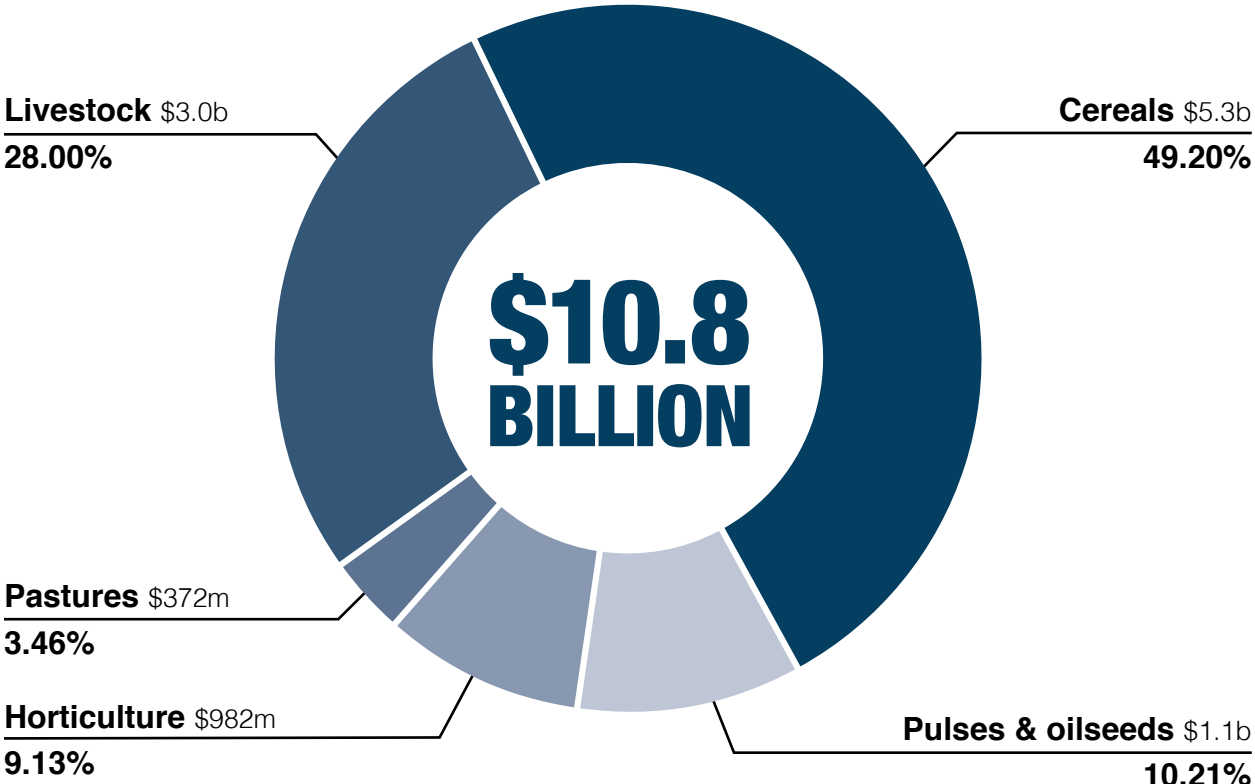


Figure 3. Agricultural production generated from soil (2018–2019) determined from Gross Value of Agricultural Production data (Australian Bureau of Statistics 2020).

Cost of land degradation

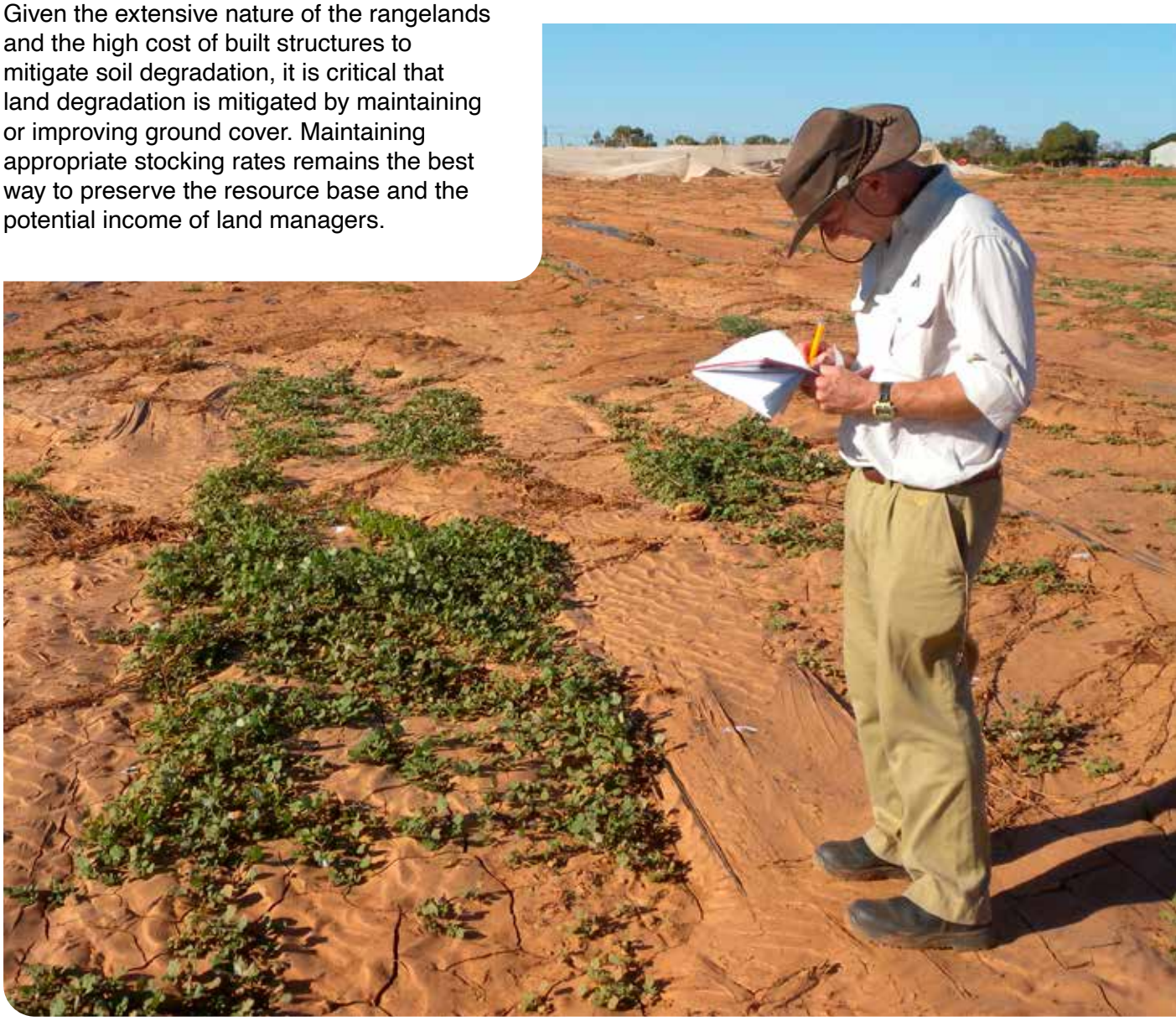
The United Nation's Food and Agricultural Organization (FAO) reported on the status of the world's soil resources, and identified and discussed the soil management challenges in WA's south-west (FAO and ITPS 2015). The FAO noted that land degradation issues, including soil degradation processes, urban development, invasive pests and diseases, seasonal variability, and a changing climate continue to affect the soil biome and the quality of our soils.

For more than a decade, DPIRD (previously the Department of Agriculture and Food, Western Australia [DAFWA]) has used the amount of affected land and yield penalties caused by soil constraints to estimate the opportunity costs (foregone income) of lost production in the south-west agricultural areas (DAFWA 2013). This data estimates the on-farm costs of lost production resulting from a soil constraint. From 2014–2015 to 2018–2019, soil acidity was the greatest cost, losing around 20% of potential Gross Value of Agricultural Production (GVAP). This was followed by salinity, compaction, sodicity, and water repellence (around 5–10% of total GVAP), with water erosion, wind erosion, water logging, and transient salinity each around 1% of GVAP or less. The opportunity cost estimates are maximums and the methodology assumes each issue is the only one present. The costs cannot be added together as many of the hazards can interact and occur simultaneously. For example, poor vegetative groundcover, which increases the susceptibility to wind erosion, may be the combined result of soil acidity and water repellence that impairs plant growth.

Land degradation in WA's pastoral rangelands is a significant cost for pastoral businesses, leading to ongoing and persistent loss of income. Using a similar methodology as used for the south-west agricultural region, DPIRD estimated the opportunity cost of degradation in the pastoral rangelands for 2013–2018 to be 1% or less of GVAP. Although these rangelands cover a vast area, the opportunity cost as a percent of GVAP is low because the value of production per hectare in this region is comparatively low compared to the south-west agricultural areas. However, the opportunity cost in the rangelands represents a high percentage of the rangelands earning potential. This estimate doesn't include the off-site impacts of degradation such as flood damage (erosion and sedimentation) to infrastructure such as roads, buildings, horticultural precincts, harbours and fisheries.

Given the extensive nature of the rangelands and the high cost of built structures to mitigate soil degradation, it is critical that land degradation is mitigated by maintaining or improving ground cover. Maintaining appropriate stocking rates remains the best way to preserve the resource base and the potential income of land managers.

DPIRD has estimated the off-site costs of land degradation due to agriculture in some parts of WA. For the south-west agricultural region, the off-site costs of wind and water erosion are estimated to be between 1.5 and 4.5 times the costs of on-farm damage (DAFWA 2015). The annual estimated costs (in Australian dollars) to rural towns is $584 million—$5 million for off-site salinity, $505 million for road repair and maintenance, $11 million for railway repairs and maintenance, and $63 million as an imputed cost for protecting 10% of affected areas of vegetation (total $584 million) with the true cost likely to be even higher (DAFWA 2015). Amongst the priority estuary catchments across the south west, for the Peel–Harvey region alone, the off-site costs of excess phosphorus leaching from farms are estimated at $361 million annually (DAFWA 2015).



Climate change

Global climate change is having biophysical, social, and economic impacts at local, regional, national, and international scales that will likely become more severe over the coming decades (Sudmeyer et al. 2016).

Climate change presents both opportunities and threats for different soil ecosystem services, and will continue to drive change in primary production conditions in WA (Department of Water and Environmental Regulation 2019). Reaching net zero carbon emissions may challenge the agricultural sector but agriculture can contribute significantly in ways that support soil health and carbon storage.

Impact

Across the state, average temperatures are rising, with a drying trend and more days of extreme heat being experienced. Annual rainfall in the south-west is expected to continue to decline, while an expected increase in the rainfall intensity of tropical cyclones in central and northern regions may be tempered by reduced frequency.

Western Australia's Climate Policy (DWER 2020) has actions that will assist industry and individual businesses with adaptation to climate change. This includes development of climate resilience action plans and the work of the WA Regional Climate Alliances. DPIRD's Primary Industries Plan outlines greenhouse gas mitigation measures for the agricultural sector. These strategic initiatives will promote innovation in agricultural practices, landscape water use, carbon sequestration activities and improved soil health outcomes.

Response

WA's Primary Industries Plan (DPIRD 2020) proposes that building mitigation and adaptation into terrestrial-based innovation, research, and policy will require:

- providing information to land managers and others to enhance their understanding of future risks associated with climate change
- implementing climate adaptation strategies including research into developing drought-tolerant grains, pasture systems, and improved tools for managing climate risk at farm or business scale
- Improving groundcover strategies to increase, and benefit from, carbon sequestration opportunities
- improving land use strategies for moving organic carbon deeper into the soil
- seeking strategic investment to improve the drought resistance of primary industries and communities (including smart dams and methods for dealing with brackish groundwater, on-farm desalination, and wastewater use).

Guiding principles for sustaining Western Australia's soils

Land users proactively seek and adapt their management strategies to optimise productivity and sustainability. Examples include using agronomic research to increase grain production despite declining rainfall and introducing no tillage systems to maintain soil moisture. At times, adaptations may lead to unintended consequences (such as increased soil acidity and greater soil compaction), but these typically result in further experimentation and adaptation.

This Strategy supports innovations and adaptations that lead to improved soil health. It embraces the rigorous assessment of new ideas and perspectives that can build on existing practices to ensure sustainable soil management into the future. Through feedback from stakeholder consultation, the Strategy also acknowledges community concerns about sustainability of soil condition and the importance of maintaining market access and social licence.

The Strategy recognises that land managers, government agencies, industry, and the community are jointly responsible for monitoring, managing, and maintaining the resilience and health of our soils. This shared responsibility requires collaborative partnerships between all tiers of government, industry, community, and the education sector to ensure a balanced approach for protecting the environmental, economic, and social values of natural resources and assets for all Western Australians.

The WA Soils Health Strategy will be guided by the following principles:

- Healthy soils contribute to food security, environmental sustainability, and climate change mitigation and adaptation.
- Within the broader landscape, soil health management is intrinsically related to good groundcover management.
- Soil health priorities should incorporate an ecosystem services approach that applies to all Western Australian landscapes.
- Practices that mitigate soil and land degradation must be measurable, actionable, and cost effective, and draw on new and existing technologies and future opportunities that can improve land and soil health.
- The role of government includes policy development, regulation, research and innovation, extension of soil management information, maintenance of soil data and maps, and monitoring the state of soil health.

Focus goals and key actions

Five goals, with associated key objectives and actions, are the focus for soil health improvement over the life of this Strategy.

These goals are considered both essential to underpin improved management of soil health in WA and to complement the current national priorities for improving soil condition across Australia's agricultural landscape (Department of Agriculture, Fisheries and Forestry 2014, McKenzie et al. 2017, National Advocate for Soil Health 2017).

Fit-for-purpose soil health practices

Goal 1: Adoption of farming and pastoral best practice so that WA soils are sustainably managed to suit land capability and soil type, and provide ecosystem services and economic returns to landholders.

Investigations into new, emerging and innovative farming systems

Goal 2: Wide dissemination of rigorous scientific and economic assessments for new, emerging and innovative farming systems for land manager adoption to improve soil health.

Track the condition and status of soil health

Goal 3: Soil health condition tracked and monitored with data accessible to landholders and the wider community so that on-farm and larger scale land degradation can be addressed.

Policy that informs landholder responsibilities

Goal 4: Widespread understanding of WA government policy that enables landholders, community and industry to meet their responsibilities to conserve and manage the soil and land resources in WA.

Conserve soil and landscapes for future growth

Goal 5: Implementation of agricultural, pastoral, and horticultural developments that sustain soil health, served by land suitability assessments and landscape monitoring and reporting.

Fit-for-purpose soil health practices

Goal 1:

Adoption of farming and pastoral best practice so that WA soils are sustainably managed to suit land capability and soil type, and provide ecosystem services and economic returns to landholders.

The interaction between soil condition and land use is dynamic and evolves as farming systems and practices change. Land managers, guided by research and supported with technology development, change their practices to remain profitable, manage seasonal risk and meet their responsibilities for soil and land conservation. However, appropriate practice at one point in time and place may not be optimal for sustaining profitability and soil health at a future time. Unanticipated impacts on soil condition that require soil amelioration, can arise, even when a best recommended practice is applied.

Understanding the risk of a practice enables better application and the ability to avoid detrimental impacts on soil health. Collaborative research and participatory action learning will be key to achieving broader knowledge and adoption. For example, systems or practices that encourage increased groundcover are especially important to the state's pastoral and agricultural landscapes, particularly in areas that are susceptible to wind or water erosion. Emerging remote sensing tools will allow monitoring of soil erosion and inform risk management and decision making.

A rapidly increasing scientific knowledge of soil biology, soil chemistry and its physical qualities is providing new opportunities for improving soil health and production. Understanding the risks of current and new practices on soil biology and function will contribute to better sustainability. This knowledge will facilitate the adoption of farming and pastoral best practice.

The conditions for adopting improved soil management practices, and the role of research and development, are generally well understood (Pannell et al. 2006). Adoption is a learning process, influenced by economic, social and personal factors; however, it is the landholder's perception of the inherent benefits of any new practice that most determines adoptability. A strong example of this is the wide-scale adoption of no-till, which together with other agricultural conservation practices, has undoubtedly reduced soil erosion in WA's cropping areas.

Through the process of Pastoral Lands Reform, the Department of Planning, Lands and Heritage (DPLH) together with the Pastoral Lands Board published the Good Pastoral Land Management Guidelines (DPLH 2019), which provide practical advice to pastoralists on good land management to assist in maintaining a profitable and ecologically sustainable pastoral business.

Collaboration across key stakeholders, is essential for success in undertaking research, development, and promoting the adoption (and guided application) of improved practices and technologies. These include research and development corporations, DPIRD, DPLH, DWER, CSIRO, universities, the National Soils Advocate, agribusiness, grower groups, and natural resource management (NRM) organisations.

Objectives

1.1 Land managers understand the risk to soil ecosystems of current and future practices and are aware of best practices that mitigate risks to improving soil health.

1.2 In partnership with government and industry, land managers are engaged in collaborative research, development, and participatory action learning of new and reassessed practices to sustain soil health and ameliorate soil constraints.

1.3 Land managers are supported with strategies that profitably maintain groundcover to prevent wind and water erosion on vulnerable land.

Key actions

a) Undertake risk assessment of current and new practices underpinned by evidence-based scientific research, investigation and analysis.

b) Government to lead collaboration with industry, community groups, and research scientists to identify practice changes for scientific research, field trials, and economic assessments that mitigate risks and strengthen fit for purpose soil health practices.

c) Develop good management guides for different industries that provide information about soil and land degradation mitigation practices and promote sustainable natural resource use.

d) Cooperative partnerships between industry, community and relevant authorities are developed to increase vegetative groundcover to protect vulnerable soil or land surfaces from potential degradation, and assist to identify and restore degraded lands through better maintenance of year-round ground surface cover.

Soil organic carbon

Sequestering carbon in soils is being investigated worldwide as a way to remove carbon dioxide from the atmosphere.

Soil organic matter contributes to a range of biological, chemical, and physical properties of soil and is essential for soil health. Striving to store carbon for the benefit of soil health will help Australia to meet its international obligations under the Revised World Soil Charter, the United Nations 2030 Agenda for Sustainable Development (FAO 2015; Department of Foreign Affairs and Trade 2018).

By global standards, WA soils are low in soil organic carbon (Hoyle et al. 2013). There is the potential to store carbon in the soil (mostly as soil organic matter), the challenge is to retain and increase the volume of permanent carbon captured (Kirkby et al. 2016).

Extensive Australian studies have quantified and mapped variations in soil organic carbon in the top 30cm layer of soil associated with agricultural management (Viscarra Rossel et al. 2014; Baldock et al. 2013). The potential exists to sequester more atmospheric carbon dioxide in soil organic carbon (Grains Research and Development Corporation 2013). This potential depends on soil type, climate, and land use. There is uncertainty as to the ability of WA soils in low rainfall areas to sequester carbon in a stable organic form. Monitoring of soil carbon initiatives will help understand the extent of this capacity (Murphy et al.2012). However, small increases in soil organic carbon over a very large area of the state could equate to significant increases in carbon sequestration (Sanderman et al. 2010, Murphy et al. 2021).

Agricultural management systems that actively support maintaining crop and/or pasture biomass for a greater proportion of the year are more likely to in soil organic carbon (DPIRD 2020). When considering changes in agricultural practice to increase soil organic carbon, land managers need to consider the change over long timeframes. Good data to benchmark and evaluate the effectiveness of management changes on soil organic carbon is critical. Measuring and monitoring the levels of soil organic carbon in our soils needs to be undertaken under approved and standardised auditing systems. The focus on increased soil carbon is consistent with the “4 per 1000” initiative which commits to increase soil organic matter and carbon sequestration through the implementation of appropriate agricultural practices. The initiative aims to increase carbon by 0.4% per year, in the first 30-40cm of soil, to significantly reduce global atmospheric carbon dioxide. The “4 per 1000” initiative is part of. of the Global Climate Action Plan (GCAA) adopted by the United Nations Climate change at COP22.

Investigations into new, emerging and innovative farming systems

Goal 2:

Wide dissemination of rigorous scientific and economic assessments for new, emerging and innovative farming systems for land manager adoption to improve soil health.

The FAO states that innovative market-driven sustainable agriculture, together with wide dissemination of research and development findings, are major goals for products and services derived from well-managed soil ecosystem services (FAO 2018).

A significant factor in increasing the productivity and market acceptance of Australia's agricultural sector is ongoing farming system innovations that have multiple outcomes, including improved productivity, reduced inputs, and improved environmental and soil health outcomes. Land managers seek to improve soil health in ways that are actionable and cost effective by drawing on new and existing technologies and practices. Demonstrating sustainable land management is also important for consumers and new and emerging markets across a number of sectors.

The role and function of biological processes in soils and how they benefit agricultural production will be increasingly understood. Soil organisms (biota) and plant-associated microbiomes are responsible for a wide range of processes that are important for soil health and fertility in both natural and

managed soils, and have a role to regulate plant resilience and yields and influence the longer-term health of the soil resource (Abbott and Murphy 2007).

Innovations and rapid advances in farming systems and practices can come from many sources. They are often novel to Western Australian agriculture. Assessment should be scientific, economically rigorous and applicability to local conditions. This requires engagement of producer and industry grower groups, regional NRM organisations and government, together with farmers and pastoralists who will have a role in shared learning, field trials, case studies and practice demonstration.

Rapid advances in technology have made available various tools that can give land managers the opportunity to readily monitor and evaluate the health of their own soils. With access to these tools and supporting services, land managers can participate in and or lead the development of future farming systems.

Objectives

2.1 Producers, researchers, educators and industry, working together will evaluate and demonstrate innovative practices that increase environmental condition and sustainable business performance for WA agricultural and pastoral rangeland landscapes.

2.2 Cooperative partnerships between industry, research organisations, and tertiary institutions continue research into building soil organic carbon that will benefit biological soil health.

2.3 Creditable science-based and economic investigations are established to evaluate new and innovative farming systems land management practices for adoption by land managers.

2.4 Land managers have access to, and understanding of, a range of decision support tools and peer supported learning, which will enable them to objectively decide on investing in practices to improve soil health.

Key actions

a) Government leads collaboration with research institutions and organisations, to establish an innovative farming systems program of field trials, case studies, and decision tool development for diverse climate zones, soil types, and agricultural enterprises.

b) The Commissioner of Soil and Land Conservation and the Soil and Land Conservation Council will provide advice on soil health innovations and sustainability before supporting wide-scale adoption.

c) Disseminate information on the risks of groundcover loss and the benefits of increasing groundcover and soil organic matter, where possible, to improve soil resilience.

Regenerative agriculture and pastoralism

Regenerative agriculture is an approach to farming and pastoralism that has a focus on building and maintaining natural capital though biological systems to improve nutrient cycling, landscape function, productivity and soil health.

The approach is guided by a series of principles, and proponents use a wide range of practices that integrate biological and ecological systems to drive production and restore landscape function.

The principles that guide the approach:

- keep the soil covered
- minimise soil disturbance
- manage water in the landscape
- maximise living plants and roots in the soil for as long as practicable
- encourage diversity
- integrate rotational grazing management into agricultural and pastoral systems
- reduce or eliminate use of synthetic compounds.

Regenerative agriculture practices are adapted to the particular farming or pastoral environment in which they are used. Factors such as rainfall, seasonality, temperature, soil type, landscape position, farm enterprise mix, markets, Traditional Owner knowledge and individual preferences are considered when implementing a regenerative approach.

A foundational goal of regenerative agriculture is to increase soil organic carbon with the outcome of supporting better symbiotic relationships between soil biology (microbiota) and plants and using biological systems to increase soil water-holding capacity through improved soil structure.

Healthy soils are a core outcome for regenerative agriculture. Understanding how regenerative practices influence soil biological activity, supports the critical need for regular measurement and monitoring of the soil chemical, physical, and biological conditions. The end point is an improved understanding of landscape ecological function and the supporting soil ecosystem services that result from regenerative practices, and the opportunity to increase or maintain natural capital.

Track the condition and status of soil health

Goal 3:

Soil health condition is tracked and monitored, with data accessible to landholders and the wider community, to inform practice change at farm and landscape scale.

Good decisions rely on good data. Technology is increasingly integral to agricultural operations, and information about soils and land is important in making suitable land management decisions.

WA has a long history of managing and moderating impacts to soil (such as acidification, wind and water erosion, salinity and or soil structure decline). Soil management also includes important ecosystem services such as increased soil organic matter and maintenance of riparian zones.

To support land use decision-making while remaining globally competitive, land managers need rapid access to data, risk-based assessments, soil interpretative maps (e.g. wind erosion susceptibility), and advance information about soil health and trends. Farming-systems based economic assessments will assist land managers to identify priority areas for interventions and implications for various enterprises within the business.

It is critical that the best use is made of soil data relevant to the decision at hand. Many people and agencies (government and private) collect, generate, and use soil data and maps. Common standards and protocols are used for sampling and analysing soils, and databases and mapping systems are developed and deployed to support the needs of land managers to better understand on-ground actions for improving soil health. Coordination and collaboration should be the foundation for future actions. While DPIRD is the custodian of WA's government soil data, the department works cooperatively with key stakeholders (universities, agribusiness, growers and other Government departments and authorities) to collate soil data and generate information for wide user benefit.

Government and policy makers at all levels also need access to soil interpretations, data, and information to guide decision-making, land use and catchment planning, and assist with regulatory reporting (e.g. 'Report Card' style reporting at set intervals). Data access is especially relevant for the state government and its industry partners, who have soil data collection and storage services and obligations, to complement national initiatives, programs, and analysis. Integrating soil condition information into existing or new databases requires cooperation and collaboration among the relevant stakeholders and partners.

Changes in soil condition can occur slowly and be difficult to measure due to spatial and temporal variation. Measuring and monitoring improvement in soil health ultimately relies on good baseline or reference data to identify management effects and assess change over extended periods (decades). Baseline criteria for key soil constraints in WA has been identified and reported through various publications dating back to 2004 (MacArthur 2004; DAFWA 2013, 2017; and Murphy et al. 2021).

Soil health monitoring is becoming more sophisticated with the application of both ecological and integrative approaches in tool design. The growing acceptance that soil health is complex by virtue of its soil biological community, should justify investment in developing monitoring tools and data sharing to satisfy more complex questions associated with land use management and climate impacts.

Objectives

3.1 WA soil land and condition tracked and monitored to enable better land condition trends.

3.2 Comprehensive soil information and aggregated data is available and accessible, allowing a wide range of analysis at a scale that equips land managers to make well informed decisions better.

3.3 An enhanced monitoring system delivers increased knowledge of WA's agricultural lands and the pastoral estate to support improvement of land condition through good land management.

Key actions

a) Commissioner of Soil and Land Conservation to review key criteria for soil condition (including salinity, acidification, compaction, water repellence, and wind and water erosion) against which future changes in soil health can be measured.

b) Adopt recognised standards and protocols for the monitoring of soil and landscape condition, to assess risk and progress, and inform timely action using direct measures for ground-based soil data and other tools such as remote sensing.

c) Assist communities to share aggregated soil data and information online, through data portals and repositories, to inform research, policy, planning and management decisions.

d) In collaboration with government and industry, report on the trends and impacts of land management practices using contemporary and quality assured data.

e) In collaboration with industry, develop and implement the monitoring policy - 'Framework for Sustainable Pastoral Management'.

Accounting for natural capital

Agricultural, horticultural, and pastoral enterprises are underpinned by natural capital (systems of geology, soils, air, water and all living organisms) that generates ecosystem services for food production and other benefits to society.

A relatively new tool that seeks to account for an 'all inclusive' economic benefit of environmental investments is Natural Capital Accounting (NCA). NCA identifies soil as having capital value within agricultural production systems and derived from broader environmental and ecological systems.

The concept of NCA aims to better account for environmental and natural resource assets, investment, and activity (Wentworth Group 2016), and aligns with the United Nations System of Environmental-Economic Accounting (UNEP 2020). Interest in using NCA for regional economic analysis and policy design is evolving.

In Australia, NCA has emerged as a possible way to provide defensible environmental-economic information, thus broadening understanding of the value of natural resource assets including the value of maintaining and improving soil health.

The ability to measure the success or otherwise of public investments in natural resource management allows for better targeting of investments in this area, and provides a cost-effective pathway for industry, farmers, and other land managers to demonstrate the sustainability of their business practices. An NCA market-based approach could provide the foundation of an accreditation system that will underpin the benefits of investing in and maintaining healthy soils and landscapes.

A coalition of WA grower and natural resource management groups are developing an NCA framework for WA. This proposed four-stage framework will offer opportunities for industry, farmers, and other land managers to take stock of their natural capital, to measure and demonstrate the sustainability of their business practices. A number of national banking and finance institutions are also progressing through the development of NCA models proposing the use of soil health indices or benchmarks to support their rural clients.

A key feature of NCA is valuing the true environmental costs and benefits of sustainable agriculture practices, and a framework supporting an improved understanding of how to manage finite natural capital will have a major bearing on the viability of many WA farming enterprises.

Policy that informs landholder responsibilities

Goal 4:

Widespread understanding of WA government policy that enables landholders, community and industry to meet their responsibilities to conserve and manage the soil and land resources in WA.

The primary legislation governing WA soils is the Soil and Land Conservation Act 1945 (SLC Act). Other legislation related to soil governance includes the Land Administration Act 1997 (LAA), the Environmental Protection Act 1986, and their accompanying regulations and policies.

Several state government agencies have responsibility for these Acts and manage, monitor, or regulate land and the activities affecting the land resource in WA. In addition to legislation, policies of applicable government agencies also highlight Public land management responsibilities including (but not limited to) Crown Land Reserve management, coastal and marine preservation, biodiversity conservation, water production and filtration, timber production, preservation of natural heritage, climate regulation, air quality, and the need to protect high-value biodiversity assets.

The SLC Act is specific in defining 'land degradation'. Under this Act, land degradation includes soil erosion, salinity, eutrophication, flooding, and the removal or destruction of natural or introduced vegetation. Land degradation affects the quality of life and economic viability of those relying on the land to provide quality agricultural produce. It also affects the ecosystem services that land owners, the broader community, and the legislation, expect from our soil resource.

This Strategy recognises that land managers, government agencies, industry, and the community are jointly responsible for monitoring, managing, and maintaining the resilience and health of our soils. Shared responsibility requires collaborative partnerships between all tiers of government, industry, community and the education sector to ensure a balanced approach for protecting

the environmental, economic, and social values of natural resources and assets for all Western Australians.

The SLC Act outlines the responsibilities of the Commissioner for Soil and Land Conservation for determination of the nature and extent of the land degradation (and consequently land condition in WA), for provision of information relative to regulation and compliance in relation to soil and land conservation, and instruction for land managers to reduce or prevent land degradation and improve soil condition across private and public land.

The Soil and Land Conservation Council is responsible for:

- advising the state government on measures and strategies to improve the condition of WA's soil and land resources
- recommending policies, programs, and land-use practices, including current and emerging opportunities that are beneficial for soil health and function.

To achieve land and soil conservation, collaboration between government agencies, local authorities, industries, and community is required to ensure development and implementation of coherent policies. Policies should promote sustainable land management by encouraging practices and methods that conserve or improve the soil resource, and regulate actions that cause degradation. These policies need to be based on sound resource condition information and be developed in consultation with community, industry, and within government. Such policies should give clarity on legislative expectations and if and when compliance will be enforced.

Objectives

4.1 Public policies and position statements clearly articulate shared responsibilities for soil and land management, consistent with the SLC Act and other linked legislation.

4.2 Compliance with state laws and regulations actively contributes to managing and conserving the soil and land resource.

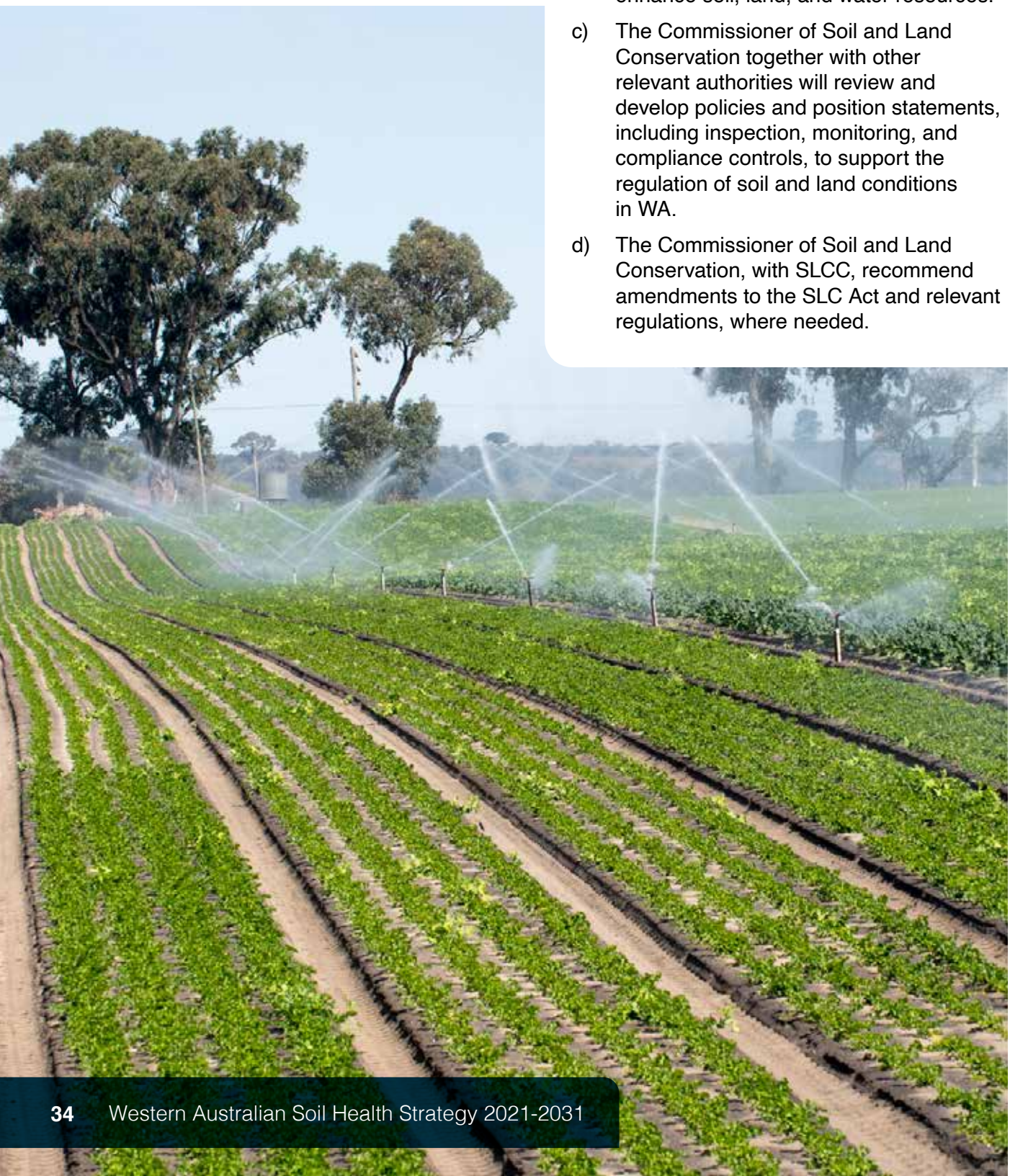
Key actions

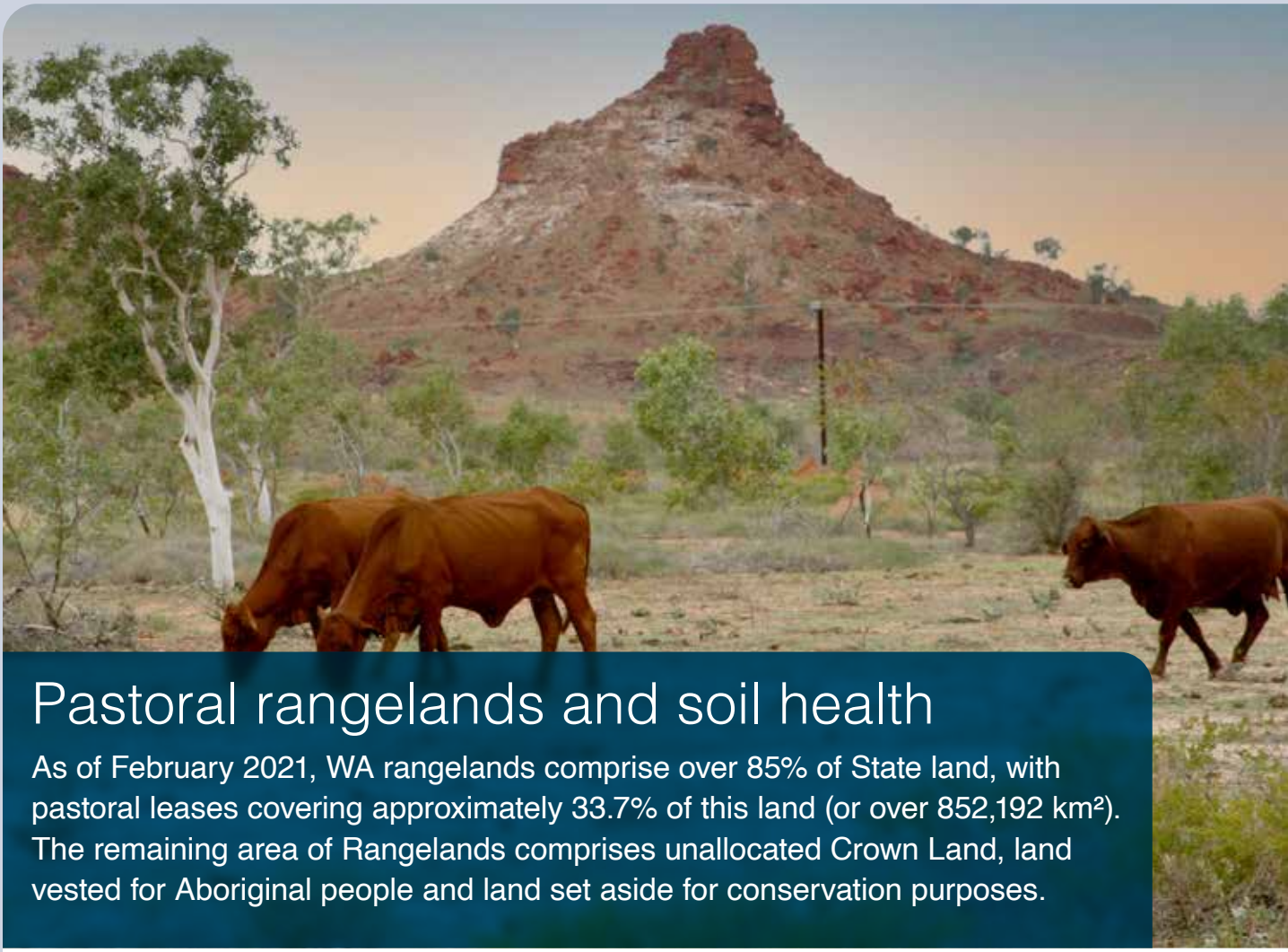
a) The Commissioner of Soil and Land Conservation provides 'tailored information' on the responsibilities of landholders, community, industry, and government under the SLC Act to bring about change.

b) The Commissioner of Soil and Land Conservation liaises with relevant government authorities to review how legislation and policies could be used to enhance soil, land, and water resources.

c) The Commissioner of Soil and Land Conservation together with other relevant authorities will review and develop policies and position statements, including inspection, monitoring, and compliance controls, to support the regulation of soil and land conditions in WA.

d) The Commissioner of Soil and Land Conservation, with SLCC, recommend amendments to the SLC Act and relevant regulations, where needed.





Pastoral rangelands and soil health

As of February 2021, WA rangelands comprise over 85% of State land, with pastoral leases covering approximately 33.7% of this land (or over 852,192 km²). The remaining area of Rangelands comprises unallocated Crown Land, land vested for Aboriginal people and land set aside for conservation purposes.

For the past 100 years or more, much of the pastoral rangelands has been grazed, and during extended dry periods soil erosion can be significant, especially on the more fertile soils along river frontages (Bastin et al. 2008). Non-grazing activities on pastoral leases may also have bearing on soil health. For example, a number of lessees cultivate non-Indigenous plant species for grazing, hay and other purposes under 'diversification permits' issued by the Pastoral Lands Board (PLB). The impacts may result in negative outcomes from the clearing of native vegetation and introduced forage species or positive outcomes through the benefit of improved land productivity.

Pastoral landscapes and soil health can also be affected by some mining industry activities such as the use heavy machinery which damage protective soil surfaces, and roads, tracks, or rail lines that can alter the direction of surface water flow.

Soil health is integral to the indigenous vegetation quality and cover in the rangelands, especially density of cover for herbaceous perennial forbs and grasses.

Rangeland soils are generally very low in nutrients, particularly phosphorus. Surface fertilisers are rarely applied because of the cost and scale of application. Nutrient deficiencies are often addressed through direct mineral supplementation to livestock. In pastoral rangeland grazing systems, productivity levels are dependent on good vegetation condition. Processes that can degrade soil, such as burning or soil erosion, critically impacts vegetative health and can result in a sustained, reduction in the level of productivity.

Herbaceous perennial cover plays a vital role in protecting the topsoil from raindrop impact and erosion . The plants slow down overland water flow to increase infiltration and increase water availability for plant growth. Soil biology is also important in rangeland soils, with termites mixing the topsoil layers. Communities of living organisms, on the soil surface of these arid and semi-arid ecosystems, including lichens and bacteria assist with water infiltration and nitrogen supply after rainfall (Belnap 2003). Other features such as the naturally rocky plains protect arid and semi-arid surfaces against erosion.

Management of rangelands is incredibly complex due to scale of leases, variability across land systems, climatic variability, historical overgrazing (from farmed and feral animals), irrigated crops, mining and tourism. The most important interaction for pastoral managers is between seasonal quality and grazing pressure. Recent climatic and vegetation cover trends indicate that the likelihood of soil erosion by water has increased slightly in parts of these rangelands (DAFWA 2017). Fire in the pastoral rangelands also causes rapid changes and requires specific management for recovery.

The State government is implementing a Pastoral Lands Reform package (DPIRD 2018b) to support pastoralists in their sustainable development and land management efforts. The PLB recognises that pastoral leases are responsible for onground management and support this through principles presented in published Guidelines, Fact Sheets and Policy.

Through the pastoral lands reform process, DPIRD is developing a new monitoring standards approach, supporting a contemporary Ecologically Sustainable Development (ESD) framework. This Framework is based on internationally accepted best practice risk-management principles for natural resource management (FAO 2014). The new framework refines the peer-reviewed ESD governance approaches that have been successfully used elsewhere.

Conserve soil and landscapes for future growth

Goal 5:

Implementation of agricultural, pastoral, and horticultural developments that sustain soil health, served by land suitability assessments and landscape monitoring and reporting.

Leading land managers are already taking action to improve soil condition and are realising tangible benefits. Relevant government policies need to support all agricultural industries to develop and implement innovative sustainable farming practices and business models that conserve the soil and landscape for future development and growth.

Ecosystem services provided by healthy soils are increasingly recognised as essential across all production systems and have an integral relationship to land use and land management. Land assessment and management incorporates the concept of sustainably securing the health of our soils. It is underpinned by science and guides integrated approaches to land management, while balancing ecosystem services, and environmental, social, cultural, and economic needs. This multidimensional view (Bennett et al. 2019) approaches land assessment and management through a quantified and market-based lens. It also considers allied soil issues including societal connections, education, policy, legislation, current land use, the requirement for land use conservation,

condition, and the economic and natural value of our soils.

Changes to land use or consideration of new developments should be informed by land suitability assessments, cumulative impacts and landscape monitoring by land managers and land use decision makers. Soil security will be achieved by the maintenance and improvement of soils so that they can continue to provide food, fibre and fresh water, contribute to energy and climate sustainability, and help protect and maintain biodiversity and soil ecosystem services (Koch et al. 2012).

The state government is considering options for revising the management of pastoral land assets in a more sustainable and innovative manner, including legislative amendments to support pastoralists in their efforts to achieve sustainable development and land management (Fletcher 2020). Enhanced land condition assessment, monitoring and compliance systems are intended to increase knowledge of the pastoral estate and encourage best practice in improving land condition and soil health.

Objectives

5.1 Collaborative actions are in place to retain soil ecosystem services under changing land use and new developments.

5.2 Partnerships are established with regional groups, government, industry and community to manage nutrient leaching and sediment run-off.

5.3 Additional pressures on agricultural and pastoral landscapes that might compromise the sustainability or security of soil health and landscapes are quantified.

Key actions

a) DPIRD works with industry, community, relevant authorities and other government departments to better understand 'fit-for purpose' soils and landscapes (i.e. matched to land suitability and in consideration of likely impacts from projected climate change assumptions) for new agricultural and pastoral developments and activities, thus ensuring suitable land resources are protected from conflicting uses.

b) DPIRD works with industry, community, and other government departments to identify key soil health indices supporting the development of Natural Capital Accounting models for Western Australia.

Implementing the Strategy

This Strategy is a framework guiding the actions of the Western Australian government in partnership with relevant stakeholders on policies, and future investment opportunities, adoption of good land management, and education to build the resilience and health of WA soils.

Land managers are essential partners to contribute knowledge, provide momentum, and implement on-ground changes to drive positive action for the improvement of soil health. DPIRD will work collaboratively with various stakeholders, including government and non-government organisations, research and development corporations, the National Soils Advocate and industry partners to achieve the Strategy's desired objectives, and will also work with the Australian Government under the National Soil Strategy. DPIRD will prepare an Implementation Plan for the Strategy, which will be overseen by the SLCC. Implementation will be delivered over a staged approach – the first stage will identify and source investment and funding opportunities for each key action.

Long-term financial investments and commitments are needed to build healthier soil and to make changes to key areas, such as ecosystem protection and soil health. Although these investments are often costly and require time to plan, implement, and manage, the economic business case for good soil health is strong.

Successful investments and innovation in soil health are frequently supported by strong partnerships (whether across value chains, landscapes, or sectors). Investment in soil health delivers both private and public benefits. Sharing costs and risks and mobilising local knowledge, expertise, and capacity will help ensure success.

Monitoring, evaluating, reporting, and improving

A monitoring, evaluation, reporting, and improvement project will be developed jointly by SLCC and DPIRD to gauge the impact of this Strategy.

This project will use measures that include:

- measuring achievements against the Strategy's goals, objectives, actions, and implementation to improve WA's soil health
- implementing community engagement programs that demonstrate changes in practice designed to improve soil health
- measuring the number of successful soil health partnerships developed
- monitoring the effectiveness of investment and providing advice on information impact and innovation benefits
- assessing systems developed to monitor and assess soil health
- providing education and training opportunities in soil health and landscape management.

The SLCC will provide an annual report to the Minister for Agriculture and Food reporting progress on achievements in implementing the initiatives outlined in this Strategy. This report will be available publicly.

The Strategy will be reviewed every three years with a mid-term update (2026) to ensure that it continues to reflect community, industry, and government priorities for managing soils and improving soil health.

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