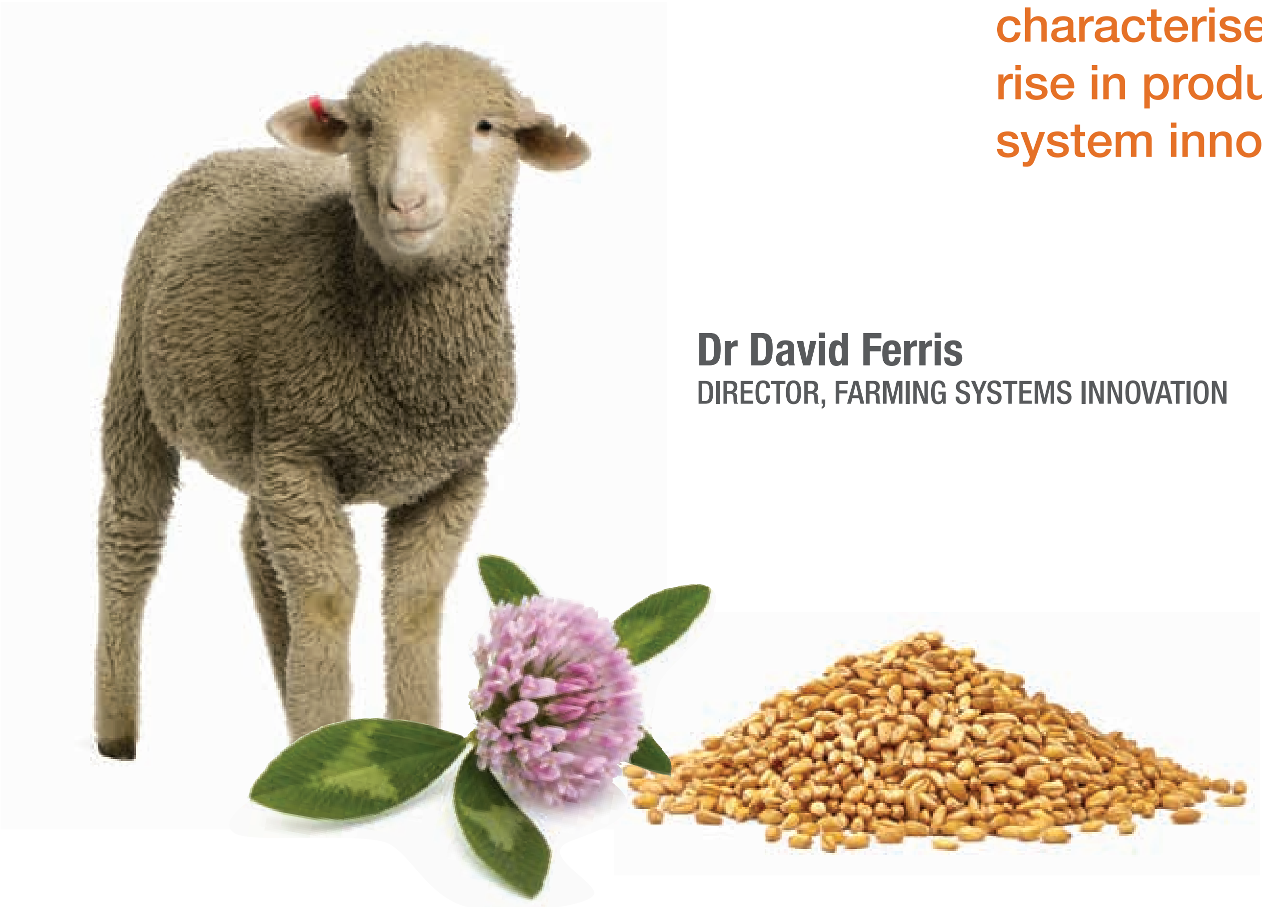
Farming Systems

Overview



The history of Western Australian farming is characterised by change, with each significant rise in productivity preceded by farming system innovation.

Dr David Ferris
DIRECTOR, FARMING SYSTEMS INNOVATION

DPIRD'S NEW FARMING SYSTEMS directorate was established to help identify and assess the scientific, technical and social innovations that will underpin the continued productivity and sustainability of WA farm businesses in the face of climate change, changing consumer preferences and more competitive markets.

Broadacre grain and livestock farms across south-west WA generate about 70 per cent of the state's agricultural production, which is valued at $6 billion per annum at the farm gate and about $11.5 billion over the entire value chain.

Farm businesses in WA are changing – with a shift towards larger farms and increased total production per farm. As a result, one-third of grain farmers now manage two-thirds of the state's cropping land and produce two-thirds of its total annual product.

Farming Systems

5725
Number of agricultural holdings (ABS by Shire)

4200
Number of grain growers

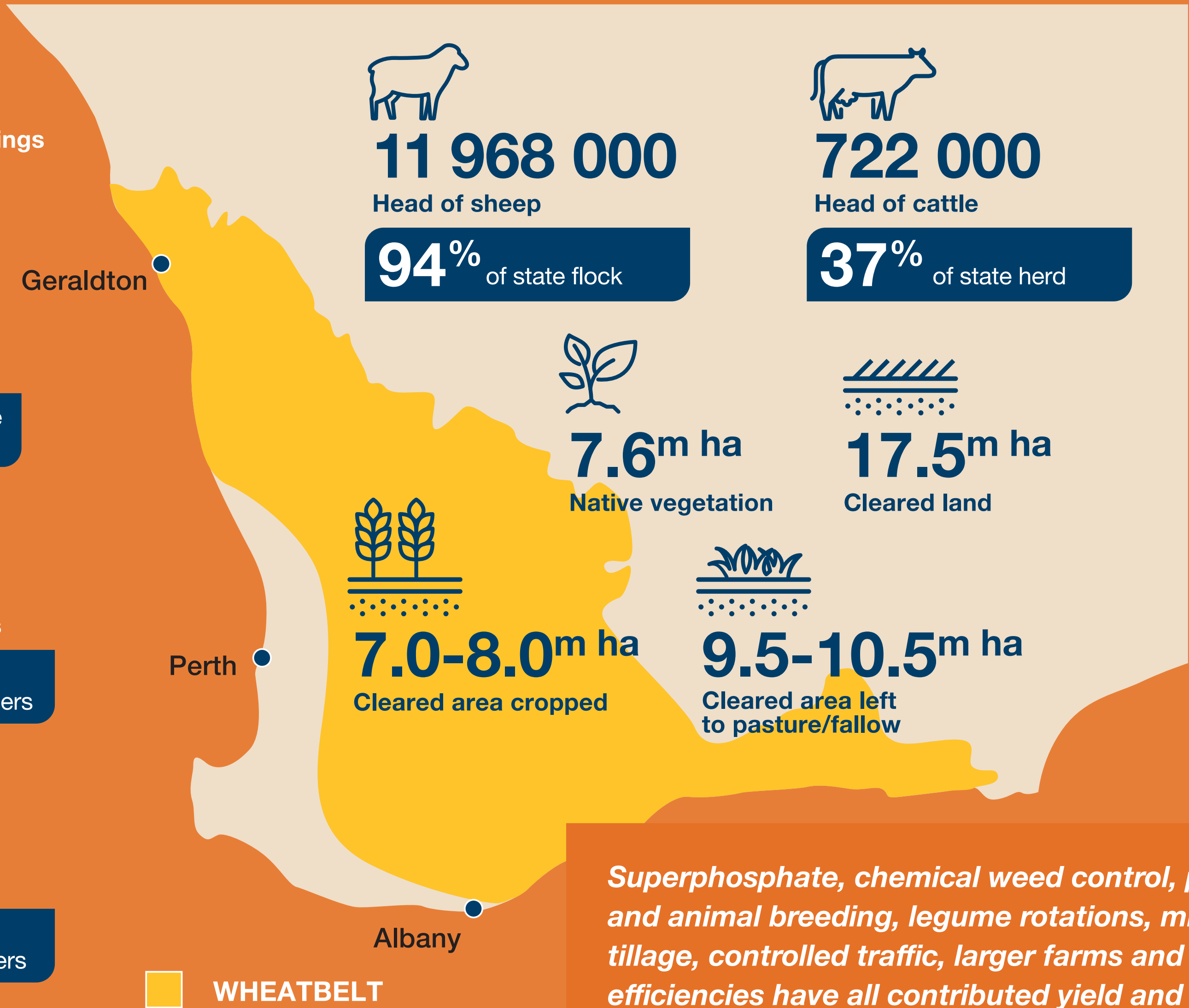
24% of growers produce 58–75% of the crop

3649
Number of sheep producers

29% of producers have 62% of sheep numbers

2419
Number of cattle producers

15% of producers have 65% of cattle numbers



11 968 000
Head of sheep

94% of state flock

722 000
Head of cattle

37% of state herd

7.6m ha
Native vegetation

17.5m ha
Cleared land

7.0-8.0m ha
Cleared area cropped

9.5-10.5m ha
Cleared area left to pasture/fallow

Superphosphate, chemical weed control, plant and animal breeding, legume rotations, minimum tillage, controlled traffic, larger farms and improved efficiencies have all contributed yield and quality advances on WA farms over the past 100 years.

Source: Adapted from Ryan, W., Ewing, M. and Roberts, P. Farming Systems Research and Development in Western Australia (March 2020)

Farming Systems

> *Ongoing farming system innovation is vital to the long-term profitability of WA farm businesses in the face of climate change, changing consumer preferences and more competitive markets.*
>
> DR DAVID FERRIS

Research and innovation are vital to the the ongoing success of WA farming systems. History shows that 75 per cent of WA's agricultural productivity generated today is due to the R&D investments made over the past 40 years (Figure 25).

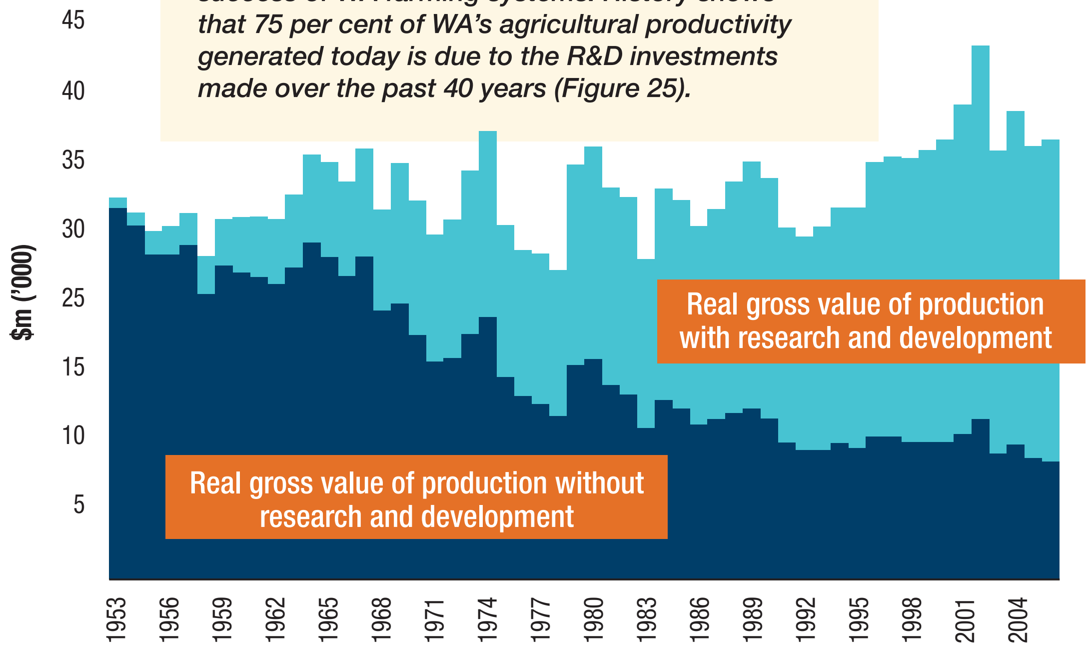


FIGURE 25. Value of research and development to gross value of Australian agriculture 1953–2006

Source: Mullen J (2007) AJARE 51: 359-384

WA farmers operate in the face of inherent challenges. Rainfall is relatively low and becoming lower due to climate change, and the state's soils are highly weathered and infertile. Local markets absorb a relatively small proportion of the state's grain and livestock products, and farmers must compete globally for international markets. Government subsidies for WA farmers are amongst the lowest in the world.

Yet, despite these obstacles, a vibrant and profitable agricultural industry has evolved, based on the export of bulk commodities, and farming systems that continue to evolve using innovation to meet challenges and opportunities.

Scientific and technological advancements have underpinned the capacity of WA farmers to keep pace with a long-term decline in terms of trade. Improved varieties, nutrition, weed control, disease management and logistics have enabled growers to maintain productivity growth and adapt their farming systems to achieve more precise and earlier sowing, improved water and nutrient-use efficiencies and higher crop yields.

Many forces will influence WA's farming systems over the next decade including:

- climate change and carbon farming
- agriculture automation and digital technologies
- changing consumer preferences and social licence
- growing middle class in Asia and increased demand for grain and red meat
- increasing grain production and market competition from the Black Sea region.

I believe farming system innovation, like never before, will be needed to address these challenges and opportunities to further boost the productivity and competitiveness of primary industries and deliver sustainable economic and regional development. Our approach will be to work with industry, innovative growers and researchers from a wide range of disciplines to conceptualise, develop and evaluate transformative farming systems for the future.

By their nature, farming systems are complex and each one is unique.

Management choices made in a given year will have implications for the profitability and performance of crop and livestock enterprises in subsequent years. And every farming system must operate with uncertainty about the amount and timing of rainfall, commodity prices, input costs, labour availability and market expectations.

DPIRD's new Farming Systems Innovation Directorate was established in 2019 to identify and prioritise research and development activities that will underpin the evolution of WA farming systems.

The directorate has 50 research, development, technical and administrative staff located at eight regional offices and in Perth. It has three focus areas:

1. **Regional intelligence and adoption:** gather, analyse and disseminate seasonal and local information, and develop strategic partnerships to facilitate extension and adoption of new technologies
2. **Systems and bio-economic modelling:** develop models and tools that inform farm decisions in real time and simulate trial results across a wider range of soil types and seasonal conditions
3. **Dryland farming systems:** multi-disciplinary and long-term research to evaluate and communicate the performance of current and transformative farming systems at local levels.

The Farming Systems team has expertise in systems modelling, climate and weather science, regional intelligence and analysis, applied crop and pasture systems research, crop and pasture legume science, digital data and information flows, and farm business-risk analysis to evaluate the performance of farming systems over time.

Key initiatives of the Farming Systems Directorate include:

- establishment of the Future Farming Systems learning hub at Merredin in 2020 to evaluate (over the next 10 years) the viability of regenerative and ag-tech systems
- increasing the effectiveness of nitrogen fixation in legume species and evaluating the capacity of new grainbelt pasture and grain legumes to increase business wealth and sustainability
- capacity building of early career research scientists based in the regions
- management of DPIRD's network of 210 automatic weather stations throughout WA to provide timely, relevant and local weather data to assist growers and regional communities to make more-informed decisions.

Our overall objective is to provide farmers with evidence-based data in a whole-of-system context, so they can make informed decisions about adopting more profitable and sustainable farming systems and practices.

What does the future hold for WA farming systems?

Continued evolution of Western Australian dryland farming systems requires research resources to be focused on issues of the highest priority and on those that will deliver the greatest and most sustainable benefits.

To achieve this, a shared strategic vision is needed across the industry.

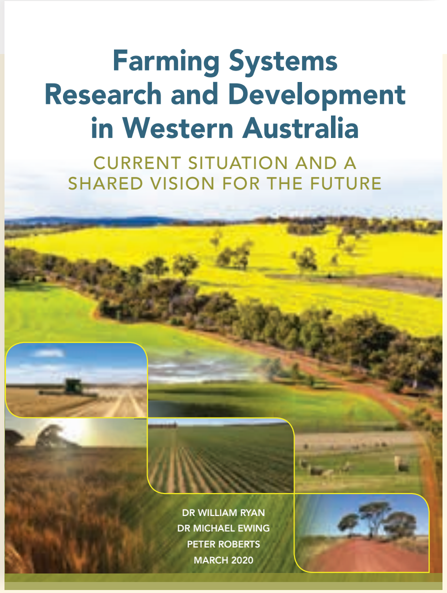
DPIRD's regional intelligence and adoption team worked closely with agricultural consultants Peter Roberts, Dr William Ryan and Dr Michael Ewing to undertake a situational analysis of the current production and farm business environment in the Albany, Esperance, Geraldton and Kwinana port zones of WA, and develop a framework to prioritise future dryland farming systems R&D in WA. Potential investment areas were also identified.

Currently 5725 agricultural producers manage 17.5 million hectares of cleared land across the WA grainbelt of which about eight million hectares are cropped annually and about 9.5 million hectares used for grazing or fallow.

About 100 individuals from 25 organisations spanning the breadth of WA's cropping and livestock industries were consulted as part of the situational analysis.

Areas of potential investment identified through the consultation approach:

- lifting wheat protein levels profitably to improve market access
- lifting the profitability and adoption of crop legumes to encourage system diversification and sustainability
- lifting canola yields for WA conditions
- lifting the potential of grainbelt pasture systems to meet livestock and cropping demands
- addressing gaps in the grainbelt feedbase to better match wool and meat requirements
- delivering more accurate climate predictions to support farm management decisions
- injecting greater diversity into wheat-dominant farming systems
- determining the circumstances under which carbon farming could be profitable in the WA grainbelt
- investigating the potential of regenerative agriculture systems to deliver sustainable and profitable benefits
- translating big data into more profitable farm decisions.



Further consultation and strategic analysis of these investment areas will be undertaken to determine if they can become part of a shared strategic vision for farming systems R&D in WA.

The goal is to use a mix of discipline-based and farming systems research to unravel the complexities of each issue and ensure the solutions fit within the mix of enterprises common across WA's broadacre farming businesses. The Farming Systems Innovation Directorate will build multi-disciplinary and cross-organisational teams to tackle proposed research investments and to undertake regional analysis to gain a clear understanding of the production and business issues facing WA's dryland farming systems.

FARMING SYSTEMS INNOVATION

Purpose: innovative farming systems that address challenges and capture opportunities for sustainability, profitability and growth.

REGIONAL INTELLIGENCE

Regional analysis of seasonal, technological, social and market forces affecting WA farming businesses to develop policy and guide research, development and adoption.

DRYLAND FARMING SYSTEMS

Research, development and extension to help farming systems respond to climate change and market forces, and adopt new innovations.

SYSTEMS MODELLING

Develop and extend decision-support tools, and insights from climate and whole-farm modelling, to guide farm management and regional development.

Science of regenerative agriculture explored in 10-year trial

A 40-hectare 'learning hub' has been established at DPIRD's Dryland Research Institute at Merredin to investigate the suitability of a range of farming systems for the eastern wheatbelt.

THE LEARNING HUB will be managed by a multi-disciplinary research team and a reference group of regenerative farmers, consultants, scientists and a representative from RegenWA.

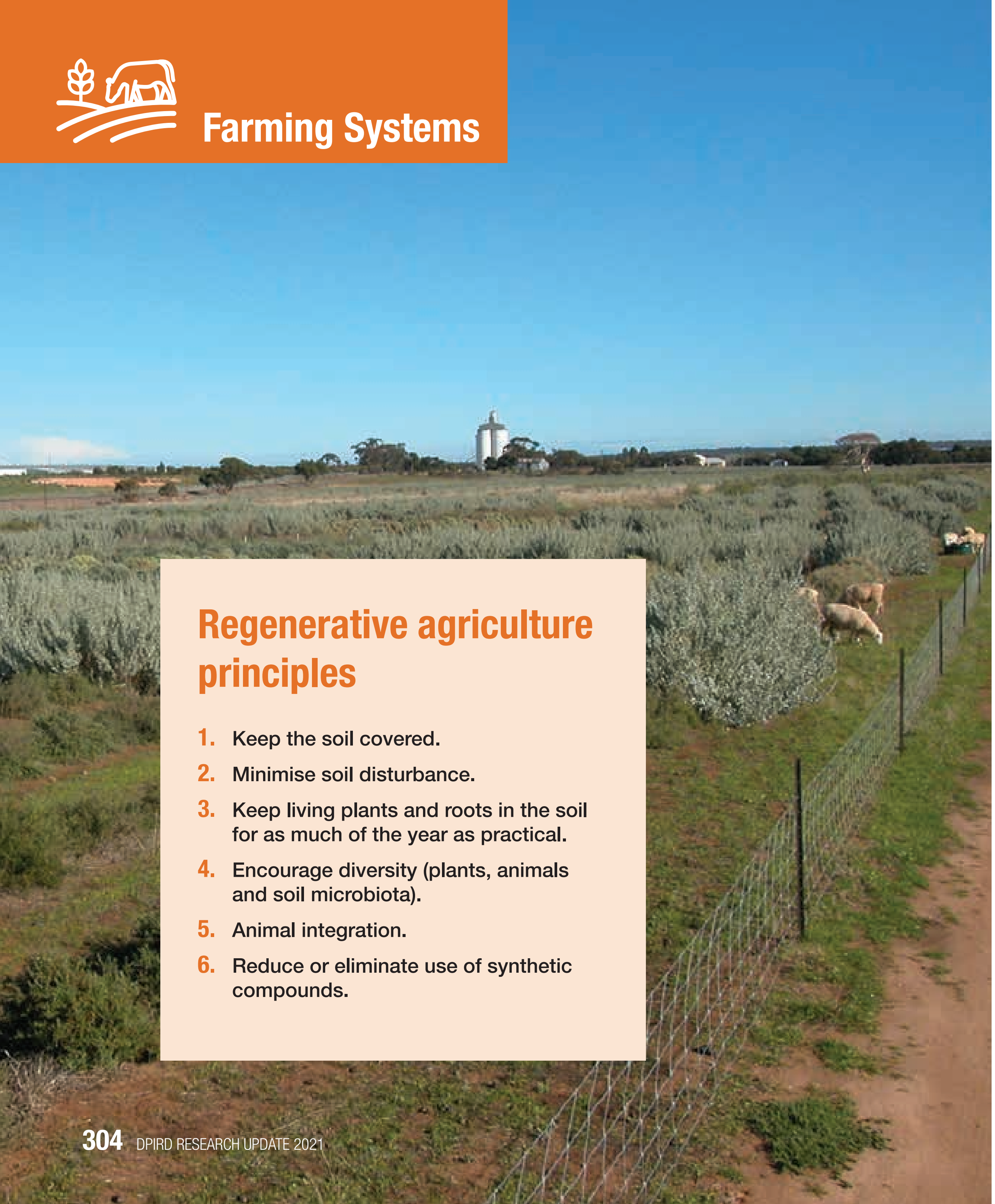
Farmers in the eastern grainbelt are seeking to adapt to an array of challenges – including climate change, rising input costs, declining protein level in cereals, herbicide resistance, soil acidification and growing consumer demand for verification about how their food has been produced.

A major focus of the learning hub will be a thorough examination of the science and economics of two 'regenerative agriculture' farming systems in comparison to current district practices and benchmark controls.

Regenerative agriculture is a growing movement globally that operates on a very broad set of principles which aim to increase soil carbon sequestration and harness soil biology to drive natural nutrient cycles for crop and pasture production. Little to no synthetic chemicals or fertilisers are used in regenerative agriculture systems, making their products potentially attractive to niche markets.

Farming Systems

The science and economics of regenerative agriculture will be investigated over the next decade at a dedicated 40-hectare trial site at DPIRD's Dryland Research Institute. The trial will examine the suitability of a range of farming systems for the eastern grainbelt while facilitating farming system discussions between growers, researchers and the broader industry. Pictured is WA Agriculture Minister Alannah MacTiernan (third from right) who launched the farming systems trial in July 2020 alongside DPIRD researchers and Hon Darren West MLC (far right).



Regenerative agriculture principles

1. Keep the soil covered.
2. Minimise soil disturbance.
3. Keep living plants and roots in the soil for as much of the year as practical.
4. Encourage diversity (plants, animals and soil microbiota).
5. Animal integration.
6. Reduce or eliminate use of synthetic compounds.

Transitioning to a regenerative agriculture system often requires a shift from a high input, low diversity farming system to one with lower inputs and greater crop–livestock diversity. Limited analysis of regenerative systems indicates they generally yield less than conventional broadacre cropping systems. However, reduced input costs and premium prices for regenerative produce can compensate for a fall in yield. Little is known about the soil biology and soil carbon effects of a regenerative agriculture approach in WA and research is needed to quantify the benefits of the system across a range of environments, soil types and enterprises.

The 40-hectare site at Merredin will deliver a long-term analysis of the science and economics of regenerative agriculture compared to more conventional crop and livestock farming methods (see Figure 26 and Table 6).

The goal of the trials, which will run for ten years, is to monitor the economics and soil biology of a range of farming systems while facilitating a valuable and much needed discussion about how to tackle the challenges faced by farmers in the eastern grainbelt.

Future farming systems for the eastern wheatbelt

This focus site is a WA Government initiative – established 2020

The aim of this trial is to compare the long-term productivity, profitability and sustainability of different farming systems in the eastern wheatbelt of WA.

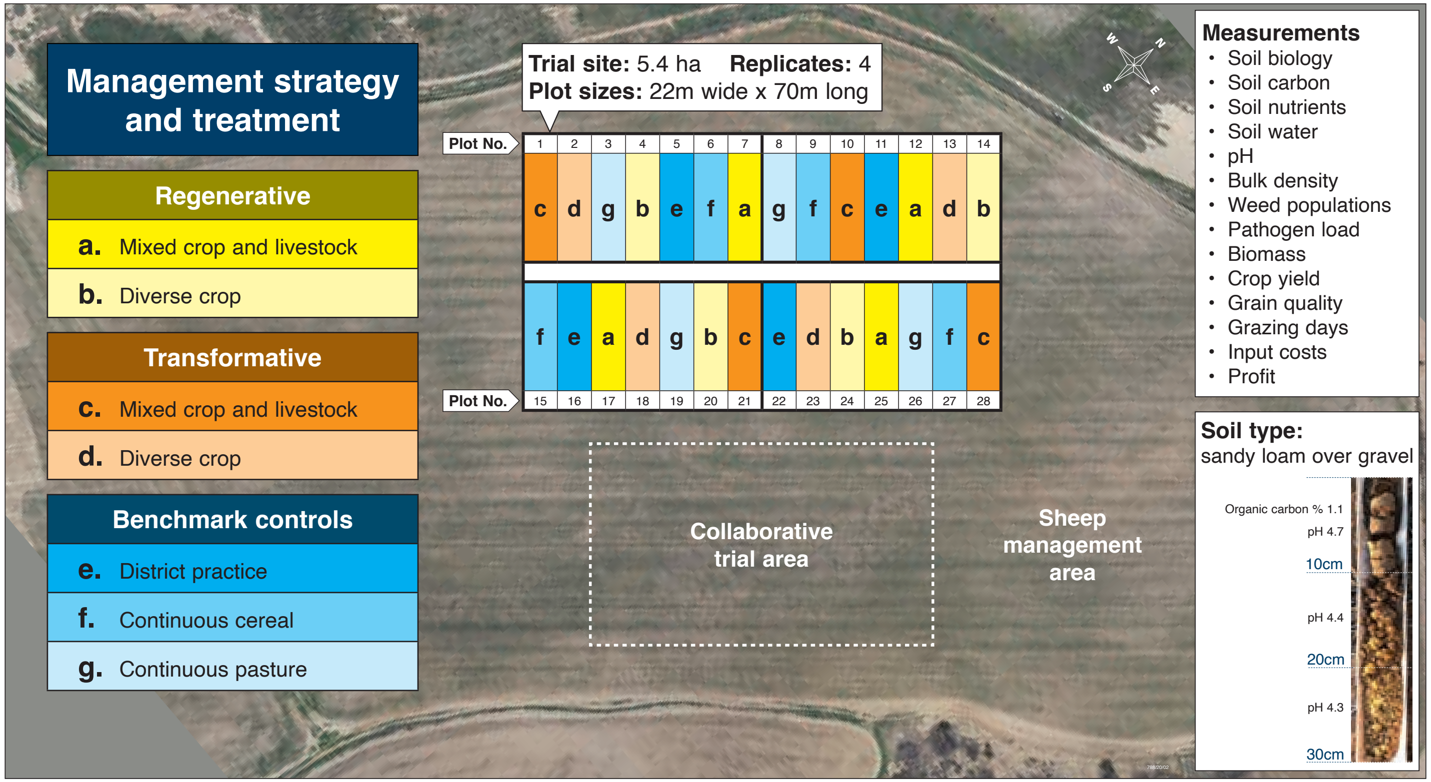


FIGURE 26. Layout of the Future Farming Systems trials for the eastern grainbelt. See Table 6 for details on the management strategies and treatments used in the trials, which will run for a decade at DPIRD's Dryland Research Institute at Merredin.

> *We expect there will be different pathways to future-proofing profitable and sustainable farming systems in the eastern grainbelt, based on a deeper understanding of soil health principles and advanced crop and livestock management skills.*
>
> CAROLINE PEEK,
> DPIRD SENIOR RESEARCH SCIENTIST

Table 6. Management and treatment details for the Merredin farming systems trial

Management strategy	Treatment	Description
Regenerative: lower input costs + stimulate soil biology by increasing diversity and using biostimulants.	Mixed crop + livestock	This represents a traditional regenerative agriculture approach: mix of annual crop and pasture species, cover crops and/or perennials with as much plant cover year-round as possible coupled with rotational and cell grazing.
	Diverse crops	Many eastern grainbelt growers have no livestock infrastructure so the use of diverse crops represents a more realistic transition to a regenerative agriculture approach for this region. Crops will be a mix of winter annuals and summer cover crops to provide as much plant cover year-round as possible.
Transformative: increase production capacity through soil re-engineering + targeted inputs based on real-time soil moisture and plant health monitoring.	Mixed crop + livestock	Focused on biomass production. Summer and winter crops grown for grazing and grain or conserved as hay or silage for sale in high-value feed markets or to finish high-value stock on-farm.
	Diverse crops	Cereals + legume/oilseed crops grown to harvest for grain production.
Benchmark controls: designed to generate a range of soil organic carbon levels from high to low, to determine what is possible in this environment.	District practice	Cereals + legumes/oilseeds + possibly fallow/pasture phases as directed by reference group.
	Continuous cereal	Cereals only with no break crops. Designed to push the system and potentially drive down soil carbon.
	Continuous pasture	Mix of annuals and perennials. Designed to maximise possible build-up of soil carbon for this soil type and rainfall zone.

DPIRD has completed an economic literature review of Australian regenerative agricultural systems and has commenced work on a scientific review of available regenerative agriculture research. Based on very few published studies, the economic review indicates regenerative agriculture can be profitable, but the loss of income associated with transition from conventional farming to a regenerative system can be a significant barrier to adoption.

Baseline information has been collected across the trial site to determine its current soil nutrient and biology status. Wheat was sown across the whole site in May 2020 to evaluate paddock performance and uniformity. The site will now be divided into seven management treatments and replicated four times (see Figure 26).

The long-term research trial will generate information about the performance of regenerative systems in the eastern grainbelt while also highlighting how current systems can be adjusted for better performance. The goal is to provide growers in the eastern grainbelt with a mix of viable options to improve the efficiency, sustainability and profitability of their farming operations into the future.

Detailed monitoring over the next decade will capture the effect of the management treatments on soil organic carbon, microbial activity, soil water and nutrient availability along with crop and livestock yields and system economics.

Farming Systems

Nitrogen bacteria breathe new life into dryland farming systems

The search for alternative pasture legumes and the expansion of the pulse industry is seeing legumes increasingly sown on soils that are challenging to plant establishment and growth. In some areas, agricultural legumes are either being grown for the first time or after a long absence and are likely to benefit from inoculation with nitrogen-fixing bacteria known as rhizobia.

Nodules containing bacteria called rhizobia, which live symbiotically inside the roots of legumes where they extract nitrogen from the air in a process known as nitrogen fixation. It is estimated that the bacteria deliver about $4 billion worth of nitrogen fertiliser to Australian farming systems each year.

RHIZOBIA ARE BACTERIA that live symbiotically inside the roots of legumes (lupins, peas, beans, chickpeas, clovers, serradellas) where they extract nitrogen gas from the air in a process called nitrogen fixation and turn it into a form of nitrogen that legumes use to grow.

The rhizobia are effectively fertiliser factories and it is estimated that they deliver $4 billion worth of nitrogen fertiliser to Australian farming systems each year.

Many consider the legume–rhizobia symbiosis second only to photosynthesis as the most important biological process on earth.

About 100 species of legumes are grown across Australia. These can be divided into grain legumes such as lupins, faba beans, field peas, lentils and chickpeas; and pastures such as clovers, lucerne, medics and serradellas.

Each legume requires a unique type of rhizobium to form a symbiosis. Inoculating legume seed with the correct rhizobium before sowing is a critical process in legume production.

Genetic diversity

Researchers at the Centre for Rhizobium Studies (CRS), of which DPIRD is a partner, are collating a genebank of rhizobia collected from across the world to use as a genetic resource to develop superior strains of rhizobia. The work will ensure that Australian legumes can be matched with robust rhizobia suited to the nation's soil and climate constraints.

The new International Legume Inoculant Genebank (ILIG) is based at Murdoch University in WA and will be managed by researchers at the CRS.

Rhizobial strains with enhanced nitrogen fixation capacity are currently being developed and tested to overcome soil constraints such as low pH. Pictured is a scientist examining a field pea crop inoculated with acid tolerant rhizobia at Gibson, north of Esperance.

INSET: A selection of freeze-dried rhizobia from the ILIG collection.

With some 20 scientists and research students who study rhizobia and legumes, the CRS is the largest group of its kind in Australia and one of the largest focused on rhizobia for agricultural legumes in the world.

The CRS has started amalgamating strains of rhizobia acquired from collections in Australia and across the world into the ILIG.

The collection currently comprises 16 500 strains of rhizobia, representing more than 100 species of rhizobia collected from 530 species of legumes in about 60 countries.

Collection of these strains began in the 1950s. Many strains are irreplaceable because some may no longer exist in nature and present-day restrictions and political instability limit collection and importation of biological materials.

Elite strains of rhizobia will be selected and optimally matched with a host legume to fix high levels of nitrogen for growers.

The Australian National Rhizobium Steering Committee (NRSC) brings together leading rhizobium specialists from across Australia and will work with the inoculant industry to implement protocols that maintain the quality of inoculum strains available to growers and to recommend the adoption of new inoculum strains based on the ILIG gene bank research.

Better bacteria to boost pulse yields

Soil constraints such as acidity, particularly when combined with practices such as dry sowing or the application of pesticides and herbicides, can profoundly affect the success of inoculation and subsequent performance of the pulse crop.

Rhizobial strains with enhanced nitrogen fixation capacity are currently being developed to overcome constraints such as low pH.

Current recommendations suggest lentil and faba bean should be inoculated with a specific type of rhizobia known as Group F while field pea and vetch should be inoculated with Group E. However, the current Group E is difficult to manufacture and, as a result, field pea and vetch are usually inoculated with Group F inoculant. Group F has exhibited a reduced capacity to nodulate plants at low pH (acid), perhaps because it was isolated from a site in Greece containing an alkaline soil.

Research is currently being completed on potential replacements for Group F (and Group E) that optimally fix nitrogen in high, neutral and low soil pH and across a host range of lentil, faba bean, field pea and vetch.

Four elite rhizobium strains, two from Murdoch University (originating from Greece and Italy) and two from the South Australian Research and Development Institute (originating from Australia), have been compared throughout WA as part of a wider national evaluation program. Data from the trials will be compiled and results presented to the Australian NRSC. If members are in agreeance with a strain replacement, the strain will be sent to commercial inoculant companies via the Australian Inoculant Research Group (AIRG) at the New South Wales Department of Primary Industries.

Quantifying nitrogen value

Researchers at the CRS are working in the Dryland Legume Pasture Systems project to develop improved pasture cultivars and quantify their benefits when grown in rotation with crops. Many of the legumes are suited to summer sowing using on-farm harvested seed to economically establish vigorous pastures. The project has six small-scale rotation trials across the WA grainbelt and will quantify how much of the biologically fixed nitrogen generated in the legume phase is transferred to the following cereal crop. The research will also determine the influence of the pasture phase on soil water, weeds, pests and diseases in the cropping phase.

Researchers are investigating how much biologically fixed nitrogen (generated by the legume phase) is transferred to following cereal crops. Pictured is a relatively new pasture legume, *Trigonella balansae*, an upright highly palatable annual species with masses of yellow flowers. Seeds are borne aerially making seed harvesting easy and providing growers with access to large supplies of cheap seed from their own pasture stands.

Boosting regional research capacity

Successful farming systems are underpinned by people and it is critical that the cropping industry attracts and encourages agronomists who are skilled in research and development.

Senior DPIRD research scientists Mark Seymour (left) and Jeremy Lemon (centre) inspect a faba bean crop with project participant and early-career agronomist Carla Milazzo (right). Faba beans are showing considerable promise as an alternative break crop to canola to diversify farming systems in medium to high rainfall areas. The regional agronomy team has compiled a booklet incorporating grower experiences and new research about faba bean production. Information was collected from 15 faba bean paddocks and research projects along the south coast stretching from Kojonup to east of Condingup, WA.

WITH THE GOAL of boosting regional capacity in research agronomy, DPIRD, with investment from the Grains Research and Development Corporation (GRDC), mentored 19 early-career scientists to develop skills in grains and farming systems research, development and extension. The program enabled participants to transition to new roles across the grains industry and into farming systems R&D.

Based in Albany, Esperance, Merredin, Northam and Geraldton, the team worked across five Western Australian port zones and focused on an array of locally identified issues of priority to the grains industry and farming systems.

Each participant was within the first five years of their career after completing their undergraduate or postgraduate qualifications. Through training, mentoring and taking on the responsibility for delivering a program of R&D adoption activities, the agronomists developed their R&D capability, skill base and confidence.

Industry consultation via the project identified four necessary areas of agronomic R&D competency:

1. **The ability to think and analyse:** understand an issue, identify potential solutions and problem solve
2. **The ability to inquire and investigate:** test ideas using scientifically valid research principles
3. **The ability to engage and listen:** collaborate and connect with broad networks
4. **The ability to communicate:** identify and communicate timely messages at a regional and local level.

Training was delivered through workshops, courses, study tours, conferences, field days, industry events, and through mentorship from experienced senior researchers in the grains industry. All learning was done within a farming systems framework so that participants could develop an appreciation of the interactions that occur within and between enterprises on-farm.

Courses were delivered in communication and extension skills along with statistical trial design, basic trial set up, soil testing and characterisation, crop growth stage assessment, frost damage and weed, pest and disease identification. The courses were developed to enable participants to apply their learnings within their daily work while building their confidence and knowledge base.

A team of mentors from DPIRD worked with the participants. Project mentor and research scientist Jeremy Lemon from the Albany DPIRD office said there had been three major highlights from the project:

- watching the team acquire confidence and new skills in writing, presenting and conducting field research
- the high standing that the team developed within the agricultural industry, including the GRDC, growers, industry groups and DPIRD staff
- the team's development of industry networks and understanding of industry issues in a farming systems context.

> ***These achievements sit above tangible outputs and are the lasting legacy of the project as participants move into the wider agricultural industry.***
>
> **JEREMY LEMON,** DPIRD RESEARCH SCIENTIST

Farming Systems

Project participants Sarah Belli, Joel Johnstone and Grace Williams checking frost symptoms in a DPIRD trial at Dale, WA.

Sarah Belli and Carla Milazzo hosting a DPIRD display at the Albany Show at which DPIRD's decision-support apps, including iLime, were promoted. iLime estimates the productivity and economic benefits of applying lime in broadacre cropping systems.

The art of building networks

The team identified issues to work on by talking with growers, agribusiness and others involved in regional research, development and extension, and the Western Region GRDC Grower Networks. This enabled participants to develop an awareness of current and recently completed research in WA and nationally. Sometimes the team connected researchers to the local issue – while at other times they established and undertook field-based activities to address the local nuances of an issue.

The opportunity to build such broad networks significantly increased the team's understanding of how single farming issues fit within the entire farming system. The networking also enabled participants to gather essential industry intelligence and develop communication skills.

Addressing local R&D issues

Team members identified local priority issues by working with local growers, grower groups, agribusiness and researchers.

Some of the resultant activities were:

- crop protection trials on root diseases, crown rot, nematodes, sclerotinia, net blotch and snails
- surveillance for weeds, insects and diseases
- management of emerging problem weeds, such as matricaria
- monitoring the effect of integrated weed management on ryegrass populations
- reviewing and testing a suite of decision-support tools for crop protection
- conducting trials and activities to investigate the benefits of including legumes in crop rotations
- assessing the benefits of soil amelioration practices on soil productivity issues in small plot trials and on-farm demonstrations.

The team developed, delivered and/or facilitated more than 1000 local R&D adoption activities while tackling the different issues they had identified and prioritised. Over the five-year project, participants carried out trials and demonstrations, ran workshops, surveyed growers and industry, wrote articles and posted research outcomes on social media.

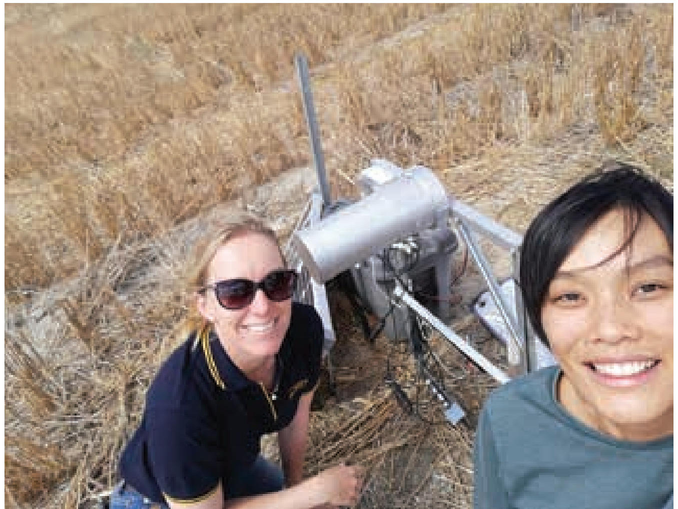
Pest and disease surveillance: With the team of agronomists dispersed across the regions, capacity to undertake pest and disease surveillance was significantly increased. The team made more than 500 reports about pests and diseases over the course of the project, including collection of samples for resistance testing and area freedom surveillance for exotic pests and diseases.

LEFT: Early-career agronomist Joel Johnstone sweeps canola for insect pests.

ABOVE: Participant agronomist Bonnie Jupp inspects weed seeds in chaff lines following harvest at Yuna in the northern grainbelt of Western Australia.

Weed management: The agronomy team investigated harvest weed seed management in the Geraldton and Albany port zones where trials were established to assess the efficacy of control methods.

Farming Systems



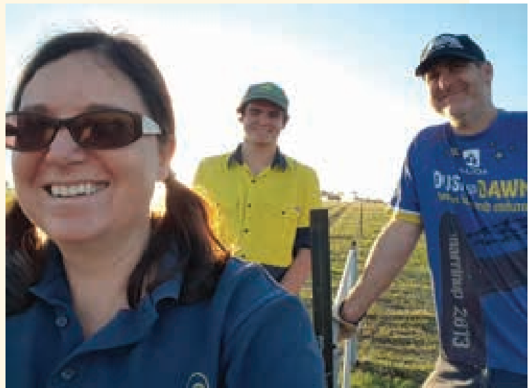
ABOVE: Project agronomist and participant, Andrea Carmody, and King Yin Lui from the grower group SEPWA, inspect a camera monitoring for snails near Esperance.

Secret life of snails: The regional agronomy project carried out snail monitoring using time-lapse cameras to correlate snail activity and lifecycles to local weather conditions. The research added value to projects being carried out by DPIRD research scientist Svetlana Micic, Stirlings to Coast Farmers and SEPWA. The agronomy team's participation increased the number of monitoring sites to five, which were monitored over two years and resulted in improved timing and efficacy of bait application. The data were also used to investigate the behaviour of other pests, in particular slaters and vegetable beetles.

> ***The project provided me with the opportunity to conduct applied research and extension activities at a local level. I have a much broader knowledge of farming systems and decision-making on-farm.***
>
> KING YIN LUI

> ***During my time in the project I gained an understanding of farming systems as a whole, and the day-to-day, season-to-season issues and constraints that WA growers face. This has made me a more rounded agricultural scientist and has led to more opportunities within the industry than were open to me previously.***
>
> BEC SWIFT

Underground menace: The agronomy team carried out an extensive root disease survey across the eastern grainbelt in the Kwinana East port zone. More than 130 soil samples from 128 paddocks were sent for analysis, with root diseases found in up to 80 per cent of samples. The results were used to generate maps identifying areas at high risk of root disease.



ABOVE: Project participant Bec Swift (right) presents results from a trial investigating the influence of different legume species on the incidence of root diseases and nematodes in following cereal crops.

Early-career scientists investigate an on-farm lime pit.

Digging holes: Project participants investigated the management of soil constraints such as acidity, compaction and non-wetting across the grainbelt while also testing DPIRD-developed decision-support tools aimed at prioritising soil constraint action and assessing the potential benefit of liming on soil pH. In the Kwinana East port zone, the team investigated the value of using on-farm lime sources through a series of small plot trials, large-scale demonstrations, field days, decision-support tools and workshops. Many positive interactions and connections were developed with farmers and grower groups. Results from the trials and feedback from the workshops were incorporated into DPIRD's iLime app.

Project participants and DPIRD staff being shown how to identify the level of frost damage in wheat with DPIRD frost researcher Dr Ben Biddulph (top right).

Is there grain in there?: On average, every second year frosts are significant enough to wipe out tens of millions of dollars worth of Western Australian crops. Trial site visits and working alongside experienced researchers was an important part of the training program – enabling early career participants to develop research networks and a wide base of skills.

> *I think the most valuable thing from my time in the project is that I was exposed to the whole farming system (soils, agronomy, pathology). This helped me as I moved into a research scientist role, as I have a greater understanding and appreciation of the different facets of the system rather than focusing only on the one thing I am researching.*

STACEY HANSCH

> *It consolidated the skills that I had learnt at SEPWA* while also giving me a really good foundation for undertaking and communicating quality research.*

ALICE BUTLER

*SEPWA: South East Premium Wheat Growers Association

Project participants toured the Dowerin Machinery Field Days led by DPIRD research scientist and engineer Glen Riethmuller (far left) to investigate machinery innovations. Project manager Vanessa Stewart is second from left.

Meeting the machines: Entering a new industry requires becoming familiar with specific terms and operations. Project participants appreciated being guided through the function and purpose of a range of machinery for operations such as deep ripping, spading, two-way ploughing and harvest weed seed management. The benefits of several of these operations were investigated in trials and demonstrations undertaken by the team.

Disease identification: DPIRD screens thousands of new and emerging crop varieties for disease each year to determine the resistance ratings of new varieties.

Team members learning about crop disease identification and screening with DPIRD senior research scientist Geoff Thomas at the South Perth screening facility.

Crop agronomy: Project participants explored the effect of growing legumes and canola in rotation with cereals on the productivity of cereal crops at Grass Patch north of Esperance. Break crops such as canola and pulses can increase following cereal yields through disease and weed control and increased nitrogen availability.

RIGHT: Esperance-based project participants King Yin Lui and Emma Pearse carry out a seeding inspection in a break crop trial.

> *This is the best opportunity a learning agronomist can get. I hope that these positions will continue to be provided, so that others can have the same fantastic opportunity that I had.*
>
> ADRIAN ROSSI

Water-use efficiency: Water availability is the largest determinant of crop yield in dryland farming systems. Project participants learned about the influence of seasonal rainfall patterns and soil water-holding capacity on crop water use efficiency and profitability.

> *The most valuable part of being part of the project was being able to spend the time learning about the entire farming system and the drivers behind decision-making. This has allowed me to not only focus on the questions of my current research but to see where this research fits into the farming system as a whole.*
>
> KYLIE CHAMBERS

> *The project provided me with the opportunity to gain knowledge and skills related to broadacre agronomy. I built up connections through a work Twitter profile, met industry people through field days, workshops, and conferences, and gained a foundational knowledge of broadacre agronomy.*
>
> JOEL JOHNSTONE

Soil moisture monitoring: Merredin-based project participants Ashleigh Donnison and George Mwenda measure soil moisture

Forward planning made possible with real-time weather data

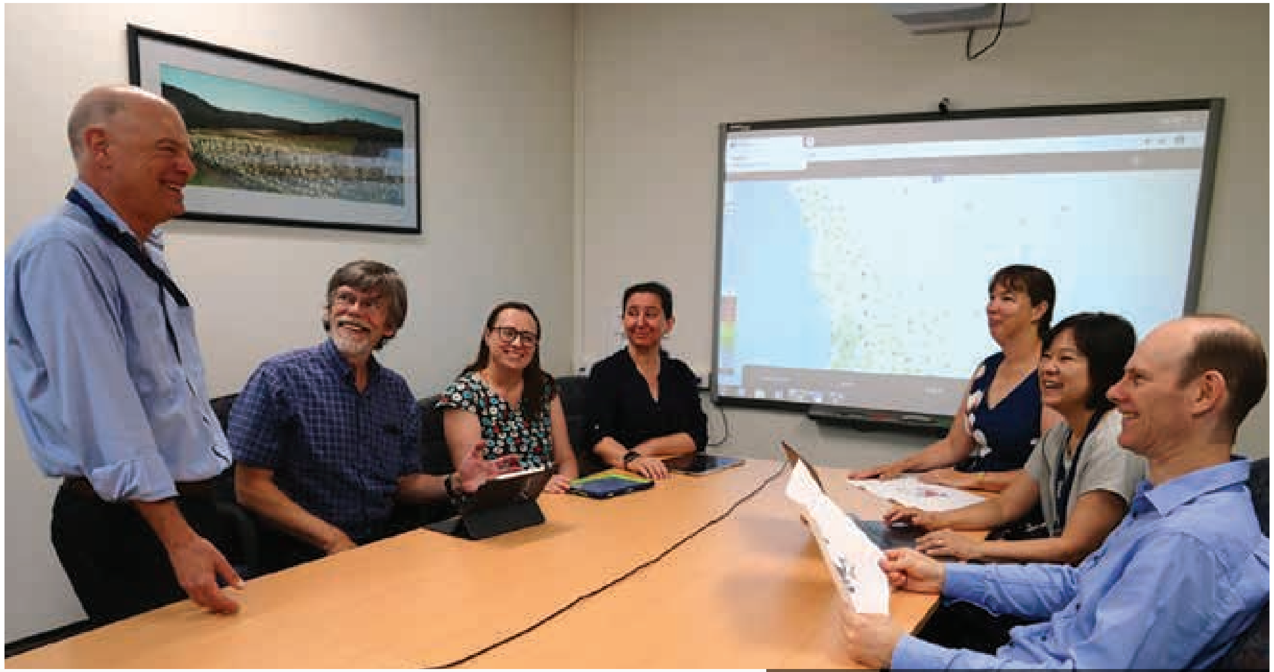
DPIRD maintains a network of more than 200 automatic weather stations across Western Australia and delivers real-time climate data in customised maps, seasonal forecasts and farm management apps for the agricultural industry.

THE CLIMATE DATA is used by a wide range of organisations and individuals – from farmers and consultants making decisions about sowing times, fertiliser inputs and spraying and harvest operations, through to the horticulture industry and local shires for irrigation scheduling, and the Bureau of Meteorology (BOM) and the fire and emergency services for bushfire and flood predictions, warnings and control.

Other users of the weather data include Western Power for wind farm location, lawyers involved in cases of chemical spray damage, architects for house design parameters and engineering consultants for construction of power lines in windy areas.

The weather stations are spread across WA from Kununurra in the north to Esperance in the south. The stations collect real-time information, which is then sent to a central computer for display on the DPIRD website. The data also feeds into BOM and supplements rainfall estimates coming from BOM radar stations over south-west WA.

DPIRD's systems modelling team integrates the weather information into computer models and decision-support tools used by researchers, consultants, farmers and policy makers to predict and respond to disease outbreaks, pest movements and extreme weather events such as frost, drought and floods (Figures 27–30).



DPIRD's crop and climate modelling team collates real-time data from more than 200 weather stations located across Western Australia. The information is available via the DPIRD website and is also integrated into maps, seasonal forecasts and a range of agricultural decision-support tools.

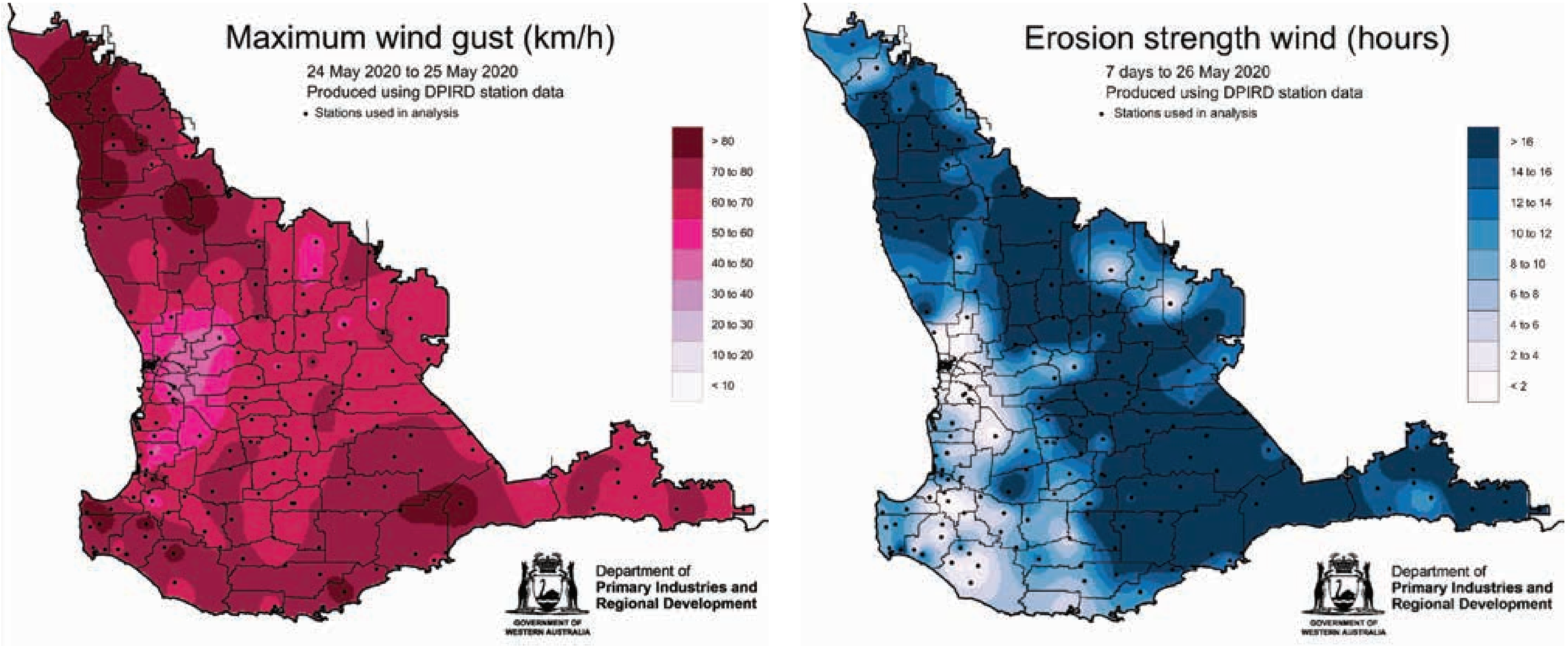


FIGURE 27. Following a once-in-a-decade storm across south-west WA in May 2020, DPIRD's modelling team generated custom maps to inform the Minister for Agriculture and the Commissioner of Soil and Land Conservation of the erosion potential of the high winds. Most of WA experienced more than 16 hours of winds over the wind erosion threshold of 28km/hr. Areas in the northern agricultural region and along the south coast received wind gusts of more than 80km/hr and many farmers lost crops and topsoil.

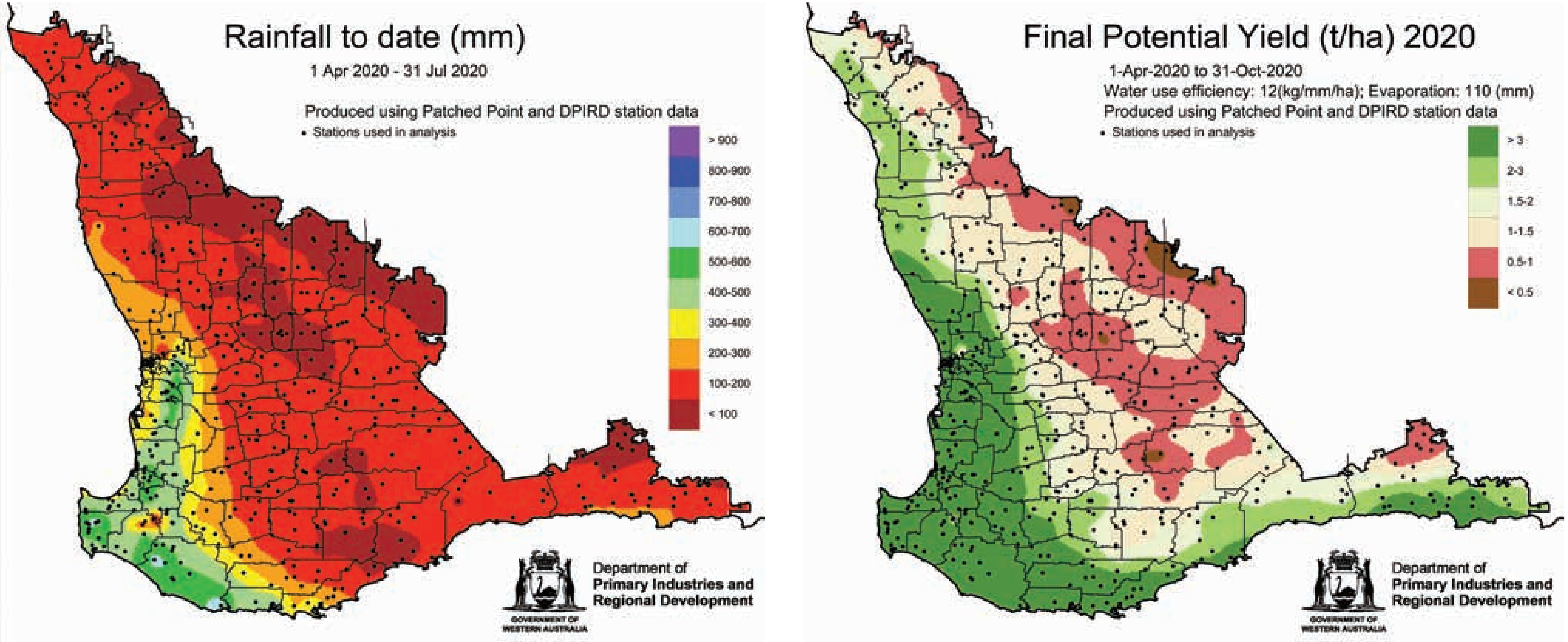


FIGURE 28. Rainfall-to-date maps (left) are generated each week during the growing season and agricultural zones are rated on how the seasonal rainfall is tracking compared to long-term historical averages. The rainfall and soil moisture data are integrated into potential yield maps (right) so that farmers and consultants can estimate how much yield is possible in a particular season and the amount of nitrogen fertiliser required to match the yield prediction.

DPIRD development officer Kelly Ryan (left) and research scientist Dr Meredith Guthrie (right) who helped develop the extreme weather tool.

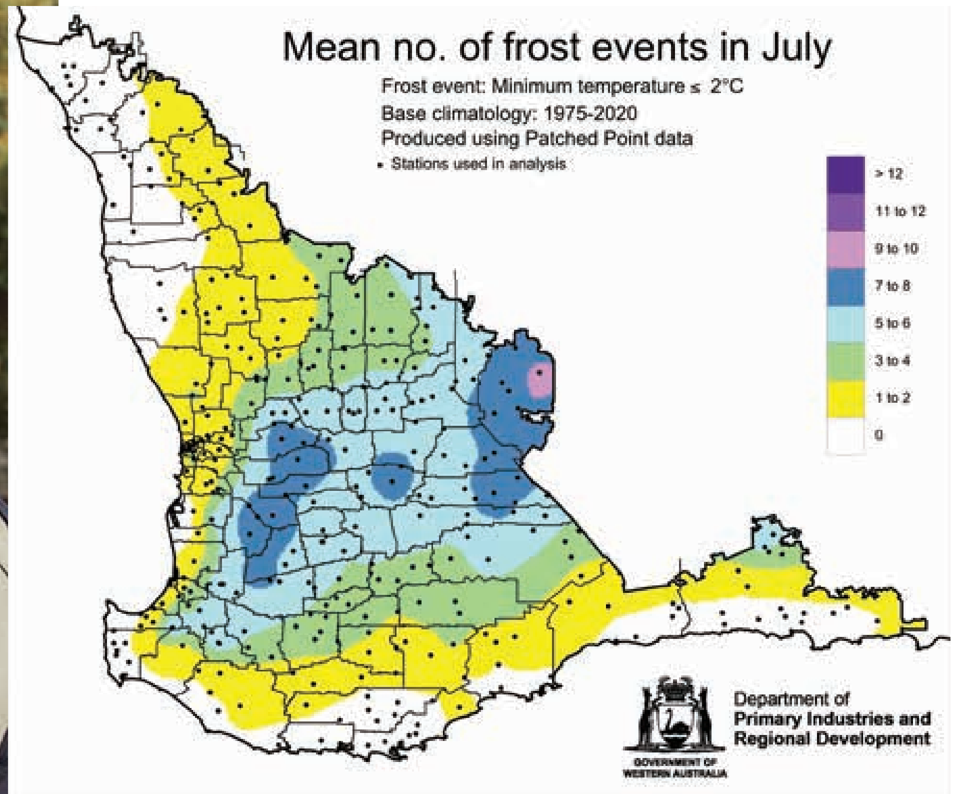


FIGURE 29. Data collected from DPIRD-managed weather stations is used to generate extreme weather maps and tables via an online Extreme Weather tool that calculates how long sub-zero or high temperatures have occurred in a particular area. The information can be used to indicate the severity of frost and heat damage on farms and identify areas requiring crop monitoring. The maps are also used to inform government responses to extreme weather events. The tool is easy to use and can be applied immediately or days or weeks after an event.

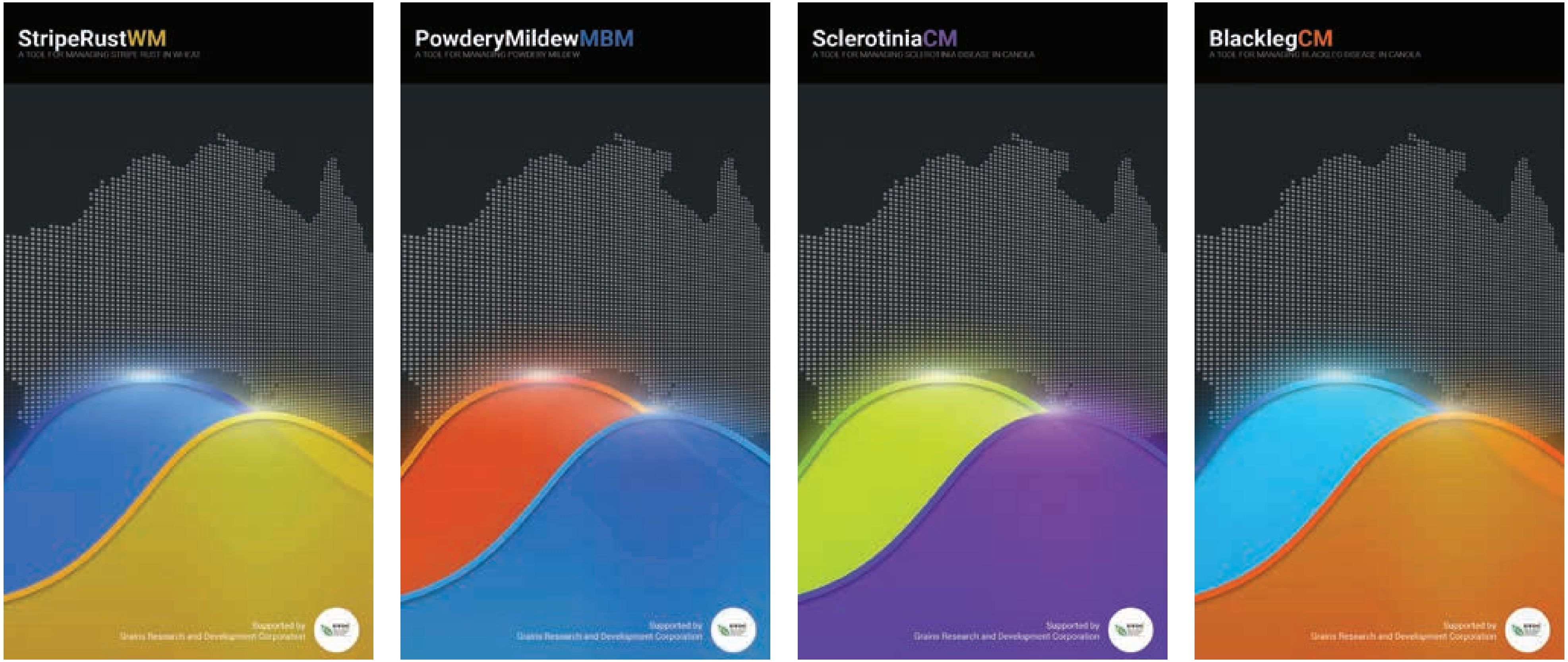


FIGURE 30. Weather data collected across WA is integrated into online disease management tools that enable farmers, researchers and consultants to monitor the likelihood of disease incidence throughout the season. Stripe rust, powdery mildew, sclerotinia and blackleg are all crop fungal diseases that can collectively cost Australian farmers hundreds of millions of dollars in lost yield each year. The fungal lifecycles are controlled by the weather and each of the apps above uses decades of research trial data to model how each fungus will behave in response to local climatic conditions and the disease rating of the crop being grown. The apps forecast the likelihood that the disease will become a problem and provides information on the likely economic returns from fungicide decisions on a paddock-by-paddock basis.