

NSW DPI Long-term Science Strategy

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More information

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CONTENTS

Preface	2
Foreword	3
Primary industries overview	4
NSW Department of Primary Industries	4
Primary industries in NSW	4
Primary industries science and research	5
Benefits of primary industries science and research	5
Rationale for NSW Government co-investment with industry and other partners in	
science and research	6
Context	6
NSW DPI LONG-TERM SCIENCE STRATEGY	9
The pillars of NSW DPI's Long-term Science Strategy	9
PILLAR 1: Anticipate the future	10
PILLAR 2: Link to transformative new technologies	11
PILLAR 3: Work across disciplines, collaboratively, and internationally	13
PILLAR 4: Invest in people	14
PILLAR 5: Translate information into knowledge and practical outcomes	15



DEPUTY DIRECTOR GENERAL, RESEARCH EXCELLENCE, NSW DPI



Dr John Tracey Deputy Director General, Research Excellence, NSW DPI

As the Deputy Director General, Research Excellence, for the NSW Department of Primary Industries, I have the privilege of working with the primary industries of NSW - a critical sector not only for regional and rural communities but also for the broader NSW economy; and consumers and users of our products.

The NSW Government is committed to seeing the farmers, foresters and fishers of NSW remain among the most productive and innovative in the world and that the future potential of the sector is fulfilled.

To do this the sector requires access to world-class science that is focused on solving real-world problems and is informed by the best research globally.

This Strategy focuses on ensuring that this science and knowledge is available into the future. It will boost our worldleading primary industries, drive innovation and assist in meeting future challenges.

I am confident that this Strategy will leave a lasting legacy by guiding and directing the Department's science and research now and into the future.

FOREWORD

NSW DPI CHIEF SCIENTIST



Dr Philip Wright Chief Scientist, NSW DPI

The NSW Department of Primary Industries (NSW DPI) and its predecessor organisations have a long and proud history of undertaking high-impact research. NSW DPI's unique science and research capability continues to solve significant problems for primary industries in NSW and enables the Department to carry out its functions and achieve its goals.

The science that NSW DPI undertakes is critical to the continued prosperity of the primary industries of NSW.

We are in an era of rapid and transformative change in science and technology. This includes advances in gene technology, nanotechnology, robotics, big data and machine learning, to name a few, each of which are likely to have significant impact on primary industries.

The international and national research environment is also undergoing significant change with trends towards fewer specialised international institutions and the substantial rise in collaborative and cross-disciplinary research.

This Long-term Science Strategy is designed to provide guidance over the next 20 years as to how we can ensure that NSW DPI and the industries and communities that we serve flourish and are well placed to meet future challenges.

This Strategy outlines principles that NSW DPI can adopt to ensure that we have a fit-for-purpose research and development system for the long term and that NSW DPI is well placed to meet future challenges. This will ensure that NSW DPI continues to deliver critical outcomes for government, community and industry over the long term and drive improvements in how this is done.

PRIMARY INDUSTRIES OVERVIEW

NSW Department of Primary Industries

NSW Department of Primary Industries (NSW DPI) has a key role to play in driving economic growth and increasing the value of primary industries in NSW. To achieve this, NSW DPI manages a broad portfolio of research and development focused on productivity, biosecurity, food safety and natural resource management. In addition, science is used across the organisation to ensure an evidence-based approach to key policy issues.

To drive economic growth across primary industries, NSW DPI is focused on innovation that boosts productivity, improves resilience and promotes sustainable use and access to natural resources; and provides tools and approaches to mitigate and manage risks to the community and industry. The applied focus of the Department's research has resulted in a strong track record of achieving real change in the field, with key innovations adopted by industry and resource managers. The close interaction with industry and stakeholders enables NSW DPI to be focused and agile in responding to emerging challenges and issues.

The benefits of primary industries research often flow over many years and the science may take a decade or more to fully deliver industry practice change. Practice changes that are happening now largely reflect the scientific break-throughs of the past and the long-term investment by NSW DPI.

This Strategy provides principles that will guide NSW DPI in developing and delivering the new science to build productive and resilient systems over the next 20 years.



Primary industries in NSW

Primary industries play an important role in the NSW economy. In addition to providing food and fibre for our citizens, the sector through its production creates employment, generates exports and makes a significant contribution to the Gross Value of Production (GVP). For example, in 2017 the GVP for the agriculture, fisheries and forestry sectors in NSW was \$15.44 billion¹, a substantial increase from a GVP of \$11.8 billion in 2013-14².

The sector also has a wider impact on the economy and generates additional production value for NSW. This is because primary industries require goods and services from suppliers and primary industries outputs, such as grains and beef, which are key inputs to a wide range of downstream industries, including food processing. Industries such as road and rail transport and shipping, as well as storage and handling, are all beneficiaries of the activity generated by NSW primary industries. It has been estimated that the 'extended' GVP generated by NSW primary industries in 2013-14 was approximately \$25.9 billion³.

The Australian Bureau of Statistics 2011 census indicated that 69,434 people were employed in primary industries in NSW. This represents 3.2% of total NSW employment and importantly more than 11% of regional employment. The 'extended' employment figure (including suppliers and downstream industries) is larger at about 129,000 employees, representing about 19% of regional employment.

Those involved in the primary industries sector also play a crucial role in managing the State's natural resources with more than 70% of the State's land surface managed by producers and a significant portion of the State's aquatic and marine environments influenced by primary industries. In fact, the State's primary industries are heavily reliant on maintenance of high quality soil and water resources.

^{1.} Department of Primary Industries 2017. NSW Primary Industries Performance, Data and Insights 2017

^{2.} Department of Industry 2016. The Contribution of Primary Industries to the NSW Economy – Key Data 2016

^{3.} Department of Industry 2016. The Contribution of Primary Industries to the NSW Economy – Key Data 2016

Science and research are key contributors to productivity growth and sustainability in the primary industries and natural resource management sectors; and therefore in maintaining the fabric of NSW and Australia's regional and rural communities.

Primary industries science and research

In this document, the term 'science' is used to refer to the broad application of evidence and knowledge derived from experimentation and observation and 'research' is used to refer to original investigation undertaken in order to acquire new knowledge. NSW DPI draws on a broad range of sciences encompassing more than 50 different disciplines from agronomy, horticulture, hydrology, biology and ecology through to molecular genetics, mathematics and social science.

Gains in productivity have been a driving force for growth in primary production across the world and Australian science and research has played a key role in driving productivity gains in Australian primary industries. Whilst most primary industries research occurs outside NSW and Australia, local research and development is essential as, unlike medical or mechanical innovations that are almost equally applicable worldwide, international primary industries innovations need to be adapted to local conditions. For example, most primary industry technologies are sensitive to local climate, soil and water conditions and other biophysical attributes, making them less easily transferable.

A skilled domestic science and research capability is essential not only to develop local innovations but also to adapt overseas research and to trade in ideas within the international market place. Science and research are undertaken in NSW and Australia to provide an evidence base for policy, establish the local relevance of international innovations; and to drive the uptake of knowledge required to underpin improvements in productivity and sustainability.

Benefits of primary industries science and research

The benefits from primary industries research and development are substantial and include higher productivity and competitiveness, improved environmental outcomes; and improved social outcomes⁴. The reported rate-of-return on primary industries research investments is high, with the Productivity Commission⁵ estimating returns of between 48 and 68 percent across all areas. These high rates of return are confirmed by a wide range of studies, including a metaanalysis of more than 1800 published rate-ofreturn estimates, which showed a median value of 48 percent per year⁶.

"There is little doubt that the overall payoff for both producers and the community from past investments has been significant".

Productivity Commission 2011, Inquiry Report No 52 – Rural Research and Development Corporations



- Productivity Commission (2011). Rural Research and Development Corporations, Report No. 52, Final Inquiry Report, Canberra.
- 5. Productivity Commission (2007), Public Support for Science and Innovation, Research Report, Canberra.
- Alston J, Chan-Kang C, Marra M, Pardey P, and Wyatt T. (2000).
 A Meta-Analysis of Rate of Return to Agricultural R&D: Ex Pede Herculem. International Food Policy Research Institute, Washington

Rationale for NSW Government coinvestment with industry and other partners in science and research

It is widely recognised that research has a significant role in driving productivity growth, lifting living standards and improving the quality of life. It is also an important factor in enabling economies to adapt to shocks and future uncertainties. As a result, research and broader innovation policy is increasingly seen as a central aspect of economic policy⁷.

There are several important rationales for NSW government co-investment, in primary industries science and research, through NSW DPI in collaboration with industry and other partners, including to:

- address spill-over effects the large number of small geographically-dispersed individual producers who do not have the capacity or incentive to engage in substantial research activity. This is exacerbated by the high degree of uncertainty involved in primary production (e.g. climate, price, biosecurity threats, etc...). In the absence of government co-investment, underinvestment by industry in primary industries science and research would be likely.
- **manage public resources** such as the State's fisheries.
- address other forms of market failure reducing negative externalities from the use of the resource base.
- achieve policy support providing the NSW government with information in order to frame policy which is effective and does not produce perverse outcomes.
- provide 'absorption capacity' through a domestic research system and highly skilled scientific workforce to enable the implementation of innovations made by others globally.
- provide an additional or alternative tool to economic, environmental or social policy.

Context

Primary industries and the NSW community face a rapidly changing, interconnected and interdependent world that is fiercely competitive, full of uncertainty and contains major challenges including: plateauing productivity; emerging biosecurity threats; uncertain energy, water and food security; climate change; and, habitat decline. These challenges are occurring in an environment of increasing pressure on government expenditure. The scale of these challenges necessitates a strategic focus on research.

There is compelling evidence that research to date has driven enormous progress in primary industries and offers NSW and Australia one of the most effective means of addressing these challenging issues into the future. The NSW DPI's science capability and track record is unique and highly regarded; and has served NSW well.

NSW DPI is a significant contributor to the national primary industries innovation system and broader Australian innovation system. The work of NSW DPI is deliberately coordinated with that of other Australian jurisdictions, universities and rural research and development corporations with agreed areas of leadership and support nationally.

NSW DPI's work is aligned with the National Rural Research Priorities and the broader National Science and Research Priorities. It also complements the National Collaborative Research Infrastructure Strategy (NCRIS) roadmap and the focus of the National Industry Growth Centres.

The links between this plan and the NSW DPI Strategic Plan 2015-2019, Divisional plans and the broader national primary industries innovation system are outlined in Figure 1.

To ensure the continued delivery of value, NSW DPI's current capability and its place in the large, complex, interconnected and diverse Australian primary industry research and development system will require ongoing adaptation. In a world where the future poses significant challenges and uncertainties, long-term strategic planning is critical.

Cutler & Company. (2008). Venturous Australia: building strength in innovation, Department of Innovation, Industry, Science and Research, Canberra.



Primary Industry Innovation

Figure 1. Long-term Science Strategy in context



NSW DPI Long-term Science Strategy

8

NSW DPI LONG-TERM SCIENCE STRATEGY

The pillars of NSW DPI's Long-term Science Strategy

NSW DPI's Long-term Science Strategy is based on five key pillars





PILLAR 1: Anticipate the future

Trying to predict the future is fraught with difficulty. However, for NSW DPI research to be best placed to meet future challenges, insight into emerging and intensifying trends and issues is important. It is useful to consider the social, economic and environmental megatrends identified by CSIRO, which are anticipated to have a major impact on Australia over the next 20 years⁸.

These megatrends are likely to have significant implications for primary industries. For example, an increased need for more efficient use of mineral, water, energy and food resources is likely because of escalating demand and constrained supply. This will increase the need for efficiency and will put pressure on resources and ecosystems, on which production systems depend and may intensify resource use conflict. There will also be an increased need to conserve the environment and protect threatened species, which is a key driver in the establishment of Marine Parks.

CSIRO and the Rural Industries Research and Development Corporation (RIRDC) undertook further analysis of these trends and identified five megatrends for primary industries, including⁹:

- **a hungrier world** population growth will drive demand for food and fibre;
- a wealthier world a new middle-income class will increase food consumption, diversify diets and eat more protein, and at the same time have increased expectations of environmental stewardship and amenity;
- choosy customers information empowered consumers of the future will have expectations for health, provenance, environmental sustainability and ethics (animal, environmental, genetic etc...);
- transformative technologies advances in digital technology including the way data are collected and analysed, genetic science and synthetics will change the way food and fibre are made and transported; and,
- **a bumpier ride** globalisation, climate change and environmental change will reshape the risk profile for primary industries.

There are also significant long-term trends emerging in science, including¹⁰:

- the century of biology¹¹ the impact of advances particularly in genetics is expected to see biology having the largest research intensity and delivering the greatest economic value across the century;
- the rise of data science the enormous volume of data now available to science and society will continue to increase and dataintensive science will be a major feature of science over the next 20 years;
- more collaborative and cross-disciplinary approaches – the intensifying challenges we face display an increasing complexity and the interconnectedness of human and natural systems. Such complex challenges typically require cross-disciplinary approaches and the science and research required to solve these problems is beyond any one institution;
- **intensifying competition for talent** increasing mobility including international mobility has seen researchers moving to work with the best teams and infrastructure available; and,
- erosion of community trust in science increasing doubt about expert judgement and scepticism of traditional authority. Discussing science and research application will no longer be confined to scientists and policy makers.

There is a clear sense that the rate of change is accelerating with no sign of abating. To continue to deliver value, NSW DPI will require a high degree of nimbleness, harnessing the insights of NSW DPI researchers, and fit-for-purpose portfolio management, to ensure near- and long-term benefit.

Hajkowicz SA, Cook H, Littleboy A. 2012. Our Future World: Global megatrends that will change the way we live. The 2012 Revision. CSIRO, Australia.

Hajkowicz SA, Eady S. 2015. Rural Industry Futures: megatrends impacting Australian agriculture over the coming twenty years
 Group of Eight Australia. 2014. The Changing Environment for

Australian University Research

^{11.} K Kelly 2006. Speculations on the Future of Science. The Edge

NSW DPI will ensure the effective allocation of resources between applied and fundamental research into the future. As an agency with a clear mission to drive economic growth, increase the value of primary industries in NSW and ensure long-term resource sustainability, NSW DPI will continue to focus on applied problem-solving research.

NSW DPI will invest in some fundamental research with a clear focus on linking to the investments of others, both internationally and nationally, to bring forward applications and benefits to primary industries (see Pillar 2).

PRINCIPLES:

- NSW DPI's research portfolio focuses on the long-term drivers of change (megatrends);
- NSW DPI's research portfolio focuses on applied research to achieve clear practical aims and objectives, but includes investments in fundamental research through strategic partnerships; and,
- NSW DPI harnesses the insights of both its researchers and its links to industry and stakeholders to nimbly respond to emerging issues.



PILLAR 2: Link to transformative new technologies

The pace of development in science and technology is rapid and new branches of science are appearing with increasing regularity. Whilst we cannot predict all of the new technologies that will become available in the next two decades we do have some insights into technologies that will have a transformative effect on biology and primary industries.

NSW DPI has identified advances in gene technology such as synthetic biology, gene editing, epigenetics, environmental DNA (eDNA), rapid complete genome sequencing and analysis, speedy bar coding and gene drive as key technologies.

It is estimated that about half of the one to three percent annual increase in productivity in crops¹² and livestock¹³ to date has been driven by enhanced genetics. It is conservatively estimated that rates of genetic gain will be more than doubled by the new emerging genetic technologies. Advances in big data, machine learning, the Internet of Things and robotics will have significant impacts as will nanotechnology and the development of novel sensors including biosensors.



"Advances in technology within the fields of digital, genetics and materials science will change the way food and fibre products are created and transported. Genetic technology will allow crop and pasture yields to improve and become more resistant to weeds, pests and climate risks. Advanced sensory systems and data analytics will permit advanced and highly integrated farm- to-fork supply chains. Customers will be able to readily trace food and fibre products from their origins, and supermarkets will have increased tools for quality assurance."

Rural Industry Futures: megatrends impacting Australian agriculture over the coming twenty years

^{12.} Evenson RE and Gollin D. 2003 - Crop variety improvement and its effect on productivity – FAO

Thornton PK. 2010. Livestock production: recent trends, future prospects – Phil. Trans. Royal Soc. B.

NSW DPI will form strategic research partnerships to ensure that these technologies are pulled towards applications relevant to NSW primary industries as soon as possible, accelerating the delivery of benefits. Evaluating new technologies and their effectiveness in addressing issues faced by primary industries will be an important part of NSW DPI's work. The increasing volumes of data and the need to derive knowledge and insight from these will also impact upon all aspects of NSW DPI's activities.

"A nation that fails to make its contribution to ground breaking research will also become marginalised in terms of coming up with new ways of bringing about a sustainable society in the longer term".

Royal Swedish Academy of Sciences 2012. Fostering breakthrough research: A comparative study. Stockholm

The increasing rate of science and technological advancement and the knowledge externally generated, including by international institutions, increases the need for NSW DPI to maintain a broad, flexible and networked science capability that acts as 'absorption capacity'¹⁴ to acquire new science advances and focus them on primary industry applications.

Some new transformative technologies, such as nanotechnology and robotics, are derived from science areas outside NSW DPI's current core biosciences capability. NSW DPI will maintain its core bioscience capability as an ongoing driver of productivity in primary industries and seek to strategically link and partner with others where capability is required outside biosciences or broad enabling sciences such as informatics and data science. This will include partnerships, commissioning of research and the use of shortterm post-doctoral appointments.

Camison and Fores 2010 – Knowledge absorptive capacity; new insights for its conceptualization and measurement. Journal of Business Research 63, 707 -715

PRINCIPLES:

- NSW DPI builds sound knowledge, skills and capability where required in emerging transformative technologies;
- NSW DPI forms strategic research partnerships with leading research groups in key areas; and,
- NSW DPI maintains a broad, flexible, highlynetworked bioscience capacity.

Key transformative new technologies

NSW DPI has identified the emerging and transformative technologies we need to effectively link with and influence appropriate regulatory controls. In priority order, they are:

1. Advanced genetic technologies

Beyond the 'omics' and routine bioinformatics to gene editing and gene drives, epigenetics, synthetic biology, RNA interference, apomixis, and gene regulatory networks

2. Big data

The analysis and reuse of complex multiformat and large data sets, data mining, machine learning, Big Learning, populationscale high throughput genomics and 'personalised agriculture'.

3. Robotics and artificial intelligence

Following on from basic agbots comes precision agriculture, the Internet of Things, drones, sensors, collaborative robots ('cobots') and robotic swarms.

4. Nanotechnology

Application of nanomaterials for disease detection and management, crop protection, smart delivery of active ingredients, plant and animal nutrition, nutrient management, filtration and desalination.

The recently released Australian Academy of Science "Grow. Make.Prosper: the decadal plan for Australian Agricultural Sciences 2017-26" identifies a very similar list.

PILLAR 3: Work across disciplines, collaboratively, and internationally

Primary industries in NSW face significant challenges including population-driven demands for increased productivity, resource scarcity, emerging and re-emerging biosecurity threats, climate change and loss of biodiversity. These challenges are complex and often interconnected. They increasingly require crossdisciplinary problem solving not only locally but also at a national and international scale.

There is emerging evidence that research is increasingly being driven by international collaborations between elite research groups. This may result in global research being increasingly isolated from the industries in which the research technologies may be applied. NSW DPI is in a unique position of being close to industry users of technologies and providing an interface between research providers and industry.

The drivers for increased collaboration and cross-discipline research in the natural resource management area, for example, will see NSW DPI increase its linkages to NSW agencies such as the Office of Environment and Heritage, the Environment Protection Agency, and Local Land Services; as well as to Commonwealth agencies and institutions in other jurisdictions.

Economies built on deep technical knowledge are more agile and betterplaced for the structural change necessitated by geopolitical realignment and the move to sustainable development. New sources of technology must be prospected and tapped, placing great expectations on the whole STEM enterprise."

Office of the Chief Scientist (2013) 'Science, Technology, Engineering and Mathematics in the National Interest: A Strategic Approach", Australian Government, Canberra

Citizen science is likely to increase in the future and NSW DPI will engage with citizen science initiatives to ensure that design of those programs is robust, in turn enhancing NSW DPI's capacity to collect high-quality data. For example, the citizen science initiative Redmap (the Range Extension Database Mapping Project) encourages fishers, divers, snorkellers and beachcombers who see any marine species new to a neighbourhood to post an image and description online using an app, website or Facebook page. This project has made small but influential data contributions to a number of peer-reviewed publications and has been instrumental in developing a strong understanding of species and ecosystem changes occurring in one of the fastest-warming regions of the southern hemisphere.

"Institutions that do not form international collaborations risk progressive disenfranchisement."

Adams 2013 Nature

PRINCIPLES:

- NSW DPI coordinates its approach to scientific partnerships and national and international collaboration with deliberate links to elite institutions;
- NSW DPI harnesses citizen science initiatives where appropriate to enhance the acquisition of new information; and,
- NSW DPI adopts a cross-disciplinary approach to solving major problems.





In a world where certainty about the future is decreasing, an organisation's people are the most important asset. High-quality staff with the right skills and capabilities will enable NSW DPI to continue to deliver outcomes for the community and industry; and prepare for an uncertain future. Science and research is an intensely human endeavour that relies heavily upon creativity and adaptability.

"Preparing to face national challenges requires a strategic approach to building a capacity to respond effectively and to sustaining that capacity."

Office of the Chief Scientist

A key plank to NSW DPI's Long-term Science Strategy is to have the right people with the right skills and capabilities. NSW DPI will need to continue to value and grow its staff. It takes time for NSW DPI's mostly regionally-located applied research scientists to develop both their discipline skills in the field and the deep industry knowledge that uniquely characterise NSW DPI's capability. Likewise, it is necessary to grow core science staff in laboratory settings to support critical functions such as biosecurity research and diagnostics. Areas that tend to be more focused on linking to external transformative technologies (see Pillar 2) and are higher risk and speculative, are more likely to be characterised by temporary appointments such as postdoctoral appointments. NSW DPI will need to balance the need to develop deep skills and capability within some areas, with an ability to rapidly respond to critical and emerging issues based on the demands of industry, policy makers and resource managers.

NSW DPI's people provide a key source of insight and wisdom into current and emerging systems, technologies and issues; and of novel approaches to key challenges. Our scientists have considerable knowledge about where research can deliver the highest return for NSW. This knowledge will be used to guide decisionmaking and respond to new opportunities.

PRINCIPLES:

- NSW DPI builds, maintains, benchmarks and measures science excellence;
- NSW DPI continually assesses, attracts and retains skills and capability to respond to future needs; and,
- NSW DPI exposes its scientists to broader national and international perspectives and different approaches to collaboration.

"Having a good mentor in one's career can mean the difference between success and failure in any career."

Nature's guide for mentors







PILLAR 5: Translate information into knowledge and practical outcomes

NSW DPI has played a leading role in assisting government, industry and the community to make decisions by integrating information from data into genuine change on the ground. Major successes, such as the development of minimum tillage and integrated pest management, have depended on the capability of NSW DPI scientists to synthesise a broad range of information, place their findings in relevant contexts (such as farming systems and ecosystems) and provide practical solutions about the application of new technologies in the field. NSW DPI's science and research capabilities also play a leading role in policy development, for example supporting evidence-based regulation of the State's fisheries.

NSW DPI will increase its focus within the research portfolio on the next user and the end user. NSW DPI works with a wide range of partners including NSW Local Land Services (LLS), to deliver practical outcomes. LLS works directly with local communities to achieve: resilient, self-reliant and prepared local communities; biosecure, profitable, productive and sustainable primary industries; and, healthy, diverse and connected natural environments.

The volume of data and information is rapidly growing in all areas of primary production resulting in inundation of end-users with information from which it is difficult to distil and apply knowledge. NSW DPI has a competitive advantage through the ability of its scientists to synthesise information across a wide range of disciplines. It will be important for NSW DPI to publish key reviews.

NSW DPI's strength lies in its scientists with expertise across an array of disciplines and their capacity to provide rigorous scientific support to practical decision-making. NSW DPI will increasingly need to act as a deliberate synthesiser of information.

PRINCIPLES:

- NSW DPI develops research projects and programs that will clearly articulate the pathway to adoption or commercialisation (e.g. end user, commercial partner, resource manager, policy maker);
- NSW DPI maintains appropriate data protocols and platforms to enable data reuse, develops an approach to synthesise data into knowledge and publishes key systematic reviews; and,
- NSW DPI takes a deliberate approach to communicating the implications of its science to the community and policy-makers.



16 | NSW DPI Long-term Science Strategy

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LIST OF FIGURES

Cover: iStock ©

Inside cover: Cropping trials at Wagga Wagga Agricultural Institute (credit: NSW DPI Image Library)

- Page 4: Ewan Leighton and Daryl Reardon checking cropping trials at Condobolin Agricultural Research and Advisory Station (credit: Deb Slinger)
- Page 5: Heath Folpp surveying fish in Botany Bay as part of the assessment of artificial reefs (credit: Michael Lowry)
- Page 7: Robert Gowing yard-weaning angus calves at Castlerock, west of Scone (credit: Todd Andrews)
- Page 8: Monitoring tree growth in Cumberland State Forest (credit: NSW DPI Image Library)
- Page 9: iStock ©; Shutterstock ©
- Page 11: Poppy crop in the Cowra Region (credit: Brendan Cooper)
- Page 13: Eucalypt seedling at Grafton Nursery (credit: NSW DPI Image Library)
- Page 14: BOTTOM LEFT: Tony Napier checking an irrigated canola trial crop at Leeton Field Station (credit: Bernadette York). BOTTOM RIGHT: Ashleigh Kilgannon undertaking meat research in the laboratory at The Centre for Red Meat and Sheep Development, Cowra [credit: Ben Holman]
- Page 15: Isabelle Thiebaud releasing a tagged Murray Cod on the Namoi River [credit: Tony Fowler]'
- Page 16: Diver unknown retrieving monitoring equipment from the Sydney Offshore Artificial Reef (credit: Andrew Boomer)

More information

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