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RURAL INDUSTRIES
Research & Development Corporation

Honey Bee and Pollination Program

Five Year Research, Development & Extension Plan
2014/15 - 2018/19



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May 2015

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Foreword

This Five Year Plan outlines the investments that will encompass the RIRDC Honey Bee and Pollination RD&E Program, which will be administered as one Program from 1 July 2014. Activities commissioned under the Honey Bee and Pollination RD&E Program will continue to be funded by the combined investments of Horticulture Innovation Australia Limited (HIA) and RIRDC.

Program RD&E Plans are a key part of implementing RIRDC's broader RD&E strategies, and are the basis on which RIRDC invests on behalf of industries.

These RD&E Plans identify productivity and sustainability RD&E priorities and the planned outcomes for each industry, and each has an appropriate balance of productivity and sustainability RD&E priorities.

RIRDC has three clear top-level strategies to increase profit and productivity in rural industries:

1. Undertake priority research development and extension which meets specific industry needs.
2. Facilitate investments which deliver economic, social and environmental benefits for rural industries and the broader community.
3. Adopt a life-cycle approach to investment in new, developing and established industries.

The profitability, productivity and sustainability of rural industries is RIRDC's core business, and the Corporation works with its portfolio industries to invest in their priority RD&E needs. RIRDC fosters strong relationships with industry partners, including the pollination industry, to ensure RD&E investment leads to practical knowledge and innovation which can be adopted by industry members.

In making its RD&E investments for new, developing and established industries, RIRDC takes a life-cycle approach. These investment decisions acknowledge the maturity and development of each of the industries within the RIRDC portfolio. Whilst managing a very diverse portfolio of new, developing and established small industry opportunities for Australia, the life-cycle approach assists RIRDC to make appropriate RD&E investments.

RIRDC will continue to work with the honey bee and pollination industries to ensure the industry's five year research priorities meet industry needs and are informed by government priorities. The adoption of RD&E outcomes is fundamental to success, and just as we have with this Honey Bee and Pollination Program Five-Year Plan, RIRDC will work with industry and government stakeholders to ensure the Corporation invests in knowledge that is useful and adopted by end users.

Craig Burns

Managing Director

Rural Industries Research and Development Corporation

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What is a Five Year Plan?

This Five Year Plan has been developed by RIRDC, in consultation with industry stakeholders, to outline the Honey Bee and Pollination industry's research, development and extension (RD&E) objectives until 2019. These objectives have been shaped by the goals and strategies of the RIRDC Corporate Plan 2012-2017, available on the RIRDC website, www.rirdc.gov.au/about-rirdc.

The Five Year Plan has been developed to accommodate the merger of the Honey Bee and Pollination Programs in June 2014. The Five Year Plan draws heavily on the Honey Bee RD&E Plan 2012-2017 and the review of the Pollination 5-Year R&D Plan 2009-2014. The Plan has been prepared in consultation with Horticulture Innovation Australia Limited (HIA), the Australian Honey Bee Industry Council (AHBIC), and members of the RIRDC Honey Bee Program Advisory Committee and Pollination Program Advisory Committee. These committees were superseded in mid-2015 by the Honey Bee and Pollination Advisory Panel, appointed by RIRDC. The draft Plan guided Program investment from July 2014, to allow for HIA to provide additional input before recommended to the Board. In April 2015 HIA advised that their industries that rely on honey bees for pollination recommended that no amendments to the draft Plan were required. The Chair of the Advisory Panel recommended the draft Plan to the May meeting of the RIRDC Board. The Board approved the Plan at their meeting in XXX.

In developing the Honey Bee and Pollination Program Five Year Plan, the Strategic Research Priorities and Rural Research Priorities have been considered. Also considered was the joint industry-government 'Statement of research and development priorities' (Appendix 1) of February 2014, for 'A honey bee industry and pollination continuity strategy should Varroa become established in Australia'.

The Program is a collaborative arrangement between RIRDC and HIA that allows coordinated consideration of RD&E proposals and investment in projects consistent with the Program objectives. The Program's Advisory Panel reviews funding applications (typically in October/November and March/April) and makes recommendations to RIRDC and HIA regarding investment. RIRDC and HIA typically manage projects separately, with project typically starting in July.

RIRDC's annual open call for proposals in August can be accessed by the Program. The Program can also procure projects through mechanisms.

HIA also has calls for proposals that are considered by the Advisory Panel.

The Honey Bee and Pollination program

Honey Bee and Pollination Industry profile

The Australian honey bee industry produces between 20,000 and 30,000 tonnes of honey annually. The estimated production in 2008 was 21,000 tonnes (Kneebone 2010). Other honey bee products include paid pollination services, beeswax production, queen bee and packaged bee sales. In 2014 the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) determined that the gross value of production (GVP) of the beekeeping industry in 2012-13 was \$88 million, with a forecasted GVP of \$92 million in 2013-14 (ABARES 2014).

The relatively small beekeeping industry GVP understates the industry's value to agriculture and the economy in general through pollination services (which are essential for some crops, while for others it raises yield and quality) and potentially, the value of honey and honey products in medical uses. Honey bee pollination provides significant worth to Australian horticulture and agriculture with services valued at \$1.7 billion per annum in 1999-2000 for the 35 most important honey bee dependent crops (Gordon and Davis 2003). When other crops, including pasture species such as Lucerne, canola and clover are also considered this estimate becomes even larger.

The main honey production period is from October to March and August to October is the major pollination season.

There are approximately 12,400 registered beekeepers in Australia with around 528,000 hives (AHBIC 2014). Some 102,000 hives are used for paid pollination and between 80,000 and 100,000 hives provide pollination services on a mutually beneficial basis (honey production). Over 70% of hives are operated by commercial beekeepers with more than 200 hives and most commercial apiarists operate between 400-800 hives but some have more than 3,000 hives. NSW is home to 33% of Australian apiarists, Queensland 31%, Victoria 15%, Western Australia 10%, South Australia 8% and Tasmania 3% (Rodriguez *et al* 2003).

Approximately 70% of Australian honey is produced from native flora. This requirement for native flora highlights the dependence of Australian beekeeping on public and private land. About half the accessible apiary sites in native forests are on private land and half on public land. Access to native flora on public land has declined over time. Beekeepers also often rely on access to native flora on public land to ensure hives are in good condition to provide pollination services to horticultural and agricultural industries.

Exports of Australian honey averaged 4,630 tonnes per year of the three years to March 2014. The top five export destinations for Australian honey in the 2013 financial year were Singapore, Malaysia, UAE, China and Hong Kong. For the first three quarters of the 2014 financial year the top five (5) are UK, Singapore, China, Hong Kong and Malaysia. Imports of honey to Australia averaged 3,170 tonnes per year of the three years to March 2014 (AHBIC 2014).

The drought in Australia throughout the 2000s coincided with high international honey prices, resulting in substantial increases in wholesale prices in Australia. While prices subsequently declined, farm gate prices increased significantly in 2014 (AHBIC 2014). Consumption of honey has followed an inverse relationship to honey prices. Australian consumers readily substitute other spreads for honey.

The beekeeping industry faces a number of risks, including the risks of entry and spread of exotic pests and diseases (for example the Varroa mite), economic pressures on the honey producing industry, and reduced access by beekeepers to areas of native flora (Pollination Australia Business Plan, 2008).

The impact of an exotic pest or disease incursion is considered to be the most significant risk. Such an event would substantially increase beekeepers' costs, reduce their productivity and limit the current

extensive movement of hives around Australia. Moreover, it would severely impact on, if not destroy, the existing feral honey bee population, leading to the loss of much of the incidental honey bee pollination that many horticultural industries now rely upon – even though that reliance is not always recognised (Pollination Australia Business Plan, 2008).

There is a widely held view in the Australian scientific community that an incursion of the highly destructive Varroa mite is almost inevitable and that at some point the mite will become established. It is estimated that 20,000 crop industry businesses will be affected by the arrival of Varroa mite.

Queen bee breeding is specialised and there are growing markets, especially in North America, for Australian queen and package bees, although the USA have a current ban on the importation of live bees from Australia. While this sector of the industry is relatively profitable, the major constraints are: freight costs; the constant threat of export bans; and the limited number of skilled queen bee breeders (AHBIC 2014).

Industry position in the RIRDC life cycle

RIRDC’s commitment to rural industries is to support appropriate RD&E given their stage of maturity in the Australian market. RIRDC clearly defines its role as an investor in industries based on their development stage and the unique attributes of each specific industry. Much of RIRDC’s portfolio is in the new, developing or maturing phase of industry development. Unlike much of the RIRDC portfolio, the honey bee and pollination industry is an established rural industry. It has a levy arrangement in place to support RD&E. The industry chooses to operate its RD&E Program within RIRDC as this arrangement delivers a number of benefits, including a range of administrative efficiencies. The position of the beekeeping and pollination industries in the RIRDC life cycle is shown in the table below.

	<i>Honey Bee and Pollination Industry Development Stage</i>				
	<i>New</i>	<i>Developing 1</i>	<i>Developing 2</i>	<i>Maturing</i>	<i>Established</i>
<i>Current stage</i>					●
<i>Stage goal, to be achieved: already achieved</i>					●

Being an established industry, the beekeeping and pollination industries have the ability to rapidly adopt new outputs from RD&E investments.

Financial commitments

The budget in the table below has been prepared based on forecast income. RIRDC program funding reduce through the years to 2017/18, as reserves are reduced to a sustainable level. It is acknowledged that HIA industries are yet to consider funding for the Honey Bee and Pollination Program following the current commitments through the ‘Protecting pollination for the Australian horticultural industry - Stage 3’ that expires in June 2016.

Program budget	2014/15	2015/16	2016/17	2017/18	2018/19
RIRDC funding	\$1,000,000	\$1,000,000	\$800,000	\$700,000	\$700,000
HIA funding	\$150,000	\$150,000	?	?	?
Total	\$1,150,000	\$1,150,000	\$800,000	\$700,000	\$700,000

The Honey Bee and Pollination program relies on both statutory levies and contributions from the beekeeping and horticulture industries. HIA funding is from the apple and pear, almond, avocado, cherry, dried prunes, summer fruit and onion levies and voluntary contributions from the melon and canned fruit industries with matched funds from the Australian government. HIA usually invests in, and manages, projects that benefit HIA's industries. Voluntary industry contributions are also, on occasions, made to the Program. For example, in 2013-14 the AHBIC arranged for \$150,000 of funds to be provided from the Honey Bee Disease Contingency Fund Trust to RIRDC to support a project to modify the *National Bee Pest Surveillance Program*.

The research and development component of the honey levy and queen bee levy are provided to RIRDC for expenditure within the Honey Bee and Pollination Program. The Australian Government matches expenditure from the Program (less the cost of levy collection), up to 0.5% of the gross value of production of the honey bee industry.

A levy is payable on honey that provides funding for research and development by RIRDC, testing for pesticide and other contaminants by the National Residue Survey to all exports of honey to the European Union and the Honey Bee Disease Contingency Fund Trust for managing emergency disease responses. The Department of Agriculture collects the levy and distributes the funds. The Department charges a collection fee based on full cost recovery.

The levy on honey is 2.3 cents per kilogram of honey sold. Levy is not payable on honey sold in a year if the total weight of honey sold is not more than 600 kilograms. The Program receives 1.5 cents per kilogram of honey from the Levy Revenue Service. There is no levy on pollination services as the legislation prevents a levy on services. AHBIC is currently engaging with beekeepers to change the Contingency Fund component of the honey levy.

The levy for queen bees sold at \$20 and under is 0.5% of sale price and the levy on queen bees sold for over \$20 is 10 cents per queen sold. If a queen bee is sold as part of a transaction and the price for the queen bee is not separately determined, the queen bee is taken to have been sold for \$9.00. Levy is not payable on queen bees if, in a levy (financial) year, the total amount of levy the producer is liable to pay for queen bees is less than \$50. As the levy collection cost for the levy on queen bees has recently exceeded the total levy collected, AHBIC has applied for this levy to be set at zero (AHBIC 2014).

Honey Bee and Pollination Program RD&E objectives, 2014/15 - 2018/19

On the advice of the Advisory Committees for the Honey Bee and Pollination programs, in early 2014 RIRDC decided to combine the programs under a single RD&E Plan. It was expected that the Plan and a single Honey Bee and Pollination Program Advisory Committee would take effect from July 2014.

Honey Bee Program Five Year R&D Plan 2012-2017: Review summary

The Honey Bee Program Five Year RD&E Plan 2012-2017 is not reviewed, as the plan had only been implemented for 18 months at the time of preparing this plan. However, the Honey Bee Program Advisory Committee is satisfied with investments over this period against the objectives of the 2012-2017 Honey Bee Program RD&E Plan.

Pollination Program Five Year R&D Plan 2009-2014: Review summary

A review summary of the Pollination Program R&D Plan 2009-2014 is provided below, with more detail provided in Appendix 2.

More than \$1 million has been invested in the Pollination Program since 2007 as part of a multi-industry research effort to ensure industries are protected from exotic pests.

Below are the six objectives of the 2009-14 Pollination Program RD&E Plan.

1. Incursion risk minimisation – for early detection of a threat to pollination service supply.
2. Improving the effectiveness and economic return from pollination – living with Varroa.
3. Resource access – landscape and nutrient management for effective pollination.
4. Pest and disease management – to ensure ongoing supply of pollination services.
5. Reducing crop dependence on honey bees – native pollinators and self-pollinating crops.
6. Communication – including pollination education, extension and capacity building.

Performance against strategies to deliver objectives

Objective 1 attracted the majority of investment on the basis that incursion risk minimisation delivers the greatest return on investment across the biosecurity spectrum. However, significant projects addressed each objective. Of the 36 strategies, 22 (or 61%) have been addressed through projects. The Pollination Advisory Committee noted that in hindsight, the plan's strategies had been ambitious and that unaddressed strategies would inform the 2014/15 – 2018/19 plan.

The RIRDC project, *Economic Evaluation of Investment in the Honey Bee R&D Program including the Pollination Sub-program* published in 2012 assessed three clusters of investment made under the 2007-2012 Honey Bee R&D Plan.

The projects evaluated demonstrated a wide range of predominantly economic benefits, a number of which were quantified in value terms. Funding for the three projects analysed totalled \$0.79 million (present value terms) and produced aggregate total benefits of \$4.71 million (present value terms). The analyses found each of the three investments provided positive returns with benefit-cost ratios ranging from 2.05 to 28.61. The positive results in terms of the benefits identified and those valued demonstrate that the Program is delivering impacts and is providing a return on investment.

The Pollination Program Advisory Committee, noting stakeholder feedback received by members, is satisfied with the extent to which the RD&E investment has delivered the objectives of the 2009-14 Pollination Program RD&E Plan.

Program/industry RD&E objectives, 2014/15-2018/19

Aim

Support RD&E that will secure a productive, sustainable and more profitable Australian beekeeping industry and secure the pollination of Australia's horticultural and agricultural crops.

Objectives

Stakeholders through the Honey Bee Program and Pollination Program Advisory Committees outlined the major concerns and obstacles facing the Honey Bee and Pollination industry, and the types of RD&E that could assist in overcoming these issues. A joint meeting of the Advisory Committees in April 2014 recommended this draft plan, with the minor amendments that have been incorporated into this version of plan be:

- approved by the RIRDC Board, following support from the Australian Honey Bee Industry Council; and
- the Honey Bee and Pollination Program, that is scheduled to become established on 1 July 2014, operate under this version of the plan until further consideration of the plan is obtained from HIA industries in late 2014.

The Australian Honey Bee Industry Council, the industry's peak body of the beekeeping industry, supported this version of the RD&E Plan in June 2014.

The RIRDC Board noted in June 2014 that the draft plan would be take effect as a draft in July and would guide the Program until early 2015. To provide the suite of HIA industries adequate time to consider this plan, this version of the plan was provided to relevant industries for consideration at their annual industries forum in November 2014. The migration from Horticulture Australia Limited to Horticulture Innovation Australia Limited delayed this consultation process. It is acknowledged that some changes to the plan may then be required. The plan will be provided to the Board for approval in late 2014 or early 2015.

RIRDC is committed to achieving significant benefits to industry within our available resources, through the implementation of **targeted** and **high-impact** RD&E projects. The consultation process highlighted a number of issues that the Honey Bee and Pollination industry/program considers roadblocks to growth and development. Of these impediments, those that can be addressed with targeted RD&E have shaped RIRDC's investment priorities for the next five years. Whilst not every problem raised can be addressed, these priorities aim to achieve high-impact, far-reaching benefits to industry.

- 1. Reduce the incidence and impact of pests and diseases on the beekeeping and pollination services industries**
- 2. Increase the productivity and profitability of beekeepers**
- 3. Increase understanding of the role of flora in honey bee management**
- 4. Understand the role of pollination in delivering more productive systems**
- 5. Promote extension, communication and capacity building**

The program's objectives have been mapped against the strategies of the RIRDC Corporate Plan 2012-2017 and the Australian Government's Strategic Research Priorities and Rural Research Priorities (see Appendix 3).

The Plan's objectives will be reviewed annually, as part of RIRDC's Annual Industry Review process. Further consultation and feedback will be sought from stakeholders, to adjust or amend objectives as the Plan is implemented.

Allocation of funding for these priorities will also be considered annually, as part of RIRDC's Annual Operating Plan (AOP). The AOP is available on the RIRDC website.

Objective 1: Reduce the incidence and impact of pests and diseases on the beekeeping and pollination services industries

Background

Australia is free from some of the most important pests of honey bees, namely *Varroa destructor* and *Tropilaelaps clareae*, being the two major pests. The establishment of these pests in bees in Australia would be a catastrophe for the beekeeping industry causing huge losses of production in both bee products and pollination services as well as the virtual elimination of feral colonies. The beekeeping and pollination services industries must be well prepared to ensure border security is delivered through efficient and cost effective surveillance and eradication of any incursion of exotic pests. In the event that any incursion is not contained, efficient control strategies need to be quickly implemented to minimize the impact of any new pest.

In recent years technological advances in genetics have facilitated the development of powerful tools which can be used to reduce the incidence and impact of pests and diseases on honey bees. This can take several forms; the development of resistant bees, the identification of resistance to pathogens and the identification of undesirable genes.

The more intensive management of bees caused by necessity and the impact of these changes together with emergence of new diseases and pests such as *Nosema ceranae* and the Small Hive Beetle have contributed to a general increase in the incidence of diseases and pests in honey bees in Australia. Effective control strategies that minimize losses caused by the pathogens are necessary to increase the productivity of beekeepers in Australia and ensure hives are able to deliver pollination services to industries reliant on honey bees.

Strategies

- Implement the National Bee Pest Surveillance Program (NBPSP) and encourage ongoing Program funding.
- Support genetics research for pests and diseases control:
 - the development of a test for the detection of Africanized bees to help facilitate the introduction of new genetic stock into Australia;
 - investigations of the ecology of *Apis cerana* to enhance the understanding how far this pest will spread in Australia
- Support measures to increase awareness of the need to manage and control endemic pests and diseases including American foulbrood, *Nosema apis*, *Nosema ceranae*, European foulbrood, Chalkbrood and sacbrood virus.
- Monitor the effectiveness of current control measures to reduce the impact of the Small Hive Beetle with a view to further studies should the impact of this pest increase.
- Undertake *Tropilaelaps clareae* research and ensure incursion response strategies are appropriate and best practice
- Provide industry with tools to ensure wide uptake of an industry QA Program or Code of Practice that include pest/disease control and chemical residue management.
- Develop non-chemical controls for pest and diseases to ensure Australian apiary products.

Performance indicators

- The National Bee Pest Surveillance Program incorporates project outputs from the Pollination Program by 1 July 2015.
- Ongoing NBPSP funding by the beekeeping, horticultural industries and other organisations is encouraged.
- The incidence of pests and diseases in hives delivering pollination services is considered to be low.

- Development of the Australian Beekeeping Code of Practice or QA Program for bee health management, particularly for managing American Foulbrood.
- Development of a test to identify Africanized genes in semen.
- Early detection of any Varroa or Tropilaelaps incursion
- Industry survey indicates a reduction in production losses caused by pests and diseases as a result of RIRDC RD&E investments.

Impact and consequences

- The incidence and impact of pests and diseases on the beekeeping and pollination services industries is reduced.

Objective 2: Increase the productivity and profitability of beekeepers

Background

Prices paid for honey have not kept pace with production costs. This has forced beekeepers to change beekeeping practices to strive to maintain their economic viability. Income diversification including new product development is an area which could increase profitability. Increased productivity could be achieved by improvements in bee genetics, best management practices and industry benchmarking.

A profitable beekeeping industry is vital to ensure that sufficient hives of well-managed honey bees are available to deliver high quality pollination services to horticultural and agricultural industries.

Strategies

- Facilitate genetic improvement in the Australian honey bee industry including through the introduction of superior queen bees
- Facilitate genetic improvement to lift bee hygienic behaviour and control pests and diseases
- Increase the efficiency of beekeeping operations by rapid identification of queen bees in beehives.
- Facilitate the development of at least one new Australian apiary product.
- Undertake industry production and financial benchmarking to raise average industry productivity for beekeepers working under similar conditions.

Performance indicators

- Survey industry undertaken to evaluate whether RIRDC RD&E investments have resulted increased productivity and profitability of beekeepers

Impact and consequences

- The productivity and profitability of beekeepers is increased.

Objective 3: Increase understanding of the role of flora in honey bee management

Background

Honey bees collect nectar and pollen from native flora. Honey bees can also deliver pollination services to horticulture, agriculture and native flora. There is a need to better understand the role of flora in honey bee management, hive build-up for crop pollination, and the role of the honey bee in native ecosystems.

The beekeeping industry depends on native floral resource for about 70% of its honey production. Access to native flora continues to be a major issue facing the industry. Continued adequate resources are vital to sustain a profitable and productive beekeeping and pollination services industries.

Pesticides and other chemicals are required to manage crops. It is therefore important to understand the extent to which chemical residues are found within bee hives following crop flowering.

Strategies

- Measure the extent of chemical residues in hives that have been used to pollinate canola and almonds.
- Develop better understanding of the interaction between native flora/fauna and honey bees.
- Communicate to policy makers research outcomes regarding the role of public forest flora to the beekeeping and pollination services industries.
- Develop technologies and techniques for determining floral resource yields.
- Invest in research to determine native flora flowering cycles.
- Determine climate change impact on floral production and the beekeeping and pollination services industries.
- Develop advice, based on research about pyrrolizidine alkaloids that could inform FSANZ as to the allowable level of pyrrolizidine alkaloids in food.

Performance indicators

- The level of chemical residues are measured in hives used to pollinate canola and almonds.
- Funds invested in resource access, landscape and nutrient management for effective pollination.
- Research outcomes regarding the role of public forest flora to the beekeeping and pollination services industries are communicated to land-use policy makers to help inform decisions regarding beekeeping and pollination services industries access to public land.
- Technology developed to determine floral resource yields.
- Native floral flowering cycles determined.
- A synthesis is undertaken of the likely impact of climate change on productivity in the beekeeping and pollination services industries.
- Research undertaken that could inform FSANZ as to the allowable levels of pyrrolizidine alkaloids in food.

Impact and consequences

- The understanding of the role of flora in honey bee management is increased.

Objective 4: Understand the role of pollination in delivering more productive systems

Background

It is vital to ensure that horticultural and agricultural producers ensure they produce crops that are of sufficient quality to meet the demands of consumers. For many crops this requires pollination by insects, with European honey bees being the primary pollinator. It is important to understand the role of well-managed honey bees in pollination to deliver more productive systems.

It is also important to investigate whether alternative pollinators or artificial or mechanical techniques would improve the cost-effectiveness of pollination, particularly if Varroa were to become established in Australia.

Strategies

- Invest in understanding the optimal deployment of hives for key crops to ensure effective pollination that delivers increased yield and productivity.
- Support investigations into whether non-honey bee pollinators or artificial or mechanical techniques would deliver cost-effective pollination.

Performance indicators

- A 10% increase in average productivity of pollination, or a 10% reduction in cost of pollination, results from an investment to understand the role of pollination in delivering more productive systems.

Impact and consequences

- The understanding of the role of pollination in delivering more productive systems is improved.

Objective 5: Promote extension, communication and capacity building

Background

The Honey Bee and Pollination Program Advisory Committee has effective linkages with industry, the research community, relevant community groups and government departments. These linkages are important for the efficient management of honey bee and pollination research – defining objectives, developing priorities, evaluating results, applying research findings as well as promoting extension, communication and capacity building.

Strategies

- Ensure honey bee and pollination program RD&E outputs are in a form that is suitable for internet delivery and association newsletters of state honey bee associations and industries reliant on honey bee pollination.
- Extend information about how to prepare hives that will deliver high quality pollination services.
- Extend information about how pollination services can deliver more productive systems.
- Support capacity building initiatives, such as increasing beekeeper leadership skills.
- Sponsor conferences at which researchers present the results of their Honey Bee and Pollination Program funded project, so as to increase adoption of RD&E project outputs.
- Fund travel that pursues the Program's objectives.
- Inform the public and policy makers about the Program's findings.
- Deliver a Honey Bee and Pollination Program Newsletter three times per year.
- Investigate collaborative funding opportunities with other industries and agencies, including Cooperative Research Centres, that are aligned with the aim and objectives of this plan and agricultural policies.

Performance indicators

- Program outputs are made available in user-friendly format.
- Initiatives for capacity building are supported.
- Conferences supported at which researchers present the results of their Honey Bee and Pollination Program funded project.
- Production of three Honey Bee and Pollination Program Newsletters each year.
- Collaborative funding opportunities with other industries and agencies are pursued that are aligned with the aim and objectives of this plan.

Impact and consequences

- The Program's outputs are adopted by stakeholders in the honey bee and pollination industries.

Glossary

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AHBIC	Australian Honey Bee Industry Council
FSANZ	Food Standards Australia and New Zealand
GVP	Gross Value of Production
HAL	Horticulture Australia Limited
KPI	Key Performance Indicator
R&D	Research and Development
RD&E	Research, Development and Extension
RIRDC	Rural Industries Research and Development Corporation

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Appendix 1

A honey bee industry and pollination continuity strategy should Varroa become established in Australia

Statement of research and development priorities, February 2014

Introduction

The varroa mite (*Varroa destructor* Korean haplotype) is a destructive pest of the European honey bee that spread worldwide during the late 20th century, killing unprotected beehives. Globally, only the Australian honey bee industry remains free of the pest.

In 2010 the Australian Government, through the then Department of Agriculture, Fisheries and Forestry, led a government–industry committee that consulted nationally with state and territory governments, honey bee and crop industries and the scientific community, and prepared a strategy to support the continuity of honey bee businesses, and the crop industries they support, in the event of the varroa mite becoming established in Australia. The strategy is available at <http://www.agriculture.gov.au/pests-diseases-weeds/bees>.

The varroa mite is highly likely to establish in Australia in the future—the balance of expert and scientific opinion is that this is inevitable. If it does establish, it will transform our beekeeping and crop industries. The strategy recommends 10 actions to strengthen the capacity and preparedness of Australia’s honey bee and crop industries.

The strategy concludes that more research and development needs to be done now to help keep Australia free from varroa for as long as possible and to support Australian industries with the information, skills and tools they’ll need if the varroa mite establishes here.

The mite has transformed beekeeping industries in other countries where it must be controlled by chemical and other treatments. Its presence has also forced some overseas farmers to change the way they pollinate some crops. The effective eradication of wild European bees, which pollinate crops for free, has compelled them to make greater use of commercial pollination services, increasing their costs and sometimes leading to shortages in the number of hives available for crop pollination.

While Australia’s freedom from varroa mite is unlikely to last, it is important we make every effort to retain our varroa-free status for as long as possible. Despite best efforts, it is highly likely that varroa will establish here, affecting 1700 commercial honey bee businesses, 20 000 crop industry businesses and 10 000 hobby beekeepers.

Australian industries will face unique challenges in coping with the varroa mite. In particular, the nomadic nature of our honey bee industry, coupled with a high labour requirement and high labour costs, will make it harder and more costly to manage the pest.

Australian crop industries are likely to face higher pollination rental fees than those in other countries due to higher costs for bee keepers and greater competition for available pollination services.

The Varroa Continuity Strategy Management Committee of industry, government and scientific representatives has identified four research and development priorities.

Key Points

1. We need to prepare for varroa mite— research and development is a vital part of a national strategy to protect our beekeeping and crop industries.
2. Varroa mite is a destructive pest that kills unprotected beehives—it's highly likely the mite will establish in Australia in the future.
3. Australian scientists and organisations involved in honey bee, varroa mite and crop pollination research should be guided by this Statement of research and development priorities as they develop research proposals.

The Department of Agriculture prepared this document in collaboration with:

- Australian Honey Bee Industry Council
- Almond Board of Australia
- CSIRO
- Department of Agriculture and Food Western Australia
- Horticulture Australia Limited
- New South Wales Department of Primary Industries
- Plant Health Australia
- Rural Industries Research and Development Corporation
- Victorian Department of Environment and Primary Industries

It is also endorsed by the Varroa Continuity Strategy Management Committee.

Research and development priorities

1. Improving the efficiency and effectiveness of crop pollination under Australian conditions

In the absence of the pollination services provided by wild European honey bees, crop industries dependent on honey bee pollination (particularly higher value horticultural crops) will increasingly rely on beekeeper-provided commercial pollination services. This increased demand is likely to cause a significant rise in the price of pollination services. To support the adoption of paid pollination services and reduce the cost and potential yield effects on crop industries, research and development is needed to:

- a. quantify the contribution of wild honey bees and native insects to crop pollination
- b. improve the efficiency of crop pollination by managed honey bees (more pollination by fewer honey bees)
- c. understand the influence and effects of pathogens on honey bee foraging and pollination activities, so that the quality of pollination provided by honey bees can be maintained
- d. establish practices to maintain, or increase the level of free pollination from wild insects
- e. develop systems for managing and using alternative pollinators (such as stingless, blue banded and leaf-cutter bees) for specialised production environments
- f. select stronger self-pollinating traits in relevant crop cultivars or species
- g. investigate artificial or mechanical pollination in relevant crop cultivars or species.

2. Keeping managed honey bees healthy

Effective varroa mite management strategies are only possible with a clear understanding of the biology and pathology of the varroa mite – honey bee interaction. Recent publication of the honey bee

genome and work underway on the varroa mite genome will help advance this research.

Australian scientists are well placed to contribute to the global research program that is underway.

By participating, Australian scientists will be better placed to rapidly transfer the benefits of this research to the Australian honey bee industry, and pollination-dependent plant industries.

Bee pathology research also needs to focus on the cluster of viruses and other pathogens that kill bees weakened by the varroa mite. The pattern of secondary infection is complex and likely to differ from place to place. Research and development is needed to understand the role of these pathogens in bee mortality, and the scope for directly reducing the impact of secondary infection. Research and development is needed to:

- a. improve our understanding of the genetic basis of honey bee immunity (tolerance/resistance) to pests and diseases which will allow more effective selection of high-quality breeding lines
- b. identify novel ways to subvert the varroa mite's reproductive cycle
- c. develop rapid field tests for key honey bee pathogens
- d. develop bio-control agents for the varroa mite
- e. understand key mechanisms and variations in immune functionality in managed and wild honey bees
- f. identify immune functionalities that help combat major pests and diseases.

3. Improving the efficiency of beekeeping and facilitating expansion of the paid pollination services sector

The varroa mite will significantly change the cost structure of Australian beekeeping businesses. Labour costs will rise as beekeepers are forced to monitor hives more intensely and apply appropriate treatments or cultural practices. Research and development is needed to:

- a. develop equipment or practices to increase the labour efficiency of beekeeping businesses
- b. educate Australian beekeepers on the varroa mite and how to adopt effective mite monitoring into their apiary practices
- c. assess, compile and report approaches developed by overseas beekeepers to reduce the labour costs from managing with the varroa mite.

4. Refining surveillance and monitoring systems

Australia enjoys freedom from a wide range of exotic bees and bee pests. We have a range of awareness, surveillance and quarantine measures in place across the biosecurity continuum (pre-border, border and post-border) to maintain this freedom. However, we need to further refine our surveillance and monitoring systems in order to detect a varroa mite incursion early enough to have a chance of eradication. Research and development is needed to:

- a. determine the sensitivity of sentinel hives to detect exotic honey bee mites such as varroa
- b. refine remote surveillance catch-box technology and placement at high risk ports
- c. conduct surveillance auditing, training and simulation workshops
- d. develop tracking systems (similar to the National Livestock Identification Scheme) that could be used in a varroa mite outbreak
- e. develop tools to measure the location and spread of an incursion.

Implementation—building on existing research and funding

Scientists based at Australian universities, the CSIRO and state government agencies, in partnership with funding agencies such as the Rural Industries Research and Development Corporation and the Australian Research Council, have built a body of work on the biology and genetics of the European honey bee and the varroa mite, and the pollination of crops in Australia. Substantial related research is also underway in other countries. This provides a solid foundation for funding future work as outlined in this statement.

Appendix 2

Review of the Pollination Program Five Year R&D Plan 2009-2014

More than \$1 million has been invested in the Pollination Program since 2007 as part of a multi-industry research effort to ensure industries are protected from exotic pests.

Some examples of the research undertaken by the Pollination Program has found:

- hitching a ride in ships is the most likely way for exotic bee pests to reach Australia
- both chemical and non-chemical options are vital for the control of Varroa mite
- urban beekeepers can play an important role in the national surveillance of exotic pests
- it is important to develop a good working relationship between beekeepers and the many growers reliant on them for crop production

Research underway is investigating:

- the development of a new system of remote electronic hive monitoring
- the development of a website to provide information on Varroa mite
- improved understanding of port surveillance and invasive bee pests
- the impact of exotic pests on the movement of hives around the country
- the reliance of growers on feral European honey bees

A Benefit Cost Analyses undertaken for the Honey Bee Program (which incorporated the Pollination Program) in 2011, showed the benefit-cost ratio of the Pollination Program project evaluated as 28.61. The benefits identified were principally economic benefits that would be best described as productivity enhancing benefits. The positive results in terms of the benefits identified and those valued demonstrate that the Program is delivering impacts and is providing a return on investment.

Objectives of the 2009-14 Pollination Program RD&E Plan and proposed investment allocation between objectives

1. Incursion risk minimisation – for early detection of a threat to pollination service supply (10%)
2. Improving the effectiveness and economic return from pollination – living with Varroa (20%)
3. Resource assess – landscape and nutrient management for effective pollination (10%)
4. Pest and disease management – to ensure ongoing supply of pollination services (45%)
5. Reducing crop dependence on honey bees – native pollinators and self-pollinating crops (5%)
6. Communication – including pollination education, extension and capacity building (10%)

Objective 1: Incursion risk minimisation – for early detection of a threat to pollination service supply

- Implement an appropriate surveillance program (sentinel hive program, baited hive system, etc) in appropriate locations to detect biosecurity breaches consistent with the findings of the surveillance review, pathway analysis and simulation exercise.
 - *PRJ-03317: Future Surveillance needs for Bee Biosecurity - Simon Barry – <https://rirdc.infoservices.com.au/items/10-107>*

- *PRJ-003087: Simulation Exercise for Pollination Industries – Sharyn Taylor – http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-003087*
- *PRJ-006576: Remote sensing of beehives to improve surveillance – Cheryl McCarthy – http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-006576*
- *PRJ-008711: National Bee Pest Surveillance Program (2013-15) and facilitator – Sam Malfroy (Plant Health Australia) – Project objectives:*
 - *To involve each jurisdiction and the honey bee industry in designing, implementing and driving the implementation of a National Bee Pest Surveillance Program that targets bee pests and pest bees from between July 2013-June 2014.*
 - *To maintain and improve current surveillance activities in the National Sentinel Hive Program within each jurisdiction*
 - *To coordinate and implement a broader surveillance system in each jurisdiction that is based on risk and involves existing, and complementary, surveillance tools as demonstrated through the remote sensing off beehives project and the Beeforce project*
 - *To source additional funding, or the continuation of funding for the surveillance program to continue past June 2014*
 - *Have every state and territory DPI sign a contract to confirm their involvement in the National Bee Pest Surveillance Program and formalise any arrangements*
 - *To have all arrangements finalised by June 2014, to allow a formal hand over of the National Bee Pest Surveillance program to industry and each jurisdiction for continuation*
 - *PHA to continue to act as the national administrator of the National Bee Pest Surveillance Program post July 2014.*
- *PRJ-008509: Surveillance of Asian Honey Bee - proof of concept (In Progress)- Gary Kong (CSIRO) – http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-008509*
- *Build surveillance systems into B-Qual consistent with the recommendations of the surveillance needs project- ie monitoring programs, sampling procedures, reporting requirements and incentive systems designed to give the best chance of detecting an early Varroa incursion. B-Qual is used by a large number of professional beekeepers.*
 - *PRJ-005706: BeeForce: Improving high risk surveillance - Joe Riordan – http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-005706*
 - *PRJ-005707: BeeForce: Developing the regional model - Sabine Perrone – http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-005707*
 - *PRJ-006692: Biosecurity implementation to strengthen honey bee industries – Sharyn Taylor – http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-006692*
 - *PRJ-008376: T2M Risk assessment of ports for bee pests and pest bees (In Progress) - Simon Barry – Project objective:*
 - *Collate relevant information for a risk assessment of ports for surveillance for bee pest and pest bees.*
 - *Undertake risk assessment employing existing models where appropriate.*
- *Develop materials and systems to engage amateur and non B-Qual beekeepers in (Varroa) disease identification and reporting.*

- *Biosecurity Manual for the Honey Bee Industry – Sam Malfroy* – <http://www.animalhealthaustralia.com.au/wp-content/uploads/2012/11/Biosecurity-Manual-for-the-Honey-Bee-Industry.pdf>
- *The Industry Biosecurity Plan for the Honey Bee Industry – Sam Malfroy – put in link after media release*
- *Finding and reporting Varroa poster – RIRDC –* <https://rirdc.infoservices.com.au/items/12-058>
- *Almond Industry planning and preparedness for an incursion of Varroa mite (Contracting)*

Objective 2: Improving the effectiveness and economic return from pollination – living with Varroa

- Complete outstanding research on the pollination requirements of each crop included within the Pollination Australia partnership.
 - *PRJ-004588: Pollination Aware: Its Importance to Australia - Rob Keogh –* http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-004588
- Complete outstanding research on a crop-by-crop basis that demonstrates the economic advantage of moving from current pollination levels to optimal pollination and the economic losses that will be incurred from a Varroa or similar incursion.
- Understand the role of feral bees/incidental pollination on a regional crop/pasture basis especially in relation to broadacre crops (ABARE focusing on horticulture).
- Invest in research to understand what constitutes optimal hive strength for provision of pollination services and develop techniques for establishing and maintaining required hive productivity. Complete research to understand the economics of hive preparation.
 - *Pollination of Crops in Australia and New Zealand - Mark Goodwin –* <https://rirdc.infoservices.com.au/items/12-059>
- Develop a prioritised research plan for improving pollination productivity in view of forecast growth in pollination demand, especially in horticulture. Implement the plan in order to improve the productivity and size of Australian pollination services.
- Review further opportunities for productivity improvement in pollination resulting from Varroa management, if established within the Australian landscape. This activity will include better understanding what NZ, the US and others have done successfully to manage Varroa.
- Develop practical response options for managing Varroa in Australia including husbandry practices, chemical management options and strategies to avoid chemical resistance.
 - *PRJ-006390: Screened bottom boards(in progress) - Doug Somerville –* http://www.rirdc.gov.au/research-project-details/custr10_POL/PRJ-006390
 - *PRJ-005718: Non-chemical and minimum chemical use options for management of Varroa –Michael Williams –* <https://rirdc.infoservices.com.au/items/10-201>
 - *PRJ-006122: Pollination - Pesticides and Bees Booklet – Daryl Connelly -* <https://rirdc.infoservices.com.au/items/12-043>
 - *MT-09082 – Preparation and submission of permit applications for three Varroa mite control products – HAL/AKC Consulting – Permits to be available.*
- Package outputs from this research objective into education and extension materials (e.g., a pollination manual suitable for Australian field conditions) for communication to pollinators and plant industries with an economic interest in pollination services.

- *Pollination of Crops in Australia and New Zealand - Mark Goodwin - <https://rirdc.infoservices.com.au/items/12-059>*

Objective 3: Resource assess – landscape and nutrient management for effective pollination

- Investigate New Zealand hive ‘build-up’ practices, i.e. less reliance on ‘build-up’ prior to providing pollination services.
 - *Pollination of Crops in Australia and New Zealand - Mark Goodwin - <https://rirdc.infoservices.com.au/items/12-059>*
- Improve artificial diets i.e., supplementary feeding and the economics of supplementary feeding as the cost of pollination services changes.
 - *PRJ-000472 – Testing pollen substitutes that meet the nutritional needs of honey bees (a Honey Bee Program project) – http://www.rirdc.gov.au/research-project-details/custr10_HBE/PRJ-000472*
- Investigate innovative resource access options including proof of concept for ‘bee farms’ (where landholders deliberately create havens for colony build up – a priority for Qld where access to public forests is being phased out), revegetation corridors, alliances with timber companies and the encouragement of native pollinators (see also Objective 5).
 - *Bee Friendly: A planting guide for European honey bees and Australian native pollinators (a Honey Bee Program project) – Mark Leech – <https://rirdc.infoservices.com.au/items/12-014>*
- Ensure Australia remains free of biosecurity risks (e.g. Guava Rust) to native flora which provide the bulk of both build-up services and honey flows used to offset the cost of providing pollination services.
- Further investment in ecological data that may show bees have no impact in protected areas and implementation of EMSs (or similar) to manage any adverse consequences (lower order priority).
- Complete social/political science research to understand community attitudes to introduced species in protected areas, and community education on the consequences of honey bee exclusion (lower order priority).

Objective 4: Pest and disease management – to ensure ongoing supply of pollination services

Honey bee husbandry issues:

- Research the production of honey bees that are genetically resistant to Varroa. Major research initiative building on leading edge CSIRO knowledge.
- Develop Varroa tolerance through behavioural means, e.g., ‘mite grooming’.
 - *PRJ-005626: Preparing for Varroa: How susceptible are Australian honey bee stocks? – (a Honey Bee Program project) Ben Oldroyd – http://www.rirdc.gov.au/research-project-details/custr10_HBE/PRJ-005626*
- Breed honey bees that are superior pollinators (difficult to achieve and lower priority research).

Exotic pests and diseases:

- Ensure Varroa-control chemicals are registered and appropriately available in Australia.
 - *PRJ-005718: Non-chemical and minimum chemical use options for management of varroa – HAL – <https://rirdc.infoservices.com.au/items/10-201>*

- Address pesticide resistance issues in Varroa mites – recalling that any Varroa arrivals may have been exposed to miticides for many generations.
- Develop and apply new techniques to manage Varroa, e.g., pheromones.
 - *PRJ-008701: Development of an Australian Bee Health and Management website - Sam Malfroy – Project objectives:*
 - *The website will be an authoritative source of information for the Australian honey bee and crop industries on established pests and diseases, exotic pests such as Varroa, biosecurity best management practices and crop pollination information and management. The following will be the major features of the site:*
 - *Compile and link to the best sources of information from Australia and internationally on the management of current established pests and diseases in Australia.*
 - *Compile and link to the best sources of information from Australia and internationally on exotic pests such as Varroa.*
 - *Compile and link to the best sources of information from Australia and internationally on beekeeping and biosecurity best management practices, and crop pollination information and management.*
 - *Updates and international developments relating to Varroa research and management.*
 - *Work with Plant and Food Research in New Zealand and/or Australian DPI's to obtain or produce instructional films on Varroa management techniques that will be hosted on the website.*
 - *Develop a restricted Google search engine that will be hosted on the website, to direct searchers to the best sources of information about established pests and diseases, exotic pests such as Varroa, beekeeping and crop pollination management on the internet.*

Endemic pests and diseases:

- *Nosema ceranae* – implications and control strategies for this disease newly identified in Australia.
 - *PRJ-002862: A Study of Nosema ceranae in Honey Bees in Australia (a Honey Bee Program project) – Michael Hornitzky – <https://rirdc.infoservices.com.au/items/11-045>*
- American Foul Brood – management under pollination industry conditions.
 - *PRJ-008814: AFB Future Management Workshop, 14-15 March 2013 (a Honey Bee Program project) – Sam Malfroy (Plant Health Australia) – http://www.rirdc.gov.au/research-project-details/custr10_HBE/PRJ-008814*
- Ongoing management of European Foul Brood, Small Hive Beetle and *Nosema apis*.
 - *PRJ-004606: Commercialisation of the Small Hive Beetle Harbourage Device (a Honey Bee Program project) – Garry Levot – <https://rirdc.infoservices.com.au/items/11-122>*

Objective 5: Reducing crop dependence on honey bees – native pollinators and self-pollinating crops

- ‘Re-vegetate by design’ to reduce the reliance on European honey bees and increase pollination activities of other species. Using the work of HAL, this project would focus on re-vegetation to provide habitats to support or attract native pollinators.
 - *PRJ-008663: Understanding industry reliance on feral honeybees (HAL Contracting) - Daryl Connelly – Project objectives:*

- *The major objective of this project is to provide stakeholders with an understanding of the extent to which key horticultural industries / regions rely on feral honey bees for pollination, and to understand the underlying reasons for that.*
- *Bee Friendly: A planting guide for European honey bees and Australian native pollinators (a Honey Bee Program project) – Mark Leech – <https://rirdc.infoservices.com.au/items/12-014>*
- Fund ongoing and long-term research into *Tetragonula*, *Amegilla* and other native pollinators with potential for domestication and commercialisation.
- Leaf-cutter bee - research the relevance of this naturalised North American pollinator to Australian crops and conditions outside the lucerne industry. Research leaf-cutter bee pest and disease management needs if initial investigation of the bee's wider potential is favourable.
 - *PRJ-000030: Develop & assess of leafcutter bee survival, management & reproduction in Southern Australia (a RIRDC Pasture Seeds Program project) – Scott Campbell –Report not published*
- Mechanical pollination – complete basic scoping research to determine which crops are most amenable to its use.
- Support plant breeding to reduce dependence on insect pollination.

Objective 6: Communication – including pollination education, extension and capacity building

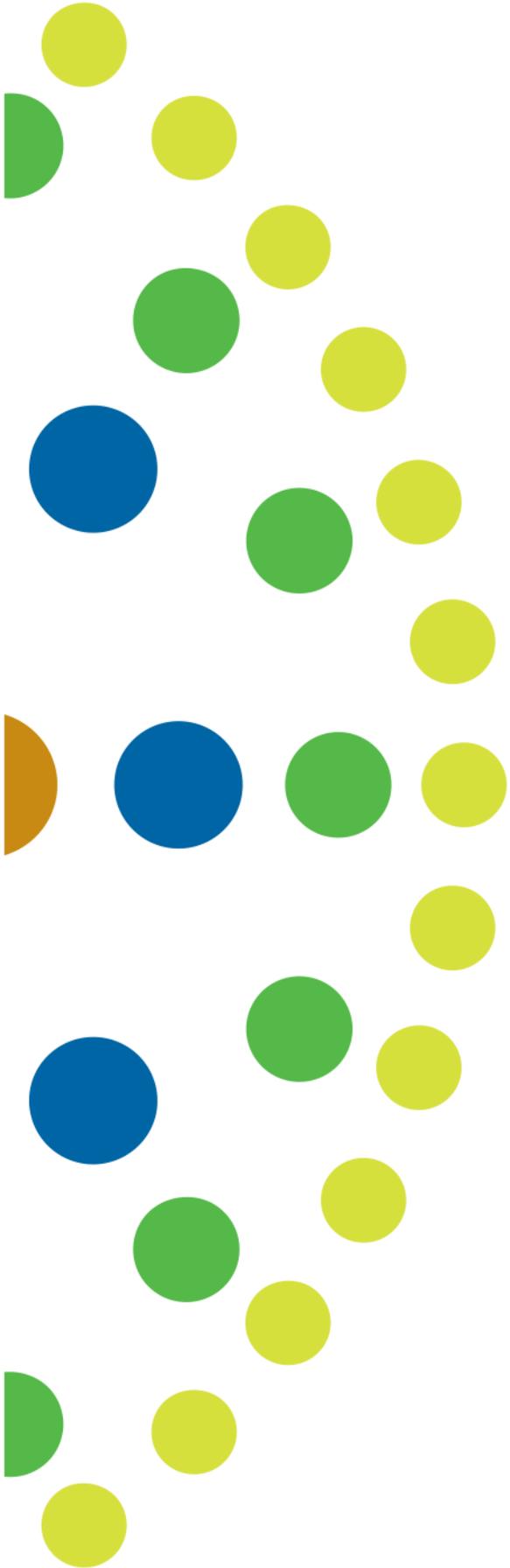
- *PRJ-005651 (MT-09090): Developing a honeybee and pollination CRC bid – David Dall – Bid not submitted as not considered to be viable due to insufficient support.*
- Communicate R&D findings from current PA and DAFF projects.
 - *PRJ-005664: Develop and implement a RIRDC-HAL Pollination Program communication strategy - Kaaren Latham.*
 - *PRJ-006221: Communication for the Pollination Program 2011-13 - Kaaren Latham.*
 - *PRJ-008578: Communication for the Pollination Program 2013-15 (In Progress)- Kaaren Latham – Project objective:*
 - *The objective of this project is to support the work of the Pollination Program by communicating the outcomes of research which helps to secure the pollination of Australia's horticultural and agricultural crops into the future on a sustainable and profitable basis.*
 - *MT-09083: Protecting pollination – Communicating awareness: Honey Bee Blues Video – HAL. Copies provided to each of the HAL industries.*
- Communicate R&D findings from projects commissioned under this Pollination R&D Plan.
 - *See above projects*
- Communicate to affected industries and the Australian community the importance of pollination.
 - *See above projects*
- Support extension of initial R&D outcomes to continue to improve the effectiveness and economic returns from pollination.
 - *See above projects*
- Invest in national capacity-building by training one new key pollination research scientist.

Appendix 3

Alignment of Program objectives with RIRDC strategies, Rural Research Priorities and Strategic Research Priorities

Strategic Research Priorities	Rural Research Priorities	RIRDC Strategies	Program Objectives and Strategies
Lifting productivity and economic growth	Productivity and adding value	<p>Manage demand driven RD&E that meets industry needs</p> <p>Facilitate investments that deliver economic, social and environmental benefits for rural industries</p> <p>Increase knowledge about rural industry development options that offer regional economic development opportunities</p> <p>Adopt a lifecycle approach to investment in new, developing and established industries</p>	<p>Objective 2: Increase the productivity and profitability of beekeepers</p> <p>Objective 4: Understand the role of pollination in delivering more productive systems</p>
	Supply chain and markets	<p>Deliver analysis on issues of national importance to the rural sector and broader community</p> <p>Assess the feasibility, value and potential competitiveness of new plant and animal industry opportunities</p>	
Promoting population health and wellbeing	Biosecurity	Work collaboratively on cross sector issues that impact across industries	Objective 1: Reduce the incidence and impact of pests and diseases on the beekeeping and pollination services industries
Living in a changing environment	Climate variability and climate change	Work collaboratively on cross sector issues that impact across industries	Objective 3: Increase understanding of the role of flora in honey bee management
Managing our food and water assets	Natural resource management	Encourage the sustainable use and management of natural resources	
Securing Australia's place in a changing world	Innovation skills	Promote leadership, capacity, skills and pathways that create opportunities.	Objective 5: Promote extension, communication and

	Technology	Encourage research that fosters science and creativity	capacity building
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