Consultation paper and situation statement

APRIL 2018

National Weeds Research, Development & Extension Investment Plan

for the Centre for Invasive Species Solutions

Alexandra and Associates Pty Ltd &

Policy Partners

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Preface

Why do we need an investment plan for weeds RD&E?

Research, development and extension (RD&E) on weeds in Australia suffers from boom-bust funding and competition for resources that is resulting in declining RD&E capabilities. Uncertainty has resulted in a dramatic decline in expertise. With the Australian Government’s R&D for Profit program soon coming to an end, another ‘funding cliff’ is fast approaching and there is an imperative to think about better approaches.

This project is exploring the opportunities for pooling and coordinating investment from multiple investors in order to develop better processes for collaboration and the allocation of RD&E funds and effort.

Who commissioned this project?

The Centre for Invasive Species Solutions (CISS) is a national collaborative research centre, focusing on RD&E to enhance invasive species management. CISS has transitioned from the Invasive Animals CRC, broadening its focus to include weeds.

CISS initiated this investment planning exercise with the intent of formulating a plan for coordinated and collaborative weeds RD&E investment over the next decade. The plan will outline the focus of the RD&E and the ways in which they priority activities should be financed and governed.

What is this document about?

This consultation paper is the first stage of a consultation process to develop a national weeds RD&E investment plan. This paper focuses on investment planning for weeds RD&E.

Essentially, we are seeking stakeholder input on:

- what kinds of RD&E are needed to achieve the highest impacts over the greatest areas of Australia?
- what kinds of collaborative investment models will work to enable stable funding that avoids the negative impact of boom/bust funding regimes?

Who can provide feedback on this paper?

Anybody interested or involved in weeds research, management, policy or practice.

How to provide feedback?

Comments can be made by completing an on-line questionnaire based on the questions in this paper.

You can access the questionnaire via: https://invasives.com.au/weeds-rde-feedback/

Alternatively, comments on this paper can be provided by email to: communications@invasives.com.au

Or mailed to:

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Executive summary

The situation—Boom-bust funding and an erosion in capability

Weeds are the focus of much activity in the NRM, agriculture and conservation. Increasingly they are being incorporated into Australia’s broader biosecurity policies, where pest plants, animals, diseases and pathogens are conceived of collectively as biosecurity threats that require targeted policy responses.

Weeds policy, management, and research, development and extension (RD&E) responsibilities in Australia are appropriately shared across many agencies, different spheres of government and the private sector but this also leads to a range of difficulties for efficient scaling of efforts, accountability and coordination. While understanding of the threats posed by invasive plant species has increased, the resourcing for weeds RD&E has declined.

Weeds RD&E in Australia suffers from a lack of continuity, the corrosive impact of boom/bust funding models, competition for available resources that erodes collaboration and declining RD&E capabilities. Investment flows, accountabilities and responsibilities are complex. There are inefficient processes of pooling and targeting investment, or in allocating RD&E funds across the spectrum of needs that occur on the invasion curve—from prevention of new incursions to reduction of impacts from established weed species. For example, there has been a dramatic decline in technical expertise in biocontrol with an estimated four-fold reduction in scientists working on weed biocontrol over recent decades, despite bio control R&D generating strong rates of return.

Over the past decade, several national R&D programs have aimed to target agreed national priorities for weeds, although actual funding has been skewed towards established weeds, rather than prevention. Furthermore, when these programs conclude, there are inevitable losses of scientific and technical capacity, due to the stop-start nature of the funding models. It is an imperative to think about better approaches. There have been persistent calls for more funding, more innovative approaches, and national collaborative programs that smooth funding cycles and sustain RD&E capabilities.

Australia has several biosecurity and weeds strategies; however, but for these to be effective, sustained national RD&E investments delivered are required. These need to be delivered through mechanisms that enhance collaboration. While there is an abundance of strategies that identify RD&E priorities, there is no effective national

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2 Priorities for Australia’s biosecurity system, The final report of the independent review of the capacity of Australia’s biosecurity system and the underpinning Intergovernmental Agreement on Biosecurity (IGAB) W. Craik, D. Palmer and R. Sheldrake 2017
platform for collaboration on implementing those strategies—either across sectors (e.g. agriculture, biosecurity and environment) or between the many actors involved in funding, policy, regulation and delivery of RD&E. Responsibilities for weeds in Australia are distributed across scales and agencies but enhancing collaboration is critical to bring the interested and affected parties together to provide critical mass, prioritisation and targeting of investments.

While weed problems will always be with us, weeds RD&E can make a major contribution to the prevention and reduction of weed-related costs, ensuring that management is more targeted and effective. However, there is never likely to be sufficient funds to undertake all of the weeds RD&E expected, and so a clear framework for priority setting is needed to focus available funds and resources on the most effective RD&E.

This paper is asking how to make the ideal of national collaboration on weeds RD&E work in practice. At this stage of the project, the paper offers more questions than answers. We are seeking feedback on these.

This consultation paper

The Centre for Invasive Species Solutions (CISS) initiated this project with the intent of designing a framework, to be agreed by all investors, for coordinating weeds RD&E investment over the next decade or more.

A successful Investment Plan will provide certainty for multiple investors about the prioritisation processes, scale and scope of RD&E investments and the ways in which those investments will be governed.

This paper is primarily focused on setting out the issues involved in investment planning for weeds RD&E in Australia. It outlines a range of key issues to guide stakeholder consideration and feedback.

Key issues for stakeholder consultation

Weed RD&E investment planning

Throughout this paper, we have identified issues pertinent to investment planning for weeds RD&E. For example:

1. What investment collaboration models are needed to enable investment in high impact RD&E?

2. What are the major issues that need to be taken into account for planning sustained collaborative investment in weeds RD&E?

3. Is there a need for new pooled funding models for weeds RD&E? If so, are there clear principles that could be used to prioritise investments in weeds RD&E?

4. What funding and delivery mechanisms are needed to be effective in delivering on Australia’s agreed weeds RD&E priorities?

5. In terms of a renewed funding model for weeds RD&E, is the primary need about multiple investors agreeing a model—including rules, scope and governance—for pooling and targeting RD&E budgets to shared priorities?

The policy settings and institutional context for weed RD&E

Weeds RD&E sits within and is framed by a wider context that affects the way we approach innovation, define policy problems and respond to institutional settings.

6. Defining the nature of the innovation systems may be critical to the kinds of RD&E investment undertaken. What kinds of innovation systems are best suited to dealing with weeds in Australia?

7. Do we need to define, or redefine, the nature of weeds and weed problems before considering how investments in RD&E can be used to ‘fix’ these problems? How does the way we conceptualise weed problems determine the kinds of R&D undertaken? Are there unrealistic expectations about what can be achieved?
8. Given the policy and social context of shared responsibilities, what models of investment cooperation and collaboration will enhance national capabilities for weeds RD&E with impact?

Specific opportunities for weeds RD&E agreed in national strategies

Australia has several national strategies for weeds and biosecurity, which identify wide-ranging priorities for RD&E along the invasion curve, and that span highly technical, policy and socioeconomic RD&E. However, these are largely underfunded or unfunded. Many of the question we are asking relate to ways to give effect to these risk and opportunities.

9. Given that the National Environment and Community Biosecurity RD&E Strategy identified that “lack of funding to maintain capabilities and support coordination frameworks” is a major weakness, what needs to be done to ensure adequate funding, effective coordination and the maintenance of adequate R&D capabilities?

10. What is needed to realise opportunities such as citizen science, international collaborations, and innovative partnering with primary industries and the non-government sector?

11. Given that the Australian Weeds Strategy provides the policy framework for weeds in Australia, what kind of national investment models are needed to give effect to its research and innovation objectives?

12. Given the prospective value of biocontrol techniques, what kind of national investment and coordination models are needed to further support and enhance this kind of RD&E?

13. The need to focus on risk-based approaches to detection, prevention and eradication of weeds in Australia is widely recognised. What kind of national investment and coordination models are needed to ensure that RD&E supporting this approach is funded?

14. Given that forming collaborative partnerships involving land managers and understanding the policy context and socioeconomic drivers are recognised as priorities, what kinds national investment models are needed to further support and enhance this kind of RD&E?

Lessons from prior weeds RD&E—evaluation and adaptive management

Investment in weeds RD&E needs to take into account critical lessons from previous programs. To do this, critical evaluations and adaptive management is important.

15. Should more rigorous and systematic evaluation be part of weeds RD&E in order to turn management into an adaptive experiment and to determine which approaches to weeds are working to achieve their stated objectives?

16. How can the Investment Plan ensure that funding is distributed to those projects that are likely to be most cost effective in dealing with prevention, early detection, effective policy and coordination, when intense pressure is likely to be expected for work on established weeds?

Redefining objectives and approaches to weeds

With weeds defined as problems, within complex landscapes and ecosystems, we are asking:

17. Do we need RD&E on the ecological functions of weeds, by explicitly examining the benefits as well as the risks posed to specified values like ecosystem conservation and/or production?

18. Would setting clearer objectives for regional landscapes or bio-regions assist with questions of weeds and their function within regional ecosystems?

19. Is there a need to reconceive weed management from singular techniques to integrated approaches that attempt to deal with weeds at the landscape scale within regional ecosystems?
1. Introduction

The purpose in this consultation paper

This consultation paper and situation analysis is the first stage in developing a national investment plan for weed research, development and extension (RD&E) for the Centre for Invasive Species Solutions (CISS).

CISS engaged Policy Partners to assist in the development of a 10-year Investment Plan for Weed RD&E (the Investment Plan). The Commonwealth Minister for Agriculture and Water Resources asked CISS to develop such a plan to guide the Centre’s weed RD&E investment over both the short term (1-3 years) and medium term (10 years), and to help determine where and how the Centre could facilitate greater coordination of the national RD&E effort addressing weeds. The Minister requested a plan that:

- emphasises RD&E with impact;
- supports effective action, not continuous strategy development
- maximises return on investment

The methods to be used in developing the Investment Plan include:

- consultation with:
  - staff and directors of CISS
  - the project steering committee
  - weeds RD&E experts and practitioners
- a review of scientific and policy literature relevant to:
  - weeds RD&E and weed strategies
  - effective investment allocation frameworks

In this paper we identify many issues for Australia’s weed RD&E investment. As part of the consultations, we are seeking constructive feedback on these issues and on how to develop an investment plan.

Drawing on prior weeds R&D strategies, it seems likely that the aim in the Investment Plan may be something like:

- ensuring that investment in RD&E makes a significant contribution to effective prevention and management of weeds, reducing their overall economic and ecological impact
- strategic investment in collaborative and coordinated weed RD&E which maximises benefits to Australia’s environment, economy and community

However, more significant than the challenge of stating the overarching objective will be achieving a plan endorsed by the RD&E investors. For this, the Investment Plan will need agreed investment allocation rules (principles and specific criteria) which can guide the allocation of limited resources to activities which are likely to result in substantive effects.

Our review identifies some key issues arising from the funding and organisation of RD&E—innovation models, innovation policy, coordination mechanisms and incentives for collaboration—and those arising from weeds and biosecurity policies that disperse and share responsibilities across Australia’s federated system.

Given that these policy and institutional settings are unlikely to change over the course of the Investment Plan, any proposed investment model needs to be functional within Australia’s federated system, enabling multiple
partners with different needs and responsibilities to cooperate on RD&E where there are common concerns and benefits.

**Who is CISS?**

This weeds RD&E investment plan is being developed by the Centre for Invasive Species Solutions (CISS). CISS is Australia’s collaborative research centre focusing on research, development and extension to enhance invasive species management strategies among landholders and land managers. CISS has transitioned from the former Invasive Animals CRC (IA CRC), moving into new agricultural and environmental domains, broadening the range of pest species of concern to include weeds and a wider range of vertebrate pest species. CISS was formed to tackle the ongoing threat from invasive species by providing a national collaboration platform bringing together the Australian and State Governments, industries, CSIRO and universities. (For more information on CISS see appendix 4).

As part of its Commonwealth Agreement obligation, CISS is developing an Investment Plan to guide future investment in weeds RD&E. Across vertebrate pests and weeds, CISS concentrates on developing smarter tools to prevent and detect new invasions, and advanced and tactical tools to strengthen integrated management strategies and knowledge. CISS works with industry and governments to create solutions to address the impact of both invasive animals and plants. More information can be found at https://invasives.com.au/

**Outline of the planned consultation**

The development process for the Investment Plan will engage key stakeholders—the Centre’s partners, the Australian Government, state governments, industry, research and development corporations (RDCs) and universities—with a view to building lasting collaborations and enabling sustainable co-investment of funds and resources.

Key steps in the consultation process are as follows.

1. **This situation analysis and discussion paper** scope key issues for consultation and outline the key themes and questions for subsequent consultations.

2. **A consultation phase** that includes face-to-face, teleconference briefings and other forms of correspondence to obtain feedback from key informants, critical stakeholders and potential co-investors. Consultation will involve:
   - a stakeholder workshop;
   - face to face, telephone and/or Skype interviews with key stakeholders including CISS’ partners; and
   - written responses to surveys and prompts.

3. **Exposure draft and a planning workshop**—after feedback and revisions, an exposure draft of the Investment Plan will be developed and distributed with the workshop structured as an opportunity to review and refine the exposure draft. The exposure draft will provide:
   - the situation analysis;
   - the prospective priorities for weeds RD&E expected to be pursued by CISS;
   - an investment action plan consisting of a ten-year investment framework, including descriptions of desired outcomes, outputs, activities (projects), assumptions, performance targets, scale of investments, guiding principles and governance mechanisms, and an initial four-year investment, consistent with the Australian Government’s funding terms and conditions for CISS; and
- a proposed framework for stakeholder engagement, communication and the oversight of co-investment which ensures robust pathways to adoption.

4. The final **Investment Plan** will be prepared, based on feedback during Stage 3.

5. Further consultation on the Investment Plan after completion of this planning project.

**Figure 2: Stakeholder consultation and indicative timeframe**

**A roadmap approach to planning**

The next stage in this consultation will be developing the draft investment plan. There will be opportunities to respond to this draft and after July CISS plans further consultation on the next version of the plan. Throughout this process we will be asking:

- What does success look like?
- What changes are needed to go from the current state to a preferred future state?
- And therefore what transitions are required?

**What would success look like?**

To inform this planning process we are asking what success of weed RD&E investment would like.

- By 2030, what will success look like for weeds RD&E investment in Australia?
• How did the 2018 investment plan contribute to this success?
• In what ways will weeds RD&E have made a substantial difference to weeds management?

Some possibilities already articulated include:
• Improved delivery with greater impact on the land (not just more reports)
• Critical mass of coordinated RD&E (and less competition for scarce resources)
• Less fragmentation of RD&E (less projectisation)
• Higher levels of adoption
• More secure funding
• Greater numbers of researchers and the sharing of expertise across agencies
• Established platforms for coordination and collaboration that still enable the delivery of individual responsibilities
• An agreed framework for governing collaboration and co-investment mechanisms
• Pathways to success / communication and engagement mechanisms
• Impact assessment / robust monitoring and evaluation mechanisms.

Have your say

An overriding purpose of this document is to generate feedback from a wide range of stakeholders to inform development of an Investment Plan.

The key issues we have identified are a simplification of the complex policy and technical problems of planning weeds RD&E in order to improve effectiveness, impact and accountabilities. For each of the key issues we have identified in this paper, we have articulated some prompts. These questions are intended to help stimulate feedback from those intimately involved in weeds policy, research and practice.

By setting out these key issues we are seeking to garner responses and generate ideas that will help guide a strategic investment approaches.

Comments can be made by completing an on-line questionnaire based on the questions in this paper.

You can access the questionnaire via: https://invasives.com.au/weeds-rde-feedback/

Alternatively, comments on this paper can be provided by email to: communications@invasives.com.au

Or mailed to:
Centre for Invasive Species Solutions
Building 22, University Drive South
BRUCE ACT 2617
The structure of this document

To catalyse innovation in the planning process, we are using this paper to prompt stakeholders to re-conceptualise weeds problems and potential responses, including approaches to weeds RD&E.

Like any policy problem, the kinds of solutions envisaged and adopted ultimately depend on the way the problem is defined. The definition of a problem also has a major bearing on the kinds of RD&E deemed to be attractive and feasible.

The need to interrogate our assumptions about weeds and weeds RD&E is explored in Chapter 2. These assumptions have a bearing on how we approach the issues surrounding weeds RD&E, including the methods and approaches to weeds research and priority setting.

Australia has complex institutional arrangements for weeds and biosecurity with numerous policies, strategies and committees with responsibilities. These current settings are summarised in Chapter 3.

Australia has had a series of weed strategies and RD&E programs over recent decades. A summary of these strategies and lessons learnt from them are briefly summarised in Chapter 4.

In Chapter 5, we explore key conceptual challenges that frame weeds RD&E. These include competing ideas about nativeness and novel ecosystems, and ideas about how priorities are established—for example, between focusing on prevention of new incursions, limiting infestation, and increasing capacity to develop effective responses to minimise impacts of established weeds.

Chapter 6 concludes with an overview of RD&E investment planning, with a focus on theories of effective portfolio allocation of investments.
2. **Key dimensions of weeds RD&E investment plan**

**Why do we need a weed RD&E investment plan?**

Weeds are a major concern of farmers, land managers and NRM groups around all of Australia (see Appendix 1) because weeds:

- affect agricultural production and the achievement of conservation objectives;
- are expensive and demanding and will remain a major focus of landscape management and biosecurity, including quarantine;
- are estimated cost to agriculture and the environment billions, with many relying on Sinden’s 2004 estimates of costs in excess of $4.4 billion per annum.

While weeds and weed problems will always be with us, weeds RD&E can still make a major contribution to weed prevention and a reduction in weeds’ related costs, by ensuring weeds management is more targeted and effective. However, there is never likely to be sufficient funds to undertake all of the weeds RD&E expected, and so a clear framework for priority setting is needed to focus available funds and resources on the most effective RD&E.

With weeds RD&E responsibilities dispersed across multiple agencies there is need for establishing a platform for national collaboration in order to target national weed issues, from prevention of new invasions to effect control of established problem plants. The envisaged collaboration will enhance capacity to deliver on responsibilities not result in cost or blame shifting.

With many well-established and emerging weeds, many potential weeds already naturalised and the perennial risks of new incursions “weeds will always be with us”. The numbers reveal the stark reality:

- of the estimated 26,000 exotic plant species in Australia nearly 3,000 species have become naturalised
- nearly 65% of naturalised plants have come from gardens.
- A further 6,000 species of garden plants have demonstrated weediness overseas.
- Of those naturalised, approximately 3,000 species are deemed to be weeds with 1,800 species are defined as weeds to natural environments and about 1,200 species are weeds in agriculture.

Given these numbers and potential for more invasions from either existing species or new imports, weeds RD&E that results in more efficient and cost-effective weeds prevention and management is likely to represent a good investment.

The concept of an invasion curve (see figure 3) is increasingly being used as a stylised way of thinking about where to intervene in invasion processes and the relative cost effectiveness of different kinds of interventions. It is useful to think of established and potential weeds and associated weed problems as existing along an invasion curve from pre-introduction to establishment of species and to use this framework to think about the kinds of

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interventions required at different strategies depending on where along this curve the species (and its risks) sits. Strategies and responses to potential or established species differ in character and likely cost effectiveness.

Figure 3: Stylised weeds invasion curve

Prioritisation and management strategies can readily build from the invasion curve concept, such as the species, pathways, sites approach (see Figure 4)

Figure 4: Species, pathways, sites prioritization approach


However, a narrow focus on plants as weeds may exclude wider ecological drivers of weeds. Weeds often tend to be indicative of ecosystem disturbance, like changes in grazing pressures, fire regimes or an increase in nutrients. In this way, weeds may be an indicator of other ecosystem changes, including poor land management practices. In other cases, weeds are contributing to ecosystem changes.

Australia is especially prone to major weed impacts due to its 60 million years of separate evolution and the unique biodiversity that has resulted\(^8\). This evolutionary history places greater responsibility on Australia’s governments and people. The relatively recent introduction of tens of thousands of exotic species has resulted in high weed burden and even without further introductions there is significant risk of many species existing as sleeper weeds (see section 5).

Australia also has a proud history of biocontrol research, with significant achievements in controlling infestation of prickly pear and water hyacinth. Biocontrol research has historically achieved high rates of return achieving an estimated average benefit-cost ratio of 23:1.\(^9\) Nevertheless, this form of weeds research has suffered from stop-start funding, opaque policy settings and complex institutional accountabilities. As a consequence, there has been a “dramatic decrease in capacity is weed biocontrol research, from a peak of thirty scientists working ... in the 1980s to approximately five in 2014” resulting in a “substantial decline in the number of weeds and agents” being researched\(^10\).

Figure 5: Current distribution of water hyacinth in Australia

Source: Australia’s State of the Environment Report 2016\(^11\)

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9 Coordinated weeds RD&E in Australia: despair or opportunity? John Virtue, Andy Sheppard, John Tracey, Cameron Allan, Ken Young and Jim Thompson use the 23:1 benefit cost ratio based on work by Page and Lacey 2006
10 Coordinated weeds RD&E in Australia: despair or opportunity? John Virtue, Andy Sheppard, John Tracey, Cameron Allan, Ken Young and Jim Thompson
While water hyacinth has naturalised and established along most of the tropical and sub-tropical east coast it only occupies a small percentage of its potential range and its impact is reduced through successful biocontrol introductions including of two weevil species that have become naturalised over much of the range 12.

Weeds and biosecurity policies more generally are dispersed, with share responsibilities across Australia’s federated system. Over recent decades the funding systems for rural RD&E has been in a period of transition, with an increased focus on the role of the RDCs and declining investment by state governments, particularly in the extension of R&D. Like many parts of the world, Australia’s rural RD&E systems have been in a period of major reforms that have reduced government funding and shifted to private sector or mixed models, including through the commodity RDCs13. Although environmental and NRM has remained largely publicly funded. With many funders and many providers, there is a dispersion of RD&E effort across many parties in an example of “many players but no captain”14. Arising from these arrangements for the funding and organisation of RD&E are concerns about the efficacy of innovation and biosecurity policies and the impact of the incentives for competition for resources.

Table 1: The decline in weed biocontrol scientific capacity in Australia15

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<th>Entity</th>
<th>Greatest capacity (1980s to early 1990s)</th>
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<td>Northern Territory</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>8.0</td>
</tr>
</tbody>
</table>

*Victoria’s technical staff has reduced from 15 people to none at present


Given that these policy and institutional settings are unlikely to change over the course of the Investment Plan, any proposed investment model needs to be functional within Australia’s federated system, enabling multiple partners with different needs and responsibilities to cooperate on RD&E where there are common concerns and benefits.

**What investment collaboration models are needed to enable investment in high impact RD&E?**

**What are the major issues that need to be taken into account for planning sustained collaborative investment in weeds RD&E?**

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12 Control options for water hyacinth (*Eichhornia crassipes*) in Australia NSW DPI 2013


14 Priorities for Australia’s biosecurity system, The final report of the independent review of the capacity of Australia’s biosecurity system and the underpinning Intergovernmental Agreement on Biosecurity (IGAB) W. Craik, D. Palmer and R. Sheldrake 2017

15 Palmer, D, McLaren, D and Sheppard, AW 2014. Australia’s present scientific capacity to progress the biological control of weeds. Proceedings of the XIV International Symposium on Biological Control of Weeds, pp 183-186
What is the Investment Plan for? —A framework for enabling collaborative R&I investments

For the planning process, at least, the scope of RD&E Investment Plan for weeds covers relevant R&D (basic and applied research) as well as the extension and adoption pathways for improved management and delivery of R&D findings. We adopt a broad definition of R&D, including work in the natural and social sciences related to weeds and weed management.

There are many existing strategies that state the higher-level prioritisation but this is about designing an investment framework that will work to address these priorities.

The intent in the Investment Plan would not be to articulate all future investment decisions. Rather, it would establish a set of principles for guiding improved collaboration across the institutions involved in weeds RD&E and provide the platform for more stable and sustainable funding streams. It will be important for the Investment Plan to articulate these principles clearly, as they will help guide future decisions on priorities and give shape to the platform. There are many frameworks for setting RD&E priorities and those empowered to govern the program must be able to use their judgement and these tools to guide their decisions.

Given the need for new pooled funding models for weeds RD&E, are there clear principles that could be used to prioritise investments?

Why we need new investment models for weeds RD&E.

‘There is currently no nationally coordinated weeds RD&E program, despite past demonstrated benefits from such investment. There continues to be industry focused weeds RD&E through bodies such as Grains Research and Development Corporation (GRDC) and Meat and Livestock Australia (MLA) but for environmental weeds and many noxious weeds there are few current investment options. Governments in all jurisdictions are under significant, long-term budget pressures. Policy drivers in biosecurity include beneficiary pays (with governments’ focus on market failure) and achieving high benefit:cost from investments. There is ongoing end user demand for better weed control. How do we shift back to a proactive approach to weeds RD&E?’ (Virtue et al, 2014)¹⁶

The Australian Weeds Committee (AWC) has identified the following needs for national weeds RD&E:

- ability to demonstrate the economic, environmental and/or social outcomes arising from widespread adoption of best practice
- efficiency and maximising value from investment (i.e. high benefit:cost)
- adoption of beneficiary pays, so that governments primarily invest where there is market failure
- long-term investment to maintain key capabilities and infrastructures
- capacity to leverage traditional funders’ investments by attracting new investors
- investment models that balance national, jurisdictional and industry interests

In relation to collaboration and RD&E capability, the AWC proposed:

- end-user involvement along the RD&E continuum, to meet needs and foster effective adoption
- a larger focus on extension of research findings, to ensure they reach end users
- greater collaboration between RD&E providers, rather than competition for limited resources
- increased collaboration between environmental and agricultural sectors
- recognising and fostering national specialist capacity to deliver on specific RD&E needs

The AWC considered weeds RD&E priorities, current capacity and investment frameworks in the context of the National Environmental and Community Biosecurity RD&E Strategy\textsuperscript{17}. It proposed that it is necessary “to tightly focus on few, achievable activities that cost-effectively meet shared national needs”, suggesting a focus on four areas for future collaborative investment in weeds RD&E:

- biocontrol for reduction in impacts of established weeds
- sustainable herbicide usage patterns (especially in cropping)
- developing improved technologies for early detections and eradications
- working on socioeconomic drivers of landholder-led weed control programs

A workshop at CSIRO in 2013, which aimed to elicit the key issues and problems with the current approaches for funding weeds RD&E, identified that possible future investment models needed to be:

- aligned with, and linked to, relevant national RD&E strategies, such as the Intergovernmental Agreement on Biosecurity and the Australian Weeds Strategy
- able to support national research and promote local/regional development and extension
- coordinated in ways that allows participants to commit their cash, people or infrastructure to support specific and targeted weeds initiatives
- enabling for multiple investors to specifically contribute to themes/programs of their interest

On the last point, it is important to note that numerous multi-investor national R&D programs have been organised in this way in the past. Several examples include NDSP and JVAP.

What funding and delivery mechanisms are needed to be effective in delivering on Australia’s agreed weeds RD&E?

\textit{What funding and delivery mechanisms are needed to be effective in delivering on Australia’s agreed weeds RD&E?}

\textit{In terms of the funding model needed for weeds RD&E is the primary need about getting multiple investors to agree on a model—including rules, scope and governance—for pooling and allocating RD&E budgets to individual and shared priorities?}

\textsuperscript{17} Virtue et al, 2014
RD&E and innovation theory—from linear technology transfer to networks

The way in which R&D is organised depends on our conceptual models of how innovation and practice change occur. It may be through very formal and high-tech lab research, through involving communities of interest in exploring innovative practices, as well as the crossover of these approaches. It may also be through citizen science networks or specialist projects and combinations of all of the above.

There are many ideas about how innovation systems are changing but increasingly networks are recognised as important, in part because of the impact of information technology enabling information to flow rapidly within and between networks.

Ideas about what is likely to be effective, and the models of innovation invested in, have a bearing on the kinds of projects that are funded. Innovation theory holds that both linear and network innovation models have different strengths and weakness. Similarly, there are tensions in the allocation of funds between basic and applied research. The innovation literature has relevance to the challenges of weeds RD&E, which needs to work across sectors. These kinds of innovation systems have been defined as co-innovation systems and rely on favourable institutional settings, including ensuring that science is not limited or “siloed”18.

Agriculture, conservation and biosecurity sectors are confronting substantial challenges that provide compelling evidence of the need to increase their capacity for innovation, including climate change and the need to meaningfully engage stakeholders in consultative processes that build trust through the co-production of strategies. While it is widely recognised that co-innovation systems capable of engaging stakeholders are critically important, deeply embedded institutional impediments tend to limit innovation through constraints of institutionalised logics and path dependencies19. Transformative approaches are rare, with most policy development restricted to “muddling through”, due the nature of public policy processes20.

Processes of research supply and demand require a juggling or negotiation of priorities but research targeted to end-users’ needs is more likely to be valuable to society21. Investment in the co-production of strategies is critical for the success of co-innovation systems because participatory methods help engage people in ambitious initiatives and establish cooperative co-innovation networks that are empowered to deliver22.

Weeds RD&E should be conceived of as a cooperative venture across the public and private sectors. This is sometimes described as a ‘networked’ innovation system, rather than more limited ‘linear’ innovation systems, where the ‘discovery’ takes place in labs or research farms followed by transfer or diffusion of the ‘innovation’ to industry. This approach is as an evolving co-learning system, where participants actively explore new possibilities.


investigate options and devise strategies co-operatively as opposed to more conventional technology transfer or agricultural extension techniques that has been extensively critiqued.\(^{23}\)

*Defining the nature of the innovation systems may be critical to the kinds of RD&E investment undertaken. What kinds of innovation systems are best suited to dealing with weeds in Australia?*

Figure 6: Calls for innovation may mean completely different things to different audiences—for some, it means harnessing digital technology

Source: [http://echord.eu/saga/](http://echord.eu/saga/)

Scoping weeds RD&E—defining and redefining weeds

The Australian Weed Strategy (2017) states that a “weed is considered pragmatically as a plant that requires some form of action to reduce its negative effects on the economy, the environment as well as human health and amenity.”\(^{24}\)

Similarly, RIRDC (2010) states that there are “many definitions of a weed but the simplest way to consider them is as a plant that is growing in a place that it is not wanted. They are also referred to a[s] invasive plants”. RIRDC (2010) notes that Australia’s weeds strategies have recurrently identified weeds as a major threat to primary production and to the natural environment, outlining how they are causing major economic, environmental and social impacts, damaging natural landscapes, agricultural and pastoral lands, waterways and coastal areas.\(^{25}\)

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\(^{24}\) Invasive Plants and Animals Committee 2017, *Australian Weeds Strategy 2017–2027*

There are some problems and issues with this definition, including that it fails to deal with conflicting or pluralistic values in a given landscape, in that one party’s weeds may be another party’s resource. For example, exotic grasses that produce abundant animal feed (biomass) may also contribute to hotter more damaging fires or cause other problems to people outside the grazing industry. Furthermore, weeds have always (and will always) be a feature of gardening, forestry or agricultural production systems, requiring “some form of action to reduce ... harmful effects”.

Kull et al 2014 analyses three separate concepts commonly used in definitions of invasion: the origin, behaviour and effects of particular species.

Defining plants as unwanted or costly, either explicitly or implicitly tells us something about what is wanted from the landscape in which the ‘unwanted plant’ is thriving—it is likely that individual or societal values result in the plants being defined as unwanted or costly. It may be more feasible to modify these kinds of expectations, rather than modify the plants themselves. Finally, it is of concern that, in many cases, the interventions adopted to reduce harmful effects of weeds on conservation values are proving ineffective, resulting in sites being recolonised by the same or similar weeds (Reid et al 2009). This finding led to calls for more critical evaluations of weed reduction practices based on ideals of ecosystem restoration.

Another view of weeds fr

Figure 7: The three components often used in defining invasive species. Different definitions emphasise different components.

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26 Grice, Tony, Weeds of Significance to the Grazing Industries of Australia, MLA Sydney 2005
What is the weed problem and how is it represented?

There are many calls for ‘innovation’ in tackling weeds. In this section, we ask stakeholders to step back from their certainty about the nature of the weed problems and ask, “what are the nature of the problems and how are they represented?”

Carol Bacchi (2009) outlines an approach to policy problem questioning using multiple questions:

- what is the problem and how is it represented?
- what presuppositions or assumptions underlie this representation of the problem?
- how has this representation of the problem come about?
- what is left unproblematic in this representation?
- can the problem be thought about differently?
- what effects are produced by this representation?
- how/where has this representation of the problem been produced, disseminated and defended?
- how could the problem be questioned, disrupted and replaced?

Bacchi is not arguing that policy problems, such as weeds and biosecurity, are not real; rather, the way we define certain ‘problems’ tends to fix them—determining likely responses—and therefore that there are benefits in interrogating these ideas more deeply. This approach asks us to treat the representations of policy problem as flexible and reflect on their origins, purposes and effects. This demands that we acknowledge, “we are immersed in the conceptual logics of our era and therefore need to interrogate our own assumptions.”

**Do we need to define, or redefine the nature of weeds and weed problems before considering how investments in RD&E can be used to ‘fix’ these problems? How does the way we conceptualise weed problems determine the kinds of R&D undertaken? Are there unrealistic expectations about what can be achieved?**

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29 *Analysing policy: What’s the problem represented to be?* by Carol Bacchi, Pearson Education, Frenchs Forest 2009 Extracts of a Book Review by Emma Partridge, [https://www.academia.edu/1365133/Analysing_Policy_Whats_the_problem_represented_to_be](https://www.academia.edu/1365133/Analysing_Policy_Whats_the_problem_represented_to_be)

30 *Analysing policy: What’s the problem represented to be?* by Carol Bacchi, Pearson Education, Frenchs Forest 2009 Extracts of a Book Review by Emma Partridge, [https://www.academia.edu/1365133/Analysing_Policy_Whats_the_problem_represented_to_be](https://www.academia.edu/1365133/Analysing_Policy_Whats_the_problem_represented_to_be)
3. Situation analysis—the context for weeds RD&E

This section sets out contemporary policy settings and strategies for weeds and weeds RD&E in Australia. In some cases, sections or summaries of these strategies have been reproduced to indicate their central foci and more detail are provided in Appendix 2.

How is weed RD&E organised in Australia? Shared responsibilities for weeds

Weed management in Australia is framed by policies about shared responsibilities. These responsibilities span local, state and national governments, NRM and catchment organisations, landholders and land managers. Therefore, any weeds RD&E that aims to target end-users’ needs, must work within this context and with multiple parties, each with different needs and responsibilities.

This section seeks to articulate this context for weeds RD&E in contemporary Australia. It recognises this complex social and institutional ecology for weed management. For example, research is dispersed across many agencies, while on-ground responsibilities often fall to management groups who are active in particular regions, focusing on priority weeds in that region, yet overall there are few ways of sharing capacity or identifying and responding to common needs.

All states, territories and regional natural resource management bodies, most agricultural industries and local land and water community management groups have weeds highlighted as a significant area of focus within their prioritisation and investment frameworks. However, within this context of shared responsibility, weeds RD&E is fragmented and lacks coordination. This can result in a lack of critical mass and in sub-optimal outcomes in terms of knowledge generation and information management and application.

Weed management is also increasingly becoming embedded into the discourse of Australia’s overall national biosecurity system, with an eye on using limited resources for national and local economic, environmental and social benefits.

A strategy rich environment

Australia has an abundance (possibly an over-abundance) of weed strategies. This project’s terms of reference acknowledged that “there is no shortage of weed investment frameworks, strategies and research and innovation plans in place across Australia. However, there is a perception that these have struggled to make significant inroads into the ongoing impacts and management of established weeds, and that far more can be done to improve early detection, intervention and prevention measures. Success has been sporadic. The weed RD&E space appears crowded, institutionally contested and lacks effective mechanism and process for sharing expertise, sponsoring collaboration and coordination, leading to concerns about overall effectiveness and impacts”31.

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31 CISS weeds investment plan project consultancy Terms of Reference
Recognising the policy and institutional context—shared responsibilities, complex institutional setting, the current fragmentation and lack of coordination of weeds RD&E—this project aims to enhance the benefits of cooperation through setting clear objectives and ways of guiding future allocation of R&D funds.

**Given the policy and social context of shared responsibilities, what models of investment cooperation and collaboration with the many parties involved will enhance national capabilities for weeds RD&E with impact?**

**Shared responsibilities—federated and networked models**

A diverse range of government and industry committees, working groups (which set priorities) and strategies (that outline the agreed priorities and implementation approach) set the strategic directions for weed RD&E in Australia. These strategies and committees are summarised below with more detail provided in Appendix2.

The National Biosecurity Committee (NBC), formally established under the *Intergovernmental Agreement on Biosecurity*, is responsible for managing a national, strategic approach to biosecurity threats, relating to plant and animal pests and diseases, marine and aquatic pests, and the impact of these on agricultural production, the environment, community well-being and social amenity. The NBC is supported by four sectoral committees, which provide policy, technical and scientific advice on matters covering all pests and disease risks to the terrestrial and aquatic (inland water and marine) animals and plants, and the environment.
The NBC has developed three RD&E strategies for guiding Australia’s investment:

- the National Animal Biosecurity RD&E Strategy 2013-2016
- the National Plant Biosecurity RD&E Strategy 2013-2016
- the National Environment and Community Biosecurity RD&E Strategy 2014-2017

RD&E priority areas identified across these strategies can be grouped under four broad categories:

- risk analysis and decision making
- detection, diagnosis and surveillance
- management methods and strategies
- stakeholder engagement

The Environment and Invasive Committee (EIC), which in 2018 is replacing the Invasive Plants & Animals Committee (IPAC) is a sub-committee of NBC. It aims to ensure an integrated and effective national approach to the prevention and management of problems associated with vertebrate pests, freshwater invertebrate pests and weeds.

The role of the Invasive Plants and Animals Research and Development Expert Group is to facilitate the establishment of a collaborative national system for undertaking high priority invasive plants and animals RD&E, with a view to reducing pest and weed establishment, spread and impacts. It is accountable to the IPAC.

It is important to note that the National Environment and Community Biosecurity RD&E Strategy (Box 1: Appendix 2) is broader in scope than weeds, given that it “focuses on pests, weeds and diseases that involve either alien or native organisms that adversely affect the environments they invade and impair their functionality. All pests, weeds and diseases of aquatic (freshwater and marine) and terrestrial habitats that affect the environment or the community are within the scope of this strategy. This includes outbreaks and incipient or slow spreading invasions of pests, weeds and diseases, in any way considered harmful to valued native organisms, natural ecosystems, community assets or human lifestyles and wellbeing”

The strategy identified “lack of funding to maintain capabilities and support coordination frameworks” as a major weakness. Other weaknesses include investment gaps and a lack of continuity to enable delivery on long-term issues and loss of R&D capabilities, including loss of promising early-career researchers. The strategy also identified the following opportunities:

- growing interest by the general public in scientific research (citizen science)
- increased international and national recognition of invasive organisms as key problems for the environment and community
- growing interest in funding research on causes of invasion rather than only treating symptoms
- scope to address fundamental science questions as part of applied projects
- innovative partnering to tackle invasive organisms problems including engaging the non-government sector and primary industries to address biosecurity issues and tackle pests, weeds and diseases.

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32 NBC National Environment and Community Biosecurity RD&E Strategy 2016 to 2019 Department of Agriculture and Water Resources Canberra
Given that the National Environment and Community Biosecurity RD&E Strategy identified that “lack of funding to maintain capabilities and support coordination frameworks” is a major weakness, what needs to be done to ensure adequate funding, effective coordination and the maintenance of adequate R&D capabilities?

What is needed to realise opportunities such as citizen science, international collaborations, and innovative partnering with primary industries and the non-government sector?

Current situation - R&D funding

Weeds management is a subset of Australia’s biosecurity system, which historically derived significant benefits from R&D. However, the R&D system no longer has the necessary structure, focus or capacity to address existing and emerging national biosecurity challenges. Craik et al (2017) comprehensively documented the current situation in their report Priorities for Australia’s biosecurity system—An independent review of the capacity of the national biosecurity system and its underpinning Intergovernmental Agreement33 describing the current situation as one of “many players but no captain.” The system for biosecurity R&D is closely linked to the agricultural RD&E system, where multiple funders and providers are involved (see figure 8 below), however, there is no lead agency for national prioritisation process. While many separate players are working well within their own domains there are opportunities for additional effectiveness through enhanced collaboration.

Weeds RD&E activities are primarily funded by the Australian, state and territory governments, rural Research and Development Corporations (RDCs) and, previously, the Cooperative Research Centres (CRCs). Both RDCs and CRCs receive significant funding from industry and government sources. Providers include the CSIRO, state and territory government agencies through their research and diagnostic facilities, and the university sector

Australian Government funding initiatives include the Australian Research Council’s Linkage and Discovery programs, Rural R&D for Profit Program and CRC Program.

As detailed above, various entities attempt to coordinate R&D prioritisation and implementation through a range of largely unfunded strategies.

Clarifying public and private benefits in R&D

Rural RD&E operates within a complex system that links funders, providers and end users (see Figure 9). It comprises the network of individuals and organisations that fund and undertake research and development activities, the extension and consultation networks that support the flow of information and transfer of technology between industry and researchers and the policy and institutional frameworks that support these activities.

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33 Priorities for Australia’s biosecurity system, The final report of the independent review of the capacity of Australia’s biosecurity system and the underpinning Intergovernmental Agreement on Biosecurity (IGAB) W. Craik, D. Palmer and R. Sheldrake 2017
The Australian Government has a long history of co-investing with industry in rural RD&E. This continued support recognises that rural industries mostly consist of a large number of small producers who, individually, may not have the capacity to invest in RD&E. The Australian rural sector includes a diverse range of industries, which largely comprise small family businesses. The incentive and capacity for individual small businesses to invest in RD&E is low, resulting in potential under-investment in RD&E in the rural sector.
The Australian Government helps rural industries overcome this by providing rural producers with the means of investing collectively in RD&E to benefit their industry and wider community. Through establishing and supporting rural research and development corporations (RDCs) and other organisations like CISS, the Government provides a way for an industry to invest collectively through levy collections, and matching government funding provides an incentive for industries to do so.

Biosecurity as a national research priority

Biosecurity is one of many existing priorities for overarching national R&D. Under the Australian Government’s National Science and Research Priorities, biosecurity is embedded within the ‘food’ national science and research priority, with the challenge of ‘protection of food sources through enhanced biosecurity’. The National Rural R&D Priorities, gave biosecurity more prominence stating the aim was: ‘To improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers’.

The National Rural R&D Priorities, developed in the 2015 Agricultural Competitiveness White Paper, have been adopted by all jurisdictions, as part of the National Primary Industries Research, Development and Extension Framework (NPIRDEF). The framework aims to generate collaboration and continuous improvement in the investment of RD&E resources nationally.

These national research priorities are intended to guide the R&I investment decisions of the Australian, state and territory governments and other funders of biosecurity R&I. But Craik et al (2017) claim that, “as they stand, they provide little clarity or substantive guidance for investment in the national biosecurity system” and that there is a necessity for a long-term commitment to funding R&D because “diagnostics, surveillance, response methodologies and treatments need to be continually developed as new technology becomes available and old systems become redundant.” Investment in biosecurity R&D is strongly linked to funding of agricultural RD&E in Australia, particularly via the RDCs. The Australian Government remains the major public funding source, therefore “it is the funding decisions of the Australian Government, primarily through the science and agriculture departments and their portfolio agencies, that will continue to determine the relative priority of biosecurity R&I—compared to agricultural productivity, for example, in the national R&I system.”

The Australian Weeds Strategy

The Australian Weeds Strategy 2017-2027 provides a strategic framework for weed policy and management for the next decade. The first Australian Weeds Strategy, developed by the former Australian Weeds Committee, built on the previous National Weeds Strategy launched in 1997 and was endorsed by the Natural Resource Management Ministerial Council in 2006. The Australian Weeds Strategy outlines three goals—each with multiple priorities—to protect Australia’s economic, environmental and social assets from the effects of weeds (see appendix 2 for details). The three goals are:

1. Prevention, detection and early intervention
2. Minimise the impact of established weeds

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34 Agricultural Competitiveness White Paper Commonwealth of Australia 2015
35 Priorities for Australia’s biosecurity system, The final report of the independent review of the capacity of Australia’s biosecurity system and the underpinning Intergovernmental Agreement on Biosecurity (IGAB) W. Craik, D. Palmer and R. Sheldrake 2017
36 Ibid
37 Invasive Plants and Animals Committee 2017, Australian Weeds Strategy 2017–2027
3. Enhance capacity and commitment to weed management

Importantly the AWS recognises that improving national approaches to coordination, capacity building and investment are priorities.

Also recognised in the AWS is the ongoing need to strengthen Australia’s collaborative R&D capabilities to address weed problems and threats into the future. The AWS does not identify specific RD&E priorities, but under Goal 3 it aims to enhance capacity and commitment to solve weed problems, identifying responsibilities for RD&E across governments and industry. For example, in specifying roles and responsibilities it states that the Commonwealth will:

- support national research and development of improved weed control or management when there is a strong public interest to do so, and through matching industry contributions to rural research and development
- work with state and territory governments to provide mechanism by which weed issues of national significance can be identified and addressed
- provide leadership, coordination and resources for research, evaluation and education to build public awareness and knowledge of weed issues of national significance

Under this strategy the roles and responsibilities of state governments will be to provide leadership, coordination and resources for research, evaluation, advisory services and education programs about weeds.

It was also recognised in the AWS that research, development and extension are crucial to sound, evidence-based systems for the prevention and management of weeds. For established weeds, specific focus areas are:

- investment in the support and maintenance of research capacity
- RD&E to sustain herbicide utility for productivity in agricultural systems
- a nationally coordinated approach to the selection of new biological control agents for priority weeds
- better understanding of landholder behaviour and their related economic drivers

An aim in the AWS is to keep research targeted and focused in areas that can strengthen the risk-based approaches adopted to cost-effectively and feasibly respond to weed challenges. RD&E help to develop and update best practice, and to customise best practice for different stakeholders, industries and/or species.

It was recognised in the AWS that weed control methods often take years to develop, and require specialist scientific skills and capabilities. To deliver the control methods of the future, it is important that RD&E activities, and associated funding arrangements are maintained with a long-term focus. Biological control demonstrates the importance of ongoing long-term commitment to research, development and extension.

*Given that AWS provides the strategic policy framework for weeds in Australia what kind of national investment models are needed to give effect to its RD&E objectives?*
Invasive Plants and Animals RD&E Priorities 2016-2020

The National RD&E Priorities for Invasive Plants and Animals (IPAC) 2016-2020 was prepared by the Invasive Plants and Animals Research & Development Expert Group, and endorsed by the former Invasive Plants and Animals Committee for release in October 2016. This IPAC paper outlines the strategic context for RD&E for pest animals and weeds, identifying national RD&E priorities for invasive plants and animals. It recommends 22 RD&E priorities for 2016-2020 within 4 programs:

- new approaches to detection, prevention and eradication
- biocontrol
- the sustainability of existing management options; and
- socioeconomic drivers of adopting best practice

The main points, re context, are that:

- pest animals and weeds have a significant impact on Australia’s economy, environment and community, with economic effects costing Australia well over $7 billion every year;
- strategic directions for RD&E is provided by a diverse range of government and industry committees, working groups and strategies—improved coordination and collaborative efforts are needed across government and industry;
- identification of national RD&E priorities for weeds is complex, with many committees, working groups and strategies in place; and
- community and industry involvement is needed to prevent and detect new invasive species

The priorities identified include that new approaches are needed for:

- early detection and prevention technologies
- adoption of surveillance systems and risk based approaches
- emerging invasive species
- pre-border risk assessment
- incursion response strategies for invasive species

In relation to biocontrol techniques key points include:

- biocontrol is a well-justified case for government and industry investment, offering significant public good benefits accruing over time (e.g. average benefit: cost ratio of 23:1 for weeds)
- weed biocontrol research is constrained by long lead times and the need for specialist skills and facilities
- a decision support tools have been developed to aid prioritisation of targets for biocontrol research
- many priority weeds for livestock industries are weeds of national significance and environmental weeds
- community ownership is fundamental to hasten establishment, spread and impacts of biocontrol agents

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38 In early 2018, the Invasive Plants and Animal Committee became the Environmental and Invasives Committee to reflect a stronger emphasis on the environment alongside agricultural production.

39 National RD&E Priorities for Invasive Plants and Animals (IPAC) 2016-2020

40 National RD&E Priorities for Invasive Plants and Animals (IPAC) 2016-2020
Given the need to develop and apply risk-based approaches to detection, prevention and eradication of weeds what kind of national investment models are needed for this kind of RD&E?

Given the prospective value of biocontrol techniques weeds what kind of national investment and coordination models are needed to further support and enhance this kind of RD&E?

Policy, compliance, extension and socioeconomic aspects

When should Government, industry, landholders invest to achieve maximum long-term reductions in impact? And what are the broader long-term implications of controlling (or not controlling) weeds on other species, for ecosystems, landscapes and production systems?

Invasive species management is primarily driven by people’s knowledge, behaviours and actions, and new knowledge doesn’t necessarily result in behaviour change. Further work is needed to target Government interventions through, for example, incentive programs which seek to motivate landholders and managers or through regulation and compliance systems that limit the species of plants that can be sold through nurseries in order to reduce the active distribution of known weedy species.

In grazing systems, greater effort is needed to develop and promote decision tools that inform the on-farm profitability of integrated approaches. A similar need remains for natural ecosystems, where managers are faced with multi-species invasions and very limited operating budgets often where weed seed bank longevity can add significant cost. Here, new and existing, broad-scale invasive species and native vegetation management techniques need to be cost-effectively combined.

It is clear that economics and social research can play key roles, for example:

- feasibility assessments of eradications and associated costs and resources because eradications can be highly labour intensive and often result in multi-million dollar programs
- designing effective regulatory or incentive regimes
- understanding barriers to, and drivers of, adoption of best practice

In addition, government investment in invasive species management, through control programs or one-on-one officer interaction with individual landholders, is in serious decline in, what some define as, a crisis in agricultural extensions that is occurring through reforms focused on reducing public expenditure to agriculture, replacing public extension services with private sector providers

In the absence of government extension, alternative, community and industry-led models of cooperative action are evolving as the social norm. Socioeconomic factors that foster widespread land manager adoption of existing and new R&D need to be factored into all research programs, rather than adopt a reliance on traditional but outmoded extension models. Likewise, presenting invasive species information in the context of a production or environmental management system is important—a decision on managing invasive species needs to be supported by a systems approach. A ‘communities of practice’ approach, bringing together landholders across multiple land uses, scientists, local authorities, socioeconomic researchers and advisers (e.g. financial, agronomic) may yield longer-term outcomes around an agreed invasive species problem of mutual concern. A key to this area is dealing with ‘causes’ and not just ‘symptoms’. For all systems, direct involvement of land managers in research and at demonstration sites is fundamental to reality check and foster broader adoption of new integrated environmentally and socially responsible approaches.

41 Rickards, L. & Alexandra J. (forthcoming), The Agricultural Extension Sector: past, present and future approaches Report ACIAR Canberra
Given that forming collaborative partnerships involving land managers and understanding the policy context and socioeconomic drivers are recognised as priorities, what kinds national investment models are needed to further support and enhance this kind of RD&E?

Federated and networked approaches

Australia’s approach to weeds is what can be described as a federated approach, with responsibilities appropriately distributed throughout the Federation. While this and several reviews identify the need for greater collaboration, this does not imply an argument for the full centralisation of control.

The Weeds of National Significance program represents an example of shared responsibilities in Australia’s federated system. Weeds of National Significance have been a feature of Australian weed management for nearly 20 years with 32 Weeds of National Significance (WoNS) agreed to by Australian governments based on a range of criteria, including the need for coordination. A list of 20 WoNS was endorsed in 1999 and a further 12 were added in 2012.

Weeds of National Significance have been the target of major programs with some successes and some cautionary tales about the need for vigilance. The aquatic weed Salvinia molesta (Figure 10) provides a useful example. The State of the Environment (2011) reported that, “Salvinia is a floating aquatic weed that can cover entire water surfaces with a thick mat of vegetation, shading submerged plant life and impeding oxygen exchange, making the water unsuitable for fish and other animals. The national response to this introduced weed shows what can be accomplished with an effective control option (in this case developed by CSIRO using a natural biological agent—Cyrtobagous salviniae), and national strategy and commitment.” Like with most biocontrol techniques complete eradication is not possible but the reduction in impacts can be substantial.

Figure 10: Distribution, spread and management actions for Salvinia molesta

Source: State of the Environment, 2011

Another group of Weeds of National Significance are the willows species that have spread in waterways throughout South Eastern Australia. Figure 11 maps the distribution of willows and Figure 12 provides an example of their persistence. This 2018 photo of a roadside sign at the Victorian Governments Ellinbank Research Farm announces the final stages of a five-year program of willow removal and replacement with indigenous species, sponsored by the West Gippsland CMA and the Victorian DPI. However, note the young Crack Willow (S.Fragilis) trees emerging beside the sign. They also line the nearby drain between the sign and Bear Creek, providing a source of propagation material (twigs) downstream into the Latrobe River system, potentially as far as the Ramsar listed Gippsland Lakes. This is an example of a high-profile weed that has remained obstinate in refusing to be eradicated, even in heavily managed areas, despite many million in program funding. This willow growing back right under the sign on a government farm demonstrates that weeds are worse than threatened species, in that they don’t ever read management guidelines or revegetation plans and, if they do, they don’t obey them

This position is not unique: Reid et al (2009) found that many Australian efforts to remove weeds and promote indigenous vegetation resulted in reinvasions

Figure 11: Distribution of Salix spp.


Reid et al 2009 recommended more rigorous and systemic evaluations are need for weed control interventions, given the apparent failings of many weed control intervention intended to restore native vegetation.

Evaluation plays key roles in adaptive environmental management and needs to be part of learning by doing programs.

*Should more rigorous and systematic evaluation be part of weeds RD&E in order to turn management into an adaptive experiment and to determine which approaches to weeds are working to achieve their stated objectives?*

**Long-term, collaborative participatory research works**

Examples of highly successful weed management efforts exist, but those with highest impact tend to reflect long-term investments and partnerships in collaborative and participatory R&D. Box 1 provides an example of this with respect to Paterson’s Curse.
Box 1: Biological control of Paterson’s curse across Southern Australia

In the 1970’s, Paterson’s curse was the most widespread, costly, and toxic broadleaved agricultural weed in Australia, covering more than 10 million hectares, and costing nearly $40 million a year in lost production. CSIRO initiated a biological control program for Paterson’s curse in France in the 1970’s³². Early releases led to a high court challenge by graziers and bee keepers from South Australia, showing assessment and management of conflicts of interest in biological control programs needed better policy instruments. This issue was ultimately resolved through an independent government inquiry (including the first comprehensive cost-benefit analysis of a classical biological control program globally) and the development and enactment of the Biological Control Act (1986).

Distribution and evaluation of agent impacts through an MLA funded CSIRO-led consortium involving all the southern States ended in 2006, although state-based redistribution of agents continued for several years after this time, as did observations of the impacts of the agents. Since CSIRO funded activities ended, the spread of agents has been a farmer led activity, some through small enterprise. The ownership of the program and its benefits passed to the farming community and Landcare groups.

Over its 30-year life, the program developed into a national network across all southern states³². Seven biological control agents were selected, import risk assessed, and released into Australia of which six established and spread. Most of these agents were mass reared in most states and redistributed to contracted numbers of nursery sites in each of the affected areas, where impacts were monitored. Farmers were trained in biological control practices, and the Paterson’s curse biocontrol agents in particular. These farmers obtained agents for their own properties/locations via field days leading to community led redistribution programs. The need for broader distribution of agents also led a state-based federally funded national redistribution program (covering other weed biological control programs as well) from 2006-2009.

This CSIRO-state program consortium led to the completely successful biological control program for this target across all states and territories, from three highly effective biocontrol agents for Echium plantagineum: the crown weevil Mogulones larvatus; the root weevil Mogulones geographicus; and the flea beetle Longitarsus echii³². The root feeding flea beetle was the most effective agent in drier areas including, Western Australia; while the weevils were more effective in higher rainfall areas, including Tasmania. While no funding has been available to formally evaluate the effectiveness of this program, the historic “blue hills”, or even fields, of Paterson’s curse in spring have progressively disappeared over the last 10 years. All collaborating farmers have confirmed that their horses and livestock are no longer dying from consumption of the weed; and that they no longer need to spray their properties for the weed. Surveys in northern Victoria suggest that weed densities and biomass have dropped between 80 and 90 per cent, with similar results being observed in South Australia and Western Australia. An economic assessment for this control program has shown that for a research and development investment of $23.1 million, the net present value benefits are on target to be $1.2 billion by 2050.

4. Previous national weeds RD&E programs

Over recent decades there have been two major national weeds RD&E investment programs. This section looks at prior research with a view to extracting key lessons for the Investment Plan. It is worth noting that there is strong alignment of the weed R&D priorities in these earlier programs and those articulated recently, so it is clear that the broad directions and scope of thinking about R&D needs have not changed.

Defeating the Weed Menace R&D Program

Defeating the Weed Menace R&D Program 2005-08 was a Land and Water Australia program (see appendix 3 for more details). The Australian Government committed $40 million to the program to tackle the management of Australia’s most threatening and invasive weeds, through research, biological control, community awareness and on-ground action. An indicative total of $5.4 million over the period 2005-06 to 2007-08 was assigned to a research and development component to deliver high priority R&D activities aligned with the National Weeds Strategy. The goal was to provide research and knowledge management to support the program, complementing existing research activities on invasive weeds. Most R&D focused on weeds that affected extensive land systems and conservation areas across Australia, where the prospective community benefit was large. The R&D component consisted of three priority themes:

1. reduce the rate of emergence of new weed problems:
2. reduce the impact of existing weed problems of national priority:
3. support national frameworks and capacity for sustainable weed management and decision-making:

National Weeds and Productivity Research Program

The National Weeds and Productivity Research Program R&D program proceeded in two phases—2008-09 and 2010-15. Initially the program was managed by the Department of Agriculture Forestry and Fisheries and then the Rural Industries Research and Development Corporation in the second phase.

The first phase funded 39 research projects costing nearly $3.6 million. The Australian Government provided a further $12.4 million for two years (2010-12) for the second phase. In 2010, RIRDC published the 2010-2015 plan, prioritising four objectives:

• improve knowledge for effective risk management of weeds
• reduce current and future impacts of weeds on Australia’s productive systems and environments
• support improved adoption of weed management approaches
• plan future funding and institutional arrangements for investment and management of weeds R&D

Evaluation of RD&E in the Australian Weeds Strategy implementation report

The most comprehensive evaluation of weeds RD&E against strategic priorities was undertaken in the implementation report of Australian Weeds Strategy 2007-2012. It documented an analysis of the R&D delivered against the agreed priorities. The Australian Weeds Strategy provided the national framework to guide the weed

45 ibid
management effort of all jurisdictions in Australia. Its 3 goals and 45 strategic actions covered most aspects of Australia’s weed management effort, including RD&E. These framed the comprehensive evaluation of weeds R&D.

The Australian Weeds Strategy implementation report 2007-2012\(^6\) includes an analysis of nearly 400 R&D Projects from 2007 to 2012 against the Strategy. This analysis showed that 68.1% of the R&D projects were aligned with reducing the impact of existing weeds (Goal 2), only 18.2 % of projects focused on preventing new weed problems (Goal 1), while 13.8% addressed enhancing capacity and capability (Goal 3).

It is important to note that the author claims that the 86.3% of projects aligning with Goals 2 was a result of pressure from stakeholders to deal with problems caused by established weeds, due to the impact of weeds on productivity and biodiversity.

Analysis of R&D projects against the objectives in the Australian Weeds Strategy was also undertaken. It showed that the number of projects dealing with existing weeds dominated, while the proportion of R&D Projects (2007 to 2012) aligned with several prevention objectives were less than 10 per cent of the total:

- 14 projects (2.7 per cent) focused on preventing the introduction into Australia of new plant species with weed potential
- 41 projects (8.0 per cent) focused on ensure early detection and rapid action against new weeds
- 18 projects (3.5 per cent) focused on reducing weeds spreading to new areas within Australia
- 20 projects (3.9 per cent) focused on weed risk management practices to respond to climate change

Furthermore, the proportion of R&D projects (2007 to 2012) focused on socioeconomic and policy aspects of weeds was only 2.2 per cent of the total:

- 1 project (0.2 per cent) focussed on raising awareness and motivation to strengthen commitment to act on weeds
- 8 projects (1.6 per cent) focussed on managing weeds within consistent policy, legislative and planning frameworks
- 2 projects (0.4 per cent) focussed on monitoring and evaluating the progress of Australia’s weed management

The proportion of R&D projects (2007 to 2012) aligned with managing existing weeds exceeded more than 63 per cent of the total:

- 209 projects (40.9 per cent) focussed on implementing coordinated and cost-effective solutions for priority weeds and weed problems
- 116 projects (22.7 per cent) focussed on developing approaches to managing weeds based on the protection of values and assets
- 59 projects (11.5 per cent) focussed on building Australia’s capacity to address weed problems and improve weed management

This analysis is revealing because it demonstrates that, while R&D objectives may be spread across all parts of the invasion curve, actual investment has been targeted to where the cost effectiveness tends to be lowest (Figure 13).

It is useful to think of weeds and weed problems as existing along an invasion curve from potential to established species and to also think about different strategies depending on where along this curve the species (and its risks) sits. Strategies and responses to potential or established species differ in character and likely cost effectiveness.

Figure 13: Stylised weeds invasion curve

The skewing of investment to established weeds and the lack of investment in prevention was also expressed more recently in the final report of the independent review of the capacity of Australia’s biosecurity system and the underpinning Intergovernmental Agreement on Biosecurity (IGAB) (Craik, Palmer and Sheldrake 2017). The report stated that numerous submissions “highlighted the relative lack of investment in the left-hand side of the invasion curve, where the greatest returns can be achieved. These views were confirmed by the 2015–16 national stocktake of biosecurity investment, which revealed that approximately 63 per cent of state and territory investment is directed at areas where the return is generally lower—that is, established pests and diseases” (Craik, W., D. Palmer and R. Sheldrake 2017).

These findings have implications for future weeds RD&E raising significant questions such as:

- How can RD&E investment allocation be directed at all stages of the invasion curve?
- Are there useful ways of thinking about investment decisions at the different stages of the invasion curve?
- Are there principles for ensuring appropriate allocation between prevention and management of fully established species?

**How can an Investment Plan ensure that funding is distributed to those projects that are likely to be most cost effective in dealing with prevention, early detection, effective policy and coordination, when intense pressure is likely to be expected for work on established weeds?**

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47 Craik, W., D. Palmer and R. Sheldrake 2017, *Priorities for Australia’s biosecurity system*, The final report of the independent review of the capacity of Australia’s biosecurity system and the underpinning Intergovernmental Agreement on Biosecurity (IGAB)
5. Re-conceptualisation- reframing of weeds RD&E

Framing weeds as problems

There is nothing simple about weeds. The way we think about them depends on what we seek to achieve from a given landscape. Sometimes, the weeds affecting agricultural production are the native plants of a district. Often, plants important for production, such as exotic species of grasses, are also deemed to be major threats to the conservation ecology of landscapes by those other than graziers. Yet weeds also perform ecological functions, such as catchment stabilisations, erosion prevention, carbon sequestration and habitat provision.

Some weeds may form part of succession processes in a landscape, as it reverts back to forest. Other weeds may stop the process of native plant succession, by locking-in the system to a particular community of species. Some researchers (for example, Tim Low in *Feral Futures*) also claim that thorny weeds, such as blackberries and lantana, provide habitat for small birds and mammals and that, without them, Australia’s extinction levels may be higher. Backing this idea, Buchanan (2016, Page 37) states that “Weeds such as Blackberry and Lantana provide a retreat from predators and a safe nesting site for many small birds”.

Weeds often thrive in modified or disturbed landscapes, yet many see weeds as a major disturbance to landscapes. Many weed species are favoured by certain grazing, cropping or disturbance regimes (for example, fire or the lack of it). Climate change is likely to enhance disturbance and favour weedy species.

*Do we need R&D into the ecological functions of weeds that more explicitly examines their benefits and the risks they pose to specified values like conservation and production?*

Novel ecosystems versus nativeism—weeds of the Anthropocene

There is a longstanding and ongoing debate about how to establish landscape conservation goals and the levels and types of weed intrusions that are acceptable. Traditionally, most landscape conservation goals have been set by reference to pre-development or natural ecosystems. However, there is an increasing acceptance of landscapes as socially constructed due to long standing human involvement, through practices such as burning or grazing. Furthermore, there are some who claim that we are increasingly dealing with novel or recombinant ecosystems in which weeds are simply part of the new mix. Novelty is enhanced by global anthropogenic impacts, like climate change, which are making static conservation paradigms redundant.

There are no simple answers, because thinking about weeds, encounters underpinning conceptual challenges about how landscape conservation goals are set. We are grappling with the social construction of goals for the trajectories of ecosystems. This is particularly apparent in urban and agricultural regions because most of the world’s terrestrial or freshwater ecosystems can be defined as anthroscapes or anthromes, because “humans have reshaped more than three quarters of the terrestrial biosphere into anthropogenic biomes (anthromes),

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49 Tim Low - 1999 *Feral future: the untold story of Australia’s exotic invaders*, University of Chicago Press
50 Buchanan R 2016, *Restoring natural areas in Australia*, NSW DPI

52 Backstrom A., Garrand G., Hoobs R., Bekessey S., 2018 Grappling with the social dimensions of novel ecosystems [https://doi.org/10.1002/fee.1769](https://doi.org/10.1002/fee.1769) Frontiers in Ecology
embedding substantial areas of remnant and recovering novel ecosystems within the agricultural and settled landscapes that sustain human populations" 53. Due to scale of these transformations, idealised pre-development benchmarks of ecosystems appear to be becoming increasingly redundant and may only be able to provide one input into the setting of goals for landscapes. Achieving socially defined forward-looking objectives for integrating human dominated systems and biodiversity conservation will always be complex and may be becoming even more so because anthropogenic impacts, including climate change, compound existing stressors on ecosystems and present new challenges for integrated assessment, planning and management, by adding uncertainty and complexity 54. Managing weeds is likely to remain part of the way we think about establishing feasible conservation or restoration objectives. Drawing on knowledge derived from minimally disturbed or reference ecosystems will remain extremely useful, and while ‘natural’ benchmarks have often been the dominant ways conservation and restoration goals are established, it is important to recognise that these goals and objectives are always socially constructed 55.

With the scale and magnitude of anthropogenic drivers of change, and the inherent complexity and the dynamic nature of the ecosystems, more flexible and adaptive approaches are called for, due to the complex relationships and non-linear feedbacks between social, ecological, and climatic systems, including the impacts of native and introduced species, defined as weeds.

Would setting clearer objectives for regional landscape or bio-regions help deal with questions of weeds and their places within regional ecosystems?

Holistic and landscape—scale versus weed-by-weed control

Do we need to shift the balance of effort from individual species and individual control techniques to more holistic and systemic approaches (bioregional or landscape scale), which rely on sustained interventions that make conditions less suitable to the targeted weed species? These might include shading, grazing regimes and competition, reintroduction of fire regimes, coupled with other control techniques.

By changing to integrated approaches, we might redefine weeds and their place in ecosystems. For example, many graziers who have adopted rotational systems (often referred to as integrated resource management) have seen a dramatic shift in the nature of the pasture systems. Some graziers who have adopted such systems are defining any plant that provides ground cover and biomass as ‘useful’ to their systems.

In other cases, sustained effort, which brings together multiple interventions, may be needed to have any impact on persistent weed species. The consideration of holistic and landscape scale approaches raise question such as:

- Are there generic approaches to understanding the ecology of weeds that may assist in devising more effective management?


54 Alexandra J., (2018) The city as nature – new visions and logics for creating the climate adaptive, bio-cities of the Anthropocene Conference paper to NCCARF 2018

• For example are there ways of thinking about weeds and reducing their effects that are more holistic?
• Is research needed to improve the use of existing established technical options and to develop new innovative management alternatives?
• What integrated and landscape management approaches will work for agriculture (cropping systems and extensive grazing) and for the environment and community?

Taking these ideas into account, we may need to move from control effectiveness (or tools alone) to a greater understanding of landscape systems approaches, appropriate scale, species interactions, bio-economics, and how and when these tools and strategies can be implemented by communities and industries.

Do we need to reconceive weed management from singular techniques to integrated approaches that attempt to deal with weeds within ecosystems?

Figure 14: Invasion graph indicating stages of expansion of a new species into a habitat

Sleeper weeds and new incursions

The Invasive Species Council estimates that there are over 26,000 exotic plant species in Australia and that over 25,000 were introduced for ornamental purposes. Approximately 8,000 species have been introduced for agricultural purposes. Of these, nearly 3,000 species have naturalised. Of those, nearly 65 per cent have come from gardens and a further 6,000 species, which exist as garden plants, have demonstrated weediness overseas. Of those naturalised, 1,765 are deemed to be weeds in natural environments and approximately 1,200 species are weeds in agriculture56.

‘Sleeper weeds’ is a term used to define species that have exponential growth and spread after a period of dormancy. They are usually plants that have or can naturalise in a region but have not yet increased their populations at the rate or size possible. Often, they have periods of low rates of increase in the period between ‘naturalisation’ and ‘exponential increase’ 57.

57 Agricultural Sleeper Weeds in Australia What is the potential threat? July 2002 Tim R. Brinkley and Mary Bomford Bureau of Rural Sciences, PO Box E11, Kingston, ACT 2604
With Australia’s diverse bioclimatic conditions the prospect that are many sleeper weeds yet to emerge as major problems is one of deep concern to many ecologists and weed specialists. In response to this threat the Invasive Species Council is calling for an overhaul to regulations on restricting the trade in many species currently widely available in what they calling a ‘white list’ approach – one that nominates those species that it is Ok for the nursery industry to use in trade and distribute.58

**Horticulture industry, garbage tips and E commerce**

The number of weedy species in circulation within gardens and in the nursery industry raises the supply chain issues—nurseries, e-commerce, transport, and consumer behaviour—that may be important for managing the net generation of weeds.

Another potential pathway of mass distribution is green waste cycling at garbage tips (recycling depots) where waste plants are chipped and distributed as mulch.59

These examples of weed redistribution pathways – nurseries, e-commerce and garbage tips – are provided to indicate the potential of some weeds RD&E focusing on the policy and institutional aspects of weed control and prevention.


59 Biological Invasions [https://doi.org/10.1007/s10530-018-1708-1](https://doi.org/10.1007/s10530-018-1708-1) - Rubbish dumps as invasive plant epicentres

Pablo I. Plaza; Karina L. Speziale and Sergio A. Lambertucci
6. Investment planning principles and approaches

Portfolio allocation approaches to investment

Portfolio allocation approaches to investment are a way of allocating investment funds across a range of priorities, a range of opportunities and a range of risk profiles. It is used extensively in allocating investment capital in the private sector and has been also adopted for public sector investment, including in R&D allocation. There are no precise formulas for portfolio allocation, instead investors and organisations adopt their own principles based on objectives, strategies and assumed risk profiles. For R&D allocation it allows those making allocation decisions to invest across a range of R&D program and projects with a view to achieving the intended outcomes from a mix of activities, some of which may exceed their expected benefits and some of which may fail. This spreading of potential returns and risks in central to portfolio allocation approaches. Given the scope, scale and sheer number of weeds, it makes sense to adopt this kind of approach to allocation of funds across diverse types of R&D priorities. The CISS approach to portfolio allocation is outlined in Appendix 4.

There are number of investment allocation principle emerging from this review that could be used to inform the development of the Investment plan. These include:

- Invest where there is a public benefit and in activities that pass the national interest test,
- Balance investments across invasion curve as per Australian Weed Strategy,
- Alignment of RD&E investments with agreed of national priorities
- Use a transparent portfolio assessment framework and agreed investment criteria
- Does not support cost shifting but results in additional benefits via collaboration across multiple scales
- Calibrate the prospects of success and likely impacts against the costs

Following on from this general discussion on portfolio allocation approaches we look at National Biosecurity Committee’s (NBC) approach to national portfolio investment optimisation and the Australian Office of Financial Management’s approach.

Using portfolio allocation theory to inform program design

The general approach of a portfolio allocation method involves balancing risks inherent in all investments with objectives, usually with a view to maximizing overall rate of return subject to accepting an estimated level of risk. The process of investment selection would normally consist of three stages, as illustrated in Figure 15.

Figure 15: Investment selection process
The National Biosecurity Committee’s portfolio investment optimisation approach

The National Biosecurity Committee (NBC) is formally established under the *Intergovernmental Agreement on Biosecurity*. The NBC has a national portfolio investment optimisation model, which categorises government investments across the range of biosecurity activities. NBC applies the model to inform a considered and holistic approach to investment to help understand investment returns.

The NBC model provides five investment categories (IC) which reflect the suite of activities across the national biosecurity system. The Australian Government also reports on a sixth category, export facilitation.

The national portfolio investment optimisation model categorises investments as follows:

- **IC1** Prevention of exotic/emergency pests and diseases (pre-border and border)
- **IC2** Preparedness for exotic or emergency pests and diseases, including early detection (surveillance)
- **IC3** National eradication/containment programs (cost-shared national programs)
- **IC4** Management of established pests and diseases of national significance
- **IC5** Management of other established pests and diseases
- **IC6** Export facilitation (Australian Government only)

The foundation for the investment model is the 2008 generalised invasion curve detailed in the IGAB review discussion paper. The invasion curve includes indicative economic returns, with the return on investment higher for prevention than for ongoing management of established pests and diseases. For the later, return on governments’ investment is improved when their investment supports collective industry and/or community action (compared with government as the sole investor).

**Australian Office of Financial Management**

*Objectives*

The *Australian Office of Financial Management* (AOFM) manages the Commonwealth’s debt portfolio to meet the Government’s financing requirements. In doing so, AOFM seeks to minimise debt-servicing costs over the medium term at an acceptable level of risk, by which is meant an acceptable level of variability in cost outcomes. It also seeks to maintain liquid bond lines to facilitate the issuance of debt at acceptable cost and to manage the refinancing risk that arises when bond lines mature.

To meet these aims, the AOFM endeavours to execute a debt issuance strategy that appropriately accounts for the trade-offs between cost and risk, while simultaneously providing effective and transparent stewardship of the Australian Government Securities (AGS) market in order to underpin confidence and promote participation in the market. Through its strategy and operations, the AOFM contributes to an efficient and resilient market while providing continuity of access to financial markets for the Government.

The AOFM uses measures that appropriately reflect the costs and risks faced by a sovereign debt manager. The primary cost measure used is historic accrual debt service cost. This includes interest payments made on AGS, realised market value gains and losses, capital indexation of indexed debt and the amortisation of any issuance premiums and discounts. Total accrual debt service cost can be expressed as a percentage of the stock of debt outstanding to provide the effective yield of the portfolio. The use of an historic accrual debt service cost measure excludes unrealised market value gains and losses.
**Approach to achieving the objectives**

Variability in portfolio outcomes can be measured in several ways. The AOFM calculates and compares several metrics to assess risk. In general, an acceptable level of risk can be characterised as an acceptable level of variation in interest cost outcomes over time. Debt issuance decisions made today impact the variability of future interest cost outcomes because of their influence on the maturity profile of the portfolio and hence the amount of debt that needs to be refinanced (and ‘repriced’) through time.

The AOFM influences the cost and risk profile of the portfolio primarily through the maturity structure of the debt securities it issues (and to a lesser extent, the mix between nominal and inflation linked securities).

- Issuing longer-term securities will typically involve paying higher debt service costs (in the presence of a positive term premium) although this is compensated by reduced variability in future interest cost outcomes and lower exposure to refinancing or rollover risk.

- Issuing shorter-term debt securities by contrast will typically be cheaper (avoiding a term premium) but result in higher variability in cost outcomes through time and a greater debt refinancing task.

Striking the right balance between these cost and risk considerations is the debt manager’s ongoing challenge.

Strategic decision-making around the portfolio is informed by an ongoing research program focussed on exploring the cost and risk characteristics of alternative portfolio structures and issuance strategies. This is done in light of prevailing fiscal and economic circumstances. Drawing on this research, a strategy for the structure and composition of issuance for the financial year was formulated and ultimately approved by the Treasurer. Separately, a range of complementary limits, thresholds, guidelines and targets governing the AOFM’s operations were submitted to the Secretary to the Treasury for approval through an Annual Remit. Implementing the strategy requires weekly operational issuance decisions such as determining how much and which lines to issue or when a new maturity should be established. These operational decisions were influenced by several factors including general market conditions, relative value considerations and feedback from investors. The ongoing suitability of any issuance and portfolio strategy is constantly under review.
Appendices

Appendix 1: Where are weeds a problem in Australia?

Australia has defined 32 weed species as weeds of national significance. Figure 4 shows where these are recognised as a problem.

Figure 4: Locations where weeds of national significance are causing problems

Source: ABARES (2017)

Figures 4 and 5 illustrate the extent of weed problems. Australia’s bioregional classification system defines 89 bioregions as the spatial basis for bioregional conservation planning (Figure 5). NRM or landscape management occurs throughout Australia’s 89 bioregions, with varying degrees of intensity, capacity and effectiveness. Another useful system for classifying regional ecosystems uses a framework based on Australia’s 11 agro-ecological zones (Figure 6).

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In terms of agricultural production and bioclimatic zones the agro-ecological zones (Figure 6) may be more relevant to understanding the likely spread and impact of specific weeds.

Figure 6 Australia’s agro-ecological zones where weeds cause problems
Appendix 2: Australia’s weeds strategies

The National Environment and Community Biosecurity RD&E Strategy (Box 2 below) has been prepared and agreed to but it has not been funded. The Rural RD&E for Profit initiative (sometimes referred to as the DAWR White Paper funding) is currently funding some weeds projects. However, when it comes to an end, there’s little prospective funding on the horizon for weeds RD&E.

The National Environment and Community Biosecurity RD&E Strategy documents 21 RD&E priorities grouped into the 4 themes:

- risk analysis and decision making
- detection, diagnosis and surveillance
- management methods and strategies
- stakeholder engagement

The seven cross-sectoral RD&E priority areas most frequently selected during the expert elicitation exercise were:

- develop and apply risk analysis approaches to prioritise pests, weeds and diseases for management actions pre- and post-border, including ecological and socio-economic modelling of distribution, spread and impacts
- characterise and prioritise pathways of pest, weed and disease movement, including between land uses and between jurisdictions
- refine and further develop approaches to understand and quantify potential socioeconomic and environmental direct and indirect beneficial and harmful impacts of pests, weeds and diseases, including cross-sectoral risks, and the cost effectiveness and benefits from policy and management options
- refine or develop novel detection and surveillance techniques and diagnostic procedures for pests, weeds and diseases not yet established or established at low levels (for examples, remote diagnostics, genetic identification, automated approaches, and social media)
- review and improve eradication and containment tools and strategies for national and regional use against priority pests, weeds and diseases
- refine and further develop management tools and integrated strategies for priority pests, weeds and diseases, including biological control
- improve methods to increase public awareness of the impacts of pests, weeds and diseases, and influence behaviours in response to biosecurity issues
The National Environment and Community Biosecurity RD&E Strategy has been developed under Schedule 8 (National Biosecurity RD&E Framework) of the Intergovernmental Agreement on Biosecurity (IGAB).

The IGAB was developed to improve the national biosecurity system in Australia by identifying the roles and responsibilities of governments and outlining priority areas for collaboration.

The overall goal of Australia’s national biosecurity system is to minimise the impact of all biological threats (pests, weeds and diseases) on the economy, environment and the community.

The National Environment and Community Biosecurity Research, Development and Extension (RD&E) Strategy aims to establish a national, coordinated and strategic approach to biosecurity RD&E for the environment and community, which is urgently required to maximise benefits from past and future RD&E investments. Current national approaches and investments in RD&E are highly fragmented and irregular, and are a major impediment to generating cost-effective RD&E that deliver major national outcomes.

Australia’s research, development and extension to reduce impacts of pests, weeds and diseases on the natural environment and community are well-coordinated nationally, directed at national priorities and effectively delivered through stakeholder collaboration.

**Goal 1** Efforts are focused on nationally agreed RD&E priority areas and build upon previous achievements as well as identifying opportunities to lead and support innovation

**Objectives**

1.1 Coordinate national RD&E priority setting within groups of pests, weeds and diseases.

1.2 Collaboratively develop a framework to guide RD&E investment decisions to assist both proponents and decision-makers.

1.3 Identify gaps and vulnerabilities in RD&E capabilities and develop plans to address them.

1.4 Raise awareness in the community of the need for and benefits to be derived from targeted RD&E activities which improve management of pests, weeds and diseases.

**Goal 2:** The effectiveness of RD&E is enhanced to ensure maximum benefit is derived from stakeholder investments

**Objectives**

2.1 Enhance coordination and collaboration in investing, undertaking and maintaining capabilities in RD&E within and across groups of pests, weeds and diseases.

2.2 Identify and take advantage of existing and potential new collaborations between biosecurity RD&E for the environment and community, and for primary industries.

2.3 Improve linkages between national research and development, and regional or local extension.

The national biosecurity RD&E priorities aim to i) align resources and activities to address biosecurity priorities; ii) build and maintain scientific and technical capacity; and iii) contribute to the collaborative management of biosecurity risks.

The following four national biosecurity R&D priorities have been identified:

- minimise the risk of entry, establishment, or spread of pests and diseases
- eradicate, control or mitigate the impact of established pests and diseases
- understand and quantify the impacts of pests and diseases
- cost-effectively demonstrate the absence of significant pests and diseases

Box 3 Goals and priorities of the national weed strategy

**Goal 1. Prevention, detection and early intervention**
Priorities:
1. commit to and continuously strengthen effective risk-based approaches to pre-border and border activities
2. adopt consistent risk assessment and prioritisation approaches within Australia
3. develop and implement early detection, diagnostics and monitoring systems for priority weed species

**Goal 2. Minimise the impact of established weeds**
Priorities:
1. develop and improve national approaches to coordinate, invest and manage the impacts of weeds
2. increase participation in coordinated management approaches across all land tenures
3. improve the national approach, capacity and commitment to weed containment
4. enhance weed control techniques and integrate management options

**Goal 3. Enhance capacity and commitment to weed management**
Priorities:
1. develop the knowledge, capacity and commitment of key stakeholders to play an active and constructive role
2. maintain and enhance long-term research, development and extension capacity and capability
3. develop and apply national data, information and knowledge infrastructure to support effective management
4. improve institutional arrangements and decision support resources to increase the effectiveness of weed management
Weeds of National Significance

Thirty-two Weeds of National Significance (WoNS) have been agreed by Australian governments based on a nationally agreed assessment process that prioritised these weeds based on their invasiveness, potential for spread and environmental, social and economic impacts. Consideration was also given to their ability to be successfully managed.

The WoNS were selected as they require coordination among all levels of government, organisations and individuals with weed management responsibilities. A list of 20 WoNS was endorsed in 1999 and a further 12 were added in 2012.

A strategic plan for each WoNS was developed, including RD&E priorities, to define responsibilities and identify strategies and actions to control the weed species. Coordination of these plans at a national level improves linkages between research and on-going control, and encourages commitment from a wide range of stakeholders. Some WoNS also have published best management practice guides.

There are three phases of national management for WoNS.

- In phases one and two, each WoNS had a Management Coordinator and a National Management Group/Steering Committee to oversee implementation of the goals and actions of the WoNS strategic plans and to develop and coordinate priority actions.
- In phase three, state and territory governments take responsibility for national coordination within their jurisdictions. From July 2013, the currently listed WoNS are in phase three.

A national focus on WoNS continues through funding investments under the Agricultural Competitiveness White Paper, the Rural Research & Development for Profit Program, and through the work of the Invasive Plants and Animals Committee. Government agencies report to this Committee on progress against any remaining actions under the strategic plans.

Landowners and land managers at all levels are responsible for managing WoNS. State and territory governments are responsible for legislation, regulation and administration of weeds.
Appendix 3: Past national weeds R&D programs

Defeating the Weed Menace R&D Program 2005-08

Defeating the Weed Menace R&D Program 2005-08 was a Land and Water Australia program. The Australian Government committed $40 million to the program to tackle the management of Australia’s most threatening and invasive weeds, through research, biological control, community awareness and on-ground action. An indicative total of $5.4 million over the period 2005-06 to 2007-08 was assigned to a research and development component to deliver high priority R&D activities aligned with the National Weeds Strategy. The goal was to provide research and knowledge management to support the program, complementing existing research activities on invasive weeds. Most R&D focused on weeds that affected extensive land systems and conservation areas across Australia, where the prospective community benefit was large. The R&D component consisted of three priority themes:

1. reduce the rate of emergence of new weed problems:
   a. assess the risks of different sources and pathways of weed ingress into Australia
   b. explore the reasons for the persistence and emergence of sleeper weeds
   c. understand the drivers of, and develop approaches to reduce ecosystem invisibility
   d. develop robust target lists for incoming species and sleeper weeds
   e. develop efficient methods for surveying and eradicating agreed priority emergent weeds (sleepers and new arrivals)
   f. develop new approaches to help weed source sectors reduce their risk

2. reduce the impact of existing weed problems of national priority:
   a. update the list of weeds of national significance and review progress on control of the existing weeds of national significance
   b. support the development of biological control for agreed national priority weeds
   c. develop new integrated management strategies that incorporate an understanding of weeds within landscape scale ecological processes

3. support national frameworks and capacity for sustainable weed management and decision-making:
   a. identify the social and institutional factors that drive or impede understanding of weed issues and implementation of solutions
   b. propose workable new policy instruments and institutional arrangements to reduce weed incursion and impact.

National Weeds and Productivity Research Program

The National Weeds and Productivity Research Program R&D program proceeded in two phases—2008-09 and 2010-15. Initially the program was managed by the Department of Agriculture Forestry and Fisheries and then the Rural Industries Research and Development Corporation in the second phase.

The first phase funded 39 research projects costing nearly $3.6 million. The Australian Government provided a further $12.4 million for two years (2010-12) for the second phase. In 2010, RIRDC published the 2010-2015 plan, prioritising four objectives:

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61 ibid
• improve knowledge for effective risk management of weeds
• reduce current and future impacts of weeds on Australia’s productive systems and environments
• support improved adoption of weed management approaches
• plan future funding and institutional arrangements for investment and management of weeds R&D

The research priorities in a five-year plan (2010-2015) plan were to:

• investigate and solve the most serious invasive plant problems focusing efforts to improve productivity and the environment
• investigate new methods which reduce reliance on herbicides and promote integrated approaches which also help to reduce energy and chemical inputs in agriculture
• refine landscape-scale integrated weed management strategies to manage the risks associated with invasive plants in agriculture, forests, pastures and native vegetation, including addressing climate change mitigation and adaptation issues
• identify motivators and barriers to the uptake of cost-effective integrated weed management strategies and options to encourage the uptake of integrated practices
• improve understanding of economic, social and environmental impacts of invasive plants
• ensure better coordination and information exchange between researchers, land managers and regulatory agencies about integrated approaches for priority management of invasive weeds

The key elements of the RD&E strategy were:

• advance foundational knowledge
• develop tools, methods and technologies
• evaluate current social, economic and institutional influences
• test and translate existing resources and make them more accessible
Appendix 4 - The portfolio approach used by CISS 2017-22

Investment categories

The draft operational plan of CISS contemplates a portfolio approach to investment in invasive species RD&E, which references three distinct investment categories:

- **Portfolio No. 1 Research**: this is the research component core to the Portfolio Agreement No. 1 and funded through the Australian Government, State Government and Industry partners cash and in-kind contributions, and accountable through a specific Portfolio Research reporting mechanism.
- **Portfolio Aligned Research**: other IAL R&D closely aligned and adding value to Portfolio Research, but funded through other mechanisms, such as the Australian Government’s Agricultural White Paper, and not associated with the Portfolio Research reporting mechanism.
- **IAL Research**: a small number of third party funded IAL projects not aligned to Portfolio No. 1 research nor associated with the Portfolio Research reporting mechanism.

RD&E focus areas

Across its research portfolio, CISS deals with six focus areas addressing different elements associated with the invasive species innovation pipeline:

- **insight**: understanding root causes of problems so appropriate strategies or solutions are pursued.
- **coordination**: gaining critical mass of effort to develop and implement effective strategies.
- **prevention**: putting in place strategies to avoid invasive animal and plant incursions and impacts.
- **detection**: building effective surveillance capacity to trigger responses when and where necessary.
- **development**: creating innovative tools, strategies and human capacity to manage invasive species and impacts.
- **management**: mobilising human capacity, tools and strategies to manage species and impacts.

Innovation outcomes

In the plan, research activities are also structured into five innovation domains—high order outcomes—high order outputs and focus areas for synthesis and reporting.

**Innovation Domain 1: Incursions**

**Rationale**

Australia continues to face vertebrate pest threats. A compilation of new vertebrate detection data from all jurisdictions in the period 2010-2015 had 1551 records of incursion incidents, with reptiles the most frequent detection and mammals the least. This data included national border interceptions and extension of ranges of

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63 Source: Centre for Invasive Species Solutions, Draft Operational Plan 201722
species that are already established (or native) in some parts of the country. At least 126 different exotic species were detected, with more taxa only identified at the genus, family or order level. In general, fish are under-reported at present in these datasets. Examples of species of high pest risk commonly being detected are eastern corn snake, red-eared slider turtle and Asian black-spined toad. New vertebrates pose a wide range of pest risks including competition, predation, exotic diseases, fouling and public safety.

Outcome
This domain will contribute to the protection of Australia’s economy, environment and social amenity from the impacts of new pest animals and plants through a national incursion management system.

Innovation Domain 2: Integrated Landscape Management

Rationale
Established vertebrate pests continue to cause considerable impact to Australia’s agricultural industries, its environment and the well-being of its communities. These include production losses, spread of endemic and potentially exotic diseases (zoonotic, livestock and wildlife), and biodiversity loss. In some cases, such as wild dogs in the rangelands, impacts are increasing as control effort has waned, while in other areas new species such as wild deer have emerged. While biological control continues to depress rabbit numbers, it is not an option for all pest mammals and so their control has relied on conventional tools such as poison baits, trapping, shooting and fencing. New tools such as PAPP, canid pest ejectors and livestock guardian animals are now available, but their application has been wanting, yet remain critical to successful control. This requires a coordinated approach across land tenures requiring high rates of participation in control among landholders and support from all stakeholders. For mobile and widely dispersed species, control must also be applied at a landscape scale to be effective. These are well established principles of pest management.

Outcome
This domain will contribute to the reduction in the economic, environmental and social costs associated with invasive species through development and demonstration of large-scale integrated management strategies.

Innovation Domain 3: Biocontrol

Rationale
Classical biological control of rabbits using self-disseminating viral agents has served Australia well as the basis of cost effective continental scale management. The biocontrol of rabbits in Australia using Myxoma virus and Rabbit Haemorrhagic Disease Virus (RDHV) has resulted in agricultural benefits of $70 Billion over 60 years, as well as reduced impacts on a number of the 304 nationally listed threatened species impacted by rabbits and improved landscape condition. Biological control of carp using CyHV-3 may soon to be available. Biological control requires strategic investment to ensure the ongoing development of such efficient broad-scale control tools including potential next generation gene-tech biocontrol options to ensure ongoing large economic and environmental benefits. While the returns on investment are large, viral biocontrol agents for vertebrate pest control only come along very rarely, have a long lead time due to the rigor of risk analysis towards non-target species under pinned by a robust regulatory and policy approval process. Viral biocontrol agents also tend to have reduced effectiveness over time due to the host-pathogen co-evolution and building population immunity in the target host. These circumstances necessitate a long-term research and innovation approach to maintain a biocontrol technology pipeline, and on-going bioprospecting to identify possible viruses, parasites and other agents that have potential as cost-effective biocontrol agents. With new gene technologies becoming more common, there is also scope to consider genetic biocontrol solutions within the research portfolio mix.

Outcome
This domain will contribute to the sustainable reduction of the impacts of established pest animals and plants through innovative landscape scale biocontrol strategies.
Innovation Domain 4: Management Systems and Tools

Rationale
Decision support systems and tools provide important mechanisms for translating research knowledge into options and guidance for on-ground management practice. The refinement and use of existing systems and tools relevant to the management of incursions and specific invasive species sit within the first three domains. Investment in this domain provides an avenue for supporting new tools and potentially patentable innovations that may otherwise be overlooked within the current paradigms of other domains.

Outcome
This domain will contribute to optimal cost-effective pest animal and plant management through new and improved tools and systems.

Innovation Domain 5: Community Engagement and Education

Rationale
Acceptance and implementation of best management practices for invasive weeds and animals ranges across a continuum. At one end, there are “adopters”, those who implement best practice on land that they manage and have reduced or minimised impact of pest animals on their enterprise or environment. At the other end are “non-adopters”, who, for a range of reason, fail to implement best practice. Changing behaviour, and sustaining these changes over time, is an arduous process. Widespread adoption of best practice by landholders requires a more sophisticated approach informed by the behavioural sciences. Engagement practitioners need evidence-based methodologies for engaging in constructive interactions with stakeholders, jointly defining problems and co-developing solutions. Best practices for managing invasive animals and plants will continue to be developed in other Centre domains, however, this domain will value-add to these through embedded collaborative projects with state and industry partners and through web-based and complementary communication systems.

Outcome
This domain will contribute to improvement in the human and institutional aspects of the management of pest animals and plants through engagement in science and evidence-based on-ground responses.