Invasive Animals Cooperative Research Centre

"Together, create and apply solutions"

Towards a more durable institutional base for invasive animals R&D

Andrew Campbell

Triple Helix
CONSULTING

Invasive Animals Cooperative Research Centre

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Summary

Invasive animals in Australia represent a classic problem — chronic, diffuse, pervasive, fragmented, insidious, cumulative, with strong public and private good dimensions — that exemplifies the drivers behind the establishment of the original Cooperative Research Centre (CRC) model.

Invasive animals are among the biggest threats to Australia's biodiversity, they impose costs on most agricultural and horticultural industries (exceeding $700m annually), they pose serious biosecurity risks, including potentially to human health, and they compound significant land and water degradation problems. However, perhaps because invasive animals are pervasive and chronic across Australia, no-one has clear ownership of the issue. This has contributed to a lack of critical mass and a fragmented research, extension, regulatory and policy effort.

While there have been some successes in managing invasive animals in specific places through targeted programs, and some substantial gains through biological control programs such as rabbit haemorrhagic disease (RHD), overall the impact of invasive animals in Australia has continued to spread and intensify. Rabbits illustrate the critical importance of strategic, integrated long-term (decadal) approaches to invasive animals research, innovation, extension and management. Despite two major breakthroughs with biocontrol agents (the *Myxoma* virus and RHD) that radically reduced rabbit populations — with major benefits for agricultural production, native vegetation, native animals and soil health — virus resistance has emerged and rabbit populations are increasing again.

New and emerging pests, such as via aquarium fish and aviary escapes, or through existing pests increasing their range in a changing climate, represent new threats. The recent widespread flooding in eastern Australia highlights the potential intersection between extreme events and invasive animals, as it is likely that floodwaters over vast areas will have substantially increased the spread of invasive fish species. The Beale Review (Beale et al 2008) sets out a comprehensive roadmap to build a more robust Australian Biosecurity System and it makes the link between invasive animals and national biosecurity risks. It recommends a greater emphasis on managing pre-border and post-border risks — including those posed by invasive species.

The Invasive Animals (IA) CRC has improved the effectiveness of the invasive animals sector in Australia, particularly in terms of the research and development (R&D) effort, in the face of declining investment in invasive animals R&D and extension within state agencies, rural R&D corporations and the CSIRO. That decline in investment is reflected in a reduction in numbers of researchers, with many approaching retirement age, which makes the outstanding education program of the IA CRC doubly significant.

However, the current IA CRC is due to cease in June 2012. This means that applied, collaborative, national invasive animals research and development in Australia is approaching a strategic juncture.

There is a compelling case for continued public investment in a national institutional framework to plan, fund and coordinate collaborative applied invasive animals research and development in Australia.

Market failure in this sector is deep and broad. Restricted markets, free rider issues, low return on investment and high registration costs in heavily regulated markets limit development of new products and tools. Notwithstanding the significant aggregate

costs to the Australian economy of invasive animals, it is not in the economic interests of any individual industry or firm to fully fund the type of research, over the necessary timeframes needed to develop and commercialise new technologies.

Some existing control technologies like RHD are losing effectiveness in some areas, and changing community values in areas like animal welfare threaten the long-term viability of traditional technologies like 1080 (sodium monofluoroacetate). The regulatory outlook for pest animal control technologies looks even more difficult over coming years. Regulatory restrictions are already affecting second-generation anticoagulants for rodent control in agriculture in the USA and zinc phosphide for rodent control in Europe.

Were the use of 1080 poisons as a vertebrate pest control measure to be banned in Australia, as is forthcoming in Tasmania, and has already occurred in some other countries, the options for invasive animal control in Australia would be dramatically reduced. In the absence of the new, more humane technologies being developed by the IA CRC, the outlook would be grim indeed.

Conversely, the development of new technologies that satisfy current OECD regulatory requirements and protect agricultural industries, food security, human health and environmental health, would not only benefit Australia by providing it with alternatives to zinc phosphide and anticoagulants, but also could create a new export industry.

If the IA CRC ceased to exist — without replacement by an organisation performing similar functions and delivering similar services — it seems very likely that within a few short years it would need to be reinvented, no doubt at considerably greater expense.

Looking more broadly at the likely policy context to 2020, the fiscal outlook for the federal budget is tight, and the current reluctance at Commonwealth level to create new bodies under the CAC or FMA Acts[1] may well persist. However, an unprecedented array of major policy reviews and reports[2] all point to the need to invest in measures that assist public and private land managers to better anticipate, identify and manage risks in an inherently volatile and uncertain climate.

When funds are tight, it becomes ever more imperative to focus public investment through intelligent purchasing structures and management agencies that are fit for purpose. Organisations that are designed, established, led and staffed specifically for the purpose of investing in and managing national, collaborative, applied research and development and capacity building services, generally perform those functions much better than agencies whose core business is provision of policy advice to ministers.

Public investment in invasive animals research is justified if market failure exists, and the benefits of intervention outweigh the costs and deliver a reasonable return on investment. These conditions are easily satisfied based on the experience and achievements of the IA CRC, which is estimated to have delivered $5.70 in benefits to the community for every dollar invested by the Australian Government, at an internal

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1 *Commonwealth Authorities and Companies Act 1998* and *Financial Management Accountabilities Act 1997*

2 Including the Garnaut Climate Change Review, the Beale Biosecurity Review, the Hawke Review of the EPBC Act, the National Review of Drought Policy, the Productivity Commission Inquiry into Rural Research and Development and the Prime Minister's Science Engineering and Innovation Council's reports on Food Security and the intersections between Climate, Energy and Water.

rate of return of 32 per cent.[3] The IA CRC product pipeline at Appendix C illustrates the value of a clear focus on delivering triple bottom line outcomes and bringing new products to market.

In analysing the invasive animals research sector, and reviewing the IA CRC experience, via its Third Year Review and discussions with key stakeholders, several criteria emerge against which to evaluate potential institutional options to support invasive animals research in a continuing way beyond 2012.

Ideally, institutional arrangements for long-term invasive species research funding and management in Australia should be able to:

a) function effectively within the emerging 2020 institutional and policy context, including as part of a more coherent national approach to biosecurity

b) foster collaborative research between different jurisdictions, government agencies, universities and industries to achieve the critical mass necessary to deliver innovations that address national scale pest animal problems

c) develop and grow a stable funding base drawing on public, private, industry and philanthropic investment to reflect the mix of beneficiaries, with sufficient critical funding mass that transaction costs do not dominate the budget

d) achieve national scale vertical integration to enable efficient development, and commercialisation or diffusion of research outputs

e) achieve sufficient national scale horizontal integration to deliver research, development and extension (R,D&E) services and related education and training across all jurisdictions, capturing economies of scale while accounting for regional differences and priorities

f) build and sustain invasive species research, policy and management capacity, having regard to professional and vocational career paths and succession and retention strategies

g) ensure close linkages between policy development and regulatory activities, innovation of new technologies, and delivery of research, development and extension (R,D&E) services

h) foster and consolidate international collaborations focused on national benefit to Australia.

Section 4.3 of this report evaluates a range of potential institutional models against these criteria. The most promising examples are not-for-profit companies limited by guarantee, owned by a range of partners including government agencies, industry and regional bodies and research providers.

Of these, Water Quality Research Australia (WQRA) appears to offer the best model for invasive animals research. Its funding comes primarily from its 46 member organisations, which is then used to leverage other government and industry funds. It is national in scope. It is not reliant on a single funding source for the bulk of its revenue, However, the Commonwealth remains a significant investor through WQRA at a research program level. It operates like a CRC, retaining a strong emphasis on its education program to build capacity within the sector, and on linking science, policy and regulation. It has a very clear focus on a critical issue that has major social,

[3] Centre for International Economics (CIE 2008)

economic and environmental dimensions. Its value proposition around collaboration, national coordination, strategic capacity building and sharing of resources and knowledge seems cogent. It does serve to illustrate that it is possible for a CRC to morph into a more permanent institutional form while retaining many of the best features of a good CRC.

It is clear from this analysis that securing a durable institutional base, and in particular a stable long-term funding base for national collaborative applied invasive animals R&D after the wind up of the IA CRC — whether that occurs in 2012 or 2017 — will be extremely challenging.

But not impossible.

The best pathway for IA CRC to a more permanent institutional base is to seek an extension from the CRC program to 2017. That bid should be based on a compelling business case around the value to Australia of on-going collaborative applied invasive animals research, and the necessity for national coordination. The business case should map how IA CRC would evolve during 2012-2017 so that by 1 July 2017 it would be operating as a not for profit company owned by its government and industry participants, with a complementary role in the national biosecurity system and a clear strategy out to at least 2023 and preferably 2030.

The business case should be informed by an updated economic analysis in the light of the various reviews discussed here, exploring both the prospective return on investment from the IA CRC portfolio as it evolves, and also the 'without case' — the potential implications of allowing momentum to stall and the legacy to depreciate. The value proposition needs to be extremely clear and hard hitting — not just about the importance and value of invasive animals R&D, but why it needs a national institutional base, why it needs long-term funding, why the education and training dimensions are so important, and why collaboration across all jurisdictions and between governments, industries and SMEs is so critical in this sector.

1. Introduction

Invasive animals in Australia represent a classic problem — chronic, diffuse, pervasive, fragmented, insidious, cumulative, with strong public and private good dimensions — that exemplifies the drivers behind the establishment of the original Cooperative Research Centre (CRC) model.

Invasive animals are among the biggest threats to Australia's biodiversity, they impose costs on most agricultural and horticultural industries, they pose serious biosecurity risks, including potentially to human health, and they compound significant land and water degradation problems. Changing climatic conditions characterised by higher temperatures and more frequent and intense extreme weather events are likely to favour some invasive animals and potentially facilitate the emergence of new pests, weeds and diseases.

However, perhaps because invasive animals are pervasive across all land tenures and most land uses in Australia, no-one has clear ownership of the issue. Diffuse ownership and opaque accountability has contributed to a lack of critical mass and a fragmented research, extension, regulatory and policy effort.

Fragmented approaches with short-term funding and a lack of strategic, long-term ability to build critical mass are not uncommon across the Australian Federation. The CRC model evolved in response, with an explicit focus on collaboration, on strategic business cases and seven year funding allocations, and on building future research capacity through a strong emphasis on educating emerging and early career researchers.

The Invasive Animals (IA) CRC has improved the effectiveness of the invasive animals sector in Australia, particularly in terms of the research and development (R&D) effort. The Third Year Review of the IA CRC was conducted in December 2008 by an independent panel comprising Andrew Campbell (Chair), Sharon Brown, Dr Andrew Burbidge and Dr Keith Steele. The panel concluded that the IA CRC is performing extremely well and is on track to deliver to a very large degree the achievements set out in its Commonwealth Agreement. It concluded:

> *The Invasive Animals Cooperative Research Centre is a high performing CRC making a big difference to an important issue for Australia. If the IA CRC did not exist, this sector would look very different indeed. Australia would be ill-equipped to deal with significant threats to its terrestrial and freshwater biodiversity, its food and fibre production and the viability of many rural businesses and communities.*

However, the current IA CRC is due to cease in June 2012. This means that applied, collaborative, national invasive animals research and development in Australia is approaching a strategic juncture.

The purpose of this document is to consider how invasive animals research in Australia might be placed on a more durable footing, in terms of its funding base and related institutional arrangements. The Board of the IA CRC has commissioned this paper to explore the most appropriate path to a national invasive animals R&D institution able to maintain over a longer timeframe the innovation rate, collaborative culture and research capacity fostered through the IA CRC.

The paper first analyses the strategic context within which invasive animals R&D operates now, and likely developments to 2020, then examines alternative funding and institutional models.

2. The external operating environment for invasive animals R&D

2.1 Drivers for a collaborative national research effort

2.1.1 A growing problem

Invasive animal impacts are extensive and expensive. The costs to the Australian economy of invasive animals exceed $700 million annually (McCleod 2004, Gong et al 2009). These are simply the measurable direct costs in terms of lost agricultural production and the cost of control measures, using conservative assumptions and without attempting to quantify or monetise biodiversity impacts, biosecurity risks, or the very real social impacts of problems like wild dogs. So the actual cost to Australia of invasive animals each year, when the loss of natural capital is considered, is much higher. Invasive animals have been identified as a major threat to Australia's biodiversity in Australia's Biodiversity Conservation Strategy 2010-2030 (NRM Ministerial Council 2010), and as a significant biosecurity risk[4] in the Beale Review of biosecurity (Beale et al 2008).

While there have been some successes in managing invasive animals in specific places through targeted programs, and some substantial gains through biological control programs such as RHD, overall the impact of invasive animals in Australia has continued to gather momentum. Rabbits illustrate the critical importance of strategic, integrated long-term (decadal) approaches to invasive animals research, innovation, extension and management. Despite two major breakthroughs with biocontrol agents (the *Myxoma* virus and RHD) that radically reduced rabbit populations — with major benefits for agricultural production, native vegetation, native animals and soil health — virus resistance has emerged and rabbit populations are increasing again.

A recent New Zealand review (Hellstrom et al 2008) highlighted risks associated with new and emerging pests, particularly aquarium fish and aviary escapes, that are also likely in Australia. The recent widespread flooding in eastern Australia highlights the potential intersection between extreme events and invasive animals, as it is likely that flood waters over vast areas will have substantially increased the spread of invasive fish species such as Tilapia, probably entering the Murray-Darling Basin for the first time.

The CSIRO (Hajkowicz and Moody 2010) has just completed a global foresighting study that analysed 100 trends identified by scientists across CSIRO, and 36 potential global risks or shocks identified by the World Economic Forum. They distilled this down to five 'megatrends' and eight shocks of particular relevance and importance for Australia, summarised later in Box 1. The above examples illustrate the relevance for

[4] For example, feral pig populations exist over close to 40 per cent of mainland Australia, with between 4 and 23 million head, depending on environmental variables such as drought. They are the second most damaging animal (after rabbits) to Australia's agricultural industries, causing damage of around $106 million each year to livestock, habitats, fences and water sources. Feral pigs affect other animals, plants and the landscape, and they provide a potential reservoir for at least 20 exotic diseases, including foot and mouth disease (FMD). Were FMD to arrive in Australia and spread to feral pigs, it would be almost impossible to eradicate.

invasive species of one of the megatrends (a more interconnected, urbanised 'on the move' world in which more goods are traded and more people travel more often); and one of the shocks (extreme, climate change-related weather).

Australia's Biodiversity Conservation Strategy 2010-2030 (NRM Ministerial Council 2010) has invasive animals as one of its ten targets:

> *By 2015, reduce by at least 10% the impacts of invasive species on threatened species and ecological communities in terrestrial, aquatic and marine environments.*

Meeting such a target will require a very well coordinated and integrated approach to invasive animals using best available technologies and a complementary suite of policy instruments including *inter alia* planning, R&D, extension, incentives, regulation, monitoring and evaluation.

2.1.2 Market failure and economic impact

No particular industry or sector 'owns' the problem of invasive animals in Australia. Invasive animals affect National Parks and biodiversity, just as they affect agricultural production and water resources. They affect the grazing industries and the cropping industries, broadacre and intensive, irrigated and dryland, in high rainfall regions and in the rangelands, across a wide range of commodities. While their impact is widespread and insidious, the market for individual invasive animal control technologies (with the possible exception of rodenticides) is too small to attract investment from major agrichemical companies — especially in the research required to develop new technologies and in the work required to navigate a complex federal and state regulatory regime to bring new products to market.

The evidence of market failure in this sector is compelling. Restricted markets, low return on investment and high registration costs limit development of new products and tools, even though these may provide massive returns to users in relation to whole of industry and government investment. Notwithstanding the significant aggregate costs to the Australian economy of invasive animals, it is not in the economic interests of any individual industry or firm to fully fund the type of research, over the necessary timeframes needed to develop and commercialise new technologies. Biocontrol can be exceptionally cost effective, but long-term R&D and delivery costs are beyond a level that can be borne by a single company, or even a single industry or government agency.

When new technologies are commercialised, it is relatively easy for other firms to copy them and to undercut the first mover who has incurred the development costs. The structure of the market translates into product ranges that are characterised by low margins, which make it generally uneconomic for SMEs to research and register new products without public or industry co-investment. Revenue per unit of product sold is often very modest compared to the return to the end-user. For example, $50 spent on mice control at a time of plague can save hundreds of thousands of dollars worth of product. Products often need a long shelf life because of the sporadic nature of invasive species population explosions. Heavily regulated markets entail very high compliance costs and long timeframes that further erode the low return on investment. The high regulatory costs limit development of new products and tools.

2.1.3 Climate change risks

The impact of climate change on invasive species is inherently uncertain. However, it is clear that the stressors placed on natural environments, human settlements and primary industries by a warming climate with more extreme and frequent major events (droughts, floods, fires, storms), mean that it becomes even more important to manage existing threats such as invasive species (Campbell 2008). An ecosystem or farming system that is already stressed through competition or predation from invasive species is more vulnerable and less resilient in the face of drought, flood, fire or cyclone. Moreover, changing climatic conditions may favour invasive species (Campbell 2008), or substantially increase the range of existing pests, causing 'sleeper' pests to emerge (BRS 2006).

2.1.4 Land use change and development pressures

Land ownership and land-use patterns in Australia are changing more rapidly than most people realise, with a shift away from the 'traditional' family farm towards more corporate agriculture (and large family-owned businesses with corporate structures), and more pluriactive and lifestyle properties (particularly in the 'tree change' and 'sea change' regions in south-eastern Australia and along the eastern seaboard) which do not derive the majority of their income from primary production.

It is not axiomatic that either corporate agribusinesses or lifestyle landowners are better or worse than family farmers at managing invasive animals — there are good and bad managers within all categories. However, an increasing proportion of absentee landholders and people who are absent during working hours, and shortages of rural labour more generally, makes the development and implementation of coordinated invasive animals control programs much more difficult. Moreover, as peri-urban and rural residential areas expand into agricultural lands and population density increases, so does the risk of release of domestic mammals, fish and birds, and the application of traditional control measures such as shooting, trapping and poisoning becomes more problematic.

Australia's very high and increasing level of urbanisation reduces the awareness of the general public about the impacts of invasive species on the environment and production systems, meaning that political pressure for investment in invasive animals control or research is modest and patchy at best.

Another area of relatively rapid land use change is the expansion of the conservation estate, both on public and private lands. The Australian Government is investing $180 million over the five years to 2013 to increase the size of the National Reserve System from 98 million hectares to 125 million hectares — a 25 per cent increase.[5] Australia's Biodiversity Conservation Strategy 2010-2030 (NRM Ministerial Council 2010) has as another of its ten targets:

> *By 2015, achieve a national increase of 600,000 km^2 of native habitat managed primarily for biodiversity conservation across terrestrial, aquatic and marine environments.*

This target equates to a further 60 million hectares, although the baseline and the split between terrestrial, aquatic and marine are not clear. What is clear however, is

[5] http://www.environment.gov.au/parks/nrs/about/management.html accessed 7.2.11

that a key priority in managing ecosystems for conservation objectives is the control of invasive species. Any serious attempt to reach these national goals will generate a significant demand for invasive animal control technologies across all tenures.

2.2 Constraints

2.2.1 Declining investment

The government agencies with the longest tradition of pest animal control (and most on-ground management expertise), mainly in the states and territories, have been reducing their investment in this area over recent decades. The CSIRO, once the single largest research provider in wildlife ecology and pest animal management in Australia by a considerable margin, has also made major cuts to this area of its portfolio over recent years, reducing the attraction of invasive animals work for promising young scientists.

Private sector investment, particularly from the agricultural industries that suffer the largest direct costs from invasive animals, and that carry major biosecurity risks from invasive animals, has also declined. Regulatory and compliance complexity and cost provide significant barriers to many land managers becoming involved in invasive animal pest management. A decade of drought over much of the agricultural lands, followed by severe floods in many regions, has severely eroded the capacity to fund invasive animals work. This applies both for individual land managers, and also for research funded through the Rural R&D Corporations, which saw their levy income (and consequently public matching funding) decline significantly during the worst drought years. Again, the fact that invasive animals tend to be a second- or third-order issue for most industries mean that such research is vulnerable when budgets are tight.

2.2.2 Declining capacity

The cumulative impact of incremental (and occasionally radical) cuts to pest animal research, management and extension across Australia has seen this sector reduced to a cottage industry. A diverse range of uncoordinated small players, highly fragmented and scattered across the country, lacks critical mass both horizontally (across regions, industries and target species) and vertically (along the value chain from basic research through *inter alia* applied research, commercialisation, extension, policy, planning, regulation and education).

According to an audit undertaken by the Vertebrate Pests Committee[6], Australia-wide there are only 42 permanent staff working in pest animals research, and only 30 if the Commonwealth agencies (ABARES and CSIRO), which do less applied field research, are not counted. Veterbrate pest research capacity within CSIRO declined by 60% from 2000 to 2010 according to this audit. Most of the temporary staff (8 of 10 professional officers) counted in the audit are funded by the IA CRC. According to these figures, were the CRC to close it would directly affect the employment of about one quarter of the professionals in the sector and more in terms of funding and support.

Many invasive animals researchers are approaching retirement age (the average age is 47) and succession planning within the sector is generally poor. The 'balanced

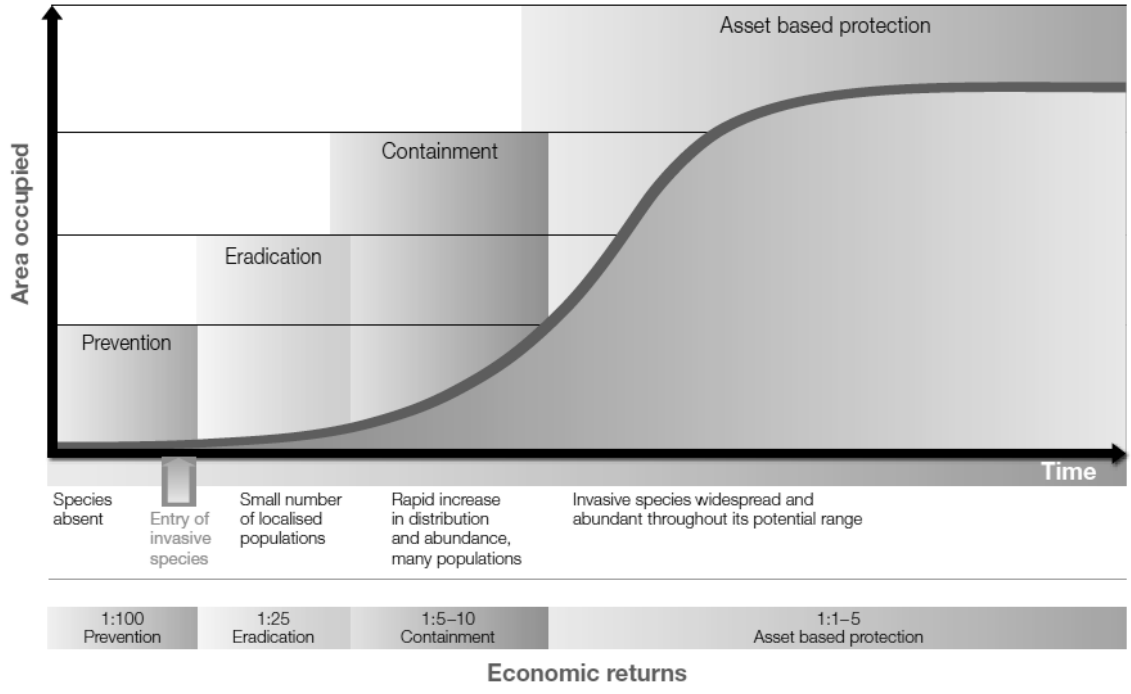
[6] Comprising senior officials from all jurisdictions and reporting to the Natural Resources Standing Committee under the Natural Resource Management Ministerial Council

scientist' post-graduate education program run by the IA CRC is outstanding across the whole spectrum of CRCs, and it is developing very well trained and equipped early career researchers for the sector. However, it is critical that there are jobs and career pathways for such researchers or they will be lost to other areas of science, or to science altogether.

Compounding reductions in research investment, state agencies have largely abandoned their pest animals extension programs. While private sector advisory services have filled extension gaps in areas where they can charge for their services, this has not been the case with public good invasive animals extension. This places further pressures on research funding arrangements, as an ever-increasing proportion of the research dollar needs to be allocated to promoting the uptake of research outputs.

The diagram below is from the Victorian Government's policy framework for invasive plants and animals (Victorian Government 2010), which provides an excellent articulation of the public policy case for public investment on these issues. It depicts a generalised invasion curve that underlines the importance of prevention and early intervention in tackling these problems, with the benefit:cost ratio being very high for anticipatory or early actions when eradication is feasible, and much more modest after invasive species have become abundant throughout their potential range.

Figure 1. Generalised curve for invasive plants and animals (Victorian Government 2010)



While prevention and early intervention best limit emerging invasive pest problems and yield excellent returns on investment, control measures frequently commence only when pest populations are well entrenched. The relatively short-term nature of many invasive pest control programs (commonly measured in years rather than decades) leads to instability and failure to fully prosecute and secure initial gains.

2.2.3 Changing community values and regulatory regimes

Some existing control technologies like RHD are losing effectiveness in some areas, and changing community values in areas like animal welfare threaten the long-term viability of traditional technologies like 1080 (sodium monofluoroacetate). The trend towards greater regulatory restrictions in the US and Europe is very clear, particularly in relation to second generation anticoagulants for rodent control in agriculture (US) and restrictions on zinc phosphide for rodent control use in Europe.[7]

The 2008 Australian Pesticides and Veterinary Medicines Authority (APVMA) 1080 review[8] recommended tighter restrictions on primary producer use of 1080. Were the use of 1080 poisons as a vertebrate pest control measure to be banned in Australia, as is forthcoming in Tasmania, and has already occurred in some other countries, the options for invasive animal control in Australia would be dramatically reduced. In the absence of the new, more humane technologies being developed by the IA CRC, the outlook would be grim indeed.

Conversely, the development of new rodenticides that satisfy current OECD regulatory data requirements and protect agricultural industries, food security, human health and environmental health would not only benefit Australia by providing it with an alternative to zinc phosphide and anticoagulants, but also has the potential to create a new export industry.

Community suspicions and potential reluctance to accept GMO-based techniques — especially those related to fertility — pose a further risk to some of the more promising angles of research on invasive animals control technologies. There are formidable technical challenges in developing such technologies, but it is also possible that even if they can be technically proven, social and political constraints may make them commercially unviable.

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7 Zinc Phosphide is no longer an approved chemical active constituent in the EU http://www.pestmagazine.co.uk/content/NewsItem.aspx?id=356 Under new EU proposals, biocides may be regulated on a hazard basis alone and risk need not be considered. The Commission has proposed a series of hazard-based criteria that apply to any chemical that may cause cancer, causes changes to genes or affects reproduction — potentially disqualifying from sale 9 of 14 rodenticides, including all anticoagulants. This proposal to the environment committee of the European Parliament will, if carried, remove anticoagulants as a class of chemicals and almost 95% of all the current pesticides used in the control of rats and mice in Europe.

8 http://www.apvma.gov.au/products/review/completed/1080.php

BOX 1. GLOBAL TRENDS AND POSSIBLE SHOCKS RELEVANT TO AUSTRALIAN SCIENCE (after Hajkowicz and Moody 2010**)**

MEGATRENDS:

1. **More from less**. Depletion of natural resources and increasing demand for those resources will see increasing focus on resource use efficiency.
2. **A personal touch**. Growth of the services sector of western economies is being followed by a second wave of innovation aimed at tailoring and targeting services.
3. **Divergent demographics**. The populations of OECD countries are ageing and experiencing lifestyle and diet-related health problems. At the same time there are high fertility rates and problems of not enough food for millions in poor countries.
4. **On the move**. People are changing jobs and careers more often, moving house more often, commuting further to work and travelling around the world more often.
5. ***i* World**. Everything in the natural world will have a digital counterpart. Computing power and memory are improving rapidly. Many more devices are connected to the internet.

POTENTIAL SHOCKS

1. **Asset price collapse**. Australia has witnessed unprecedented growth in household debt over the past 30 years and Australians now hold $1.1 trillion worth of debt. Our economy and lifestyles are sensitive to national and global asset prices.
2. **Slowing Chinese economy**. During fiscal 2008/09 the total value of merchandise traded between Australia and China was $76 billion, having grown at an average of 22% per year over the past decade. China is now Australia's largest trading partner. Any major changes to the Chinese economy will impact most sectors of the Australian economy.
3. **Energy price spikes.** The oil price determines a vast number of production and consumption decisions throughout the world economy. Australia's agricultural sector, transportation and manufacturing are heavily dependent on oil and cannot adjust easily.
4. **Extreme climate change related weather**. Most of Australia's population is concentrated in coastal areas with high vulnerability to extreme events driven in part by climate change.
5. **Pandemic**. A 'mild' influenza pandemic is estimated to lead to the loss of 1.4 million lives and US$330 billion (0.8%) of global GDP, and a severe scenario would cost 142 million lives and US$4.4 trillion of global GDP. In addition to the social impacts, Australia's tourism-sensitive economy could be substantially impacted.
6. **Biodiversity loss**. Since European arrival in Australia there has been a rapid increase in the loss of biodiversity. As a wealthy and stable country with many at-risks species, Australia presents a great investment for contributing to the protection of global biodiversity.
7. **Terrorism**. A single terrorist event can involve tragic loss of human life and property. Severe attacks have enormous follow-on economic, social and geopolitical consequences. The national loss of income by 2003, following the September 11 2001 terrorist attacks, is estimated at 5% of GDP or roughly half a trillion US dollars. Those attacks were followed by military action in Afghanistan and Iraq that continues.
8. **Nanotechnology risks**. This recent and rapidly emerging field offers many solutions for human health and manufacturing. However, based on current knowledge there are real, but unquantifiable risks, to human health and the environment.

3. The prospective 2020 strategic context for invasive animals R&D

There are no facts about the future. As the Nobel Prize winning physicist Niels Bohr said, 'prediction is very difficult, especially about the future'.

Irreducible uncertainty notwithstanding, this section envisages the likely 2020 strategic context within which a national invasive animals R&D institution might operate.

As a starting premise, it seems reasonable to assume that the drivers and constraints discussed above will continue to be relevant in 2020 to a greater or lesser degree. However, it is worth noting the five megatrends and eight potential shocks relevant to Australian science and technology identified by CSIRO (Hajkowicz and Moody 2010) in Box 1 on the previous page. Shocks that would seem highly prospective within this timeframe include a steep rise in energy prices, and the possibility of a 'double dip' global recession with profound implications for China and hence Australia.

Analysing this context, and informed by discussions with key stakeholders in invasive animals R&D, there appear to be two meta countervailing forces at play in the broader Australian political and policy context at present.

The first is the dominant political rhetoric about the need to return the Federal budget to surplus as soon as possible, notwithstanding the need for large expenditures in response to recent floods and cyclones. Both sides of politics have identified longer-term expenditure cuts to offset necessary relief and rebuilding measures in areas affected by extreme weather events. The irony of cutting renewable energy programs to pay for cyclone and flood damage repairs has been noted.[9]

The second is the background influence on policy thinking and development — particularly within the federal government and among industry leaders and NGOs — of a series of significant reviews commissioned by the Australian Government. The best known of these are the Garnaut Climate Change Review[10] (now being updated) and the Henry Tax Review[11]. Others with particular relevance for the future of invasive animals R&D include the Beale Review of Biosecurity[12], the Hawke Review[13] of the *Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999*, the National Drought Policy Review[14] and the Productivity Commission Inquiry[15] into the Rural Research and Development Corporations (final report due 15 February).

Each of these reviews is very significant in its own right. All are comprehensive, well-considered analyses of important issues undertaken by very senior and experienced people with a detailed technical grasp of those issues, and able to take a long view from a national perspective.

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9 For example, see http://www.crikey.com.au/2011/02/04/garnaut-on-climate-science-its-a-pretty-sad-story/ for a précis of Professor Ross Garnaut's views.

10 http://www.garnautreview.org.au/ accessed 8.2.11

11 http://taxreview.treasury.gov.au/Content/Content.aspx?doc=html/home.htm accessed 8.2.11

12 http://www.quarantinebiosecurityreview.gov.au/ accessed 8.2.11

13 http://www.environment.gov.au/epbc/review/index.html accessed 8.2.11

14 http://www.daff.gov.au/agriculture-food/drought/national_review_of_drought_policy accessed 9.2.11

15 http://www.pc.gov.au/projects/inquiry/rural-research accessed 8.2.11

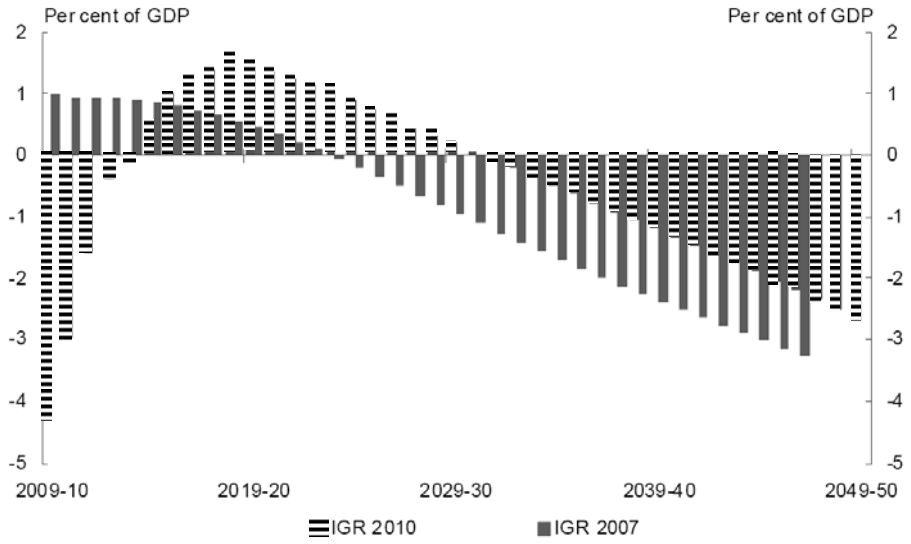
A critical observer might contend that the response of government to these reviews to date has been generally timid, highly selective and risk-averse.[16] It is of course too early to make that judgement in the case of the rural R&D review, but it would be surprising if its recommendations were to be accepted wholeheartedly and implemented with alacrity. A more charitable observer might respond that the Global Financial Crisis (GFC) made it difficult for the government to implement the findings of these reviews comprehensively and systematically, both because of the sheer magnitude of the task of responding to the GFC and the financial constraints the stimulus package placed on the federal budget.

Nevertheless, policy reviews of such authority tend to have a long half-life in Canberra. When the political planets are favourably aligned (such as in a pre-election period, or when Departments are preparing their incoming government briefs), the findings and recommendations of such reviews can be revisited, updated if necessary, and presented as new policy proposals with the confidence that they are founded on a solid analytical base.

3.1 The budgetary outlook

The short-term budgetary outlook in Canberra according to most observers is grim. The May 2011 budget will be characterised by expenditure cuts and no new policy proposals unless offset by cuts elsewhere. Ministers will be battling to save programs and institutions, not to initiate new ones. The 2012 budget may well be similar, whereas the 2013 budget will be a pre-election budget with the possibility of some new initiatives, especially those with electoral appeal. Any replacement for the Caring for our Country program will not be announced until 2013 at the earliest, and is unlikely to be a major source of research funding.

Figure 2. Projected fiscal gap 2010-2050 (IGR 2010)



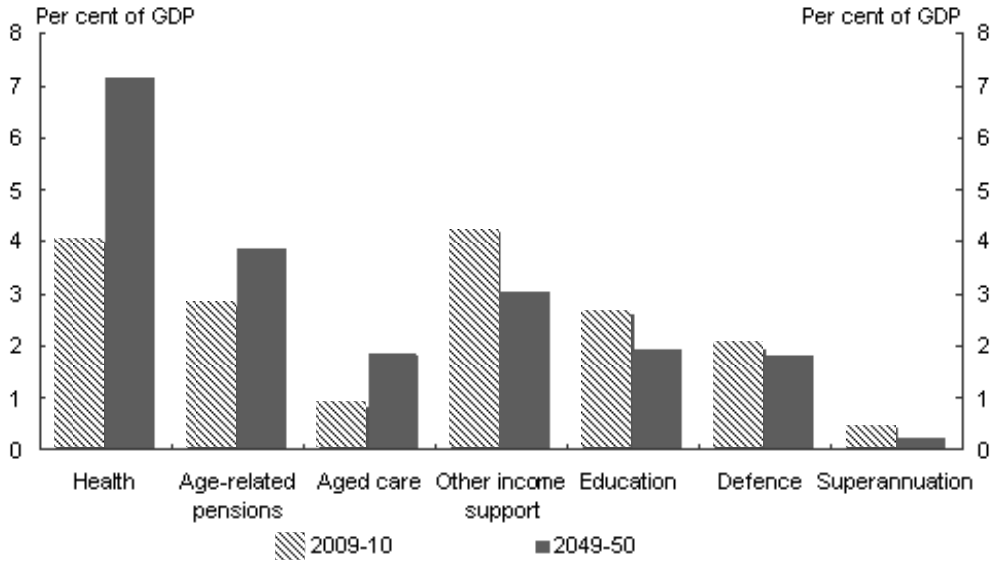
[16] See for example http://media.crikey.com.au/dm/newsletter/dailymail_c69faa15d767a1126c7fb3cb3be628eb.html#article_9195 accessed 8.2.11

The graph in Figure 2 above, from the Intergenerational Report prepared by the Treasury (IGR 2010), illustrates one of the key 'big picture' factors underlying the government's wish to return the federal budget to surplus as soon as possible. It projects the 'fiscal gap' out to 2049-50, which is the gap between projected Commonwealth revenue and expenditure expressed as a proportion of Gross Domestic Product (GDP). The IGR 2010 posits that the ageing of the Australian population will, in the absence of structural changes in the economy and in federal budget settings, lead to a worsening of the fiscal gap over coming decades:

> *Population ageing will create pressure for increased spending, particularly in the demographically sensitive areas of age related programs and health. Health costs will also escalate as a result of technological enhancements and rising demand for better quality health services. Population ageing, by reducing the proportion of working age people in the population and hence potential economic growth rates, will also reduce Australia's capacity to fund these spending pressures...*

The IGR 2010 goes on to project this changing distribution of Commonwealth expenditures between now and 2050, as outlined in Figure 3 below. Note that the projected increased in health and other age-related expenditures are far from offset by changes in the other major areas of spending depicted here, which implies that other sectors (presumably including environmental, agricultural and innovation investment) will also be affected.

Figure 3. Projections of Australian government spending by category (IGR 2010)



The prevailing wisdom is that the seven year funding commitment enjoyed by CRCs is as good as it gets, and that even a five year extension provides rare funding security. It would seem prudent to assume that there will not be a new golden age of abundant, easily-obtained funding for research collaborations in the period leading up to 2020.

3.2 A new National Biosecurity System

The Beale Review (Beale et al 2008) sets out a comprehensive roadmap to build a more robust Australian Biosecurity System and it does make the link between invasive animals and national biosecurity risks. The Beale Review recommended a continuum of biosecurity risk management from pre-border to border and post-border approaches, with a greater emphasis on managing pre-border and post-border risks — including those posed by invasive species.

The Australian Government has accepted, at least in principle, all 84 recommendations of the Beale Review. Accordingly, coming years are likely to see the introduction of a new Commonwealth Biosecurity Act and the establishment of a new Commonwealth Biosecurity Authority to bring together the major functions currently delivered by Biosecurity Australia, Australian Quarantine and Inspection Service and parts of the Product Integrity, Animal and Plant Health Division of the Department of Agriculture, Fisheries and Forestry, with associated administrative arrangements. Recommendation 57 of the Beale Review is that:

> *The National Biosecurity Authority should develop national research priorities, including for new technologies to better address biosecurity risk, and should work with research bodies to coordinate the research effort towards those priorities.*

The IA CRC, or a successor to it, would be an obvious research collaborator for the new Biosecurity Authority.

3.3 The broader policy context

While the immediate outlook may be unfavourable, a lot can and will happen between now and 2020, not least a minimum of three federal elections. There is much in the content of the major reviews listed above that could be drawn upon to make a case to improve the institutional and policy context for invasive animals research, including:

- The Hawke Review argues persuasively that the emphasis in environmental policy and programs should shift more towards prevention of environmental problems or early intervention when problems are more manageable, rather than waiting for environmental damage to occur before policy responses are triggered. This includes the development of foresight reports to help government to better manage emerging environmental threats.
- The National Review of Drought Policy highlights the importance of moving away from industry assistance measures such as freight, fodder and interest rate subsidies in favour of measures that build resilience and preparedness.
- A comprehensive approach to climate change adaptation and mitigation as advocated in the 2008 Garnaut Report (and in the updates currently underway) would include a more systematic framework for anticipating and responding to invasive animals problems, and for innovation in developing new control options and technologies. The emergence of a carbon market may well accelerate changes in land use and management, especially if policy settings favour vegetation offsets, potentially exacerbating the issues mentioned earlier about the difficulties of developing and implementing invasive animal control programs in districts with many absentee landowners.

- The Draft Report of the Productivity Commission Inquiry into rural R&D recommended the establishment of a new, $50m/year, public-good focused, cross-sectoral R&D Corporation to provide national research funding coordination across land (presumably including soils, vegetation, biodiversity, pests and weeds), water and energy. If this recommendation survives in the imminent Final Report, its implementation would have significant implications for longer-term invasive animals research funding. A compromise government response might well be a substantial expansion of the Rural Industries R&D Corporation (RIRDC).

More broadly, particularly if extreme climatic events continue to cause serious social, economic and environmental damage and dislocation, it is likely that the political pendulum will swing back on its arc from reactionary to strategic. The firefighting, sand-bagging, knee-jerk, short-term response mode characterised by ad hoc funding responses and rescue packages cannot be sustained for too long. More durable institutional responses will emerge and evolve. Climatic data consistent with the overwhelming scientific consensus (rising ocean, land and atmospheric temperatures, increasing energy in the atmosphere, more frequent and intense weather events etc) will continue to accumulate. Australia's relatively poor performance in reducing the carbon and energy intensities of its economy will become more apparent and a stronger refrain in the political discourse. Business leaders and successful Australian companies will vote with their feet, adopting cleaner technologies to remain internationally competitive. A carbon price will emerge in some form.

In a nutshell, there are some grounds for optimism that by 2020, while the environmental and economic context for invasive animals R&D may be even more challenging than it is today, the policy and institutional settings might be smarter and less myopic.

However, it is an open question whether it will become more or less difficult to establish new, more durable institutions to deliver on strategic national priorities.

Since the 2004 Uhrig Review of Corporate Governance of Statutory Authorities[17] there has been a deep-seated reluctance to establish new institutions in Canberra. The abolition of Land & Water Australia in the May 2009 budget illustrated that having a statutory base is not necessarily insurance in a tight budget. Even high-performing CAC Act bodies are vulnerable, particularly if they are perceived to be 'too small' and if they don't have passionate advocates with political clout. This is not unusual for cross-sectoral, public good institutions. In the innovation and education sector, even high-performing initiatives with passionate advocates can become casualties of the quest for savings, as underlined by the more recent abolition of the highly-regarded Australian Learning and Teaching Council (ALTC) to offset expenditure on flood reparations.[18]

The abolition of such organisations is usually accompanied by the incorporation of some of their key programs back into policy departments, amid arguments that this will lead to greater streamlining and efficiency. The author has reviewed or provided strategic advice to research and development programs managed by several Commonwealth policy agencies including DAFF, the then DEWHA and the then DCC. As a general observation, research management tends to be more competently

[17] See http://www.apo.org.au/research/uhrig-review-and-future-statutory-authorities and http://www.aph.gov.au/library/pubs/rn/2004-05/05rn50.pdf both accessed 8.2.11

[18] http://www.theaustralian.com.au/higher-education/champion-of-learning-and-teaching-gets-the-chop/story-e6frgcjx-1225995531923

delivered by organisations or agencies established, staffed, equipped and dedicated for that purpose than it is by policy Departments. Policy Departments suffer from a number of constraints in delivering research management services, including that they:

- perform a wide range of roles other than research management, many of which impose more urgent daily requirements and deadlines
- are subject to the FMA Act, which (compared with the CAC Act) places restrictions on the management of multi-year funding and partnering with commercial organisations
- have a high level of staff turnover (compared with most research providers and dedicated research funding organisations) which undermines continuity, cohesion, credibility and corporate memory
- find it difficult to train and retain sufficient staff in research or knowledge management roles
- lack specialised project and contract management systems designed for managing research activities (eg with on-line application processes and sophisticated measures for managing intellectual property)
- tend to use generic professional services contracts to procure research (rather than contracts designed specifically for the purpose of research investment)
- lack dedicated outreach systems to communicate and promote research outputs (beyond passive communication mechanisms such as press releases), and have difficulties with publishing findings that are inconsistent with the policies and priorities of the government of the day
- find it difficult to manage knowledge legacy issues, especially after the funding period for the relevant project or program has ended. Departments often have difficulty finding project outputs funded even five years ago, let alone ten or twenty years ago. Their evaluation processes tend to be oriented to accountability within particular programs, rather than adaptive learning across a research portfolio through time (Campbell 2006).

These limitations are rarely acknowledged within policy-focused agencies, which tend to default to running competitive grants programs, and generally believe they do so competently, despite many audit reports suggesting otherwise. A compelling case will be required to underpin any new policy initiative, and especially any new institution.

4. Potential models for invasive animals R&D funding and delivery

This section outlines a general argument for on-going government support in this area, and then analyses alternative institutional models for the provision of such support.

4.1 The business case for government intervention in animal pest R&D and adoption

Taking up the last point in the previous section, it is worth contemplating what such a compelling case might entail. Firstly, it must be highly persuasive in its economic arguments, both in terms of the importance of the issue for Australia, and also the likely return on investment to be delivered by any particular institutional model. Industry ownership and advocacy will be critical. Ideally, it should hit the major public policy objectives of the government of the day, it should have powerful advocates respected by all sides of politics, and it should resonate with the wider public. If the case can't be made cogently in a *Gruen Transfer* type 'pitch', then it is unlikely to be competitive.

The Victorian Government (2010) policy framework for invasive species (animals and plants) sets out a very clear and logical case for public investment to manage invasive species, and as shown in Figure 1, it emphasises that early anticipatory and preventative interventions deliver by far the best return on investment.

Harley Smith and Stewart Webster (2010), in a paper to the Australian Agricultural and Reseource Economics Society conference, proposed a decision framework for analysing investment decisions related to biosecurity threats. The decision tree at the heart of their framework is reproduced at Appendix 1. In essence, Smith and Webster argue that government intervention in a biosecurity matter is justified only if market failure exists, and the benefits of intervention outweigh the costs, and if the intervention is funded through an appropriate mechanism, that seeks to recover costs first from the 'risk creators', then from the beneficiaries of the intervention (eg industry), and then — as a last resort — from the taxpayer via consolidated revenue. According to Stewart Webster (pers comm), the framework has been applied to more than a dozen biosecurity investment decisions in New South Wales and is also being used by biosecurity agencies in Victoria and Queensland.

There are many parallels between invasive animals and biosecurity threats such as diseases. As the feral pigs example mentioned earlier illustrates, there is a significant intersection between invasive animals and biosecurity.

4.1.1 Market failure

The three most prevalent categories of market failure in the biosecurity arena described by Smith and Webster (2010) are externalities, public or industry goods, and asymmetric information. The first two of these are most applicable to invasive species issues.

Externalities or spillover effects, in which action or inaction on the part of one party may impact on other parties including the environment, are rife with respect to invasive animals problems. The deliberate or accidental introduction of a new pest species to a country, state or region, or failure to adequately control existing pest populations, can impose significant costs on others, and often on native species and/or their habitat. Where pest animal impacts fall to a significant degree on the environment, then it is most unlikely that private firms or industries will invest to a socially optimal level in

mitigating those impacts, as they cannot capture the full return on that investment. Smith and Webster (2010) point out that in the case of 'all or nothing' eradication campaigns requiring a minimum level of investment to proceed, it may not be in industry's interests to invest if the benefit derived by industry itself is less than the cost of that investment.

Invasive animals problems typically involve a very high degree of industry and public goods, whereby the benefits of invasive animals control work flow to the environment, to other producers and to regional communities as well as to the individual landholders or firms undertaking control works. Industries or the public as a whole would find it profitable to invest in invasive animals work, but characteristics of the investment act as a barrier, resulting in a less than socially optimal level of investment. In the case of invasive animals R&D, such characteristics were described earlier, including the high costs and long timeframes involved in developing new technologies, the complexity of regulatory approval processes, the small domestic market and low profit margins for most control products, social concerns about animal welfare, and the necessity for most invasive animals of developing and sustaining well-coordinated control programs over large areas, multiple land tenures and landholders, and long timeframes.

Responsibility and ownership for invasive species control is diffuse and accountabilities are rarely clear cut. This often results in ill-coordinated, ad hoc and poorly scaled operations (both spatially and temporally) that are ultimately less effective and less efficient. As with biosecurity, effective invasive species control requires rapid response and emergency management capabilities, which in turn implies having experienced, capable staff able to be deployed at short notice. Again, the market failure issues described above mean that such capabilities are unlikely to be maintained in the absence of significant public investment.

4.1.2 Return on investment

Smith and Webster (2010) argue strongly that market failure is a necessary but not sufficient condition for government intervention. The benefits of such intervention must outweigh the costs. Moreover, funding for such intervention should be based on cost recovery principles as far as possible, so that ideally, costs are recovered in the first instance from 'risk creators' (polluter pays principle), then from beneficiaries (beneficiary pays principle), and finally from government.

Analyses commissioned by the IA CRC, and undertaken independently of the CRC, show that funding invasive animals research is an excellent investment. However, measuring the projected benefit of research that delivers economic, environmental and social benefits in varying proportions is inherently difficult.

For example, it may seem straightforward to quantify and monetise the economic benefit to a farmer from reduced fox predation of lambs. But even this relatively simple example is fraught with complexities. Estimating how many lambs would have been lost in the absence of the technology is a matter of conjecture, and setting up a valid experimental control is difficult. Quantifying the environmental impact in terms of reduced predation on native species is even more difficult, and assigning an economic value to such a reduction is problematic. If a control technology developed by the CRC has improved animal welfare outcomes, assigning a monetary value to the net improvement in animal welfare is similarly vexed. The use of safer and more humane control technologies also reduces Occupational Health and Safety (OH&S) risks and stress levels for both the direct users of the control technologies and beneficiaries such

as farmers and park rangers. Again, conventional economic tools for measuring such impacts capture only a portion of the value added.

Campbell and Schofield (2007) explored in more detail the issues associated with evaluation of applied research investments, including evaluation of return on investment where substantial non-market benefits are involved. There are two broad options for estimating the economic impact of a portfolio of applied research delivering a mix of economic (market and non-market), environmental and social benefits:

1. Apply conventional benefit-cost analysis for those impacts that can be quantified and monetised with some confidence to determine a minimum estimate for the economic impact; and then describe qualitatively the envisaged social and environmental impacts that are difficult to quantify, let alone to monetise, in the knowledge that the total benefits will be higher than the quantified estimate.

2. Apply conventional benefit-cost analysis for those impacts that can be quantified and monetised with some confidence; then apply other economic tools such as Contingent Valuation (CV) methodologies (such as Choice Modelling, Willingness to Pay, Hedonic Pricing and Travel Cost Method) to estimate non-market economic benefits for impacts that can be quantified; and then describe the envisaged social and environmental impacts that are difficult to quantify.

For a given research portfolio, the second approach will generate a higher estimate of the total economic return. But Contingent Valuation methodologies are expensive to apply well, are only as good as available data, and involve assumptions that are not as well accepted as the more established conventional benefit-cost analyses. So while the bottom line number may be much higher, so will its error bars and the scepticism with which it is received.

The IA CRC adopted the first approach in commissioning the Centre for International Economics (CIE 2008) to estimate the economic impact of its research portfolio. Examining only 9 of 39 technologies under development within the CRC, and ignoring those benefits that could not be monetised rigorously, the CIE estimated that IA CRC outputs will deliver benefits to the community worth around $142 million in present value terms over 30 years (in 2007 dollars, using a discount rate of 5 per cent). This exceeds the Australian Government's investment in the IA CRC of around $24.9 million in comparable terms, by around $117 million. This equates to $5.70 to the community for every dollar invested by the Australian Government. The internal rate of return on the Government's investment is estimated at 32 per cent. The CIE noted that the environmental benefits not captured in these estimates are likely to be significant.

These estimates are in line with many other analyses of return on investment in research and development, and rural R&D in particular, undertaken within Australia (eg Mullen 2007, Chudleigh, Simpson & Schofield 2006, Schofield et al 2007, Rural RDCs 2008) and internationally (eg. Pardey & Alston 2010, Alston, Beddow & Pardey 2009a and 2009b). Alston, Beddow and Pardey (2009a) in an article in *Science*, argued that there are strong linkages between levels of investment in R&D and productivity growth in agriculture, and that declining public investment in agricultural R&D is correlated with declining rates of productivity growth — and consequently in food security, economic development and environmental protection.

4.1.3 Investment coordination and efficiency

Aggregate Return on Investment (RoI) is determined not just by the magnitude of benefits, but equally by the level of costs. Maximising efficiencies in delivery of services like R&D is critical in determining the ultimate return on investment. For a fragmented, disaggregated sector like invasive animals research, characterised by a lack of critical mass across eight jurisdictions, there are compelling arguments for nationally coordinated, collaborative approaches to deliver research, development, education, training and extension. As outlined by Campbell and Schofield (2007), collaborative approaches to applied research have several advantages, in that they:

- can make best use of scarce research resources
- minimise unnecessary duplication of effort
- allow the sharing of risk among investors and providers, enabling larger and riskier projects to proceed than individual agencies could progress alone
- build a critcal mass of investment across different funding sources
- avoid the need for wholesale restructuring of existing organisations to tackle cross-cutting issues.

Against these advantages, collaborative approaches incur greater transaction costs in time and money, they can dilute brand recognition for individual partners, and they risk defaulting to lowest common denominator approaches. Consequently, it is important that the broker or coordinator of collaborative approaches is skilled at managing the collaboration to minimise transaction costs while maintaining partner engagement, input and recognition, and to ensure that the portfolio is not too 'safe' — ie that it has an appropriate balance across a range of risk/return profiles.

From a public investment perspective, as argued by Smith and Webster (2010), it is also important that funding arrangements reflect as far as possible the causes and beneficiaries of invasive animals problems and responses. In reality, this means trying to facilitate investment from industries and other stakeholders that benefit from invasive animal control, for example through the rural R&D corporations funded in part by industry levies.

4.1.4 Lessons learned from the IA CRC

The experience of the IA CRC and its predecessors, gleaned from the Third Year Review and the IA CRC Commercialisation and Utilisation Plan, illustrates a number of important success factors for national collaborative applied invasive animals research:

- The broad mix of participants achieves scales and economies of capability and capacity, with a diverse breadth of cross-disciplined expertise and networks across individuals and organisations, that reduces the overall risk of innovation, implementation and adoption within the field of invasive species management.
- The skills mix of CRC IA employees complements the core competencies of its participants.
- The large number of end-user groups involved in the IA CRC facilitates end-user involvement in and ownership of the technology development and usage of CRC products and strategies.
- The organisation operates at a continental scale.

- The CRC provides public and industry funds to bridge the product development-registration gap that is a major commercialisation barrier preventing innovation and investment by SMEs in this market.
- The CRC promotes and encourages direct early-stage partnerships with established invasive animal pest management SMEs spanning the research-to-registration-to-market spectrum that build capacity and reduce product development and commercialisation risks. Together, this makes investment in commercialisation, production and distribution of new CRC technologies more attractive.
- Investment in CRC IA projects is dependent on a commercial participant committing to its commercialisation at an early stage of development. This fosters their engagement with researchers, end-users and key influencers in generating a product.
- Overseas participants facilitate the CRC's ability to access or create potential new markets for CRC technologies.
- International reach also creates potential new markets that build capacity and economies of scale for CRC technologies and commercial participants.
- Co-investing in the development and commercialisation of products reduces the costs to be recovered (amortised) once the product is marketed, enabling products to be sold at more attractive price points, while retaining an impetus to deliver a product to the market within 5-7 years.
- The IA CRC is linked to the Vertebrate Pest Committee and has direct policy linkages.

However, the CRC model is not perfect. Disadvantages experienced by the IA CRC include:

- The 6-7 year funding timeframe is relatively brief in a context where the most effective invasive species management structures generally have to span decades.
- The IA CRC has limited untied or discretionary funds that can be used to anticipate emerging issues, or accelerate promising research, without attracting external funds.
- Transaction costs across so many participants and the need to meet administrative milestones as well as operational goals, give rise to significant overheads.

4.1.5 Likely outputs from the IA CRC

In making the case for on-going investment in national, collaborative, applied invasive animals research, it is important to illustrate the timeframe required to bring to market the invasive animals control technologies developed through such research. Notwithstanding careful planning and proactive management to deliver products and technologies within the life of the CRC, the product pipeline at Appendix C suggests that there will need to be an on-going 'home' for these technologies beyond 2012. This is especially so when the market failure and regulatory hurdles discussed earlier are considered. While the IA CRC's commercial partner Animal Control Technologies (Australia) P/L can promote and support products already in the marketplace, it is much less able than the CRC to bring them to market.

4.2 Desirable features of an institutional framework for invasive animals R,D&E

From the contextual analysis, both contemporary and prospective to 2020, and from the discussion above, some desirable features or design criteria can be distilled for assessing possible institutional arrangements for invasive species R&D.

Ideally, institutional arrangements for long-term invasive species research funding and management in Australia should be able to:

a) function effectively within the emerging 2020 institutional and policy context, including as part of a more coherent national approach to biosecurity

b) foster collaborative research between different jurisdictions, government agencies, universities and industries to achieve the critical mass necessary to deliver innovations that address national scale pest animal problems

c) develop and grow a stable funding base drawing on public, private, industry and philanthropic investment to reflect the mix of beneficiaries, with sufficient critical funding mass that transaction costs do not dominate the budget

d) achieve national scale vertical integration to enable efficient development, and commercialisation or diffusion of research outputs

e) achieve sufficient national scale horizontal integration to deliver research, development and extension (R,D&E) services and related education and training across all jurisdictions, capturing economies of scale while accounting for regional differences and priorities

f) build and sustain invasive species research, policy and management capacity, having regard to professional and vocational career paths and succession and retention strategies

g) ensure close linkages between policy development and regulatory activities, innovation of new technologies, and delivery of research, development and extension (R,D&E) services

h) foster and consolidate international collaborations focused on national benefit to Australia.

4.3 Alternative institutional models for national invasive animals R&D

There are few examples where successful environmental CRCs have evolved into durable research institutions. A guide prepared for the CRC Association (Capital Hill Consulting 2010) identifies three pathways as CRC 'exit strategies': establishing a spin-off company(s); establishing a new organisation funded by participants; and incorporation into another more permanent research organisation like a university or CSIRO. Table 1 overleaf expands these pathways into a range of potential institutional models, providing examples of organisations, programs or initiatives that fit them. The commentary on each model against the criteria above is intended to apply to the generic model, not the exemplar organisation or initiative.

Table 1. Alternative institutional models for national invasive animals R&D

Type	Example/s	Funding arrangements	Evaluation against criteria from Section 4.2	Comments
Evolution into a federally funded entity	Reef and Rainforest Research Centre (RRRC) The RRRC was created in 2006 to implement the Australian Government's $40m Marine and Tropical Sciences Research Facility (MTSRF) in North Queensland. MTSRF was a federal election commitment. It evolved from the Reef CRC and the Rainforest CRC. http://www.rrrc.org.au/	Commonwealth Environment Research Facility (CERF) and now National Environmental Research Program (NERP)	Delivers: b, c, g, h Does not deliver: a, d, e, f	Closure of Reef and Rainforest CRCs was followed shortly after by a Federal election (Herbert is a marginal seat), and coincided with a solid Federal budget surplus. The RRRC has a regional rather than a national focus, and the unique characteristics of its region — the only place in the world where two World Heritage Areas [reef and wet tropics] intersect — mean that it will always be able to claim a special status.
Evolution into a joint Commonwealth-state funded entity	National Weeds Research Centre The Centre was a 2007 Federal Labor government commitment, that resulted from the unsuccessful rebid of the Weeds CRC. It was intended to manage the $15.5m of Commonwealth funds, which was to be leveraged by matching State government support. Due to limited financial support from the States, DAFF decided that the transaction costs associated with a Centre were not warranted and and that a grants program – the National Weeds and Productivity Research Program – would be the mechanism used to allocate funds. That program is now managed by RIRDC.	Not funded Commonwealth election commitment	Delivers: g (partial) Does not deliver: a, b, c, d, e, f, h	The failure of this model is instructive for IA CRC, since Commonwealth expectations for matching state cash are likely to remain high. 29 It is very difficult to build long-term collaborative research partnerships between research providers with a short-term grants program that requires them to compete with each other. Moreover, grant programs cannot deliver the same strategic capacity building within a sector that a typical CRC education program does — and that the IA CRC Balanced Scientist proram does exceptionally well. By definition, short-term grants programs do not develop and grow a stable funding base for long-term R&D programs.

	Plague Locust Commission The Australian Plague Locust Commission (APLC) undertakes monitoring of locust populations in inland eastern Australia and manages outbreaks that have the potential to inflict significant damage to agriculture in more than one member state as a result of population build-up and migration. http://www.daff.gov.au/animal-plant-health/locusts	The APLC is jointly funded by the Australian Government and the member states of New South Wales, Victoria, South Australia and Queensland.	Delivers: a, c, g (partially) Does not deliver: b, d, e, f, h	The Plague Locust Commission has deep historical origins and is focussed on responding directly to a single high-cost issue, rather than focusing on plague locust research.
Evolution into a joint Commonwealth-State-Industry funded entity	Animal Health Australia Animal Health Australia (AHA) was established as a not for profit company owned jointly by the Commonwealth, the states and territories and the livestock industries, to be a custodian for the emergency animal disease response agreement (65 specified diseases) and associated arrangements. AHA manages more than 50 national programs on behalf of its members that improve animal and human health, biosecurity, market access, livestock welfare, productivity, and food safety and quality. It plays an important national coordination and training role across governments and industries.	Cost sharing is roughly one third each from the Commonwealth, the states and industry, with the livestock industry shares determined by gross value of production.	Delivers: a, b, e, f, g Does not deliver: c, d, h	A key strength of AHA is its clear focus, sharpened in the minds of its members by the recent equine influenza outbreak. Its key role is emergency response coordination, but it also plays very important roles in provision of training within the sector and acting as a linking organisation. However, AHA is focussed on acute, potentially catastrophic risks rather than chronic, non-catastropic impacts, which constrains its relevance to invasive animals research. Overall funding for AHA is modest, and it does not deliver long-term collaborative national R&D programs at reasonable scale.
	Water Quality Research Australia	According to the WQRA Strategic Plan 2010-	Delivers: a, b, c, d, e, f, g, h	WQRA is a research funder and provider that operates more like an on-going CRC than any other model in this

	Water Quality Research Australia Limited (WQRA) is a national research centre established to succeed the CRC for Water Quality and Treatment when the CRC ended on 30 June 2008. WQRA undertakes collaborative research of national application on drinking water quality, recycled water and relevant areas of wastewater management. The main focus of the research program is on urban water issues related to public health and acceptability aspects of water supply, water recycling and aspects of wastewater management. WQRA also has an Education Program, utilising the most successful elements of the CRC Program. WQRA is a not for profit company, governed by an independent board, and wholly owned by its 46 member organisations (Oct 2010), covering all states of Australia and including water utilities, research organisations, private sector companies, and state and territory government departments.	2015, WQRA has a Foundation Research portfolio of more than 50 projects addressing 15 priority issues in drinking and non-potable water with a research value of $50m — a ten-fold leverage on the $5m of WQRA cash investment. WQRA was recently contracted by the Commonwealth to deliver a $20m research program on urban water quality.	Does not deliver:	table, albeit without the DIISR funding contribution. It has close linkages with policy and regulatory bodies, and it has retained the education program of the former CRC for Water Quality and Treatment. Like AHA, it benefits from a clear focus — in this case on water quality, primarily in urban water supplies — an issue directly affecting more than 20 million Australians with huge human health implications, and serviced by a multi-billion dollar industry with more than $30 billion in infrastructure projects underway. The size of the urban water sector and the cashed-up nature of its larger participants are the big point of difference with the invasive animals research sector. It would seem much more difficult to attract $5m in cash commitments from IA CRC partners that WQRA has been able to from its member organisations, but the model is a very good one.
	The Lowitja Institute The Lowitja Institute was developed by the Partners of the CRC for Aboriginal Health to continue its work and that of its predecessor, the CRCATH. The Institute now hosts the CRCAH's successor, the CRC for Aboriginal and Torres Strait Islander Health (CRCATSIH). CRCATSIH started in January 2010 following the CRCAH's success in winning an extension of CRC funding to June 2014. Beyond 2014, the Lowitja Institute will continue to undertake Indigenous health research while maintaining the underlying philosophy guiding the work	The Lowitja Institute is a not for profit company with charitable DGR (Deductible Gift Recipient) status. The Lowitja Institute will be funded through the establishment of a core fund or endowment, largely drawn from initial government and private sector investment and	Delivers [TBC]: a, b, c, d, f, h Does not deliver: e, g	 It remains to be seen how effective the Lowitja Institute is in securing government, private and philanthropic funding beyond 2014, but this model is interesting from an IA CRC perspective. It has the potential to deliver against most of the criteria from section 4.2, but that will depend to a very large extent on how much funding it secures and the degree of buy-in from relevant government agencies and end-users in the Indigenous health sector. It is noteworthy that at this stage only one state/territory government (the NT) has agreed to be a participant, limiting the capacity of the Lowitja Institute for national scale horizontal integration and policy linkages.

	done by the three CRCs: that knowledge development is best accomplished through working partnerships between researchers, and Indigenous-led health service providers; and that research priorities should be set by the Indigenous end-users of that research. The Lowitja Institute will also continue the CRCs' work of coordinating, networking, building capacity and providing an evidence base for Aboriginal and Torres Strait Islander health policy and practice.	supplemented by membership fees. Its founding participants include two government agencies, eight research providers and two end-user bodies. It also has a Congress with much wider membership to provide for stakeholder input on a biennial basis.		There are parallels between Indigenous health issues and invasive animals issues, in that both have strong public good dimensions characterised by chronic and diffuse problems, with available resources thinly scattered over vast areas, and both demand strategic, sustained, long-term, collaborative approaches to research investment and capacity building.
Evolution into a grants program	National Weeds and Productivity Research Program In November 2010, the Minister for Agriculture, Fisheries and Forestry, Senator Joe Ludwig, and Parliamentary Secretary Dr Mike Kelly approved RIRDC's five year plan for the second stage of this program. Collaborative funding will also be sought, and some research is being commissioned outside the competitive grants process. http://www.rirdc.gov.au/programs/national-rural-issues/weeds/weeds_home.cfm	The first phase of the program through DAFF in 2008-9 funded 39 projects worth $3.9m. The next phase through RIRDC has $11.4m over 3 years to June 2012.	Delivers: f, g (partial) Does not deliver: a, b, c, d, e, h	It is very difficult to achieve strategic national research collaboration and capacity building, let alone post-graduate or other training programs, or international partnerships, or durable research-policy linkages, through a short-term, competitive grants program. Campbell & Schofield (2007) discuss a range of procurement options for applied research depending on the objectives being sought. This program may deliver more benefits in time if it strategically commissions work against the five-year R&D Plan and if longer-term funding can be secured, but it falls well short of a durable institutional base.
Evolution into a spin out SME	Pestat (commercial arm of the Pest Animal Control CRC) http://www.pestat.com.au	Contract based, mostly with Commonwealth funding	Delivers: d, g (partial)	Outside of entrepreneurial opportunities, such as development of HopStop, the funding base is vulnerable to changing government priorities, and opportunistic. The

	Continued viability through ad hoc grants - such as APAS National Facilitator, and entrepreneurial technology transfer activities.		Does not deliver: a, b, c, e, f, h	IA CRC business model is very different, based instead on SMEs and state agencies being involved as Participants.
	Ninti One Ltd (commercial arm of the Desert Knowledge CRC, which now provides management services for the CRC Remote Economic Participation) Continued viability through management of the $19m Caring for our Country feral camel management project; http://www.feralcamels.com.au/	Contract based, mostly with Commonwealth funding through the CRC Program and Caring for our Country.	Delivers: d, e (partial) Does not deliver: a,b, c, f, g, h	Ninti One was established to commercialise outputs of the Desert Knowledge CRC, and is now the managing agent for the CRC Remote Economic Participation. While Ninti One manages many other projects, the vast majority of its funding comes from the feral camel project and its long-term viability when the CRCREP finishes and Caring for Country money runs out is an open question.

4.4 Discussion

Of the institutional models analysed in Table 1 above, the most prospective — in terms of their ability to meet the criteria set out in section 4.2 — would appear to be those exemplified by Water Quality Research Australia (WQRA) in particular, and to a lesser extent the Lowitja Institute and the Reef and Rainforest Research Centre (RRRC). These organisations continue to broker and coordinate significant research portfolios, to encourage innovation and to invest in long-term research capacity within their areas of interest. All three are not-for-profit companies limited by guarantee, owned by a range of partners including government agencies, industry and regional bodies and research providers.

The long-term outlook for the Lowitja Institute beyond 2014 is uncertain at this stage, as its durability and effectiveness will depend on the degree of government buy-in and funding it secures over the next three years and beyond. The RRRC appears to rely in the main part for its revenue on Commonwealth funding programs, initially the Marine and Tropical Sciences Research Facility and subsequently the National Environmental Research Program. These programs are short-term in nature, and the RRRC manages its components of those programs under contract to the federal environment department. While its funding base would appear to be vulnerable, it is well-positioned politically, focused on the Great Barrier Reef and the Wet Tropics, and centred on marginal electorates in both the Queensland and federal parliaments. The RRRC is a regional organisation, not national, and as such it does not need to work across jurisdictions, nor does it have a significant emphasis on commercialisation.

Water Quality Research Australia (WQRA) appears to offer the best model for IA CRC to investigate. Its funding comes primarily from its partners, which is then used to leverage other government and industry funds. It is national in scope. It is not reliant on a single funding source for the bulk of its revenue, However, the Commonwealth remains a significant investor through WQRA at a research program level. It operates like a CRC, retaining a strong emphasis on its education program to build capacity within the sector, and on linking science, policy and regulation. It has a very clear focus on a critical issue that has major social, economic and environmental dimensions. Its value proposition around collaboration, national coordination, strategic capacity building and sharing of resources and knowledge seems cogent. It does serve to illustrate that it is possible for a CRC to morph into a more permanent institutional form while retaining many of the best features of a good CRC.

However, there is a significant difference between the overall scale of the urban water quality sector compared with the invasive species sector. There are bigger organisations in the urban water sector, both public and private, and a significantly higher level of discretionary cash among its participants.

The challenge for IA CRC is to make the case for on-going public investment in this sector, based on some key propositions: that the need for collaborative, national applied research and capacity building is best met through a CRC-like model such as exemplified by WQRA; and that the pervasive market failure in the invasive animals sector (even more than in the urban water sector) means that on-going public investment is not only justified, but is essential in order to prevent and limit much larger costs imposed on society, the environment, and primary industries.

4.4.1 The 'Without' scenario

In the absence of an on-going institutional base for planning and funding collaborative, national, applied invasive animals research, development and capacity building, some consequences are probable:

- Research capacity within the sector would decline rapidly through attrition within the remaining state agency research groups, and as other researchers 'follow the money' and focus their efforts where funding is available.
- The national invasive animals research effort would become increasingly fragmented, lacking critical mass, cohesion and international linkages.
- Connections between invasive animals research and the policy and regulatory environments that are so pivotal in the deployment of its outputs would weaken and fragment.
- Transaction costs for anyone trying to encourage a national approach would increase substantially in the absence of the 'one stop shop' established by the IA CRC.
- If and when the use of 1080 is banned in some jurisdictions, pest populations currently managed with that poison will increase. In the absence of the new, more humane technologies being developed by the IA CRC (see Appendix C), control options would be extremely limited, and much more expensive.
- Regulatory restriction trends in the US and Europe, particularly in relation to second generation anticoagulants for rodent control in agriculture (US) and restrictions on zinc phosphide for rodent control use in Europe, suggest that the effective life of even the new more humane technologies developed by IA CRC will be limited. There will be a consequent demand for alternative control technologies, but the lag time before sufficient research capacity can be developed, research programs designed and delivered, and products brought to market would be considerable — up to a decade.
- The costs for any particular primary industry — even the big broadacre industries like meat, wool and grains — to develop its own invasive animals research program and to sustain it for the periods necessary to discover, develop and market new technologies, would be prohibitive.
- The aggregate and cumulative environmental and social costs of exploding pest mammal, bird and fish populations in the absence of effective control technologies or a coordinated research effort would be considerable.
- The biosecurity-related health risks to the human population, production risks to primary industries and environmental risks to native species through invasive animals acting as potential disease vectors are difficult to quantify, but potentially very high.

If the IA CRC ceased to exist — without replacement by an organisation performing similar functions and delivering similar services — it seems very likely that within a few short years it would need to be reinvented, no doubt at considerably greater expense.

4.4.2 A model for a durable institutional base for invasive animals R&D and capacity building

Based on the above analysis and a workshop with the board and senior staff of the IA CRC, a potential strategic framework for on-going investment in and management of national collaborative applied research on invasive animals emerged, as depicted in Table 2 below. This framework is conceptual, rather than structural — it should not be construed as a potential organisational chart. Moreover, nor should it be construed as necessarily being delivered through a single organisation. It could conceivably be realised through a very cohesive and well-coordinated network, although that still implies a very capable coordinating body to support the network. Furthermore, it could just as easily apply to invasive plants as to invasive animals.

Table 2. Conceptual framework for investment in invasive animals R&D

Sectors	New Solutions		Applications	
	Collaborative research	Commercialisation	Onground applications	Education & capacity building
Primary Industries Biodiversity Biosecurity	Ecological systems understanding Modelling Specific solutions	Production Sales & marketing Follow through	Offsets (for major developments) Coordination Extension Demonstration projects Indigenous Protected Areas (IPAs)	Policy Education and training Institutional reform Knowledge network Indigenous employment

4.4.3 Pathways to a durable institutional base for invasive animals R&D and capacity building

There are two main pathways to achieve a durable institutional base for invasive animals R&D and capacity building: one based on a successful extension bid in 2012, and a contingency plan in case the extension bid is unsuccessful.

The extension bid should be very explicit about the 2012-2017 transition period, which would in effect put in place something like the model above, with a high level of engagement of participants. A good model for that transition period is the Lowitja Institute, a not-for-profit company established to run the third CRC for Aboriginal and Islander Health to 2014, after which it will become an on-going institution delivering many of the same services as a CRC.

If the extension bid is unsuccessful, it should still be possible to move immediately to convert the IA CRC from its current institutional form into a new corporate entity — a not-for-profit company limited by guarantee and owned by its participants. The 41 partner organisations in the current CRC would be the obvious starting point to build a base of participants, but by no

means the full potential, especially given the broad scope illustrated in Table 2 above. Obviously such a process would be more hurried than under the CRC extension pathway in order to avoid a loss of momentum (and key staff). It is also inherently more risky in that it would be difficult to secure funding commitments within the necessary timeframe given the lengthy budgetary and decision-making processes of many organisations in IA CRC, especially government agencies. But with sufficient goodwill among participants and a dynamic Board and senior management team, it is doable.

5. Conclusions

It is clear from this analysis that securing a durable institutional base, and in particular a stable long-term funding base for national collaborative applied invasive animals R&D after the wind up of the IA CRC — whether that occurs in 2012 or 2017 — will be extremely challenging.

But not impossible.

It is equally clear that establishing a durable institutional framework for strategic national investment in collaborative, applied invasive animals R&D and capacity building that could satisfy the criteria in Section 4.2 would be an extremely good investment for Australian taxpayers and for many Australian primary industries. The case for on-going public investment in a sector characterised by pervasive market failure is very strong, both at the level of the nation as a whole, and at the level of specific agricultural industries. The rural R&D model has been designed explicitly to deliver sufficient public and private investment on such issues.

The best pathway for IA CRC to a more permanent institutional base is to seek an extension from the CRC program to 2017. That bid should be based on a compelling business case around the value to Australia of on-going collaborative applied invasive animals research, and the necessity for national coordination. The business case should map how IA CRC would evolve during that period so that by 1 July 2017 it would be operating as a not for profit company owned by its government and industry participants, with a complementary role in the national biosecurity system and a clear strategy out to at least 2025 and preferably 2030.

The business case should be informed by an updated economic analysis in the light of the various reviews discussed here, exploring both the prospective return on investment from the IA CRC portfolio as it evolves, and also the 'without case' — the potential implications of allowing momentum to stall and the legacy to depreciate. The value proposition needs to be extremely clear and hard-hitting — not just about the importance and value of invasive animals R&D, but why it needs a national institutional base, why it needs long-term funding, why the education and training dimensions are so important, and why collaboration across all jurisdictions and between governments, industries and SMEs is so critical in this sector.

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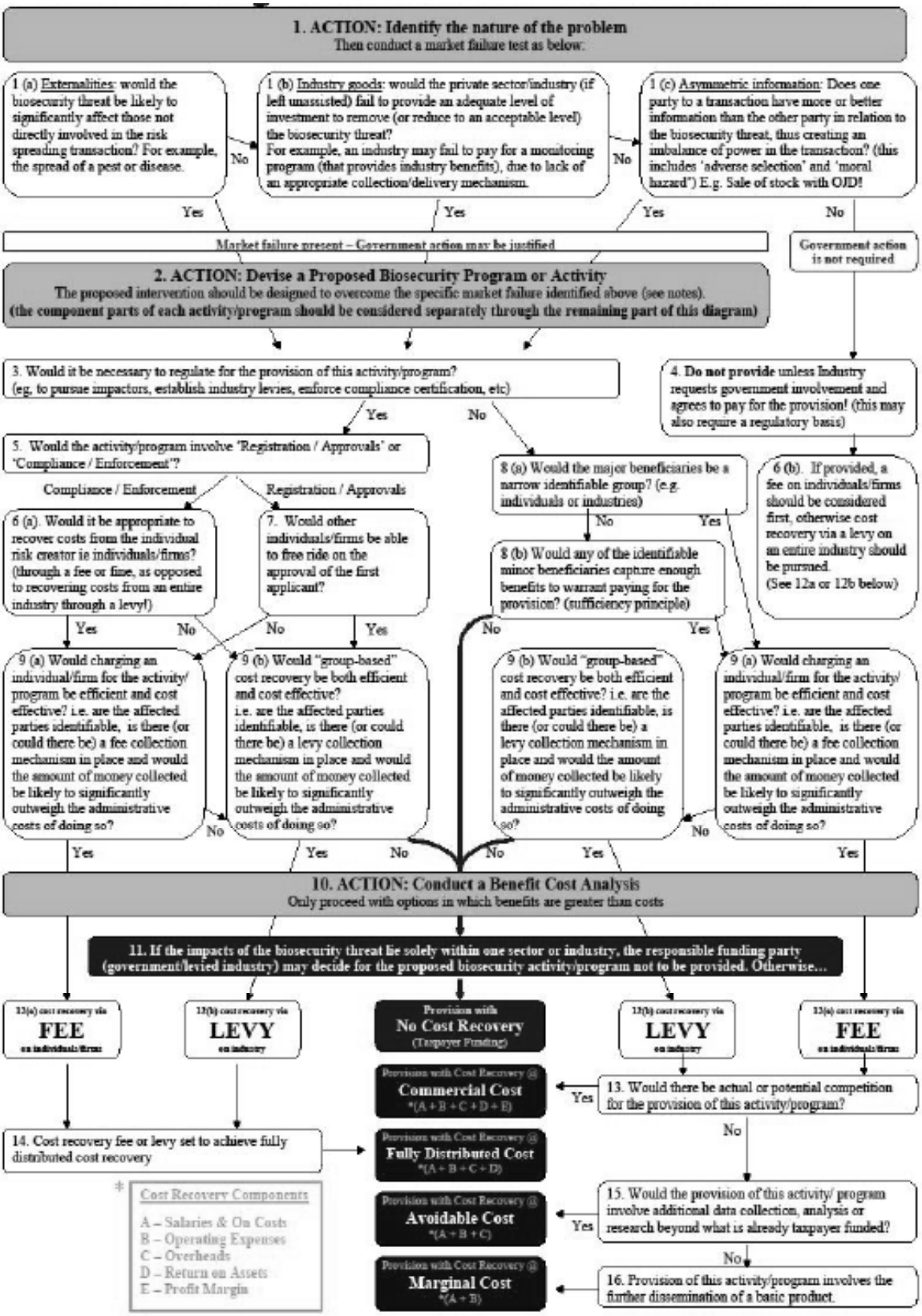
Appendix A. Respondents

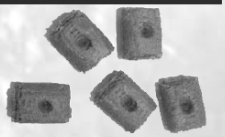
In addition to a workshop with the Board and senior staff of the IA CRC, the following people were interviewed as part of this project.

Dr Jeanine Baker	Director, Invasive Species and Innovation, ABARES, Department of Agriculture, Fisheries and Forestry
Mr Roger Beale AO	Chair of the Beale Biosecurity Review
Dr Mike Bond	CEO, Animal Health Australia
Mr Andrew Inglis AM	Chair of the Biosecurity Advisory Council, Chair of the Future Farm Industries CRC, and member of the Beale Biosecurity Review
Ms Pieta-Rae Laut	Director, Environmental Biosecurity, Department of Sustainability, Environment, Water, Population and Communities
Mr Stewart Webster	Manager Industry Policy, Economic Policy & Research Branch, Industry and Investment NSW

Appendix B. A decision framework for assessing biosecurity threats (from Smith & Webster 2010)



Appendix C. The current 'product pipeline' for IA CRC

Product	Benefits	Availability*	
Wild dogs / Red foxes			
DOGABATE® FOXECUTE®	PAPP – a new predacide, humane, Blue Healer™ antidote.	Late 2012	
Mechanical ejectors	Cyanide version used in USA for 40 years. 1080, cyanide and PAPP versions likely. High target specificity and good field longevity.	Late 2012	
Lethal Trap Device (LTD; green tube)	Contains cyanide- rapidly euthanizes trapped dogs and foxes, improving animal welfare and reducing labour requirements. Export potential.	Late 2012	
Blue Healer™ - PAPP and nitrite antidote	Save accidentally poisoned dogs or wildlife. IV injection and oral product for vets, oral product can also be used by dog owners. Export potential.	Mid 2012	
Feral pigs			
PIGOUT®	The world's first manufactured feral pig bait. Easy to use, shelf stable, high target specificity, internal 1080 core.	Launched March 2008	
HogHopper™	Target specific, peace of mind feral pig baiting, reduced labour requirements, protects manufactured or grain bait. Export potential.	Launched December 2010	
PIGOUT® Econobait	Bite-sized, cheaper 1080 bait to use in HogHopper™'s. Longer hopper longevity and easier to use than grain.	Late 2012	
HOG-GONE®	Humane sodium nitrite (food preservative) active ingredient, greater availability, high target specificity, low residues, Blue Healer™ antidote. Export potential.	Early 2013	
Nitrite concentrate	Same as HOG-GONE®, but can be applied to grain and other bait types. Export potential.	Late 2013	

Rabbits			
Carbon monoxide fumigator	Easy to use, portable, humane fumigant, smoke tracer, runs on readily available LPG or propane. Export potential.	Mid 2012	
Freeze-dried Rabbit Haemorrhagic Disease virus	Shelf stable RHD virus for use on carrot or oat bait, easy to transport and apply.	Early 2012	
Mice/Rats			
MOUSEOFF® ZP	Use extension to Banana plantations, Brassica vegetables, Root and tubers, Zucchini and Tomatoes.	Late 2011	
RATTOFF® ZP	Use extension to Teak plantations, Banana plantations & Chick pea crops.	Late 2011	
MOUSEOFF® BD Block	Use extension to industrial areas and domestic situations.	Late 2011	

**Availability times are estimates only as the government registration process will dictate ultimate availability.*

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