

PROCESSES AND INSTITUTIONS FOR SCIENTIFIC INDEPENDENCE – REFLECTIONS ON LAND & WATER AUSTRALIA

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Independent and impartial scientific research provides critical contributions to many contemporary policy debates, including those about climate adaptation and natural resources. Therefore, institutional arrangements that enable and protect scientific independence are central to resolving environmental problems in advanced liberal democracies. This paper provides an overview of the research and development (R&D) funding organisation Land & Water Australia (LWA) that, due to its statutory independence, was effective and influential in promoting sustainable natural resource management. Established by legislation that provided structural independence, LWA was insulated from direct interference, enabling it to operate at arm's length from executive government. The paper profiles LWA contributions to changing policies and practices, and explores the features that enabled LWA to coordinate, organise and fund R&D, until its abolition in 2009. LWA provided a useful precedent of a statutory authority, chartered with a clear legislated purpose and legal mechanisms for ensuring independence. The paper highlights institutional arrangements that protect scientific independence, arguing that LWA provided an important model of public R&D investment directed to sustainability transformations.

Keywords: R&D policy, sustainability, natural resource management, land and water conservation, innovation, scientific independence

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INTRODUCTION

Recent controversies involving water policies and questions of scientific independence have included those surrounding the South Australian Royal Commission into the Murray-Darling Basin (Walker, 2019), the groundwater plan for the Adani Carmichael mine (Currell & Werner, 2019), and the ongoing debates about the Great Barrier Reef and the massive fish kills in the Darling River (Australian Academy of Science, 2019). These debates highlight the need for institutional processes of ensuring scientific independence that are sufficiently insulated from political interference (Walker, 2019). However, achieving this ideal can be particularly challenging because the majority of Australian science is publicly funded, and funding decisions made by governments affect projects, programs and entire agencies. Therefore, institutional arrangements and organisational models of 'arm's length' funding arrangements that can minimise direct and indirect interference by Ministers and bureaucrats deserve serious attention.

This paper explores one example of such an

organisation, that of Land & Water Australia (LWA) – a national statutory authority that funded R&D on natural resources management (NRM) between 1989 and 2009. Established as a statutory corporation – the Land and Water Resources Research and Development Corporation (LWRRDC) under the *Primary Industries and Energy Research and Development Act 1989* (PIERD) – its legislated mandate was to organise and fund R&D on the sustainable management and conservation of land, water and vegetation resources (Campbell, 2006).

This paper examines the case of LWA and the way it operated, for the purpose of discerning its key features and how these could be replicated in future arrangements. These include legislated arrangements for structural independence that minimised interference in its research funding decisions.

Despite its record of significant achievement, LWA was abolished in 2009 – ostensibly as a savings measure. Other reasons offered for this decision include increasingly strained relationships with the Minister and the Department after the election of the Rudd government,

and that LWA's relevance to the Agriculture Department was significantly diminished after the move of water policy responsibilities to the Environmental portfolio.

This decision to abolish LWA was widely criticised, including by political parties, the Australian Conservation Foundation (ACF) and the National Farmers' Federation (NFF) (APH, 2009). Yet a decade on, Australia lacks any similar agency, despite the Productivity Commission's (2011) recommending that "if the Government is serious about having its broader research priorities appropriately addressed within the RDC arrangements, it should create and fund a new RDC — Rural Research Australia — to sponsor non-industry research directed at promoting the productive and sustainable use of resources". In its draft report, the Productivity Commission recommended a \$50 million annual allocation to this new entity, for public-good R&D (Campbell, 2010).

LWA's role in the nation's life deserves further analysis. As a research broker, it successfully initiated numerous collaborative R&D programs, facilitating purposeful co-investment with industry and governments. Its programs are too numerous to document comprehensively, so this paper takes a synoptic rather than comprehensive view of LWA's contributions, drawing on specific programs for illustrative purposes. Comprehensive documentation of LWA's diverse R&D programs can be found in Campbell (2006) and Campbell & Schofield (2007).

Many of LWA's R&D programs were relevant to Queensland (and northern Australia more generally), including work on water, rangelands, vegetation and savanna management. Its remit did not extend to marine and coastal waters, but R&D on catchments and riverine systems improved understanding of nutrient and sediment runoff processes affecting estuaries and near-coastal waters, including the Great Barrier Reef.

I was involved with LWA over its 20-year life, initially as a representative of the ACF (under the PIERD Act, LWA was required to formally consult with the ACF and NFF on its strategic plans), as a Board member (1996 and 2002), and as the Vegetation and Biodiversity R&D Program Coordinator (2002 and 2006).

This paper draws on that experience, and subsequent reflections on how R&D is organised and funded, to provide insights about the institutional settings that enable or constrain effective, policy-relevant R&D. My subsequent experience as a senior executive at the Murray-Darling Basin Authority (2008–2013) emphasised that well-structured arrangements for generating

impartial scientific research are critically important to sound policy development and therefore to the functioning of advanced liberal democracies dealing with complex and compounding environmental problems, including climate adaptation (Ison et al., 2018; Walker, 2019; Alexandra, 2019).

The paper concludes with some ideas about institutional arrangements for revitalising public-good R&D. I argue that the experience of LWA provides important insights into the kinds of R&D arrangements needed to tackle the 21st century's systemic problems. These require purposefully designed, boundary-spanning organisations that can accelerate urgent sustainability transformations (Cash, 2001; Cash et al., 2003). Given this, Australia should create more entities like LWA, in the States and Commonwealth, that are empowered to generate transformative innovations across multiple domains, including agriculture, energy, water and urban planning. These entities need to be established using institutional designs that incorporate the best features of what has been learnt, in terms of directing R&D funding towards generating and adopting effective, policy-relevant innovations.

ORIGINS AND MANDATE – ASSISTING RESOURCE POLICIES IN TRANSITION

LWA can be credited with contributing to NRM knowledge, driving institutional, policy and practical reform. However, its existence and legacy are framed by the wider operating context.

Since LWA's inception, profound changes occurred in Australia's policy settings for land, water and natural resources. The nation's cultural, institutional and economic relationships with natural resources have evolved. Across the continent, changing relationships with country^a are manifesting in the policy and physical landscapes. Through numerous plans and policies, NRM goals have been redefined, incorporating objectives such as conservation of biodiversity and of the capacity to deliver ecosystem goods and services (Alexandra & Riddington, 2006).

LWA contributed to and reinforced this redefinition, recognising that Australia's rich and diverse landscapes help to shape our spirits, our values and cultural icons, and therefore our national character. LWA promoted the idea that "rural landscapes are

^a 'Country' is a holistic term, encompassing land, water, plants and animals, and is often used to describe Aboriginal Australians' relationship to place, territory or region – as in 'Welcome to Country' ceremonies which are used to open conferences and meetings.

inherently diverse, and incorporate production, lifestyle and amenity values. They are socially constructed, reflecting the way natural resources are managed, perceived and understood ... While a factory, quarry or mine is an adequate analogy for systems that produce commodities: cathedrals, theatres, museums, universities or great art galleries are appropriate analogies for the multi-faceted relationships we have with nature” (Alexandra & Riddington, 2006).

These profound changes can be traced back to the late 1980s when the nation’s institutions, identity and sense of place in the world were changing and when ambitious programs, like planting a billion trees to restore landscapes and inspire hope, were promoted (Eckersley, 1989; Campbell et al., 2018). Agriculture was declining in economic significance (Keating & Harle, 2004), but caring for country was elevated to a national ideal, including through Landcare initiatives (Marriot et al., 1999). The continent was no longer seen as a cornucopia of natural resources available for crude exploitation, but as an inherently valuable, bio-diverse continent in need of care (Alexandra & Riddington, 2006; Campbell et al., 2018).

In the 1980s, local land conservation groups, landcare groups and environmental restoration initiatives emerged independently in Victoria, Queensland and Western Australia (Campbell, 1994; Marriott et al., 1999). The ACF and NFF formed an alliance, campaigning for an end to land degradation and a decade of commitment to landcare (Toyne, 1992). Prime Minister Bob Hawke launched the Decade of Landcare at the confluence of the Murray and Darling Rivers in 1989 (Commonwealth, 1990), confirming that sustainable resources management was recognised as a national priority. That year, the Commonwealth also established LWRRDC, later rebadged as LWA (Campbell, 2006).

LWA’s origins were in this ‘landcare dreamtime’ – the optimistic days of the late 1980s – when sustainable landuse was high on the nation’s policy agenda (Campbell et al., 2018). The legislative mandate for LWA was to change the way natural resources were managed (Campbell, 2006) despite persistent and potent forces driving resource exploitation (Industry Commission, 1998). The idealistic goal of solving the “wicked problems” (APSC, 2007) of land degradation was enshrined in legislation. In effect, Australia had established a ‘sustainability’ research corporation whose mission became “generating knowledge, informing debate and inspiring innovation and action in sustainable natural resource management” (LWA, 2001).

This legislative mandate – with its clarity of purpose, ambition and inherent idealism – established a purposeful entity. The mandate was coupled with statutory independence and a relatively small, but discretionary R&D budget, strategically invested by successive Boards (Campbell, 2006). Using its R&D funds, LWA convened extraordinary networks – farmers, officials, researchers and conservationists – that together formed and activated Australia’s NRM knowledge system, pursuing the ideal that conservation and production could be integrated (Campbell, 2006).

LWA explicitly recognised that the technical, cultural and social dimensions of NRM are intimately and inherently linked (LWA, 2001). LWA’s land, water and vegetation R&D programs catalysed changing ideals about Australia’s landscapes, celebrating them as places of diverse lifestyles and livelihoods (Campbell et al., 2018). Throughout the 1990s, local landcare and regional groups emerged as key actors in NRM (Curtis et al., 2014). A new ethos that many people called landcare^b – was enfusing communities, infusing into policies, and diffusing through countless networks (Campbell et al., 2018). LWA supported these groups’ efforts in tackling their land and water conservation priorities. Its R&D programs brought together diverse disciplinary perspectives of policy professionals, researchers and practitioners. Through these diverse partnerships, LWA created networks that recognised that NRM knowledge and practice are co-produced (Bouleau, 2014; Bremer & Meisch, 2017), and that partnerships offer the best prospects for achieving enduring change (Campbell, 1994; Alston & Whittenbury, 2011; Abel et al., 2016).

LWA recognised and reinforced an emerging culture of landscape restoration during a time when the nation’s relationship with the continent was changing. Australians were becoming more respectful and appreciative, celebrating their landscapes’ intricate patterns, rich biological diversity, and profound cultural history (Griffiths & Russell, 2018).

A LEGACY OF WATER REFORMS –

DAMPENING THE NATION’S WET DREAMS

In the 1990s, Australian water policy settings were under pressure to change. The Prime Minister’s Science and Engineering Council warned that the continuation of past policies “will severely and adversely

^b Landcare is used as a generic term, covering all land conservation efforts – not just those programs labelled as ‘Landcare’.

affect every aspect of contemporary life” (PMSEC, 1996).

Australian governments agreed to national water reforms in 1994. These aimed to increase the productivity and efficiency of water use and ensure the health of aquatic systems, committing to environmental flows in all rivers, based on the best available science (COAG, 1994). These commitments have been repeated in all major water policies in the 25 years since 1994, including the Commonwealth Water Act; however, implementation has been challenging (Walker, 2019; Grafton, 2019). Despite recognising the central role of science in guiding the restoration of riverine ecosystems, there have been continuing contestations about how to apply science to this policy challenge. These contestations highlight the critical role of impartial and independent research in policy development and implementation (Alexandra, 2018; Walker, 2019).

Sustained R&D on river health and environmental flows can be traced to LWA-funded and -coordinated R&D programs, including the National River Health Program (1993–2001), the Environmental Water Allocation Program (2001–2009) and the Tropical Rivers and Coastal Knowledge Consortium (TRaCK) (Campbell & Schofield, 2007).

The National Program for Sustainable Irrigation also supported the COAG commitments, focusing R&D on opportunities for improving the efficiency and environmental performance of water-intensive industries (Raine et al., 2005). This efficiency focus was a fundamental shift, because for most of the 20th century water resource policy was supply focused, through construction of dams, reservoirs and weirs (Alexandra, 2018).

With its high-value, reliable production, irrigated agriculture produces approximately half of Australia’s farm gate profit, mostly from the Murray-Darling Basin (NLWRA, 2002a). This productivity has inspired numerous schemes for developing northern Australia’s rivers for irrigation. These rise to prominence repeatedly (Davidson, 1966 & 1969), especially during droughts in southern Australia, despite stated commitments to environmentally sound and economically rational policies (COAG, 2004), and warnings about poor soils, hostile climates and inadequate infrastructure (Connors, 2019). More importantly, other forms of economic development are likely to be more socially advantageous, internationally competitive and culturally appropriate (Hill et al., 2007; Connors, 2019).

LWA’s support for R&D on northern Australia, including through TRaCK, has been important in drawing attention to these rivers’ biological and cultural values (see, for example, NESP 2019a,b). These programs have led to a greater understanding of the severe constraints to irrigation development, helping to inform policy debates about risks and to articulate opportunities for innovative ways of sustaining nature, industry and culture in Australia’s north (Hill et al., 2007; Connors, 2019).

Fundamental debates about the merits of large-scale irrigation development continue, with a topical example provided by Western Australia’s Fitzroy River. Large-scale irrigation proposals motivated the Fitzroy River Declaration (MRFC, 2019) and the Fitzroy River Statement (Moritz et al., 2019), indicating that recognition of Indigenous rights to govern decisions about water resources remains a pressing social justice issue (Jackson & Altman, 2009; MFRC, 2019).

These debates emphasise the value of rigorous R&D in generating quality-assured, peer-reviewed information that can support informed public debate and policy development. However, high-quality, independent science capable of informing water policy remains challenging in Australia’s highly politicised and heavily contested policy environment (Alexandra, 2018; Grafton, 2019). These pressures emphasise the importance of R&D funding bodies, like LWA, that through statutory independence were able to support impartial research into matters of national significance (Campbell & Schofield, 2007).

A LEGACY OF NATIVE VEGETATION CONSERVATION

LWA R&D on Australia’s native vegetation spanned the continent, from studying remnants in agricultural landscapes to the vast woodlands and grasslands beyond the agricultural fringes (Lindenmayer et al., 2008; Douglass et al., 2011).

LWA’s R&D influenced the large-scale adoption of practical and policy outcomes. Since the 1990s, most Australian states have regulated broad-scale clearing of native vegetation, with regulation often accompanied by incentives to enhance conservation management. LWA contributed to the design of incentive mechanisms (Binning & Young, 1997). Similarly, R&D on savanna burning has contributed to implementing large-scale, carbon-funded fire regimes that lower CO₂ emissions whilst improving cultural and conservation outcomes (Douglass et al., 2011).

Responding to the need for science-based principles

to guide conservation practice, LWA supported the refinement and articulation of guiding principles for landscape conservation (Lindenmayer et al., 2008). These principles are documented in several publications, including: *Managing and designing landscapes for conservation: moving from perspectives to principles* (Hobbs & Lindenmayer, 2007); *The Bowral Checklist – A framework for ecological management of landscapes* (Lindenmayer & Salt, 2008); and a paper in *Ecology Letters* (Lindenmayer et al., 2008).

A LEGACY OF INSPIRED COMMUNICATION

LWA's publications articulated the ideal that landscapes had room for people and nature, for conservation and production and for integrating economic and cultural activities. LWA delivered loads of scientific and technical advice, via publications and websites that documented, transferred and enlightened Australia's NRM practice and enhanced capabilities. Perhaps more importantly, LWA inspired communications that tapped into a deep vein of commitment to sustainability. LWA communications complemented its technical and scientific innovations. Rigorous technical knowledge was coupled with digestible material that supported those searching for data, guidance, technical manuals, and knowhow.

Many publications are colourful and inspiring benchmarks of effective science communication, using photos, diagrams and visual art to convey meaning. That LWA commissioned and used paintings in its publications is not surprising, given that it is through the visual arts that the power and richness of Australian landscapes are often conveyed (Alexandra & Campbell, 2002). On my bookshelf several colourful bindings stand out, including the golden artwork covering *Principles for riparian land management* (Lovett & Price, 2007).

The publication *Investing in our landscapes – an assessment of the benefits of LWA research* (LWA, 2005) documents evaluations of R&D on rivers, climate forecasting, controlled traffic cropping, cleaning up cotton pesticides, salinity and irrigation efficiency. It illustrates the value of systematically designing and evaluating R&D, and provides insight into the power of using a framework of rational analysis to guide R&D on applied solutions. These evaluations illustrate the value of R&D in reversing land degradation and resolving other sustainability dilemmas. They also emphasise the importance of dedicated, independent agencies with roles in prioritising, designing and funding R&D programs.

A LEGACY OF EVIDENCE – THE AUDIT OF A NATIONAL LANDSCAPE CRISIS

“The incorporation of ecological sustainability into policy has been ad hoc, incomplete and tentative. The central problem is that Australian governments have yet to put in place a comprehensive, integrated and far sighted way of promoting the ecologically sustainable management of natural resources” (Industry Commission, 1998).

Australia has a continental landscape crisis with symptoms that include the deteriorating condition of rivers, estuaries and near-coastal waters; the numbers of threatened and endangered species; and extensive land degradation (NLWRA, 2001, 2002a,b,c).

LWA brought together divergent information on the condition of Australia's landscapes, to deliver the National Land and Water Resources Audit (NLWRA, 2001, 2002a,b). This comprehensive assessment of the condition of rivers, catchments and estuaries, agricultural land, rangelands and biodiversity remains the benchmark of a status report on the continent which, unfortunately, comprehensively documents Australia's continental-scale landscape crisis (NLWRA, 2001, 2002a,b,c).

However, simply bringing forward this evidence is not enough to shift dominant policy paradigms. Objective assessments of the biophysical conditions, while fundamentally useful for informing policy, need to be complemented by a deeper sense of Australia's policy history and the implicit values embedded in our policy settings (Alexandra, 2018). This understanding needs to support the design of reforms to policies and the institutional arrangements that empower them.

The work of organisations like LWA can inform and reinforce the resetting of policy directions. LWA demonstrated that ambitions for transformative policies could be grounded and guided with quality analysis of options, often co-produced with industry. Thus, the R&D did not just provide evidence of problems but was focused on offering feasible solutions. Amplifying investment into salient, relevant and purposeful R&D is needed for dealing with the complex and converging Anthropocene challenges (Ison et al., 2018).

A CONTESTED HISTORY

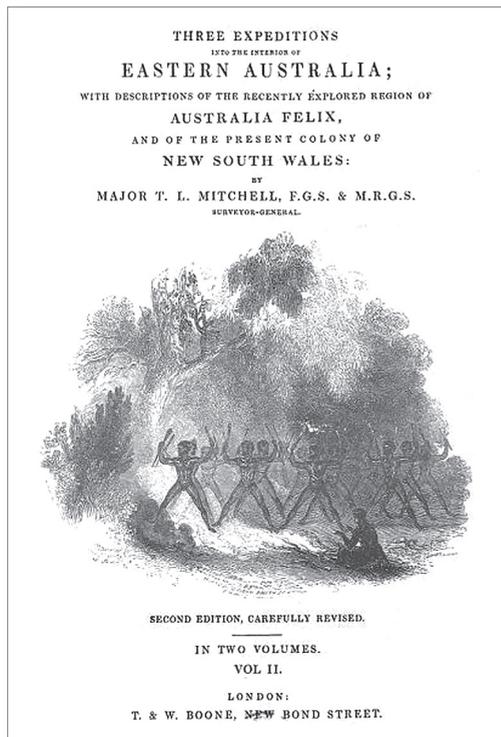
For over a century, policies for managing Australia's natural resources have been subject to a sustained contest between boosters, those backing 'Australia unlimited' – who subscribe to the view of unconstrained abundance – and those who believe in natural constraints to settlement and production

(Strange & Bashford, 2008). For example, Griffith Taylor (1940) argued that government schemes to settle the inland and north were destined to failure due to constraints of climate and geography, and that the population would inevitably move to more hospitable, coastal regions. Australia's demographics trends – with population growth along the coastal belts – demonstrate the accuracy of Taylor's insights (Salt, 2004).

Visions of what is deemed possible in terms of agricultural development depend on the observer's bias, and the seasonal conditions they encounter during surveys. Contrasting visions are illustrated with two accounts from 1836:

The soil in these grassy flats was of the richest description: indeed the whole of the country seemed capable of being converted into good wheat land, and of being easily irrigated, at any time by the river ... the genial southern breeze played over the reedy flats, which one day might be converted into clover-fields (Mitchell, 1836).

FIGURE 1. Cover of Mitchell's 1836 publication *Australia Felix: Three Expeditions Into the Interior of Eastern Australia*



Charles Darwin's observations are in stark contrast to Mitchell's pastoral optimism. He visited New South Wales in 1836 and after "an uncomfortable tramp over the Blue Mountains in a heat wave", he concluded that Australia could never become another America – its soil was too poor, its rains too unpredictable. Instead it must depend on becoming "the centre of commerce for the southern hemisphere and perhaps on her future manufactories" (McCalman, 2002).

Despite this advice, successive governments have sought to develop intensive agricultural production, sponsoring closer settlement and irrigation development (Alexandra, 2018). Dreams of taming rivers, greening deserts and making land productive run deep in the national psyche (Lines, 1994), with political commitments to agricultural development withstanding punishing droughts and misconceptions about the severity of the natural constraints (Taylor, 1940; Connor, 2019).

Agriculture's environmental impacts have resulted in substantial economic costs through salinity, loss of biodiversity and declining water quality (Industry Commission, 1998). The sizable direct and off-site environmental impacts include the poor condition of many rivers and the eutrophication and sedimentation of near-coastal waters, including the Great Barrier Reef. These degradation problems and their severe ecological consequences have been extensively documented (SoE, 1996, 2001, 2006; NLWRA, 2001, 2002a,b,c). While the degradation of the environment became unacceptable to the public (Cullen, 1997), these "wicked problems" are systemic, persistent, and resistant to simple policy prescriptions (APSC, 2007).

In the sustained policy debates between boosterism and ecological determinism, both camps seem to have an irrepressible capacity to emerge at opportune times, advocating more irrigation development or arguing that Australia is over-populated due to water shortages. Both camps seem to be immune to the facts about Australia's highly variable climate and high per-capita water resources.

Through the use of quality, applied science, LWA brought some objectivity and insights into these debates. For example, the Climate Variability R&D Program provided excellent frameworks for understanding and responding to Australia's inherent variability. Subsequent climate science built on this, furthering the understanding of the drivers of the climate systems, and how these are responding to climate change (CSIRO, 2010, 2012).

A LEGACY OF IDEAS – RETHINKING THE NATION

LWA contributed to broadening thinking about Australia's natural resources. For example, the Social and Institutional Research Program (SIRP) invested over \$12 million in policy-relevant, social and institutional research, encouraging involvement of researchers from different disciplines – including social scientists, historians and landuse planners.

Over time, LWA explicitly recognised that regions and resources are culturally defined (Alexandra, 2017) and that therefore attention is needed to recognise living, cultural relationships to country. This shift encouraged researchers to move beyond a narrow, 'colonial' definition of resources, which privileges those valued primarily through monetary exchange, to broader definitions of value (Gibbs, 2009). These include the non-monetary economy and recognition that the nation is enriched through people's lifestyles and intimate, lived experiences of country, including those of Indigenous People.

LWA brought multi-stakeholder networks together. These provided opportunities to share understanding with the people who work with, lived in and managed landscapes, without condemning them, in any way, to simple stereotypes. It celebrated these diverse relationships as both modern and enduring – part of our legacy of continuity and change in a peopled landscape with deep history (Griffiths & Russell, 2018).

The Wik and Mabo Decisions of the High Court changed Australia's identity. These, and subsequent legislation, established native title as law, confirmed the limitation of tenure granted by pastoral leases and demolished the legal fiction of 'terra nullius' that had infected Australia for nearly 200 years (Brennan, 2006). Indigenous Australians now own and manage over 25% of the Australian landmass, including the majority of the coastline between Broome and Cape York, with considerable opportunities for diverse enterprise development (Alexandra & Stanley, 2007). They also co-manage significant national parks, such as Kakadu and Uluru. It is clear that NRM is a cultural activity because "all Australian landscapes are cultural – in that they have been fashioned by the numerous choices of countless generations, including ours. These landscapes are interpreted and reinterpreted through the lens of our culture. Both belief and physical landscapes are formed by cultures working on or with nature (and nature working on culture) and understood through frameworks of belief and cultural understanding that continue to evolve and adapt" (Alexandra & Campbell, 2002).

Sustainable resource management is often narrowly defined as the ability to sustain production in the longer term. LWA broadened interpretations of societies' relationships to landscapes by funding research exploring the celebration of cultural connections to country. It did not place these connections in 'cultural museums', but instead actively investigated living, working cultures – including those of modern woolgrowers and remote Indigenous communities. This broader perspective reinforced a more dynamic view of natural resource management, giving recognition to the fact that it is people who live in, manage, work on, understand and celebrate landscapes.

There is value in thinking about Australia's diverse landscapes in different ways and adopting new approaches to old problems. The R&D on strengthening a conservation and cultural economy for northern Australia explored alternative economic futures for the continent's north that are people focused and multi-functional (Hill et al., 2007). To genuinely explore these possibilities in keeping with the potential offered by our multicultural country, we need to redefine our cultural connectivity to country, moving beyond stereotypes of pastoralist, miner or 'noble savage'.

The examination of property rights regimes reveals much about a country and its system of governance. LWA funded R&D that examined property rights regimes for land and water and their impact on sustainable resource management. For example, Hill et al. (2007) argue that all resources are culturally defined, and that access to and ownership of resources are politically, historically and institutionally defined. Therefore, all NRM operates in deeply political and socialised contexts that are not value neutral. The prioritisation and distribution of research funds are also not neutral. This is another reason for funding arrangements that are transparent and place these decisions at arm's length from the executive government.

A LEGACY OF INSTITUTIONAL DESIGN

LWA investigated questions about institutions for adaptive governance of natural resources. Certain 'design' features or arrangements maximise chances of success because institutional arrangements have a significant bearing on NRM outcomes (Abel et al., 2016; Hasselmann, 2018; Hassenforder & Barone, 2018). However, Australia can reasonably be defined as a contested landscape where deep tensions remain about policies, paradigms, priorities and objectives, with any arrangements negotiating these tensions

(Alexandra, 2018; Grafton, 2019). Overarching questions about the kinds of institutional arrangements needed include:

- (i) How can rigorous science best support policy decisions?
- (ii) What governance systems enable transparency and accountability?
- (iii) What mechanisms can ensure scientific independence?

Natural resource policies and programs need to be able to attribute their impacts and effectiveness. However, the impacts of Australia's NRM programs have been difficult to quantify reliably (Campbell et al., 2018), drawing attention to the need for independent and scientifically credible monitoring of environmental trends (NLWRA, 2001, 2002a,b; SoE, 2006). Furthermore, these assessments need to be integrated, assessing environmental conditions in a holistic way, in order to guide policy settings and to ensure greater accountability of the government agencies responsible (NLWRA, 2006).

LWA furthered the ideal of integration of conservation and production in diverse landscapes, legitimising new approaches to the problems of working in an ancient landscape. It helped to refine production systems, working with industry on improving irrigation efficiency, reducing pesticide impacts and forecasting future climatic conditions (see LWA, 2005). Its R&D generated and promoted practices, incentives and innovations that will have productive impacts for decades, including in intensive plantation forestry (Lindenmayer et al., 2003), revegetation and agroforestry (Alexandra & Campbell, 2002; JVAP, 2002) and the continent's vast savanna ecosystems (Douglass et al., 2011).

It is near impossible to measure accurately the full extent of LWA's impacts, but without its work, it is likely many practical and policy-orientated solutions would not have been adopted.

EVALUATING LWA'S IMPACTS

Successive Australian governments have espoused policies that explicitly aim to deliver ecological sustainability and promote environmental stewardship. National policies include the COAG water reforms (1994 & 2004), the Decade of Landcare Plan, National Water Quality Management Strategy, and the National Strategy for the Conservation of Australia's Biodiversity (Commonwealth of Australia, 1990, 1992, 1996). There are numerous corresponding

state policies and regional plans (Curtis et al., 2014; Abel et al., 2009; Campbell, 2018). Collectively, these reflect a vision for living well in this ancient continent and give expression to communities' desire for more sustainable management of the country and its natural heritage (WWF, 2002; Alexandra & Riddington, 2006). Likewise, local landcare efforts give practical effect to these sentiments (Campbell, 1994; Marriot et al., 1999; Campbell et al., 2018).

It is always difficult to accurately attribute what R&D contributed, and the degree to which any specific R&D enabled, reinforced, motivated or reflected these wider social changes. Nonetheless, LWA regularly and rigorously evaluated its programs, adopting robust systems for evaluating the impacts and effectiveness of its work. Its evaluations asked and found ways of answering the question: how did the generation and communication of knowledge effect change (LWA, 2005; Campbell, 2006; Campbell & Schofield, 2007)?

Furthermore, it is almost impossible to specify what the abolition of LWA has cost Australia in the lack of coordination and strategic investment in public-good R&D. However, given the ongoing contestation and disputation about land and water policies, and the need for science to inform these policies, an agency like LWA is sorely lacking from Australia's current institutional framework.

LWA'S DEFINING CHARACTERISTICS

In *The Getting of Knowledge*, Campbell and Schofield (2007) examine LWA's strategic and systematic approach to R&D program design. Likewise, in *The Australian NRM Knowledge System*, Campbell (2006) outlines principles for intelligent R&D investments, arguing that it is critical to focus effort and attention on asking the right questions, and to selecting R&D likely to have enduring impacts. Adopting these approaches, LWA strategically invested in generating applied results, but was not bound to any particular modes or methods of R&D, nor to sustaining any specific organisation. It was not required to support any specific disciplinary approach, research agency or problem-solving paradigm, because the legislation enabled discretion in prioritising and allocating R&D funds, so long as those decisions aligned with the strategic five-year plan. As a result, R&D programs drew on and combined the capabilities provided by researchers in the humanities and the social and natural sciences from governments, universities and the private sector. LWA recognised it is people

who make things happen, becoming a network of networks, of linkages and relationships that spanned the continent.

LWA's defining characteristics were:

- (i) discipline in scoping significant issues and opportunities for R&D in the public interest;
- (ii) rigour in analysis about what would yield to research;
- (iii) a focus on research with durable impact;
- (iv) a willingness to innovate in developing Australian solutions to Australian problems;
- (v) pragmatism about leveraging modest financial resources through building alliances, partnerships and networks; and
- (vi) a willingness to invest in people – through fellowships and scholarships, and through its staff and coordinators.

The institutional arrangements that contributed to LWA's successes included:

- (i) a legislated clarity of purpose – a sustainability mission aligned with the public good;
- (ii) a broad mandate but with significant discretion in allocating R&D funds according to clear principles;
- (iii) statutorily defined independence; and
- (iv) bespoke program governance and management systems, including communications and engagement on shared challenges.

In terms of independence from political directions, LWA's statutory independence was an important feature. Under the PIERD Act, the Minister and the Department could direct LWA only by way of written advice, particularly through advice on its five-year strategic plans. Therefore, any attempts to direct how priorities were set and R&D funds allocated were on the public record and subject to external scrutiny.

GENERIC LESSONS FROM THE LWA MODEL – NRM IN A CHANGING WORLD

NRM is a global sustainability challenge due to the pressing need to decouple production, resource use and pollution intensity (Campbell, 2006). Biodiversity conservation, water and land use, food and energy production and carbon intensity are converging 21st-century challenges, sometimes referred to as global limits or planetary boundaries (Rockström et al., 2009). There are compelling arguments that innovative, scalable solutions are needed, particularly given a growing global population, and constraints to land,

water and energy use (Weaver et al., 2000; Pahl-Wostl, 2017).

Sustainability imperatives demand technical and policy innovation, in order to innovate the way we undertake R&D (Weaver et al., 2000). Transformations of agriculture and NRM require integrated responses including systemically redesigning and revitalising R&D systems (Andersson & Sumberg, 2017), particularly in light of the increasing uncertainty induced by climate changes (Alexandra, 2012). R&D should be one of the powerhouses of sustainability transformation, but this requires effective institutions for innovation that are often characterised by boundary-spanning relationships and multi-scalar networks (Cash, 2001; Cash et al., 2003).

Sustainability science “demands integrated and at times radical approaches to complex problems. Sustainability science plays critical roles in articulating preferred futures and in developing smart ways to create these futures” (Alexandra & Campbell, 2002). Yet many established institutional models and governance paradigms appear ill-equipped to deal with Anthropocene challenges (Ison et al., 2018). Resources and creativity need to be focused on social, technical and governance innovations (Weaver et al., 2000).

So what generic lessons can be extracted from the LWA model?

LWA's approaches evolved to have an explicit focus on integrating the technical, human, policy and social aspects of NRM. R&D programs focused on the complex dynamics between scientific understanding, public policy and social change, including on pathways to achieving adoption (Campbell, 2006).

LWA demonstrated that R&D could be a powerful instrument in tackling the “wicked problems” plaguing sustainability (APSC, 2007) when funds are allocated by skills-based boards, granted statutory independence (Campbell & Schofield, 2007).

LWA demonstrated that with focus, discipline and skill, R&D funds could be directed to national priorities. This experience provides some useful and important lessons for developing integrated solutions (Campbell, 2006). Solutions to the challenges of becoming a more sustainable society are unlikely to be found by funding science randomly (Cash et al., 2003). So governments and multilateral organisations could apply the ‘LWA model’ to driving the innovations needed for accelerating transformations.

There has been much speculation on what led to LWA's abolition, with numerous reasons offered. What is important to recognise is that no government agency

is immune to budget cuts and legislative change. However, it is ironic that LWA was abolished in the same year that the review of Australian public service identified the pressing need for strategic policy and innovation capacity, proposing that this be achieved by policy agencies forming long-term R&D partnerships (APSC, 2010; Ison et al., 2018) like those formulated and coordinated by LWA.

Some regard LWA's demise as a strategic blunder, rather than an example of ideology-driven bloody-mindedness. However, this seems unlikely given that the pattern of Commonwealth government departments terminating small, effective satellite agencies is well established. Terminations include the Commission for the Future, the Resource Assessment Commission, the Energy R&D Corporation and the National Water Commission (Marlow, 2019). This disturbing pattern needs further investigation in the interests of determining how to ensure better and more durable arrangements are developed in the future.

CONCLUSION

Australia's systems of governance need to generate new wealth from our old landscapes, without destroying the priceless treasures of 600 million years of separate evolution and 60,000 years of human occupation (Alexandra & Riddington, 2006). This unique evolutionary and cultural heritage is entrusted in contemporary Australia's care. This is a burden of responsibility. Unfortunately, Australia's entrenched land degradation and failures in biodiversity conservation are sobering. The nation's capacities to deliver on conservation policy commitments are limited (NLWRA, 2002b), and the chaos of climate change will pose additional pressures and challenges (Alexandra, 2012).

LWA demonstrated that a relatively small R&D budget could drive innovation and adoption. It focused R&D on practical solutions, working with people to co-develop and deliver solutions that combined knowledge and practice (Campbell, 2006).

However, history demonstrates that knowledge is contingent and fragile. The capacity for impartial research focused on sustainability needs to be enabled through legislative processes, transparent institutions and dedicated funding. This capacity must be cultivated, nurtured, nourished and sustained because knowledge is not contained in artefacts – books, journal papers, databases, reports and communication products – but in people, who have the capacity to apply, refine, educate and teach. Institutional settings can enable or constrain these capabilities. Small, purposefully designed, boundary-spanning organisations can accelerate transformations towards sustainability.

LWA provided an important precedent for the kinds of R&D arrangements needed for tackling the 21st century's systemic problems. The Productivity Commission (2010) recommended that a new entity be established to continue public-good research, in the trajectory established by LWA. Acting on this need remains overdue and urgent. Any government could enact new legislation to create such an entity. Those of us who want to see more impartial research need to advocate such an approach.

The institutional arrangements needed for revitalising public-good R&D can draw on the insights provided by the experience of LWA. The 21st century's systemic problems require institutional innovations that can accelerate urgent sustainability transformations. Australia should pursue the creation of more entities like LWA in the States and Commonwealth. However, these do not need to be limited to rural R&D. We could have equivalent bodies focused on the transformation of our cities, our energy and transport systems, and on adapting to climate change. For these to work we need to adopt institutional designs that incorporate the best features of what has been learnt, in terms of directing R&D funding towards generating and adopting effective, policy-relevant innovations.

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