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Introduction

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Writing a History of Scientific Endeavour in Australia's Deserts

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This special issue of *Historical Records of Australian Science* explores some of the sciences that have contributed to our understanding of inland Australia, country variously known as desert, the arid zone, drylands and the outback. The sciences that have concentrated on deserts include ecology, geomorphology, hydrology, rangeland management, geography, surveying, meteorology and geology, plus many others. In recognition that desert science has surged ahead in the past few decades, we have invited contributors who describe various different desert initiatives. We use these case studies to open up the discussion about how Australians see their desert lands, how this has changed over time and how desert scientists from the rest of the world regard the distinctive desert country in Australia.

Australian Desert Science

Scientific endeavours reflect the cultural values of their era in deserts as much as elsewhere. As J.W. Gregory explored northern South Australia in the summer of 1901–2, at the end of the 'Federation drought', he saw what he called a *Dead Heart*.[1] In the 1930s H. H. Finlayson shifted the ground by describing the inland as the *Red Centre*, a beating heart rather than an arid wasteland, his work being informed by conversations with Aboriginal people about animal behaviour and survival under extreme conditions.[2] This 'red shift', from the dead heart of one era to valuable and interesting country in another, is one of the dramatic changes of the twentieth century. It has fed a new interest in tourism in outback Australia. Research has gradually revealed how Australia's deserts are ecologically and historically distinctive from each other and also from deserts elsewhere, which tend to have less vegetation and life, and a lower but more certain rainfall pattern. The ephemeral waters of the Australian deserts and their responses to fire have meant that it has taken a long time to come to terms with the way they function.

Agriculture and Deserts: A Long History

The Earth's arid zones mostly surround the equator, between 15–30 degrees of latitude in Africa, South America, the Americas, India and Australia. In the Middle East (31°–35°N), the cradle of agriculture, historical expansion of deserts has resulted from long intensive use of drylands. There are also cold deserts in higher latitudes.

The idea of 'making deserts bloom' existed long before white settlers arrived in Australia.[3] A region is merely *arid* where its climate provides insufficient rainfall for crops to grow. However, a desert is perceived to be 'deserted', that is, without people. It is not surprising, then, that the 'just add water' approach to developing Australian deserts has had enthusiasts since the nineteenth century.[4] In the 1950s the supposed need to develop the inland to accommodate an expanding nation gathered pace, in parallel with developments in the Middle East, North America and elsewhere.

Science for the arid zone has its deepest origins in international concerns about desertification, the rendering useless of formerly productive country. Paul Sears captured this concern in 1935 in *Deserts on the March*, which was the inspiration for the United States Soil Conservation Service.[5] In the 'dirty thirties' both mid-western USA and south-eastern Australia experienced massive dust-storms as topsoil blew away following the disturbances of broad-scale wheat-growing.[6] In Australia, Francis Ratcliffe's 1936 report to the Council for Scientific and Industrial Research (CSIR) about soil drift in arid South Australia was partially instrumental in the establishment of soil conservation authorities in New South Wales (1938) and Victoria (1940).[7] Ratcliffe's book, *Flying Fox and Drifting Sand*, also captured public interest in ideas about limits to agricultural enterprise, and as a set text on the curriculum in several States in the 1950s it introduced children to the idea of soil conservation.[8] It was even distributed as propaganda, in a bid to show how 'worthless' the Australian inland was for Asian interests at a time when a fear about northern invasion still lingered.[9]

Sears and Ratcliffe both republished after the war, in Sears' case with an additional chapter. Concerns about threats to agriculture became entangled with the urgency of post-war reconstruction and with anxiety about civilization itself as the full horror of the atrocities of war was revealed. 'The dust-clouds are carrying with them the material that should be taking the shapes and forms of life', wrote Elyne Mitchell, whose 1946 book *Soil and Civilization* sought to 'retrieve the land' for the sake of 'civilization as we know it', fearing that it would be 'gone under the tide of man-made deserts'.[10] Sears' post-war epilogue was a strong call for science in the national interest.

> [C]onservation of our resources is not a subject. It is a moral attitude in the employment of technical resources and in our way of living …There is a body of knowledge, a point of view, which peculiarly implies all that is meant by conservation, and much more …It has been called by H. G. Wells, who cannot be accused of a failure to anticipate events, the science of prophecy. Certainly it is the science of perspective …It is the approach to biological knowledge which is called ecology.[11]

The biologist Sir Julian Huxley was a great advocate of science in the public interest, and was behind the addition of science to the United Nations Educational, Scientific and Cultural Organization (UNESCO).[12] Huxley was appointed UNESCO's inaugural Director-General. In 1951, UNESCO launched an Advisory Council on Arid Zone Research.[13] The program first concerned itself with the politically strategic deserts of the Middle East and northern Africa, which had seen much of both world wars, as well as research to help India and another new post-war nation, Israel, whose national identity had been promoted under the banner of 'making the deserts bloom'.[14]

By 1952, representatives from Australia and Peru had been added to UNESCO's Advisory Council on Arid Zone Research. When Australia was asked to contribute data, it became quickly apparent that many questions could not be answered because of a lack of information. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) took on the task of co-ordinating an Australian response. CSIRO appointed a scientific officer based full-time in Alice Springs from 1953.[15] In 1956 began issuing an *Arid Zone Newsletter*, edited by C. S. Christian. The *AZN* pulled together efforts of States and Territories to create a national picture of Australia's research. A land system survey of the Alice Springs area was conducted in 1956–7, using the model developed by Christian in the tropical parts of the Northern Territory in the 1940s.[16] These surveys considered the potential for pastoralism, agriculture and mining. They also marked the arrival of an era of more intensive science. Before proceeding to examine the trends exhibited in the past five or six decades, however, it is worth reflecting further on the scientific efforts of earlier periods (Table 1).

Farming and Developing the Australian Arid Zone

From the colonial era, scientific work in arid Australia was funded through government initiatives to support agricultural and pastoral development. In early twentieth century Australia, occasional boosterism encouraged some speculative pastoralism in the 'outside country', and maps were sometimes drawn to minimise the region designated as desert. Thus, even the perceived size of the arid zone may change over time! It was 'unpatriotic' to speak of deserts, geographer Griffith Taylor commented regretfully, even where pastoralism was impossible.[17] Science in support of national development began to consider deserts as a priority, as in other parts of the world.

Experimental farms were a concrete expression of science for agricultural development, inspired by the example of Rothamsted Research Station, established to the north of London in 1843 and still running today.[18] The experimental tradition was exported throughout the British Empire and later, Commonwealth.[19] In South Australia the surveyor, George Goyder, had warned against farming beyond the line of reliable rainfall, but the good years of the 1870s had encouraged development far into the saltbush country to its north. Selectors in the Terowie district became anxious about the seasons in

Table 1. Early and long established ecological sites in Australian deserts
Table is drawn largely from data aggregated by LTERN, and is intended to be illustrative rather than exhaustive[i]

Year established	Name	State	Institutional affiliation	Comments
1926	Koonamore	SA	University of Adelaide/ CSIR in 1930s	Chenopod and acacia shrublands; gift of Hamilton-Wilcox pastoral group; repeat photography since 1930s.[ii]
1952	Fowlers Gap	NSW	Initially NSW Soil Conservation Service; University of NSW since 1965	Chenopod and acacia shrublands UNSW now runs an artist-in-residence program and a strong association with Badger Bates, senior elder for the area. Nici Cumpston (cover art) was resident 2011.
1953	Alice Springs	NT	CSIRO	Multiple vegetation formations studied; CSIRO now part of a joint Desert Knowledge Precinct.
1964	Simpson Desert	Qld	University of Sydney; also University of California and Bush Heritage Australia	Spinifex grasslands and stony plains; Sandringham, Ethabuka, Carlo and Cravens Peak Stations; more continuous from 1990; conservation research linked to Bush Heritage since 2004.[iii]
1968	Charleville Pastoral Laboratory	Qld	Qld Department of Primary Industries, then Agriculture, Forestry and Fisheries	Mulga lands; research for the pastoral industry, with important contributions to ecology.[iv]
1972 (grazing ceased 1984)	Flinders Ranges	SA	SA National Park Service	Mountain ranges; National Park initiative, esp. 'Bounceback' study (1994–2004).[v]
1977–1995	Mulga Research Centre (Kalgoorlie)	WA	Curtin University (West. Aust. Institute of Technology (WAIT)) Western Mining Corporation	Included *Mulga Research Centre Journal* (1984–1995) WAIT Lead researcher: John E.D. Fox Other industry sponsors (1977): Utah Foundation, Agnew Foundation, Forests Department of WA.
1984	Kellerberin Wheat belt studies	WA	CSIRO; Agriculture Protection Board of Western Australia; University of Western Australia	DA Saunders/RJ Hobbs CSIRO Kellerberin site (1680-km^2 study area) est. 1984 (+ earlier Wheat belt studies from 1950s).[vi]
1987	Uluṟu/ Kata Tjuṯa	NT	CSIRO/Parks Australia	Intensive surveys carried out from 1987–1990[vii], now conducted every 2 years.
1998	Arid Recovery Reserve	SA	BHP Billiton, SA Department for Environment, Water and Natural Resources, University of Adelaide	Chenopod shrublands; Roxby Downs; partnership involves industry, government, universities and community.[viii]

1877, and invited Goyder and the Commissioner of Lands, John Carr, to view their plight. Despite such poor conditions, six more northern farming counties were proclaimed. The government did agree to establish an experimental farm at Manna Hill in north-central South Australia (a site chosen by Goyder), to test the suitability of land beyond the agricultural frontier for cropping.[20]

At Manna Hill experiments examined different types of tilling techniques appropriate to the dry country, but the topsoil blew away in the dry years of the 1880s.[21] Experimentation was eventually abandoned, and today the only facility remaining at Manna Hill is a weather station of the Bureau of Meteorology.

In the twentieth century, the Departments of Agriculture in South Australia and Western Australia continued to be interested in experimental farms in arid regions. The University of Adelaide's Professor of Botany, T. G. B. Osborn, visited Koonamore Station to provide advice on management of soil erosion and rabbit infestations. Following his report, owners Hamilton-Wilcox Ltd offered him a portion of the station for an experimental reserve, known initially as the Koonamore Vegetation Reserve and later the T. G. B. Osborn Reserve. The Reserve was fenced in July 1925 and sites established to follow regeneration and to consider the ecology of economically valuable native pasture grasses.[22] The sampling-points at Koonamore have become the basis for a unique series of repeat photographs continuing to the present.[23]

Immediately after the war CSIRO was the greatest single employer of biological research scientists in Australia, with numbers more than doubling from 145 in 1945 to 309 in 1951.[24] As we have seen, the first Commonwealth officer was sent to Alice Springs in 1953 to create an arid zone experimental station and to begin agricultural extension for the pastoral region of central Australia. The Alice Springs initiative was complemented by work at the Fowlers Gap Rural Investigation Station in arid western New South Wales, established in 1952. Fowlers Gap was selected for research into soil conservation and pastoral development, via a partnership among the NSW Soil Conservation Authority, CSIRO and several universities. Research at Fowlers Gap broadened beyond pastoral production to include studies of kangaroos, led by Geoff Sharman, who from 1961 worked in CSIRO Wildlife Research, Canberra. In 1966, when Sharman moved to the University of New South Wales, the lease was given to the University and the name changed to Fowlers Gap Arid Zone Research Station.

CSIRO's work from 1952 onwards in what became known as rangeland science was conducted not only in Alice Springs, but also at Deniliquin. Further scientists were employed to work in pastoral laboratories set up by State and Territory Governments, especially in Queensland. Together, all these initiatives resulted in a flurry of work in animal production, pasture science and ecology. Several influential syntheses have made this growth in knowledge widely accessible.[25] By the 1970s, the economic and social motivations in support of research for farming and pastoralism had created a foundation of scientific knowledge and experience in arid Australia. Increasingly, conservation in association with pastoral production became a prominent stimulus, as indicated by the spread of scientific effort into work on kangaroos. Tom Newsome's paper on research into red kangaroos in the present volume outlines an element of this endeavour.

Science for Conservation

As times and attitudes changed from the 1940s to the 1980s, the area of Australia designated as arid increased once more.[26] 'Desert' gradually became a word no longer to be equated with wastelands, and voices in favour of farming and pastoralism were joined by other interests. Perceptions altered as many people came, in time, to value the beauty of waterless lands and to argue for conservation of their special plants and animals.[27] In the 1960s, when the Australian Academy of Science was leading efforts to create national parks, there were few areas of the desert included, but this has changed dramatically.[28] The change of heart about use of biological diversity that was reflected in Victoria's Little Desert dispute of 1969,[29] was also emerging in arid country in Western Australia, as Andrea Gaynor shows in this volume in her study of conservation in semi-arid Western Australia.

Conservation is inherently a multidisciplinary activity because it involves both ecology and social science. Ecological scientists working to assist managers in conservation initiatives in the deserts have frequently been drawn into contact with disciplines beyond their own fields. Within this context, a wealth of ecological work has been accomplished in the past four decades or so. It has been motivated by the possibility of looking after the Australian deserts better, as well as by simple fascination with the unusual attributes of their plants, animals and habitats. Essays in this volume by Chris Dickman and Libby Robin about Sandringham Station, a long-standing field site in the Simpson Desert, and Steve Morton and Angus Emmott on lizard ecology, explore examples of such work.

Science and Indigenous Knowledge

A further emerging trend in society with significant effects on science has been increasing recognition of Indigenous interests. Diverse land tenures have been created in the various Australian jurisdictions as a result, and now some 16% of Australia is held as Indigenous land. Since the passage of the *Native Title Act 1993*, native title has been found to exist in entirety in 14% of Australia and in part in 21%.[30] In addition, Indigenous Land Use Agreements are in place across substantial areas. Since 1998, 60 Indigenous Protected Areas, land owned and managed by Indigenous communities for conservation, have been declared, their 48 million hectares representing 36% of the National Reserve System. The deserts show these advancing trends in Indigenous interest even more than other regions of Australia.[31]

Native title recognition is an important driver of increasing formal Indigenous land management in Australia, often known as 'caring for country'. Contemporary Indigenous management is based in the holistic relationships between traditional Aboriginal societies and their customary estates. Consequently, it has broad aims including natural resource management, cultural resource management, commercial economic activity and improvement in livelihoods. Such approaches might appear sensible enough now, but early proponents of respect for Indigenous knowledge were not always welcomed wholeheartedly as prophets, as Saskia Beudel and Margo Daly mention here in their contribution on Olive Pink, noted anthropologist and botanist in central Australia from the 1930s. Today, the depth of traditional ecological knowledge, in particular, is increasingly reflected in ecological work and related natural resource management in the deserts.[32]

In response to the trends noted here, scientists have been exploring ways of interaction that respect Indigenous law, knowledge and responsibility, while also broadening the range of technical skills in response to a demand for holism. In the past two decades we believe it is possible to discern a trend away from specialisation in desert sciences towards working in multidisciplinary teams.[33] This development is not solely due to the influence of the more encompassing Indigenous approaches to knowledge. It stems also from recognition that all sectors of society in the Australian deserts experience a suite of interrelated problems (and opportunities too) as a result of isolation and low productivity. Understanding of this 'desert system' leads in turn to demands for application of science in multidisciplinary ways. Through such initiatives as the 'Desert Knowledge Movement' there has been an emphasis on bringing knowledge from a variety of traditions, including Indigenous, in search of improved livelihoods across all sections of society.[34]

Archaeological understandings of the Australian desert country have been growing in parallel with ecological knowledge, particularly since the first archaeological work by Richard Gould in the Western Desert (1966–70) and the important studies of Lake Mungo by Jim Bowler at the same time (see back cover images). Our cover contributions consider some of the relations between ecology, Aboriginal knowledge and archaeology. The front cover image, by artist Nici Cumpston, is work created as part of a 2011 creative arts fellowship at Fowlers Gap ecological research station. The University of New South Wales now regularly enables artists to create work in the landscapes there. Cumpston is an artist of Afghan, English, Irish and Barkindji Aboriginal heritage, who has traditional connections with country in this area. Nici's sister, Zena Cumpston, has studied archaeology, and is pictured here searching for evidence of an Aboriginal past as she looks toward the former settlement at the station. Archaeology also works closely in partnership with traditional owners, as the image of Yangi Yangi and Mike Smith shows (back cover). Archaeological work on grindstones depends on understanding of traditional use patterns, and on the ecological properties of the seeds ground. The evocative image of the dust blowing around the Walls of China geological formation is a reminder that the important discovery of Mungo Man in 1974 has its 40th anniversary this year. The final image is of current archaeological workers re-calibrating

Figure 1. Ecologist Imanuel Noy-Meir among desert oaks and spinifex south of Alice Springs, NT, October 1986. Photograph: Steve Morton.

the early work of Richard Gould using current archaeological techniques in 2014.

Basic Ecological Understanding

The science undertaken since the 1970s in response to the stimuli mentioned above has had a significant effect on the basic understanding of how Australian deserts function ecologically. Three examples of such influence are mentioned here as illustration, without attempting to be comprehensive (Fig. 1).

In 1973, Israeli ecologist Imanuel Noy-Meir theorised a whole-of-ecosystem approach to deserts. Noy-Meir's paper in the *Annual Review of Ecology and Systematics* defined 'pulse and reserve systems', a concept that Noy-Meir credited to Australian ecologist, Mark Westoby.[35] Noy-Meir's task had been to study Australian deserts for the International Biological Programme, beginning in 1964 to coordinate large-scale environmental science. The Australian desert was his major case-study. The pulse of desert life here depends on rain of a level of variability greater than in most other deserts, so that there can be many years between big rainfalls. When the rain finally comes, the pulse comes into play; during the long and unpredictable dry times, the reserve maintains certain plant functions. The uncertainty of the Australian system has informed theoretical approaches since Noy-Meir's and Westoby's insights.[36]

Pasture scientists came rapidly to understand the fickle nature not only of moisture supplies, but also of plant nutrition. Although some Australian desert biomes do have relatively fertile soils, data became available showing that most soils in arid Australia contain such low amounts of nitrogen and phosphorus that they are towards the lower end of global nutrient levels. The first players in outlining these features were Alan Wild, Ted Jackson, Jim Charley and Stafford Cowling.[37] These two aspects of arid Australia—variable rainfall and low productivity—have limited pastoral intensification and expansion, while creating unusual native plants, animals and biomes through evolutionary adaptation to such conditions. At the extreme of nutrient poverty are the spinifex deserts, which produce much indigestible biomass and thereby grow fuel for regular if intermittent fires. The connections among variable and sometimes heavy rainfall, infertility, plant production and fire led American ecologist, Gordon Orians, and his colleague from South Africa, Toni Milewski, to develop an ecological overview applicable to Australia as a whole, the 'nutrient-poverty/intense-fire theory'.[38] Deserts are increasingly seen by ecologists as Australia writ large; and, globally, it is now becoming evident which ecological features of Australian deserts are similar to those elsewhere and which are distinctive.

The concepts of pulse-and-reserve in moisture supply, and of scarcity of plant nutrition leading to unusual patterns of productivity, contributed in turn to a third conceptual development, state-and-transition models. Mark Westoby and Imanuel Noy-Meir worked with CSIRO ecologist Brian Walker in outlining approaches to rangeland management that did not assume the traditional notion of succession towards an equilibrium state. Rather, they suggested, alternative ecosystem states could be generated by grazing, fire or runs of weather. This insight was further developed in Australia by Margaret Friedel and Wal Whalley, and has since become widely applied in other parts of the world.[39]

Finally, we note that both practice and insight in Australian desert science have shifted and grown throughout the past forty years, especially in its greater disciplinary reach. For example, the first published attempt to distil the ecology of Australian deserts into a conceptual framework was written in 1969 by one author, the second (1990) by two, and the third (2011) by thirteen with an accompanying broader background among its authorship.[40] Desert knowledge is now informed by a wide range of basic and applied sciences and by a variety of ways of knowing.

In this Volume

This collection explores the transition from the first sciences of agricultural extension and rangelands research through to modern attempts to integrate knowledge from many perspectives for management of desert Australia, for conservation, production and as a place for people to live. An underlying theme of the contributions is the relationship between understanding of Australian deserts and those in other parts of the world.[41] Australian deserts bear strong similarities to arid regions elsewhere on Earth (lack of rainfall!) while nevertheless being distinctive in others (such as the degree of variability of the rainfall, and the patchy ecological functioning of hummock-grass ecosystems). Understanding where Australian processes and functions are similar in relation to knowledge from elsewhere and where they are distinctive has had important consequences. Where similarity holds, rapid importation of new international insights is profitable; if distinctiveness dominates, it has sometimes taken much effort to work out precise characteristics, reasons and consequences. Most of the papers in the volume describe particular problems and opportunities that emerged in different eras, and in doing so frequently explore the balance between universality and particularity in Australian deserts.

We do not regard the combined contributions to this issue as a comprehensive treatment of the topic, or even a thorough coverage of the sciences that have helped us understand the way Australia's arid country works. We have not included histories of scientific endeavours that have been situated in arid country for practical reasons, but which are not about the deserts themselves (for example, defence science, meteorology, astronomy or atmospheric physics). Our purpose here is to present a foretaste of a more systematic inquiry, and as an encouragement for others to enter the field. The emphasis in these papers is ecological, not least because this science has had a strong role in defining arid lands, in characterising the biota that are adapted to conditions of low rainfall, and in providing an important public interface with conservation. Mike Smith's paper offers a sketch of how geomorphology and earth science have also revealed a deeper history of deserts past. Further work may fruitfully expand and clarify the first steps represented by this collection towards a history of the science of Australian deserts.

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41. This comparison has been made explicitly in archaeology for example, in P. Hesse and M. A. Smith (eds.) *23° S: Archaeology and Environmental History of the Southern Deserts* (NMA Press, Canberra, 2005).

i Based on data from Long Term Ecological Research Network (LTERN) and *Biodiversity and Environmental Change: Monitoring, Challenges and Direction*, ed. David Lindenmayer, Emma Burns, Nicole Thurgate and Andrew Lowe (CSIRO Publishing, Melbourne, 2014) and archival sources. This analysis suggests that spinifex grasslands and chenopod and acacia shrublands have fewer long-term sites than most other Australian vegetation formations. See Table 3.3: 'Location of core studies' (Lindenmayer, Burns *et al*., p. 64). The exception is tussock grasslands (Mitchell grasslands), where pastoral interest has led to 198 sites. (N for Australia=2912)

ii Libby Robin, *How a Continent Created a Nation* (UNSW Press, Sydney, 2007), pp. 105–106.

iii Dickman and Robin, this volume; see also Box 10.8: 'Training and education outcomes', (Lindenmayer, Burns *et al*., p. 427).

iv *Souvenir of the Opening of the Charleville Pastoral Laboratory at Charleville on May 22, 1968* (Department of Primary Industries, Brisbane, 1968); other pastoral laboratories in Queensland and New South Wales have made similar scientific contributions.

v Lindenmayer, Burns *et al.*, pp. 404–428.

vi D. A. Saunders, Richard J. Hobbs, G. W. Arnold 'The Kellerberrin Project on fragmented landscapes: a review of current information', *Biological Conservation* 64 (1993), pp. 185–192; Earlier studies in the 1950s and 60s near this site by Barbara York Main (spiders) and SJJF Davies (Emus) See: Barbara York Main, Adaptive responses and speciation in the spider genus *Aganippe*, in G. W. Leeper, *The evolution of living organisms*, Melbourne University Press 1962; Barbara York Main, *Between Wodjil and Tor*, (Perth, Landfall Press, 1967), Davies, S. J. J. F. 'Aspects of a Study of Emus in Semi-arid Western Australia', *Proceedings of the Ecological Society of Australia*, 3, 1968, pp. 160–166. See also Gaynor (this volume).

vii J. R. W. Reid, J. A. Kerle, J. A. and S. R. Morton, S. R. *Uluru Fauna: the distribution and abundance of vertebrate fauna of Uluru (Ayers Rock-Mount Olga) National Park, N. T.* (Australian National Parks and Wildlife Service, Canberra, 1993); also on later surveys L. Bennison, C. R. Dickman and R. Godfree, 'Habitat use and ecological observations of the Ooldea dunnart (*Sminthopsis ooldea*) at Ulu*r*u-Kata Tju*t*a National Park, Northern Territory', *Australian Mammalogy* 35 (2013), pp. 175–179.

viii Lindenmayer, Burns *et al.*, Box 11.3, p. 444.