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Guest Editorial: Linking the dynamics of people, land and water in the drylands of the Murray–Darling Basin

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Water is essential for life, and rainfall patterns in time and space dramatically influence where people live and the natural resources on which they can draw to create livelihoods. The Murray–Darling Basin is Australia's largest, has exceptional rainfall variability by world standards (Walker *et al*. 1995) and its importance is widely recognised by Australians. For its Aboriginal people, it holds tradition and meaning that has a 40 000 year heritage. Culturally, it was the place where white settlers first forged Australian notions of 'outback' and became the origin of some iconic Australian land and waterscapes, from snowy mountains and upland streams to ephemeral creeks and lowland wetlands fringed with large river redgums, to agricultural heartlands and grazed rangelands. Economically, through exports of its wheat, wool and meat, it underpinned Australia's early economic development, although today its agricultural products represent only 2% of GDP and 4% of export earnings. Nevertheless, over a third of the food for Australia's own consumption is still grown in the Basin. Environmentally it is the home to a diverse biodiversity and wetlands that are recognised internationally. Finally, it is of interest nationally as a place whose governance spans multiple jurisdictions and is a constant challenge in Australia's own constitutional framework (Connell 2007).

Opportunities to develop irrigated agriculture from the waters of the Murray River in the south of the Basin were recognised over 100 years ago but the variability of flows and growth in extractions made irrigation unreliable until a series of dam, weirs, and irrigation distribution channels were built during the 20th Century. The capacity to regulate water in the south of the Basin, lack of understanding and valuing the use of water for environmental benefits, and inadequate attention to the risk of drought, led to a very high proportion of water in the south being allocated to irrigation by the 1990s. A more detailed overview of the Basin and its water development history from a governance perspective is in Ryan (2009).

An extended drought over the last ten years, affecting both irrigation communities and water-dependent environmental assets has forced governments to redesign the governance of the Basin. The new national legislation, the *Water Act 2007*, will now treat the whole of the Basin consistently from a governance perspective. For example, the first Basin Plan, due to be finalised in 2012 will apply a uniform approach to setting sustainable diversion limits for each catchment across the Basin and to setting objectives for the allocation and management of environmental water. However, the knowledge base supporting the development of the Plan is stronger for the more southern and wetter catchments because they have a longer history of cross-border water management, are geographically closer to government and research centres, and are more important economically.

Precisely for this reason, and as part of a project funded by the Murray–Darling Basin Authority, the Australian Rangelands Society began exploring this knowledge gap in a workshop titled 'Wetlands in Drylands' in 2009. The themes in this issue, and some of papers themselves, flow directly from that workshop. We used the term 'drylands' to represent more northern, western and drier regions of the Basin. This term is one being used in the international literature (e.g. Reynolds *et al*. 2007), especially in the context of understanding drylands as linked socio-ecological systems in which enterprises might make livings from different mixes of resource use over time, in which all landscape processes are highly interwoven, and that communities want 'healthy' landscapes regardless of institutional or scientific distinctions that are made between their component parts. Reynolds *et al.* identify a 'drylands syndrome' in which the characteristics of unpredictability, resource scarcity, sparse populations and geographic and political remoteness combine to give these lands unique challenges (Stafford Smith *et al*. 2009).

More specifically, the drylands in the Murray–Darling Basin can be defined as regions where the average annual rainfall is less than 350 mm. Most of these are semi-arid (250–350 mm), rather than arid (<250 mm). However, the extreme variability in rainfall in this region means averages have little meaning; boundaries of a rainfall-defined region here 'move' depending on the window selected for their calculation. Papers in this issue are more concerned with conceptual approaches to lands of this nature than with spatial accuracy, and the contributing authors have taken a variety of approaches to identifying drylands.

The second major theme in this Special Issue also echoes this international work on drylands: that these are complex social-ecological systems in which understanding the long-term dynamics is important for managing their sustainability. We have a limited capacity to test management decisions or develop strategies to maintain the resilience of our social-ecological systems because we have not developed knowledge in a fashion that lends itself to the integration necessary. On the whole, Western science has progressed by concentrating knowledge development in single disciplines, often working at small spatial scales and over short time periods because these are practically more amenable for study by individuals or small teams. The approach has provided many technological advances useful for

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society but it has not been sufficient on its own for understanding the long-term trajectories of complex systems. Efforts to bring disciplinary knowledge together to address broader questions are challenging because disciplines have independently developed their own informal rules about what is valid (e.g. Hirsch Hadorn *et al*. 2006) and their own formal languages (e.g. Drew and Henne 2006) and these are not readily understood by scientists from other disciplines. This issue therefore sought papers that would make contributions to developing more integrated understandings of how the drylands of the Basin function.

The disciplinary structure of Western science also carries with it strong informal rules about what types of knowledge are valid. Indigenous knowledge that starts from a contrasting premise that people and ecosystems are intrinsically one system has been largely discounted in Western science. The issue opens with a paper by Muir *et al*. (2010) that challenges Western perspectives about Indigenous knowledge. The authors identify how Indigenous knowledge has been acceptable in Western ecological science when it results in lists of species, for example, but this is incomplete knowledge from an Indigenous perspective because it presents a static view that fails to make linkages between species, ecosystem function and people. The paper draws on a contemporary Aboriginal view of ecological understanding about the Darling River in the Bourke region to illustrate that, in contrast, their ecological knowledge is dynamic, adaptive and contextual.

Conceptually, the second paper (Marshall and Stafford Smith 2010) also approaches the knowledge frontier of Muir *et al.*, albeit from a Western science perspective. Drawing on the concept of adaptive governance (e.g. Folke *et al*. 2005) and recent developments in describing and analysing drylands as linked socio-ecological systems that display the common characteristics of the 'drylands syndrome' (Reynolds *et al*. 2007), their paper unconsciously echoes a similar view of the indivisibility of people and their environment. They attest that the drylands of the Murray–Darling Basin do display characteristics of a drylands syndrome, then link this finding with developments in understanding about the design of polycentric governance mechanisms (e.g. Marshall 2008) to arrive at practical steps that could be taken to increase the robustness of the MDB drylands.

Still in the context of the drylands being complex adaptive systems where economics interacts with the environment, the next paper (Hacker *et al*. 2010) focuses on pastoral properties, vegetation management and the trial of one governance mechanism for increasing the resilience of grazed drylands. The public has an interest in maintaining a certain amount of ground cover during drought because it protects biodiversity, reduces the risk of dust storms, and maintains the land further from critical thresholds (see e.g. Walker *et al*. 2009) between vegetated and denuded states. Mechanisms by which graziers can be paid for this ecosystem service are only just starting to be developed in Australia (e.g. Zimmer *et al*. 2010). The trial demonstrated that a market-based incentive scheme that rewarded graziers for achieving specified levels of ground cover would achieve the purpose.

Crimp *et al*. (2010) also view the grazed lands of the MDB as a linked socio-ecological system, and comprehensively review a full range of the nature and extent of likely impacts of projected climate change on the system. They make the point that although individual impacts can be reasonably predicted from existing knowledge, e.g. rising temperatures will lead to more heat stress of both plants and animals, particularly in the warmer parts of the Basin, their interactions with each other at the local to global scale (e.g. food production elsewhere and its impact on world market prices) are not predictable. Therefore, the capacity of grazing enterprises to adapt to change as the impacts emerge is important. They then review two approaches that have been taken to estimating the adaptive capacity of rural households or enterprises in Australia and apply them to the MDB. Major constraints to adaptive capacity were lack of capital and lack of influence over socio-economic factors at larger scales; a finding consistent with the 'drylands syndrome' discussed earlier.

The next two papers focus on complementary aspects of the floodplains that are part of the wetland systems embedded in the drylands of the Basin. Their remoteness, vast extent, low relief and undervaluation by society have led them to be neglected scientifically, yet plans for assuring their protection under the new Basin Plan need to be based on sound technical analysis. In particular there is concern about the impacts of water abstractions exacerbated by recent prolonged drought. There are ~6.1 m ha of floodplain in the Basin; the area inundated has dropped from 4.6 m ha in the decade to 1999 to 1.5 m ha in the decade to 2009 (Doody *et al*. 2009).

The first of these two papers, by Colloff and Baldwin (2010), questions the conventional conceptual framework for understanding the long-term dynamics of this floodplain ecosystem that has adapted to naturally variable flooding and drying patterns. In the context of the declining floods that have occurred with river regulation and abstractions, and recently exacerbated by a prolonged drought, how might such changes impact on the long-term resilience of these ecosystems? Rather than considering the wet and the dry as two stable and alternating states they propose a variation in which the floodplain exists in a single state with a wet and dry phase and resilience is conferred by maintaining the capacity to transition between the phases and function in quite different ways in each phase. The distinction has an important management implication: it is loss of capacity to transition from one phase to the other that would represent the threshold jeopardising resilience of the floodplain. The authors go on to propose the major ecological structures and processes that maintain this capacity for transition.

The second of these, by McGinness *et al*. (2010), also focuses on the implications of floodplains that are naturally sometimes wet and sometimes dry, and now receiving fewer floods as the result of river regulation and abstractions. They raise questions about possible linkages between changes in these floodplains and the decline in woodland (terrestrial) bird populations in south-eastern Australia. Causes of such declines have previously been attributed principally to changes in terrestrial landscapes. The authors review the literature on floodplain productivity and the use of floodplains by woodland birds, and make some specific and testable predictions that would establish whether the decline in flooding of Basin floodplains has contributed to woodland bird decline. If their hypothesis is correct, it has important implications for integrating the management of terrestrial biodiversity and environmental flows in landscapes that contain both terrestrial and wetland ecosystems.

The final two papers are a pair about travelling stock routes in south-eastern Australia, a region with strong overlap with the Murray–Darling Basin. The first paper (Spooner *et al*. 2010) returns to the theme of Indigenous knowledge and illustrates another example of where the role of Indigenous knowledge has been under-valued and overlooked. The authors review the evidence for traditional Indigenous pathways across south-eastern Australia having provided the basis for the major routes selected by early white explorers and settlers. Many of these later became designated travelling stock routes used for stock movement before the development of road transport, as well as for supplementary grazing during drought. Travelling stock routes are now valued for different reasons: they are culturally important for their historical role in white development of the region, and they contribute significantly to biodiversity conservation. This paper demonstrates that close examination of old maps and written records does provide evidence for an Indigenous role in the routes taken in part of the region, and that travelling stock routes therefore also have value for their Indigenous heritage.

The final paper, and the second in the pair about travelling stock routes, explores their entry into legislation and in particular the role of sheep diseases and the need to control how stock moved around the country in shaping the routes and their early governance (Cameron and Spooner 2010). They highlight the complexity of the history of these routes: the history was influenced not only by biophysical necessities like the need for quarantine or grazing while stock were moving, but by the lobbying of squatters with socio-economic interests to protect. The paper is another good example of a multidisciplinary approach to understanding the long-term dynamics of linked social-ecological systems in the drylands of the Murray–Darling Basin, the major themes of this issue.

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