

Editorial: Understanding change in the ecological character of wetlands

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The world's wetlands of international importance are overseen by host nations under processes established through the inter-governmental Convention on Wetlands, commonly known as the Ramsar Convention. Signatory nations to the Convention are required to list at least one wetland as internationally important (known as Ramsar sites) and describe and maintain their ecological character (Gardner and Davidson 2011). Wetlands that satisfy one of a suite of ecological criteria, many of which relate to wetland biodiversity, may be listed as internationally important; the list of internationally important wetlands currently contains 2231 sites covering 214 936 005 ha (17 March 2016). The signatories are also required to report on any likely and actual variations in the ecological character of the wetland that may bring it to a state where it may be considered degraded (Finlayson 1996). They are then required to mitigate this degradation or follow prescriptions to delist and offset, with the former being potentially biophysically complex (Alexander *et al.* 2011) and the latter potentially bedevilled by complex processes (Pittock *et al.* 2010).

As outlined in the Millennium Ecosystem Assessment (MEA 2005), many wetlands, including those listed as Ramsar sites, are increasingly under pressure from (1) anthropogenic climate change causing changes in their hydrology, and (2) the direct impacts of people, notably by modification to their water regimes (increasing water use and/or decreasing water quality), changes in land use, and the introduction or facilitation of invasive species. The Ramsar site description, which is provided at the time of listing of a wetland as internationally important, provides a baseline against which change can be measured. However, as outlined in this Special Issue of *Marine & Freshwater Research* (Gell and Finlayson 2016), evidence from the past can reveal the occurrence of a wider range of ecological conditions, and provide information about the trajectory (or trajectories) of change being experienced by a particular wetland.

As described by Finlayson *et al.* (2016), this process is very strongly influenced by the ecological condition of the wetland at the time it was nominated as internationally important by the signatory nation. It is further circumscribed by the available knowledge about the trajectory (or trajectories) of change as collected using traditional inventory or ecological approaches,

often containing significant gaps (Finlayson *et al.* 1999; MacKay *et al.* 2009). Other techniques to understand the condition or trajectory of change in a wetland include palaeoecology. While these approaches, which are largely sediment-based, may not reconstruct the nature of waterbird or fish populations over time, they are capable of reporting on long-term changes in water quality, sediment load, plant and algal communities and invertebrates, particularly ostracods, cladocerans and chironomids. These records can extend the knowledge of change back centuries or even millennia, but with decreasing resolution over longer periods. With the scope or potential of these approaches being increasingly articulated (Gell 2012), there is an opportunity, or even a need, for contemporary ecologists and managers to explore the ecological heritage of their wetlands.

Finlayson *et al.* (2016) also report that there are now many palaeoecological records from sediment sequences collected from Ramsar wetlands across the world, as shown by the papers included in this special issue (Gell and Finlayson 2016). These records show the extent of change through time, with some revealing variation in response to low-frequency climate cycles and others revealing the pervasive and more recent impacts from industrial development. These studies can be used to reveal how well the ecological condition of a wetland at the time of listing as internationally important represents the historical condition and variability of the wetland or if it is a consequence of more recent human modification. As explained by Gell *et al.* (2016), this can create considerable tension in discussions about the 'ecological character' of Ramsar-listed wetlands, as well as the 'limits of acceptable change', and what constitutes a 'degraded state', and can obfuscate the obligations of a signatory nation to remediate or offset adverse ecological change in a wetland of international significance.

These issues provided the background for the workshop 'Ramsar Wetlands: Understanding Change in Ecological Character' at Queenscliff, Victoria, Australia, 5–8 November 2013. Sponsored by the International Geosphere-Biosphere Programme (now Future Earth) project PAGES (Past Global Changes), this meeting brought together what was possibly an eclectic group of palaeoecologists and wetland managers and ecologists. It included representatives from PAGES and from the Ramsar Convention's

Scientific and Technical Review Panel. It attracted over 70 delegates, with the international nature of Ramsar being reflected in attendance, with delegates from Australia, China, India, Colombia, Tanzania, Nigeria, Sri Lanka, Thailand, Singapore, Switzerland, Russia, United Kingdom, United States of America and New Zealand.

As reported by Gell *et al.* (2014), the presentations at the meeting further highlighted the substantial pressures on modern wetlands that are responsible for (1) the loss of some wetlands, and (2) compromising the ecological character of others. While many of these recent changes have been caused by anthropogenic pressures, palaeoecological records have been used to demonstrate that change may be historic in origin, that change can be non-linear, and that the historic character of a wetland can be surprising. Importantly, in some parts of the world, where there has been limited investment in wetland inventory or monitoring, the palaeorecord may constitute the only way of understanding the extent and duration of past changes.

The meeting resolved to produce this special issue of *Marine & Freshwater Research* to provide critical background and information for wetland scientists and managers about the nature of change in wetlands, including that which can occur over different timescales, and so improve their capacity to understand the present condition and trajectory (trajectories) of change (Finlayson *et al.* 2016). It was further anticipated that the signatories to the Ramsar Convention could make use of this information when setting management targets for wetlands listed as internationally important and more generally when managing or restoring wetlands. Rarely do wetland ecologists and palaeoecologists come together on an equal footing with such common purpose. As such, this meeting represented a high-impact turning point in the understanding of wetland dynamics in response to highly variable hydro-climates and increasing human impacts, especially given an ongoing interest in understanding the causes and trajectory of ecological change in the face of global environmental change, including changes in the global climate.

The meeting had purposeful aims with respect to managing wetlands in an era of global environmental change (Gell *et al.* 2014). It was expected that a clearer understanding of the nature and drivers of environmental change would help wetland managers identify more efficient pathways to deal with changing conditions that affect their internationally important wetlands. As recognised at the workshop, understanding these conditions requires the signatory nations to the Ramsar Convention to take into account the past, current and future aspects of global change, while also addressing local factors. This is relevant for the Ramsar Convention that has hitherto not produced guidance to assist managers to respond to the requirements under the Convention to report on changes in ecological character due to climate change (Finlayson 2013).

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