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Original research article

The influence of differing protected area status and environmental factors on the macroinvertebrate fauna of temperate austral wetlands

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ABSTRACT

One means of conserving wetlands is to designate the area around them as 'protected'. Although many different types of protected areas exist, ranging from international (Ramsar-listed) to local importance, there is little information on how the type of protection influences biodiversity conservation. Studies of the effectiveness of protected area systems are a priority, if we are to understand their importance and design systems effectively. Many Tasmanian wetlands are regarded as having high to very high conservation values with more than 60% located within protected areas. This study tested macroinvertebrate richness and assemblage responses to a range of environmental attributes and differing types of protected area status at 66 protected Tasmanian (Australian) wetlands. Two hundred and eighteen taxa were identified with an average of 33 species (or morphospecies) and 18 families recorded per wetland. The wetland assemblages were idiosyncratic, four families contributed 21% of the total recorded and only two families contributed greater than 10%. Wetlands were not significantly nested on the basis of the composition of their macroinvertebrate assemblages. No single environmental attribute had a strong relationship with macroinvertebrate richness or assemblage composition and neither species richness nor assemblage composition varied significantly between different types of protected areas. Although the majority of protected area types were designed to support terrestrial conservation objectives rather than wetland values, our results suggest that the latter were also afforded protection. The state of the proximal zone (the terrestrial zone within 50m of the wetland edge) and the type of aquatic habitat present (macrophyte or sediment-dominated substrates) were the most important determinants of macroinvertebrate richness and assemblage composition across all types of protected wetlands. These results suggest that for temperate austral wetlands located within protected areas, the macroinvertebrate fauna will be best conserved by minimal disturbance of proximal lands.

1. Introduction

Wetlands are globally important ecosystems, occupying 6% of the Earth's surface and supporting approximately 20% of all living organisms (Zhao and Song, 2004). Yet in the last century almost half of the world's wetlands have disappeared as

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a result of urban and agricultural development (MEA 2005). Many types of wetlands exist. They may be natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or saline (Ramsar Convention 1987). Wetlands provide vital habitats for a range of biota as well as ecosystem services for human communities. Wetland basins form on an array of landforms, with different water regimes, and their hydrology influences physical and chemical processes within the water column. Wetlands often have a well-defined zonation with terrestrial and semi-aquatic fringing vegetation at the landward edge of the wetland, emergent and submerged macrophytes in shallow habitats and floating plants and open water regions in deeper areas (Boulton et al., 2014). Wetland ecosystems span a gradient between terrestrial uplands and truly aquatic habitats but the ecological patterns and processes in wetlands differ from those of both terrestrial environments and deeper waters (Mitsch and Gosselink 2007).

Direct drivers of wetland loss (estimated to be 50% globally since 1900) and degradation, worldwide, include changes in land use and land cover, water extraction and changes in water regimes, infrastructure development, pollution, invasive species and climate change (MEA 2005). The fundamental drivers of these impacts are global population growth and increasing economic development. For wetlands in the southern Australian island state, Tasmania, where this study was located, Kirkpatrick and Tyler (1988) found that many wetlands, particularly in the central highlands region, had been 'drowned' by artificial impoundments created for the generation of hydroelectricity in the first half of the 19th century. Wetlands elsewhere in the state had been drained for agricultural purposes and estuarine wetlands had been lost through urban landfill. Many wetlands were grazed by domestic stock and affected by a variety of recreational pursuits including fishing, duck shooting, boating and off road vehicle use. Urbanisation, mining, agriculture and forestry have increased surface run-off from exposed soils, elevating the sediment and nutrient loads entering Tasmanian waterways (Edgar et al., 2000). Water quality and aquatic habitats of both standing and flowing waters have been negatively affected, especially in lower watershed areas (Edgar et al., 2000).

The Australian federal and state governments support biodiversity conservation through various types of land protection, which, either directly or indirectly, includes the protection of wetlands (Table 1). Tasmania has approximately 2.5 million hectares of reserved (protected) land. The Tasmanian Wilderness World Heritage Area (WHA) covers about 20% of the island state and is one of the largest conservation reserves in Australia (PWS 2014). The WHA includes many wetlands. Important wetlands in Australia are listed in the Directory of Important Wetlands Australia (DIWA 2014) which is a useful database for natural resource planners and wetland managers. Australia has 65 wetlands listed as Ramsar sites, 10 of which are in Tasmania and are managed for conservation. Other forms of designated protected areas in Tasmania that contain wetlands include national parks, forestry reserves and several forms of public and private land reserves (Table 1). Sixty percent of Tasmanian wetlands are identified as having high to very high conservation value and are located in protected area reserves, with 26% in other public land and 14% in private land (DPIPWE, 2010).

Species level information is required to maximise conservation planning, however, at a global level, information on species is often lacking (Westgate et al., 2014). Environmental attributes influencing patterns of species richness and distribution differ among taxa (Kirkman et al., 2012). Congruence among taxa is often related to environmental gradients with most major terrestrial and freshwater groups richer in tropical regions than in temperate, at low elevations than at high and in forests than in deserts (Gaston, 2000). In addition to environmental factors, a range of taxa should be used for assessing conservation practises as a subset of taxa may not accurately represent biodiversity (Westgate et al., 2014). Recent studies have sought to determine congruence among wetland macroinvertebrate taxa (Ruhí and Batzer, 2014) and to identify core wetland taxa globally (Batzer and Ruhl, 2013).

Macroinvertebrates are a diverse group of taxa and they occur in a wide range of wetland types, however, knowledge of the factors that influence the structure and function of wetland macroinvertebrate assemblages is inconsistent (Batzer, 2013). The location, depth, volume and water quality of the wetland, drive the physical processes that in turn define the habitats that support aquatic biota (Boulton et al., 2014). Various factors, including hydroperiod, wetland vegetation, water quality, disturbance and biotic interactions such as predation have all been found to influence the composition of wetland macroinvertebrate assemblages (Pinder et al. 2004, Stenert et al. 2008, Davis et al. 2010, Maltchik et al. 2010, Batzer, 2013, Sim et al., 2013, Chessman and Hardwick, 2014, Meyer et al. 2015). Macroinvertebrates are considered to be useful ecological indicators, because they are present in almost all freshwater systems, are easy to collect and identify and assemblages are known to change in response to human-induced stressors (Bailey et al., 2004). The concept of using macroinvertebrates indicators for ecological condition assessment, especially rivers has evolved rapidly since the 1970s, with national river bioassessment and monitoring programs used in Australia, Canada, North America and the UK and smaller programs applied in Spain, Portugal and Scandinavia (Bailey et al., 2014, Reynoldson et al., 2014).

The aim of this study was to determine the influence of differing types of protected area status and environmental attributes on the richness and composition of wetland macroinvertebrate assemblages. This was done by analysing data collected from 66 Tasmanian wetlands in best available condition. The results of our study will help guide the development of policy, planning and management to support wetland conservation both locally and further afield. Information from this study will provide a baseline dataset for future wetland monitoring undertaken to determine the effectiveness of conservation actions and the impacts of climate change.

We would expect wetlands located within the Tasmanian World Heritage Area (WHA) to be in near pristine condition and support the richest and most diverse macroinvertebrate assemblages because they are subject to the lowest levels of human influence and afforded the greatest management effort. Wetlands within National Parks and Public Reserves are also expected to be in good condition but may support less rich and diverse assemblages than those located within