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Freshwater reserves in Australia: directions and challenges for the development of a comprehensive, adequate and representative system of protected areas

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Abstract

The establishment of a system of protected areas that samples all ecosystems, including freshwater environments, in a comprehensive, adequate and representative (CAR) manner is regarded as a cornerstone for the conservation of biodiversity. There have been few quantitative assessments of the comprehensiveness, adequacy and representativeness of freshwater reserves in Australia. This paper reviews and quantifies the effect of classification of freshwater ecosystems for conservation planning, the importance of reservation status and protection measures for developing a CAR reserve system, and aspects of reserve design for freshwater ecosystems. We propose a strategic and iterative process that incorporates these measures to assist in the efficient and effective development of freshwater reserve systems worldwide. However, the provision of suitable water regimes for freshwater reserves presents further ecological and political challenges, and even adequate reservation of freshwater ecosystems may not conserve constituent biodiversity without effective management.

Introduction

Freshwater ecosystems are recognised to be among the most threatened ecosystems in the world (Dugan, 1990; Abell, 2002; Saunders et al., 2002). The term 'freshwater ecosystems' for the purposes of this paper encompasses all inland aquatic ecosystems including rivers, wetlands, and groundwater systems as well as saline waters. An increasing human demand for supplies of fresh water, arable land and other natural resources is predicted (Baron et al., 2002). Consequently, the conservation of rivers, wetlands, estuaries, and other surface and groundwater ecosystems is a major challenge (Dugan, 1990). Anthropogenic pressures including river regulation, the development of agriculture, declining water quality, isolation from catchment processes, and degradation of riparian areas are continuing threats to freshwater ecosystems in Australia (Walker, 1985; Boulton & Brock, 1999; Kingsford, 2000; Boulton et al., 2003). As for other ecosystem types, there is a range of mechanisms available for the protection and conservation of freshwater environments, including reservation, incentives for private land conservation, restoration, and other management actions. This paper focuses on one of these approaches: the development of freshwater reserve systems to conserve biodiversity in these environments.

Internationally, the establishment of a comprehensive, adequate, and representative (CAR) reserve system is a cornerstone for the conservation of many terrestrial and aquatic ecosystems. These three objectives are defined by NRMMC (2005) where 'comprehensive' refers to inclusion of

the full range of ecosystems recognised at an appropriate scale within and across bioregions, 'adequate' refers to the maintenance of the ecological viability and integrity of populations, species, and communities, and 'representativeness' is the principle that those areas that are selected for inclusion in protected areas reasonably reflect the biotic diversity of the ecosystems from which they derive. However, the Vth IUCN World Parks Congress in Durban, South Africa in September 2003 stated 'that the global Protected Area network is far from finished, with significant gaps in the coverage of Protected Area systems for threatened species, globally important sites, habitats and realms' and reiterated the need to protect 'viable representations of every terrestrial, freshwater and marine ecosystem...within protected areas' (IUCN, 2003: 11, 13).

In Australia, the conservation of freshwater ecosystems through protected areas has received comparatively less attention than forested and marine environments. For example, less than 10% of papers presented at the 2002 World Congress on Aquatic Protected Areas held in Australia dealt with non-marine habitats and ecosystems (ASFB, 2003). Recent reviews suggest that Australia is currently lacking an adequate freshwater reserve system (e.g., Georges & Cottingham, 2002; Nevill & Phillips, 2002, 2004). Furthermore, the establishment of a reserve system for permanent and ephemeral wetlands, riverine, and groundwater ecosystems is considered to be one of the highest priorities for biodiversity conservation research (ANZECC & BDAC, 2001).

Reserve system development in Australia

Australia became a federation in 1901 following the declaration of the Australian constitution, which listed the responsibilities of the Commonwealth Government. As the constitution was silent on environmental planning and management, the responsibility for managing Crown (public) land in Australia remained largely the domain of the State and Territory governments (herein referred to as jurisdictions) (Wescott, 1991). This has resulted in the development of nine separate protected area systems, one in each of the eight jurisdictions, and a Commonwealth system. Each has its own management agency and relevant legislation. As part of obligations under the *Convention on Biological Diversity* (1992) and the *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia, 1996), all jurisdictions have been working toward the development of a protected area system that samples all terrestrial, freshwater, and marine ecosystems in a comprehensive, adequate, and representative manner. Three complementary processes have been developed to achieve this goal – the Regional Forest Agreement (RFA) process for forested regions, the National Reserve System (NRS) program for other terrestrial ecosystems, and the National Representative System of Marine Protected Areas (NRSMPA) for coastal and marine areas. The NRS in particular focuses on ensuring rapid and significant improvements in the terrestrial and freshwater reserve system by seeking to add poorly reserved ecosystems (Commonwealth of Australia, 1999).

Reservation of freshwater ecosystems in Australia

There is a range of reserve types employed to protect freshwater ecosystems across Australia, ranging from national parks, nature reserves that focus primarily on biodiversity conservation, and reserves allowing the sustainable use of natural resources (i.e., ranging from IUCN Protected Area Category Ia to Category VI (IUCN, 1994)). There are also other areas of public land that contain wetlands, rivers, and other freshwater habitats that are not considered protected areas according to IUCN criteria. That a large proportion of freshwater ecosystems occurs on private land in some Australian jurisdictions (e.g., 80% of the total number of wetlands in Victoria, Corrick, 1995), including many of the least disturbed (Stein et al., 2001), highlights the importance of private land conservation mechanisms.

Internationally, Australia is a signatory to the Ramsar Convention and currently has 64 listed Wetlands of International Importance, covering an area of 7 371 527 ha (Environment Australia, 2003). While Ramsar wetlands are not necessarily a protected area category in their own right, recent Commonwealth government legislation (*Environment Protection and Biodiversity*

Conservation Act 1999) has strengthened the protection of such sites. The *Directory of Important Wetlands in Australia* (Environment Australia, 2001), which identifies significant wetlands at a national level, offers no formal protection or management obligations under Commonwealth legislation. However, it does offer jurisdictions a tool to identify new Ramsar sites and sites of importance for particular species, including threatened or migratory species, as well as assisting with the implementation of conservation initiatives to protect migratory waterbirds through identification of important habitat and the addition of new Australian sites to the East Asia–Australasian Shorebird Site Network.

There have been few reviews of the comprehensiveness, adequacy, and representativeness of freshwater reserves in Australia. We believe there are significant gaps in understanding the requirements for establishing both individual freshwater reserves and bioregional reserve networks, and there remains a paucity of discussion regarding these topics. Ultimately, the lack of quantitative data on the reservation of freshwater ecosystems impedes the effective and efficient establishment of a CAR reserve system. This paper examines a number of issues associated with the reservation of freshwater ecosystems, and discusses the implications for freshwater conservation planning in Australia. Specifically we investigate (1) the effects of classification of freshwater ecosystems for conservation planning, (2) the importance of reservation status and protection measures for developing a CAR reserve system, and (3) aspects of reserve design for freshwater ecosystems.

Effects of classification of freshwater systems for conservation planning

A consistent and comprehensive system for the classification, inventory, and reporting of freshwater ecosystems is important to assess the requirements for a freshwater reserve system. While there have been many inventories for wetlands, rivers, and other aquatic systems in the various Australian jurisdictions (e.g., Semeniuk, 1987; Land Conservation Council, 1989; Corrick, 1995; Kingsford et al., 2004), no consistent method for the classification and inventory of these ecosystems exists across Australia (Spiers & Finlayson, 1999). This ultimately limits the ability to prioritise conservation programs at a national scale.

Few studies have investigated the outcomes for conservation planning that result from the use of one ecosystem classification system over another. We examined the differences in the extent of mapping between two widely used wetland classification systems in the State of Victoria, south-eastern Australia – one based on hydrology (Victorian Wetland Database, VWD) and one based on indigenous vegetation types and other natural features (Ecological Vegetation Classes, EVC) (Robertson & Fitzsimons, 2004). A description of the Victorian Wetland Database mapping is given by Corrick & Norman (1980) and NRE (1996b) whereas Woodgate et al. (1996) and Parkes et al. (2003) describe Ecological Vegetation Class mapping. While both the classifications (and associated inventories) are considered progressive compared to other jurisdictions, inconsistencies between the two systems were found to have significant implications for assessments of the depletion of wetlands across different bioregions. For example, in the Wimmera bioregion almost all wetlands classified using vegetation (EVC) were significantly depleted (less than 20% remaining) whereas no wetland types were calculated as being depleted by more than 50% using the hydrological (VWD) criteria (Fig. 1, Robertson & Fitzsimons, 2004). As depletion levels form a large part of determining the conservation status of ecosystems (e.g., vulnerable or endangered), the choice of classification has a significant influence on determining priorities for conservation actions such as increased reservation. However, it should be noted that many parts of the world lack any classification system or inventory that differentiates habitats at an appropriate ecological scale from which to make these assessments (Finlayson et al., 1999; Brinson & Malvárez, 2002).

Importance of reservation status for developing a CAR reserve system

Increasingly, reservation targets are based on the objective to sample a proportion of each ecosystem type that occurred in the landscape prior to

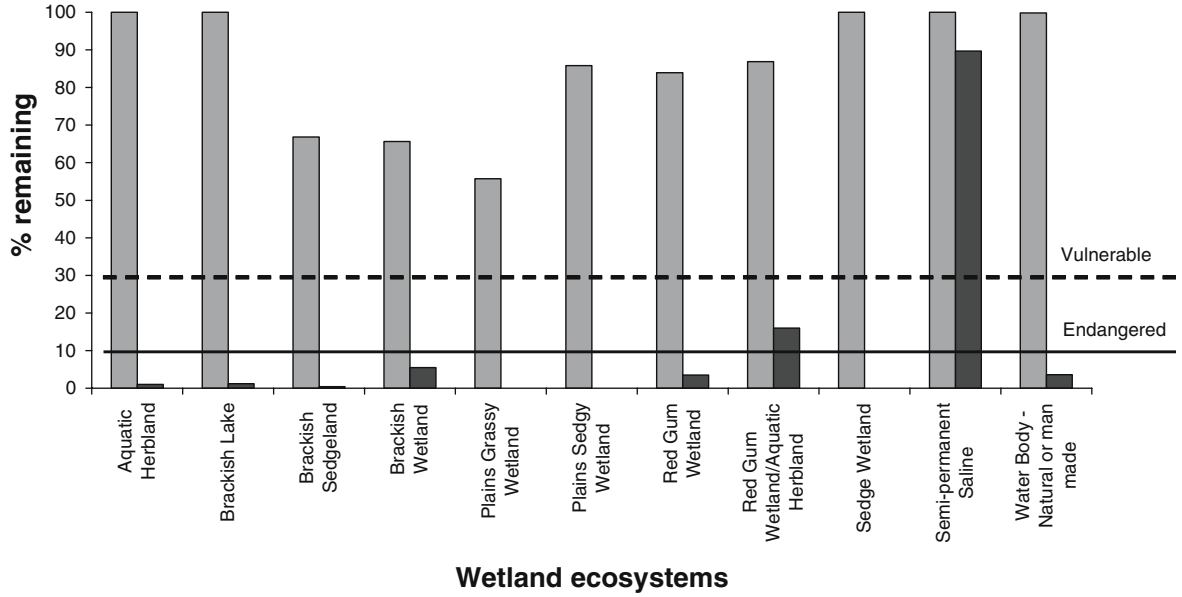

Figure 1. Percentage of wetland ecosystems in the Wimmera bioregion of Victoria remaining according to the VWD mapping (grey bars) and the EVC mapping (black bars). Note that none of the wetland ecosystems calculated using the VWD is considered 'vulnerable' or 'endangered'. Criteria for 'vulnerable' and 'endangered' designations follow JANIS (1997) (based on depletion levels only). Adapted from Robertson & Fitzsimons (2004).

European settlement (ca 1788), and are assessed within biogeographic regions rather than jurisdictional regions (Thackway & Cresswell, 1995; Environment Australia, 2000). With the availability of geospatial data of the extent of freshwater ecosystems prior to European settlement, conservation planning can take into consideration both the level of depletion and the extent of reservation, relative to current and pre-European conditions. Although these types of assessments are required for reporting under the National Reserve System (Commonwealth of Australia, 1999), up until now they have rarely been carried out.

Within the Wimmera bioregion of Victoria, the depletion and reservation levels of wetlands were analysed (Fitzsimons & Robertson, 2003). Notably, a bias towards reservation of certain wetland types was evident. Shallow, less permanent freshwater wetlands, which made up a significant proportion of wetlands in the Wimmera prior to European settlement, were relatively poorly represented in protected areas (Fig. 2). This is probably a reflection of the fact that inundation of these wetlands is typically episodic and consequently the wetlands are not permanent features on the landscape, meaning they were more easily converted to agriculture compared to more permanently inundated wetlands. Further biases in the reservation of other freshwater ecosystems may emerge through investigations elsewhere in Australia.

The study also highlighted the importance of considering the pre-European extent of wetland ecosystems. The calculation of depletion levels for each wetland type, and the level of reservation as a function of the historical (pre-1788) and current coverage across the bioregion, provided a more informed assessment than one based on reservation alone. Further measures, such as the relative level of threat to particular ecosystem types, also need to be considered when setting priorities for future reservation (e.g., Pressey et al., 2002).

Protected areas, by definition, are areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, and managed through legal or other effective means (IUCN, 1994). However, recognising that not all

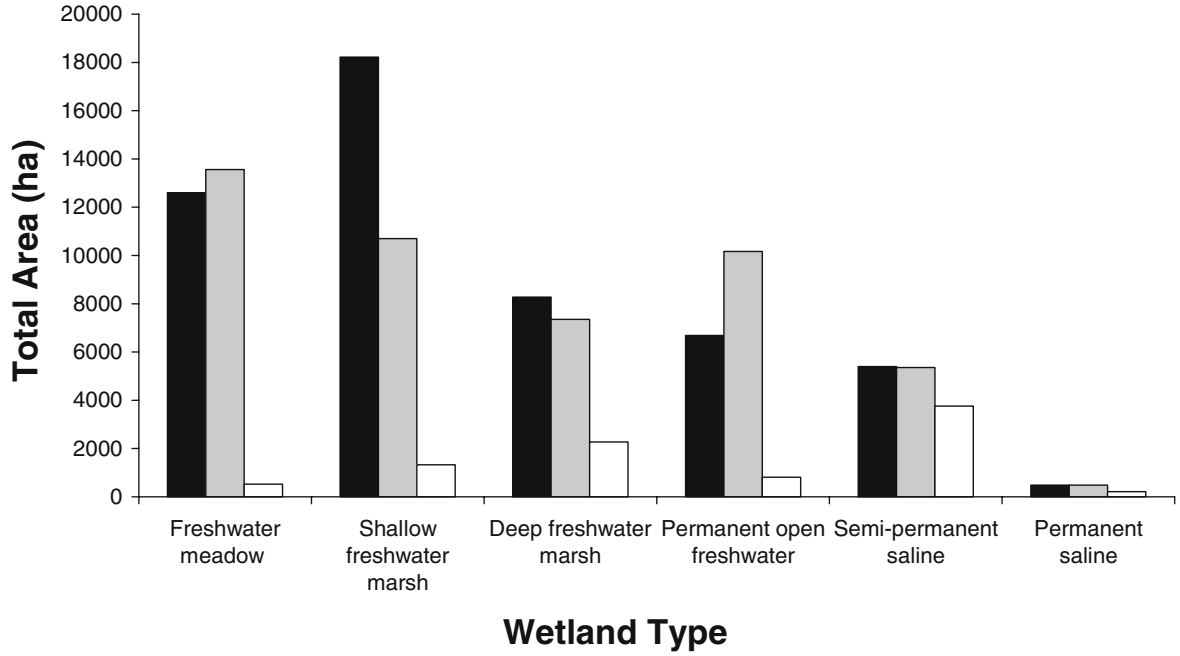

Figure 2. Reservation of wetland types in the Wimmera bioregion, Victoria. Pre-1788 wetland area (black bars), current (1994) wetland area (grey bars), current (1994) wetland area reserved (white bars). The increase in current area of some wetland types (e.g., permanent open freshwater) is likely to have resulted from the establishment of anthropogenic lakes and other human activities. Adapted from Fitzsimons & Robertson (2003).

protected areas have the same management priorities, levels of legal security or funding, the type of reserve must be considered in any assessment of freshwater reserve systems. For example, in the Wimmera bioregion, certain types of reserves contributed to a greater proportion of the total reserved area (Fitzsimons & Robertson, 2003). Reservation figures were evaluated for reserve categories meeting the IUCN definition of protected area (IUCN, 1994; NRE, 1996a). While there was a relatively low proportion of wetlands in National Parks (IUCN Category II) and Nature Conservation Reserves (IUCN Category Ia), Wildlife Reserves (IUCN Category VI) which allow hunting of selected game species and, in some cases, grazing by non-native stock represented over 70% of the total area of wetlands protected in the Wimmera (Fig. 3).

Biases in the representation of ecosystems within particular reserve types highlight areas where immediate improvements to the freshwater reserve system can be made, through, for instance, upgrading lesser protected 'reserves' such as Lake Reserves in Victoria, which are not considered protected areas (Fig. 3). Such data provides fundamental information about the reserve system, but is often not incorporated into freshwater conservation planning decisions.

Importance of reserve design in assessing the adequacy of freshwater reserves

The design of individual freshwater reserves in conjunction with the design of bioregional reserve networks is particularly significant in freshwater environments where hydrological connectivity plays a major role in ecosystem processes. Threatening processes occurring upstream are likely to have a significant impact on downstream freshwater habitats (Pringle, 2001), yet there has been little research on the basis for design of particular freshwater reserves, such as riverine protected areas (Koehn, 2003). Subdivisions in regions of Australia settled early for agricultural production resulted in allotment boundaries that were typically linear and right-angled and did not necessarily follow the contours or hydrology of the

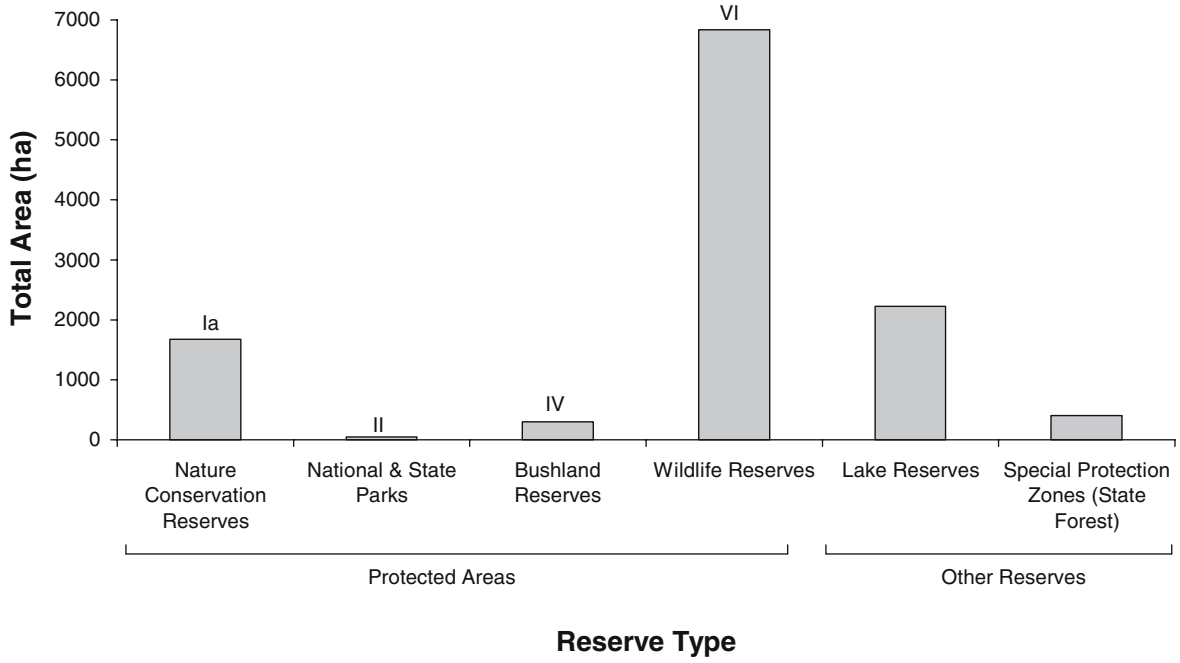

Figure 3. Areas of wetlands occurring in various reserve categories in the Wimmera, Victoria (IUCN 1994 Protected Area categories above columns: Ia = Strict Nature Reserve, II = National Park, IV = Habitat/Species Management Area, VI = Managed Resource Protected Area).

landscape. As reserves were often only an afterthought in these regions, their boundaries and shapes often reflect this historical planning. As a consequence, the reserve 'design' seldom relates to natural drainage characteristics or the boundary of the ecosystem that such reserves are supposed to protect. For example, within the Wimmera bioregion, of the 232 wetlands that are at least in part covered by a protected area, only 53 of these have their total area reserved (Fig. 4, Fitzsimons & Robertson, 2003).

Partial reservation of individual freshwater habitats may not ensure the long-term sustainability of those sections of rivers, wetlands, and other freshwater ecosystems that are considered 'protected'. For example, by only reserving a portion or even most of a wetland, it is likely that any degrading processes occurring in unprotected areas will ultimately impact on the reserved portion of the wetland. Pringle (2001: 981) also noted 'disturbances well outside the boundaries of (freshwater) reserves can have profound effects on the biological integrity of these ''protected'' areas'. The high proportion of wetlands in the Wimmera that were only partially reserved presents a number of dilemmas for conservation planners in designating new land for conservation. For example, should land purchase focus on improving the design of existing reserves? Alternatively, should land purchase attempt to acquire new reserves with under-represented ecosystems? Or should less protected public lands be upgraded?

These examples highlight the importance of considering reserve design aspects at the local scale in conjunction with bioregion reservation assessments. Dunn (2003) suggests that defining measures of adequacy for riverine systems is a particular challenge. While there are few readily quantifiable measures of 'adequacy' for protected areas, we suggest that analysing reserve design criteria, such as the proportion of a wetland reserved, could be one suitable and quantifiable measure of adequacy in freshwater ecosystems.

Directions and challenges for the establishment of a freshwater reserve system in Australia

The designation of freshwater reserves worldwide faces a number of impediments due to the nature

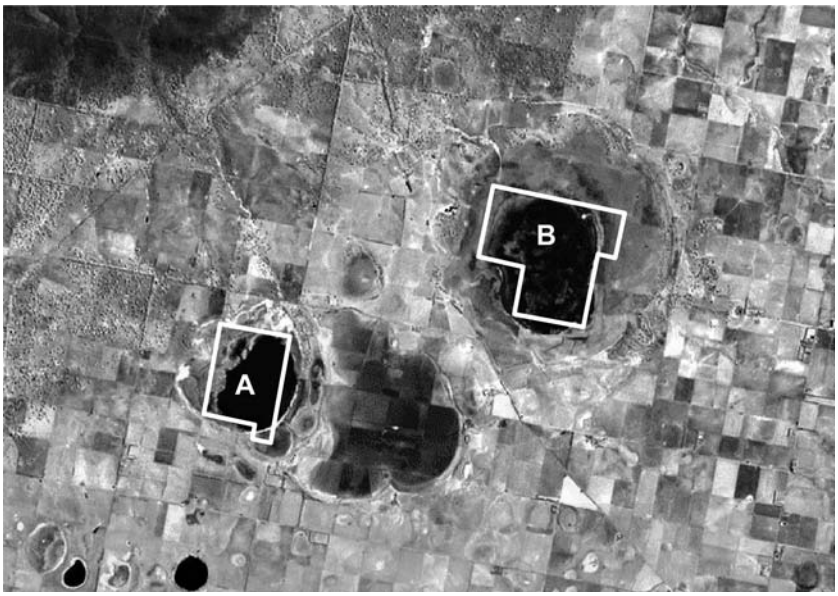

Figure 4. Lake Muirhead (A) and Mount William Swamp (B) Wildlife Reserves in the Dundas Tablelands bioregion, western Victoria (with satellite imagery in background). Note how the reserve boundaries are inconsistent with the ecosystems they aim to protect.

of freshwater environments. Protection of functional and representative samples of freshwater ecosystems often conflicts with existing human use and human dependency on aquatic resources (Abell, 2002). For example, the regulation of river flows and management of flood events is a major factor that influences the ability to conserve rivers, riparian zones, wetlands, and other freshwater habitats (Koehn, 2003). In Australia, the highly variable nature of water regimes associated with freshwater ecosystems (Cullen & Lake, 1995; Roshier et al., 2001) increases the difficulty in identifying and designating suitable reserves. While the delineation of a reserve boundary that incorporates the full range of water levels and flow regimes for aquatic systems may be desirable, the reservation of large areas of land in agricultural regions that are not permanently inundated may not be politically acceptable (Adam, 1992).

While all Australian jurisdictions have at least some level of aquatic ecosystem protection (Nevill & Phillips, 2004), there is increasing emphasis on the need to protect samples of all ecosystems in a comprehensive, adequate, and representative manner, on both public and private land. Reviews or programs in some jurisdictions have begun to specifically address developing freshwater reserve systems (e.g., Tasmania (DPIWE, 2004) and New South Wales (Hankinson & Blanch, 2002; Kingsford et al., 2004)) while the purchase of land containing under-represented freshwater ecosystems through the National Reserve System Program and other jurisdictional land purchase programs is occurring (e.g., Fitzsimons & Ashe, 2003; Fitzsimons et al., 2004). However, based on current levels of funding, land purchase alone cannot hope to protect all or most under-reserved ecosystems in a comprehensive, adequate and representative manner (Young & Howard, 1996; Possingham et al., 2002; Figgis, 2004). That many of the remaining wetlands occur on private land also needs to be considered in the development of a CAR reserve system. Conservation of biodiversity on private land has received increased attention in the past 15 years. This has taken the form of non-government organisations and land trusts purchasing land (at least one of which focuses specifically on wetlands, Brake et al., 1997), voluntary binding and non-binding protective agreements with private landowners (e.g., Platt & Ahern, 1995; Fitzsimons & Wescott, 2001), and more recently, through economic based mechanisms (e.g., BushTender, see Stoneham et al., 2003).

Ultimately, even adequate reservation of freshwater ecosystems will not conserve their constituent biodiversity without effective management. Freshwater reserves present a number of unique ecological and political challenges including the provision of environmental flows to rivers (Bunn & Arthington, 2002; Saunders et al., 2002) and water regimes to wetlands (Robertson & James, 2002; Stewart & Harper, 2002; Nias et al., 2003), and managing the impacts of water diversions (Kingsford, 2000). Much literature has noted the importance of river flows and hydrological connectivity between freshwater habitats for providing the conditions required to sustain populations of aquatic organisms (e.g., Kingsford & Thomas, 1995; Barmuta, 2003; Koehn, 2003; Dunn, 2004). Thus, the provision of river flows may be more important than a river reserve itself for the conservation of instream habitat and species persistence. From an implementation perspective, Cullen (2003) suggests that to gain widespread support for a National Heritage River Reserve System, existing uses must be able to continue, all new threatening processes prevented, and where possible current threats reduced.

Protection of Australia's freshwater ecosystems is a pressing issue. We have highlighted the importance of quantitative data for reservation status and protection measures, aspects of reserve design, and freshwater ecosystem classification. It is clear that these inter-related aspects all have important implications for implementing and evaluating a freshwater reserve network for Australia. We thus propose a strategic process for the efficient and effective development of a freshwater reserve system (Fig. 5). This process builds on that described by Margules & Pressey (2000) for systematic conservation planning and incorporates aspects particular to freshwater ecosystems. For example, we include further potential measures for the quantitative assessment of 'adequacy' for freshwater reserves (e.g., connectivity and hydrological regimes). It is envisaged that this be an ongoing and iterative process to assist in conservation planning and ultimately to improve the comprehensiveness, adequacy, and representativeness of the freshwater reserve system. Although some steps in the process may be specific to Australia (e.g., the measurement of pre-European ecosystem extent), the framework

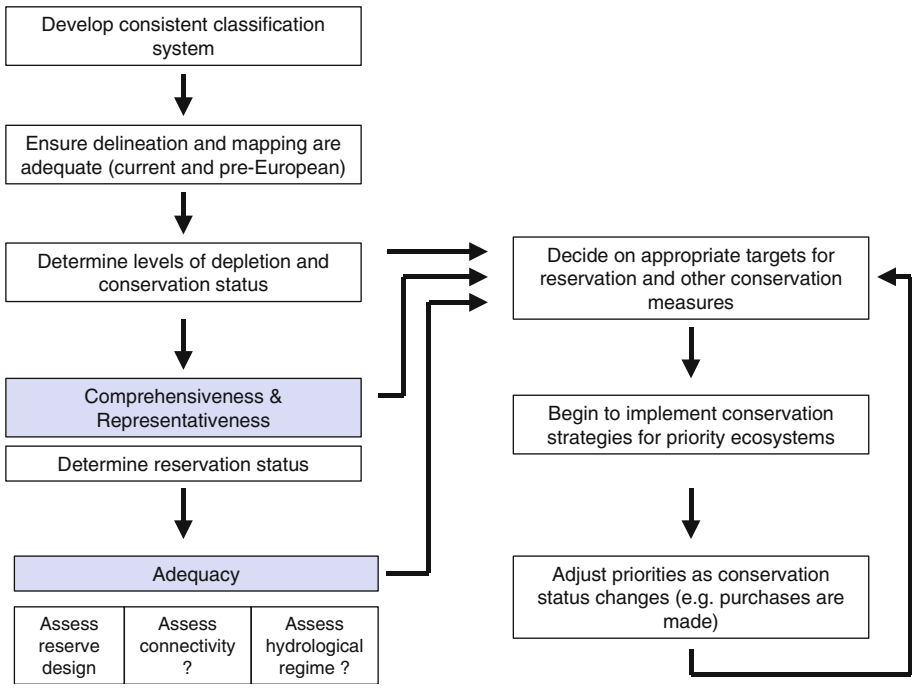

Figure 5. Strategic process to develop a comprehensive, adequate, and representative freshwater reserve system.

can be adapted and applied universally to advance the strategic conservation of freshwater ecosystems worldwide.

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