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Conservation priorities for freshwater biodiversity: The Key Biodiversity Area approach refined and tested for continental Africa

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ABSTRACT

Freshwater ecosystems represent one of the most threatened broad habitat types globally. Despite containing around a third of all vertebrates, area-based approaches to conservation planning rarely include freshwater species as an explicit target for conservation. Here we describe and apply a globally applicable methodology comparable to those for other groups (i.e. Important Bird Areas) to identify river and lake catchments that represent, or contain, freshwater Key Biodiversity Areas. We discuss the rationale behind the methodology and propose appropriate definitions and quantitative threshold values for the selection criteria. Thresholds are developed through spatial analysis of species information for four comprehensively assessed freshwater taxonomic groups in continental Africa, comprising 4203 species, as recently assessed for the IUCN Red List of Threatened Species™. To illustrate application of the methodology freshwater Key Biodiversity Areas are identified across continental Africa, and conservation planning software used to prioritise a network of catchments that captures 99% of the total species complement within catchments covering ca. 20% of the total land area. Within these prioritised catchments only 19% of river length falls within existing Protected Areas suggesting that, given the high connectivity within freshwater ecosystems and their dependence upon catchment management for effective conservation, modification or expansion of the protected area network is required to increase effective conservation of freshwater species. By applying this methodology, gaps in the coverage of freshwater species by existing Protected Areas can be identified and used to inform conservation policy and investment to ensure it is inclusive of, and effective for, freshwater biodiversity.

1. Introduction

Although occupying less that one per cent of the earth's surface, freshwater ecosystems contribute disproportionately to global biodiversity, containing around one third of all vertebrates (Dudgeon et al., 2006; Strayer and Dudgeon, 2010), and providing ecosystem goods and services estimated to be worth trillions of dollars annually (Postel and Carpenter, 1997; Millennium Ecosystem Assessment, 2005). Growth of the human population and increased socio-economic development have led to severe pressures being placed on freshwater systems globally (Vörösmarty et al., 2010), leading to an estimated extinction risk amongst freshwater species that is significantly higher than found terrestrially (Dudgeon et al., 2006; Darwall et al., 2009; WWF, 2010). For example Ricciardi and Rasmussen (1999) estimate that extinction rates of freshwater animals in North America may be fives times higher than that found in terrestrial habitats. Across Europe, assessments for the IUCN Red List (IUCN, 2010) indicate significantly higher numbers of threatened freshwater molluscs (44%) and fish (37%) than mammals (15%), reptiles (19%), and amphibians (17%). Historically fresh water has been viewed as a human resource to be exploited (Palmer, 2010), such that over 50% of available water is now captured by humans, and the natural morphology, flow regime and biogeochemical cycles of many freshwater systems are disrupted (Jackson et al., 2001; Nilsson et al., 2005; Strayer and Dudgeon, 2010). In order to halt the decline in biodiversity and the associated loss of services there is a need to legitimise freshwater species as users of water (Naiman et al., 2002) and to identify and prioritise areas for conservation of freshwater biodiversity (Moilanen, 2007; Nel et al., 2009a; Linke et al., 2011).

The establishment of Protected Areas (PAs) has become an important mechanism for the conservation of biodiversity (Langhammer et al., 2007; Gaston et al., 2008) as habitat loss and degradation are acknowledged as being amongst the principle threats to biodiversity globally (Vié et al., 2009). With a new global target for coverage by PAs set at 17% for terrestrial habitats and inland water following the 10th meeting of the Conference of the Parties to the Convention on Biological Diversity there is a need to expand the network in a strategic way (Margules and Pressey, 2000; Eken et al., 2004; Rodrigues et al., 2004a). Locations of new PAs have been identified either for pragmatic reasons (Margules

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and Pressey, 2000; Joppa and Pfaff, 2009) or on the basis of our understanding of better known groups, predominantly mammals, birds and amphibians (Brooks et al., 2004; Rodrigues et al., 2004b; Ricketts et al., 2005; Rondinini et al., 2005) in the belief that these will act as surrogates for lesser known groups. However, surrogacy between taxonomic groups from differing realms (i.e. freshwater vs. terrestrial) is low (Rodrigues and Brooks, 2007; Darwall et al., 2011) with studies in the United States (Herbert et al., 2010; Lawrence et al., 2011) and Brazil (Nogueira et al., 2010) demonstrating that existing PAs provide significantly less coverage for inland aquatic species and habitats than for terrestrial ones (Roux et al., 2008; Darwall et al., 2011).

Here we present a framework for identifying Global Key Biodiversity Areas (KBAs) for freshwater species (termed freshwater KBA subsequently). The rationale and criteria for identification of freshwater KBAs are extensions of the original concept of Important Bird Areas (e.g. Grimmett and Jones, 1989) adapted and applied to other taxonomic groups (Eken et al., 2004; Langhammer et al., 2007), with a preliminary framework methodology for identification of freshwater KBAs proposed by Darwall and Vie (2005). KBAs are sites of global significance for conservation of species, derived from a set of criteria based on vulnerability and irreplaceability, standardized globally and applicable across taxonomic groups (Eken et al., 2004; Langhammer et al., 2007). Within this definition, vulnerability refers to the likelihood that species within a site will be lost over time, and irreplaceability refers to the spatial options available for conservation of particular species (Langhammer et al., 2007). The aim of the KBA methodology presented here is identification of all globally significant sites that contain species requiring conservation action. Once sites qualifying as KBAs have been identified, gap analysis (e.g. Rodrigues et al., 2004a; Burgess et al., 2005) can be employed to examine the shortfall in representation of species within the existing PA network. The development of a methodology for the identification of freshwater KBAs can be seen as critical to inform the strategic expansion of the existing PA network for freshwater species as it provides a focus on those sites of the highest global significance.

Given the limited resources available for conservation, having identified KBAs, approaches based on expert knowledge and systematic conservation planning (e.g. Amis et al., 2009; Nel et al., 2009a,b; Beger et al., 2010; Esselman and Allan, 2011; Rivers-Moore et al., 2011 Roux et al., 2008; Turak and Linke, 2011) can then be used to prioritise investment. Recent years have seen a growing interest in the application of conservation planning techniques, developed primarily for terrestrial and marine systems, for setting freshwaters conservation targets (Linke et al., 2011). The application of existing techniques to freshwater systems presents new challenges, primarily relating to connectivity within the wider landscape (Hermoso et al., 2011; Nel et al., 2011). The identification of KBAs and the application of conservation planning approaches can be seen as having a synergistic relationship where the former identifies sites that are important for the conservation of species diversity and the latter prioritises amongst sites to identify a practical and effective network of protected or managed areas.

We consider catchments identified using the framework presented here as "potential" freshwater KBAs for a number of reasons. If a species meets any of the criteria that would trigger KBA qualification, expert knowledge must be used to refine information about the species, prioritising the most important catchments, or areas within those catchments, across its range. To shift status from a potential to confirmed freshwater KBA site designation should ideally be approved through workshops involving stakeholders (e.g. national, regional and local government, NGOs, local users, community groups). Through this engagement conservation planning principles may be used to design a national or regional reserve network that considers biodiversity targets within the social, economic and political context (Margules and Pressey, 2000) thus ensuring local engagement and approval of the process (Barmuta et al., 2011). While KBAs are identified using a set of global standards their protection/management depends on local implementation. Often they exist outside the formal Protected Area network and so such engagement is key. The process for registration of confirmed KBAs is currently being examined by the World Commission on Protected Areas and the IUCN Species Survival Commission leading to the development of a global database of formally approved KBAs.

The aim of the current study is to propose criteria to identify freshwater KBAs and to demonstrate their application by identifying a network of potential freshwater KBAs across continental Africa. In doing so, a primary consideration is to align our work with criteria for the identification of KBAs for other taxa, so that the conservation community can present a clear rationale across taxonomic groups for the identification of these sites to decision makers. Building on the work of Darwall and Vie (2005), we propose and test quantitative thresholds and examine whether threshold values based on the knowledge of other groups are appropriate for a range of freshwater taxa. We apply these criteria to data for all known species of freshwater crabs, fish, molluscs and odonates (dragonflies and damselflies) recorded from continental Africa for each group individually, and identify potential freshwater KBAs based on data for all four groups. Finally, we use optimization software commonly used in conservation planning to identify a set of potential freshwater KBAs that would collectively achieve species targets in an efficient manner.

2. Materials and methods

2.1. General methods

Data were collected based on a method developed by the IUCN Global Species Programme's Freshwater Biodiversity Unit to assess the conservation status of freshwater species. The Red Listing process is based on regional workshops that are highly participatory, involving local experts and stakeholders and as such represents a model for local engagement that could be used in the identification of freshwater KBAs. We describe a 7 step process first outlined by Darwall and Vie (2005) and focus on the development and testing of criteria for Step 5. Of the seven steps described, five have been incorporated into this analysis with Steps 3 and 6 omitted due to data limitations.

Step 1: Define the geographic boundaries within which to identify important sites.

The extent of our study is defined as continental Africa. This continent represents the first for which IUCN has assessed the distribution and conservation status of all known freshwater crabs, fish, molluscs and odonates. These four taxonomic groups were identified as priorities for assessment due to the availability of reliable information, their role in the maintenance of healthy freshwater systems, and the important contribution that they make for the provision of ecosystem goods and services and maintenance of livelihoods.

Step 2: Define the wider ecological context of the designated assessment area.

Defining the wider context is important in determining the scale at which conservation action should take place. Rivers and lakes cannot be evaluated in isolation from the surrounding