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EDITORIAL

Riverine biodiversity conservation in South Africa: current situation and future prospects

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South Africa is richly endowed with an array of natural resources, with one exception — water. In South African water law, a river system and its associated riverine biodiversity — i.e. the entire aquatic ecosystem — is regarded as the 'water resource' that provides ecosystem goods and services to society (Van Wyk *et al.*, 2006). An appreciation of riverine biodiversity in South African rivers therefore requires an understanding of the characteristics of the country's water resources, their variability in time and space and the factors that influence their use by society.

South Africa's climate is characterized by an uneven, poorly predictable and highly seasonal distribution of rainfall, while potential evapotranspiration rates exceed rainfall over the entire country (Tyson, 1987). Droughts are common and, ironically, they are often followed by equally devastating floods. South Africa has few natural lakes and the country's river network has flows that are highly variable between seasons and between years (Smakhtin, 2001; Hughes and Hannart, 2003). Rivers located in the wetter regions of the country tend to be perennial while those in the drier regions are characterized by more periodic (seasonal) and episodic (ephemeral) flows (Midgley *et al.*, 1994).

River systems are the primary source of water for agricultural, domestic and industrial uses and supply more than 85% of all the water that is used in South Africa, with groundwater systems providing the remainder. Large numbers of water supply reservoirs, farm dams, canals and inter-basin transfer schemes have been constructed to increase the reliability of water supplies for urban and rural users. The total capacity of South Africa's water storage reservoirs (dams) is equivalent to 67% of the total annual runoff in all rivers (DWAF, 1996a), and most river systems have been impounded at several points along their length, thereby altering their flow regimes 'beyond recognition' (Davies *et al.*, 1993; Davies and Wishart, 2000). Five of South Africa's most important catchments and their rivers (Orange, Limpopo, Incomati, Maputo and Thukela) are shared with neighbouring countries, further complicating the problem of sustainable water resource management (Ashton and Turton, in press).

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Almost all of South Africa's rivers receive discharges of treated domestic and industrial effluent from towns and cities, while return flows from irrigated agriculture contribute additional loads of agrochemicals. Projected population increases — coupled with continuing efforts to meet growing demands for food, fibre, fuel and fresh water, while redressing the consequences of past political iniquities — place ever-increasing demands on the country's limited water resources (Ashton, 2002). These threats are accentuated by the introduction of alien species, destruction of wetlands, removal of riparian vegetation and disruption of connectivity between fresh water habitats (Roux *et al*., 2002). The combination of geographical circumstances and socio-economic trends has crucial implications for the integrity and continued functioning of South Africa's river ecosystems and their associated biodiversity features. Sadly, the situation of South Africa's riverine biodiversity is mirrored in many parts of Africa (Denny, 1985; Davies and Wishart, 2000) and elsewhere in the world (World Wide Fund for Nature, 2004; World Conservation Union, 2006) with freshwater species having declined more rapidly between 1970 and 2000 than their terrestrial and marine counterparts (Abell, 2002).

Early country-wide studies on the conservation status of South Africa's aquatic biodiversity used expert opinion to identify aquatic biotopes and habitats for threatened aquatic species (Noble, 1974), and highlighted the degree of modification that rivers had undergone from their natural state (Chutter, 1973; O'Keeffe, 1989). The conservation status of specific taxonomic groups such as invertebrates (Moore and Chutter, 1988) and fish (Skelton *et al*., 1995) is dependent on adaptation of the biota to the flow patterns that characterize each type of river, drawing attention to the implications of declining flows in many of the country's rivers. Growing attention is now being paid to the quantities of water required to sustain the biotic diversity and ecological functioning of aquatic ecosystems (King *et al*., 1999), while the development of water quality guidelines for aquatic ecosystems (DWAF, 1996b) has prompted the inclusion of water quality issues in estimates of the environmental flow requirements needed to sustain riverine ecosystems.

At sub-national scales more systematic approaches to river conservation planning have been used to develop formal biodiversity conservation plans for rivers in the Cape Floristic Region (Van Niewenhuizen and Day, 1999) and the Greater Addo Elephant National Park (Roux *et al*., 2002). These studies provided added impetus for a riverine ecosystem classification study, which identified 112 unique combinations of river flow patterns and geomorphic provinces that form the distinctive main-stem river ecosystem types across South Africa (Nel *et al*., 2007). This national-scale study also assessed the status of riverine aquatic ecosystems and the level of protection afforded to all the main-stem rivers in South Africa. Ecosystem status was assessed as the proportion of each river ecosystem type still in a natural state, while the level of protection was assessed as the proportion of its minimum conservation target (20% of total river type length) contained within a formally protected area (Nel *et al*., 2007).

At present (2007), 30% of South Africa's main rivers are still intact and able to contribute to national conservation targets, while 47% of the main rivers have been modified to varying degrees. Importantly, 23% of the length of the country's main rivers has been irreversibly transformed (i.e. modified or submerged by water storage reservoirs and associated water transfer infrastructure) and these rivers are deemed to be unsuitable for meeting river ecosystem conservation targets though many of their smaller tributaries are still largely intact and provide important refugia for aquatic biota (Nel *et al*., 2007). In terms of the level of protection that is afforded to river ecosystems, some 92% of all main river ecosystems are located outside statutory Type I protected areas. The remaining 8% of river ecosystems are split equally between rivers that form the boundaries of protected areas — where some degree of protection is afforded — and those that fall fully within statutorily protected areas (Nel *et al*., 2007). Understandably, the periodic and episodic rivers of the more arid regions in the western interior of South Africa contain the largest proportion of river ecosystems that are not threatened by human modification because they contain insufficient water (Driver *et al*., 2005; Nel *et al*., 2007).

In an ideal world, the effective conservation of a river system requires the prudent management of the entire catchment to achieve sustainable social, economic and ecological objectives (Davies and Wishart,

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2000; Gilman *et al*., 2004; Chan *et al*., 2006). This should be based on integrative assessment and planning approaches that incorporate terrestrial and aquatic issues, including the reconciliation of conservation and water use goals both inside and outside of protected areas, into a single decision-making framework (Nel *et al*., 2007). Clearly, this emphasizes the need for a greater understanding of river use patterns by society and the values and perceptions that underlie these patterns. Systematic conservation assessment and planning methodologies have become well-advanced for terrestrial ecosystems, though river systems have often been poorly dealt with in assessments of terrestrial systems and their conservation status is often ignored (Abell *et al*., 2007). More recently, systematic conservation assessments and plans have specifically targeted freshwater ecosystems in an effort to correct this (Roux *et al*., 2002). Despite these developments, most of the efforts directed at the conservation of freshwater ecosystems are conducted in isolation from terrestrial ecosystem assessments and there is an urgent need for the plans, policies and strategies to be combined to include both terrestrial and freshwater components (Roux *et al*., 2006). This is required to meet the needs of integrated river basin management (Pringle, 2001).

Formal custodianship of South Africa's water resources is vested in the Department of Water Affairs and Forestry (DWAF, 1996a), but several government departments (e.g. Water Affairs and Forestry, Agriculture, Health, Minerals and Energy) and sectors of government (national, provincial and local) share responsibility for different aspects of the use and management of water resources. A set of cross-sector policy objectives has therefore been developed to address the complexities of conserving the country's aquatic biodiversity (Roux *et al*., 2006).

South Africa's landmark National Water Act (Republic of South Africa, 1998) makes explicit provision for sufficient water to be reserved to sustain the ecological functioning of the country's rivers, wetlands, groundwater and estuarine systems. In practice, however, the pressing shortage of water has made it extremely difficult to meet this ideal. In many rivers, the water for 'ecological purposes' or 'the environment' consists of that water which cannot easily be withdrawn for human uses (Davies *et al*., 1993; Midgley *et al*., 1994; King *et al*., 1999). Thus society needs to make tough trade-offs (Van Wyk *et al*., 2006), which should be informed by the reality that the current situation cannot persist indefinitely. Continued deterioration of the country's river systems will result in an inevitable decline in the provision of key ecosystem services that underpin social and economic development (Postel and Richter, 2003; Driver *et al*., 2005; MEA, 2005; Dudgeon *et al*., 2006; Dasgupta, 2007).

Since freshwater resources are the single most limiting resource for development in South Africa (Davies and Wishart, 2000), it is inevitable that the country's rivers will continue to be exploited to meet human needs for water (DWAF, 1996a). While increased water withdrawals and effluent discharges pose immediate threats to riverine biodiversity, possible increases in temperature and reduced precipitation caused by climate change are likely to aggravate the situation in the long-term (Tyson, 1987; Davies *et al*., 1993; Driver *et al*., 2005). In these circumstances, it will be difficult — if not impossible — to safeguard the biotic diversity of all South African rivers at an equally high level (O'Keeffe, 1989). Instead, water resource managers, scientists and conservationists need to identify and prioritize sets of rivers or portions of rivers for conservation purposes (Knight *et al*., 2007). In addition, they must ensure that these conservation goals benefit from societal support for the continued allocation of sufficient water of an appropriate quality to maintain habitat integrity and the efficient functioning of ecological processes (Rogers and Bestbier, 1997; King *et al*., 1999). Since the condition of a river system (including its biodiversity) is a direct reflection of the conditions in its catchment, prudent catchment management that encompasses the active support of society is the key to successful river conservation. Only by achieving this ideal will it be possible to ensure that the vital ecosystem services derived by society from river systems will continue to be delivered on a sustainable basis into the future. Here it is important to understand that this cannot be achieved solely through increased care and attention to riverine biodiversity issues (Davies and Wishart, 2000). Instead, there is an urgent need for all stakeholders to become more closely engaged in the social and institutional processes that are needed to ensure successful implementation of integrated river basin management plans,

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where both terrestrial and aquatic biodiversity issues are in balance with the social and economic needs of society.

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