Development of an automated desktop procedure for defining macro-reaches for river longitudinal profiles

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Abstract

This paper presents an automated desktop procedure for delineating river longitudinal profiles into macro-reaches for use in Ecological Reserve assessments and to aid freshwater ecosystem conservation planning. The procedure was developed for use where there are limited data and/or where a repeatable, statistically defensible regional or national assessment is required. The delineation of longitudinal profiles into macro-reaches between 'controls' or 'break points' such as exposed resistant rock formations, knick points, or significant changes in lithology provides the initial coarse filter for further assessment of lower levels of organisation, channel type for example. The division is necessary, as research has demonstrated that not all macro-reaches respond in the same way to disturbance or stress, nor do they have the same biotic assemblages. Four statistical methods (Von Neumann mean square error, CUSUM plots or unweighted values and the Worsley Likelihood Ratio Test (WLRT)) were used to define macro-reach breaks for four South African rivers (Crocodile, Olifants, Mhlathuze and Seekoei Rivers) and were compared to previously defined macro-reach delineations based on expert-driven approaches. Results indicate that the CUSUM and WLRT approaches most closely match the macro-reach breakspoints as defined by the expert-driven approach. An automated desktop procedure was developed for computing statistically defensible, multiple change points along profiles using an adaptation of the WLRT method. The adapted approach does not require an *a priori* knowledge of the break points, as is the case in other applications of the WLRT. It is concluded that the adapted WLRT approach can be used with a reasonable degree of certainty where there are insufficient data and/or where a regional or national assessment is required that is repeatable and statistically defensible. Where possible, however, there is no substitute for primary data collection, field work and a detailed expert-driven approach.

Keywords: South African National Water Act, Ecological Reserve, freshwater ecosystem conservation planning, river classification, ecostatus, longitudinal profiles, macro-reaches, change points, Worsley Likelihood Ratio Test

Introduction

The South African National Water Act (No. 36 of 1998) transformed water resource management in South Africa. The pre-1998 apartheid-based legislation gave way to legislation that seeks to achieve a balance between protection and utilisation of the nations' water resources for the benefit of all. This progressive legislation stresses the twin themes of sustainability and equity and seeks to 'legislate for sustainability' at a national level. These themes are echoed in parallel legislation, the South African National Environmental Management: Biodiversity Act (No. 10 of 2004), which seeks, amongst other things, to ensure that aquatic biodiversity is conserved (Roux et al., 2005). To help meet these legislative requirements, a number of enabling tools, processes and mechanisms, some in their infancy, have been developed (e.g. DWAF, 1999; Brown and Joubert, 2003; King et al., 2003; DWAF, 2004; 2005; Nel et al., 2005). As these tools were developed to meet the needs of state departments mandated to allocate water (Department of Water Affairs and Forestry (DWAF)) and to conserve the environment (Department of Environment Affairs and Tourism (DEaT)), it is important that their founding concepts, assumptions and logic trains are transparent and defensible and that the tools are practical and implementable.

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It is to this end that a method was developed to undertake repeatable and unbiased assessments where an expert-driven approach is not feasible. This paper presents a repeatable, statistically defensible technique for dividing river longitudinal profiles into units that can be used as part of the Ecological Reserve determination process (DWAF, 1999). The technique can also be used to aid the process of determining regional and national spatial biodiversity plans for freshwater ecosystem conservation (Nel et al., 2005).

River classification systems

There are numerous river classification systems (see Berman, 2002 for a recent comprehensive review), most of which recognise the biophysical complexity of river systems across space and time. Coping with this complexity in a conceptual model represents a significant challenge (Thorp et al., 2005). Nevertheless, most conceptual models recognise that hierarchical classification is a valuable means to organise, interpret and understand complex systems such as fluvial landscapes (Berman, 2002; Poole, 2002). Both structure-based (e.g. Jensen et al., 2001; Higgins et al., 2004) and process-based (e.g. Montgomery, 1999; Church, 2002) hierarchical classification systems divide the river (usually the longitudinal profile) or catchment into similar reaches, zones or patches. These are variably called macro-reaches (e.g. van Niekerk et al., 1995; Moon et al., 1997), reaches (Rosgen, 1996; Fox et al., 1996; Rowntree and Wadeson, 1997; Rice and Church, 2001), zones (Harrison, 1965; Noble and Hemens, 1978; Western et al., 1997; Rowntree and Wadeson, 2000; Thoms and