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Research Paper

Links between ecological and human wealth in drainage ponds in a fast-expanding city, and proposals for design and management

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GRAPHICAL ABSTRACT

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ABSTRACT

Sustainable Drainage Systems (SuDS) are engineering solutions for managing storm water, and they can also provide blue spaces that equitably benefit the health and wellbeing of urban dwellers. The main objectives of this study were to test whether affluent neighbourhoods have SuDS with better ecological quality in one of Europe's fastest developing cities, and to investigate whether designable or manageable habitat characteristics of the SuDS, and the adjacent terrestrial area, are related to ecological quality. We estimated SuDS ecological quality by dimension reduction of five biotic and abiotic ecosystem components through performing a Principal Coordinate Analysis. Then we regressed SuDS ecological quality against socio-economic descriptors of the neighbourhood. We next applied non-parametric Kruskal–Wallis tests and probabilistic co-occurrence analysis to assess associations between habitat characteristics and ecological quality of SuDS. Our data showed that more affluent neighbourhoods have SuDS of higher ecological quality. We identified thresholds for some easily designable and manageable habitat characteristics of SuDS clearly linked to their ecological quality. There was strong co-occurrence of habitat characteristics, with aggregation of features linked to poor and good ecological quality, in SuDS designed as detention basins/swales or ponds respectively. Our results can be applied to the design and management of SuDS to foster good ecological quality irrespective of the neighbourhood. This study will be valuable for building and managing SuDS in a nature-based way, thus providing more socially equitable access to high-quality urban blue space.

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1. Introduction

The world's human population is increasing and as it does so a greater proportion of people are living in cities (United Nations, 2014). For example, in Europe, 9% of land is classified as urban (Scalenghe & Marsan, 2009). Whilst urban expansion is clearly a threat to biodiversity (e.g. Beninde, Veith, & Hochkirch, 2015), when effectively managed, urban green (parks and gardens) and blue (coast, ponds, lakes, canals and rivers) spaces can provide valuable wildlife habitats (Aronson et al., 2017; Hill et al., 2016). Green and blue spaces can be especially important when the surrounding countryside has been degraded by intensive agriculture (Colding & Folke, 2009; Deutschewitz, Lausch, Kuhn, & Klotz, 2003). Such spaces can also contribute to habitat networks, which can connect populations, enabling movement of genes and individuals (O'Brien et al., 2015; Van der Ryn & Cowan, 1996). Furthermore, blue and green spaces offer opportunities to bring urban dwellers into contact with nature (Folke et al., 2011).

Several studies (Irvine, Warber, Devine-Wright, & Gaston, 2013; Mitchell & Popham, 2008; Triguero-Mas et al., 2015) have shown wellbeing and health benefits to people living close to urban green space, though not necessarily urban blue space. Specifically, exposure to green space has been linked to a better self-perceived general and mental health, and to all-cause mortality i.e. all of the deaths that occur in a population, regardless of the cause (van den Berg et al., 2015). Urban blue spaces, have been reported to be drivers of emotional restoration, and to enhance physical and mental health of city-dwellers (Völker & Kistemann, 2011; White et al., 2010). On the other hand, high-quality and easily accessible green spaces also contribute to reducing social and age-related inequalities (Aspinall et al., 2010; Shanahan, Lin, Gaston, Bush, & Fuller, 2014). Furthermore, access to urban green spaces has been found to break the usual link between socioeconomic and health inequality (Mitchell & Popham, 2008; Mitchell, Richardson, Shortt, & Pearce, 2015). Biodiversity plays a central role in the observed benefits for people, with health benefits positively linked to species richness of green spaces (i.e. plants and birds richness; Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007), although the relationship with plant diversity is unclear, possibly due to people being unable to distinguish different species (Dallimer et al., 2012). Indeed, it has been suggested that the qualities (atmosphere, comfort, safety, attractiveness, maintenance, naturalness, etc.) of urban green and blue spaces may be equally or more important than the quantity for human health and wellbeing (Francis, Wood, Knuiman, & Giles-Corti, 2012; van Dillen, de Vries, Groenewegen, & Spreeuwenberg, 2012). In addition, cumulative accessibility opportunity indicators of green spaces, which take all the green space within a certain distance into account, are more consistently positively related to health than residential proximity ones (Ekkel & de Vries, 2017). These multiple benefits are of great interest to policy makers and to government agencies charged with nature and environmental protection (Hansen & Pauleit, 2014; Wade & McLean, 2014).

One class of urban blue space is Sustainable Drainage Systems (SuDS): storm water management solutions that reduce flood risk and diffuse pollution, through a series of processes which mimic natural drainage processes rather than hard engineering approaches (Woods-Ballard et al., 2015). SuDS have been seen as a way of helping countries achieve their obligations under the European Union's Water Framework Directive (European Council, 2000) and Scotland was one of the early adopters of the approach, with SuDS being mandated in all new developments with more than two new premises since 2003 (Scottish Parliament, 2003). SuDS might be designed as detention basins,

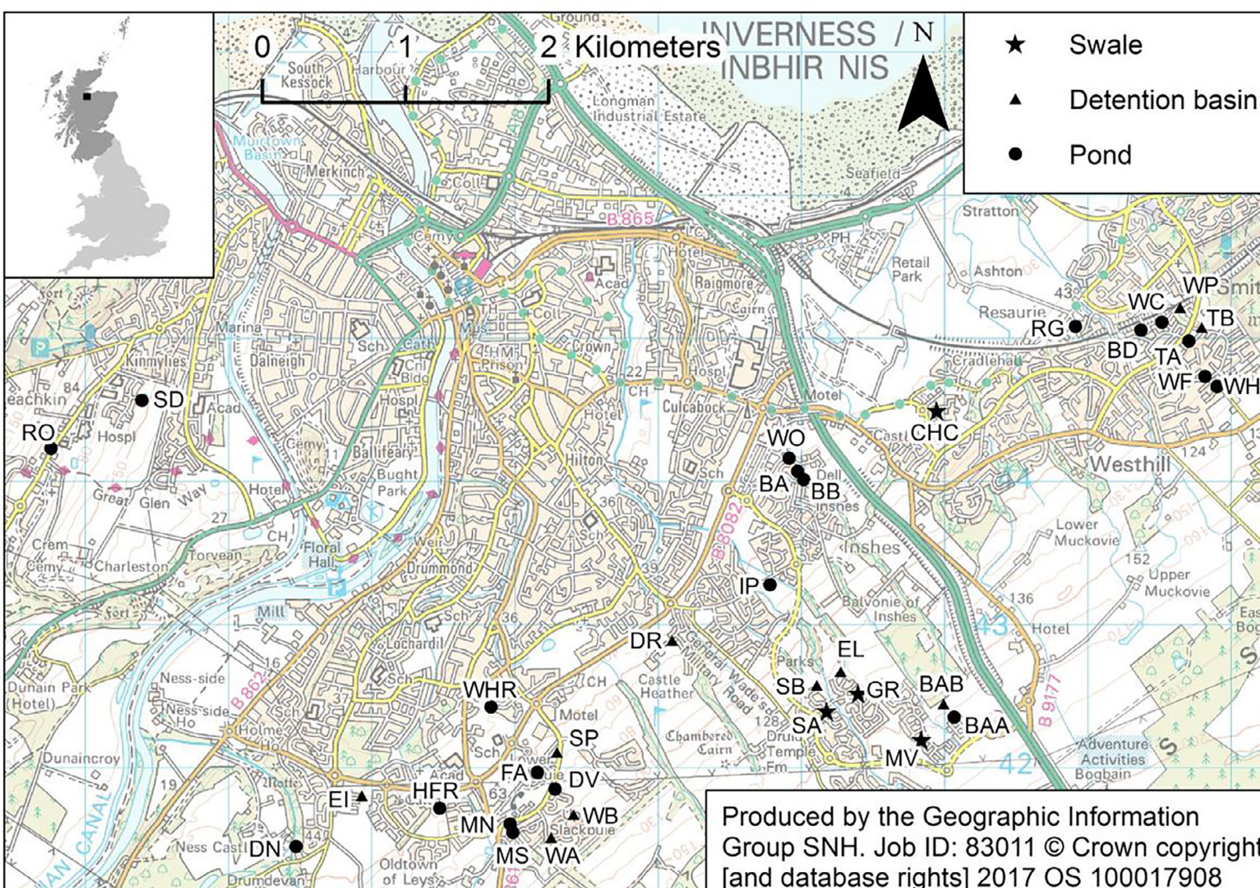

Fig. 1. Map of the studied SuDS, Inverness, Highland, UK. Site codes are given in Table A1 in Appendix A.