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Environmental data visualisation for non-scientific contexts: Literature review and design framework

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ABSTRACT

Environmental science is an applied discipline, which therefore requires interacting with actors outside of the scientific community. Visualisations are increasingly seen as powerful tools to engage users with unfamiliar and complex subject matter. Despite recent research advances, scientists are yet to fully harness the potential of visualisation when interacting with non-scientists. To address this issue, we review the main principles of visualisation, discuss specific graphical challenges for environmental science and highlight some best practice from non-professional contexts. We provide a design framework to enhance the communication and application of scientific information within professional contexts. These guidelines can help scientists incorporate effective visualisations within improved dissemination and knowledge exchange platforms. We conclude that the uptake of science within environmental decision-making requires a highly iterative and collaborative design approach towards the development of tailored visualisations. This enables users to not only generate actionable understanding but also explore information on their own terms.

Contents

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1. Introduction

1.1. The environmental science-society interface

Environmental science is an applied discipline so inevitably environmental scientists are confronted, directly or indirectly, with the need to interact with non-scientific professionals (RCUK, 2013; Rhoads et al., 1999). As environmental managers are under increasing scrutiny to make decisions based on highly complex and uncertain evidence (Fischhoff, 2011; Liu et al., 2008), they require a thorough and up-to-date understanding of current scientific thinking to inform their working process (Bishop et al., 2013). In response to this challenge, applied environmental sciences are becoming increasingly concerned with finding ways to enhance the flow and use of relevant scientific information within evidence-based, professional contexts (Sutherland et al., 2012). However, despite these advancements in research and the growing availability of scientific information, there remains a gap between scientific knowledge generation and non-scientific, societal application (Kirchhoff et al., 2013; Mikulak, 2011; von Winterfeldt, 2013).

Currently, scientists that interact with non-scientists often feel that their contributions are ignored, while the latter complain that available scientific information is not tailored to their specific needs (Liu et al., 2008; McNie, 2007). Improved uptake and application of scientific knowledge within environmental decision-making requires further consideration for, and investment in, the communication and dissemination process (Lorenz et al., 2015). Within the interface between science and society, indifference towards communication prevents comprehension, creates misunderstandings and inconsistent or bias messages (Demeritt and Nobert, 2014; McInerny et al., 2014), and will ultimately result in ill informed decisions and maladaptation in the future (Kirchhoff et al., 2013).

Choices surrounding the communication of scientific knowledge to potentially interested non-scientific communities may also raise issues of a more ethical nature (Keohane et al., 2014). While some audiences will be able to deal with complexity and ambiguity, others may respond with confusion, suspicion or even a skewed perception of risk (Han et al., 2011; Politi et al., 2007; Spiegelhalter et al., 2011). Ineffective communication can result in audiences experiencing a distorted sense of certainty, leading to poorly informed decisions and diminished trust in science (Pidgeon and Fischhoff, 2011; Taylor et al., 2015). Scientists need to find ways to convey only relevant information and associated uncertainties in a format that serves the audience's own best interests (Fischhoff and Davis, 2014). Such choices are currently underrepresented within environmental scientific training. The ability to convey not only accurate and useful information to audiences, but also an honest picture of current knowledge continues to elude most scientists.

1.2. The role of visualisation

Traditionally, the scientific community has used explanatory graphics and images to support scientific communication such as publications or conference talks; however, these figures are typically designed for audiences that are, to some extent, familiar with the underlying data or graphical form. Default design software can be crude and unhelpful but scientists are rarely given training in how to develop visualisations, particularly for non-scientific contexts (McInerny et al., 2014). Until very recently, print was the only platform to visually present and analyse information, limiting our ability to interact with data and make sense of complex subject matter (Few, 2009). The advent of computer graphics, democratisation of data and advances in information and communications technology (ICT) have combined to shape modern visualisation (Few, 2009; Spiegelhalter et al., 2011).

Today, data visualisations are ubiquitous, appearing in various technical (e.g., information visualisation, scientific visualisation and geographic visualisation) and functional (e.g., statistical graphics, information graphics and data journalism) orientations (Bishop et al., 2013). Analytical visual tools are increasingly being developed for scientific communities to analyse data and support cross-