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The potential impact of green agendas on historic river landscapes: Numerical modelling of multiple weir removal in the Derwent Valley Mills world heritage site, UK

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ABSTRACT

The exploitation of river systems for power and navigation has commonly been achieved through the installation of a variety of in-channel obstacles of which weirs in Britain are amongst the most common. In the UK, the historic value of many of these features is recognised by planning designations and protection more commonly associated with historic buildings and other major monuments. Their construction, particularly in the north and west of Britain, has often been associated with industries such as textiles, chemicals, and mining, which have polluted waterways with heavy metals and other contaminants. The construction of weirs altered local channel gradients resulting in sedimentation upstream with the potential as well for elevated levels of contamination in sediments deposited there. For centuries these weirs have remained largely undisturbed, but as a result of the growth in hydropower and the drive to improve water quality under the European Union's Water Framework Directive, these structures are under increasing pressure to be modified or removed altogether. At present, weir modifications appear to be considered largely on an individual basis, with little focus on the wider impacts this might have on valley floor environments. Using a numerical modelling approach, this paper simulates the removal of major weirs along a 24-km stretch of the river Derwent, Derbyshire, UK, designated as a UNESCO World Heritage Site. The results suggest that although removal would not result in significant changes to the valley morphology, localised erosion would occur upstream of structures as the river readjusts its base level to new boundary conditions. Modelling indicates that sediment would also be evacuated away from the study area. In the context of the Derwent valley, this raises the potential for the remobilisation of contaminants (legacy sediments) within the wider floodplain system, which could have detrimental, long-term health and environmental implications for the river system. Worldwide, rivers have a common association with industry – being the focus of settlement and development since the earliest civilisations with channel engineering a common practice. Therefore, the conceptual issues raised by this study have global resonance and are particularly important where heritage protection is less robust and structures can be removed with little consideration of the environmental consequences.

1. Introduction

On a global scale, many of the world's great civilisations have developed around river systems with growth and prosperity dependent on working with and managing their associated hydrological regimes (Macklin and Lewin, 2015; Vianello, 2015). In the UK, the exploitation of river systems for navigation and power, particularly since medieval times (Lewin, 2010, 2013), has been carried out through channel modifications, including locks, weirs, leets, and races. Weirs, in particular, are one of the most widespread forms of historical channel modification – regulating channel flows, usually to provide a head of water for power generation or to aid navigation via lock systems. The historical importance of many of these structures has led to numerous examples gaining conservation designations more normally associated with major buildings of national importance. In many ways, weirs and other riverine structures have been transformed from water management features to culturally important and protected features of the contemporary riparian corridor (Firth, 2014, 2015). As a point of

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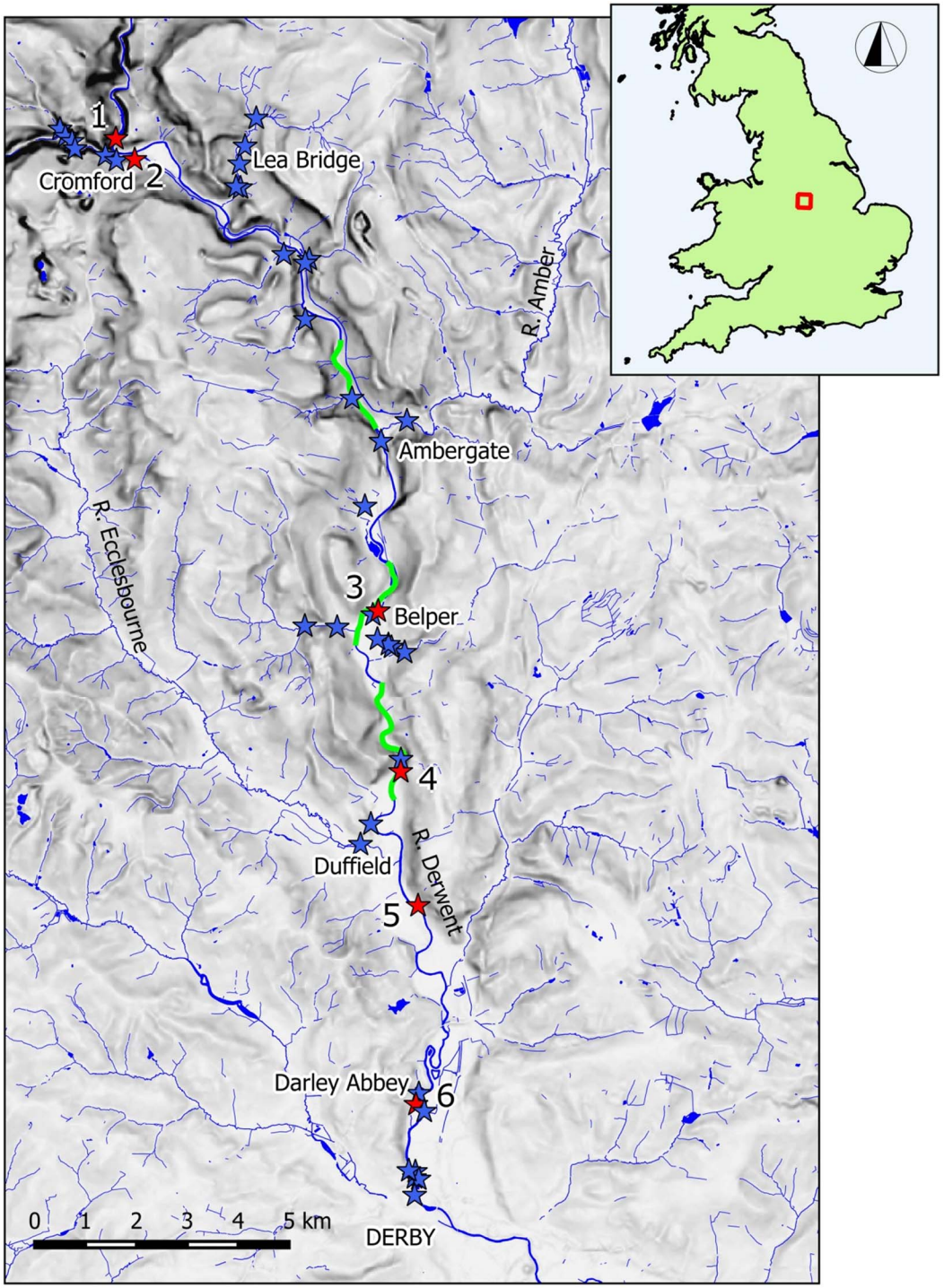

Fig. 1. The Derwent Valley Mills World Heritage Site. Mill complexes are denoted by blue stars. The listed weirs are denoted by red stars referred to in Table 1. Modelled stretches of river compared in Figs. 9–11 are shown by thick green lines (see Fig. 3 also). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)