Environmental Technology & Innovation 7 (2017) 44–53

Contents lists available at ScienceDirect

Environmental Technology & Innovation

journal homepage: www.elsevier.com/locate/eti

Spatio-temporal challenges in representing wildlife disturbance within a GIS

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HIGHLIGHTS

- Temporal behavioural fluctuations are important for disturbance susceptibility.
- Temporal GIS models can be used to synchronise development with conservation.
- Disturbance tolerances can be accounted for at the scale of the individual animal.

ARTICLE INFO

Article history:
Received 7 April 2016
Received in revised form 8 December 2016
Accepted 13 December 2016
Available online 14 December 2016

Keywords:
Ecological disturbance
Development sites
Protected species
GIS representation
Ecological networks
Temporal ecology

ABSTRACT

Assessing the potential environmental impacts of disturbance on protected species during and after the development process is a legislative requirement in most nations. However, the restrictions that this legislation places on developers are often based on limited ecological understanding, over-simplified methodologies, less-than-robust data and the subjective interpretations of field ecologists. Consequently, constraints may be imposed with no transparent methodology behind them to the frustration of, and occasionally large expense to, developers. Additionally, protected species numbers continue to decline and biodiversity continues to be threatened. This paper describes a GIS conceptual model for assessing ecological disturbance vulnerability, based upon a case study development in Scotland. First, uncertainties in traditional methods of recording and representing ecological features with GIS are reviewed such that they may be better accounted for in the disturbance model. Second, by incorporating temporal fluctuations in ecological behaviour into the disturbance susceptibility concept, it is argued that it is possible to synchronise development with conservation requirements. Finally, a method is presented to account for disturbance tolerances at the scale of the individual animal. It is anticipated that this model will enable environmental impact assessors to produce more robust analyses of wildlife disturbance risk and facilitate synchronisation between development and wildlife vulnerability to minimise disturbance and better avoid delays to the works programme.

1. Introduction

Increasing demand for housing, commerce and industry, driven by an expanding human population, is perpetuating global urban development (Millennium Ecosystem Assessment, 2005). However, as global landscapes become increasingly

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http://dx.doi.org/10.1016/j.eti.2016.12.003

urbanised, space available for new development becomes ever more constrained. This constraint is compounded by the need to maintain multifunctional landscapes that promote prosperity for both humans and wildlife (Angold et al., 2006; Rudd et al., 2002) for intrinsic purposes, and to continue the delivery of ecosystem services (Millennium Ecosystem Assessment, 2005). For these reasons, a series of legislative measures have been introduced affording legal protection to selected species and habitats deemed to be under threat or of particular cultural significance. Central to this concept of protection is the notion of 'wildlife disturbance', such as that caused by excessive noise, vibration, loss of food sources or the introduction of new predators. Disturbance is prohibited for certain species under the Habitats Directive (European Commission, 1992) and Birds Directive (European Commission, 2009), and various national laws devolved from them. There is, however, no universally accepted definition of the term 'wildlife disturbance' leaving it open to interpretation in best practice guidance issued by statutory regulators. Consequently, environmental impact assessments with a wildlife disturbance component are open to subjectivity and lack a standardised approach.

A more in-depth model of wildlife susceptibility to disturbance is clearly needed to reduce levels of subjectivity and improve the means by which development constraints are integrated into development programmes. Given that the risk of disturbing an animal is largely subject to spatial criteria, Geographical Information Systems (GIS), offer a solid foundation upon which to achieve this task. GIS data are also easily displayed via a website or server system, facilitating communication, and may be viewed at multiple scales to better understand a sites context and broader landscape connections. GIS has already established its credentials as a planning tool in ecology, for example, in the design of wildlife corridors (Jenness et al., 2010), nature reserves (Ball et al., 2009) and habitat restoration schemes (Rempel, 2008).

Goodchild et al. (2007) defines three levels of abstraction between real world phenomena and GIS representation—conceptualisation of the processes and interactions inherit to the studied phenomenon, recording of the variables of interest and representation of the variables in appropriate digital form. In the context of wildlife disturbance on a development site there are challenges at each level of abstraction.

Difficulties at the conceptual level are illustrated through a lack of legislative clarity in the definition of wildlife disturbance. Such ambiguity has led to differing requirements for the treatment of badger (*Meles meles*) setts for example, protected from disturbance in the UK by the Protection of Badgers Act 1992. In Scotland, the current requirements for compliance with this legislation involves creating a protection zone of 30 m around the sett, within which potentially disturbing activities are prohibited (Scottish Natural Heritage, 2013a). However, the English approach (English Nature, 2002) leaves the interpretation of disturbance to the field ecologist. Whilst the English approach can facilitate a more complex conceptualisation of wildlife disturbance, its application could be biased by social or cultural values and research specialisations of the individual ecologist. Conversely, the problem with the Scottish methodology is twofold: first, the discrete representation undermines the obvious distance decay in disturbance probability with respect to proximity to the sett entrance; second, the protection zone radius of 30 m, based on tunnel lengths of excavated setts (Raynor, 2012) is designed to protect the sett structure, giving little consideration to adverse effects of noise or vibration upon the badger inside. In more extreme cases of physical disturbance such as pile driving or blasting, the protection zone is increased to 100 m radius (Scottish Natural Heritage, 2013a), although the justification for this distance is not given in any of the reviewed literature.

At the recording level, challenges arise from not being able to monitor wildlife completely and directly in the field. For example, whilst animals are frequently GPS or radio tagged, giving insight into their spatio-temporal positions, which in turn allows the derivation of home range (Powell, 2000), interaction patterns (Handcock et al., 2009) and travelling routes (Nams, 2005), the capture and tagging of every animal on a large development site is impractical. Thus, ecological knowledge is often derived from field signs including faeces, hair, prints and scratches, which are easy to miss in the field (Parry et al., 2013). Although such uncertainties are reducing with the introduction of video technology (Moll et al., 2007), surveillance generally covers only a small area of a given site and a sub-selection of individual animals.

At the representational level, challenges chiefly arise from the temporally-dynamic nature of ecosystem functioning, thus affecting the severity and likelihood of wildlife disturbance. Bats for example, are extremely reliant upon undisturbed hibernation in order to maintain sufficient fat supplies to last the winter (Thomas, 1995). Similarly, The Forestry Commission (1995) advocates the cessation of works in close proximity to badger setts at dawn and dusk to allow its occupants to move in and out, illustrating the species' dependence upon daylight cycles. The lack of an innate temporal query language within most GIS applications means that answering questions regarding when a particular operation (e.g. pile driving) should be conducted to coincide with periods of low disturbance likelihood is difficult.

This paper offers a detailed assessment of the conceptual, recording and representational challenges faced in communicating wildlife disturbance constraints within a GIS for a case study site in the Central Lowlands of Scotland. To begin with, potential receptors to disturbance are discussed, along with uncertainties in their traditional GIS representations. Temporal fluctuations in disturbance susceptibility are then considered, and insights offered into how anthropogenic disturbance may be synchronised with cyclic variations in wildlife activity to minimise disturbance. Finally, in the light of these discussions, a conceptual model for wildlife disturbance vulnerability is proposed. The model accounts for a more detailed understanding of wildlife ecology and encompasses spatio-temporal uncertainties in ecological knowledge.

2. Methodology

Challenges are illustrated using ecological examples from a large (10 km^2) brownfield site, located 20 km west of Glasgow, Scotland. The site has proposals for 2500 units of housing, a 150,000 m^2 business park, related infrastructure and