Predicting visitor densities in protected areas – rules of thumb for managers based on GPS-tracks

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Introduction

In many nature areas the dual mandate to protect natural values and provide opportunities for visitors to enjoy the area might lead to potential conflicts (Reed and Merenlander 2008). Recreation can have a negative impact on biodiversity values (Larson et al 2016). However providing access to protected areas is important to build support for an effective conservation policy (Thompson 2015). Therefore managers need to plan actions with care and involve stakeholders in their decision making (McCool 2016). To make adequate choices, managers need to know where biodiversity values coincide with visitor use (Hadwen et al. 2007, Wilson et al 2004) and what the impact of their actions will be. Therefore the need to understand which features of the landscape and path network will determine the temporal and spatial distribution of visitors (Hammit et al. 2015).

Visitor densities tend to be very heterogeneous in nature areas (Hammitt et al. 2015, Marion and Farrell 2002). They are dense at the entrance or parking lots as they act as gates for the area (Beunen et al. 2008). From these gates visitors disperse into the area using the path network. Their distribution will reflect the choices they make during their visit (Wolf et al. 2015). These choices are a function of the environment surrounding the visitor, the personal aims and interests of the visitor and the way they interact (Meinig 1979, Helbing and Molnar 1995). As all these features will interact during a visit it is difficult to identify which features account for differences in visitor densities (Shoval et al. 2010).

The aim of this conference paper is to derive rules of thumb for managers to predict how far visitors will enter the area and where visitor densities are high. We will use statistics to predict what features of the path network and landscape characteristics determine visitor densities in the area. We used a large dataset of GPS tracks from walkers and dog-walkers that has been collected during the PROGRESS research project for monitoring purposes in the New Forest (UK, Edwards and Smith 2011). GPS tracking is a common method in recreation studies (Beeco and Brown 2013). However, GPS studies have focused on its utility for monitoring visitors and not on understanding what drives visitor patterns and densities (Beeco et al. 2014).

Method

The dataset has been collected in the New Forest during spring 2004 at 41 parking lots and contained 1563 GPS tracks and 110505 single data points. The data points of each track were used to derive the expected route of a visitor in three steps. First, outliers were deleted. In the second step data points were snapped to the path network. In the third step we used a travelling salesman’s route algorithm to derive the most likely route from the itinerary information of the tracks. Finally a manual check was executed. The expected routes of all tracks were combined to create a map of the expected visitor densities in the area.

The input variables of the statistical model contain several maps: path network including path type, parking lots, vegetation map, slope of the area, the openness of the landscape based on

Viewscape (Meeuwsen and Jochem 2013), traffic noise and a map with compartments that are enclosed by tarmic roads (Henkens et al. 2006).
After an exploratory data analysis, a Cubist regression tree has been built to select a small set of important explanatory variables that are related to visitor densities in the New Forest area. This set has subsequently been used to build statistical models (e.g. logit-regression) to link various dependent variables (e.g. probability of road crossings) to environmental characteristics (e.g., openness, path type).

Results

The data preparation of the GPS tracks lead to the deleting of 5% of the single data points and a final dataset of 1553 routes. The statistical model showed that distance to parking lot is an important factor for predicting visitor densities (e.g. Meijles et al. 2014, Zhai et al. 2018). Other important factors are path type, vegetation type and openness. The regression tree did not select slope as an important factor and although the exploratory data analyses indicated noise as an important factor in the combined model it was not selected as one of the top variables.
The analyses also showed that tarmic roads act as a barrier for visitors and the probability of visitors to cross a road depends on the landscape setting and type of visitor. In open landscapes the visitors tend to cross roads less often than in more closed landscapes (Figure 1). Also dog-walkers tend to cross roads less often than walkers.

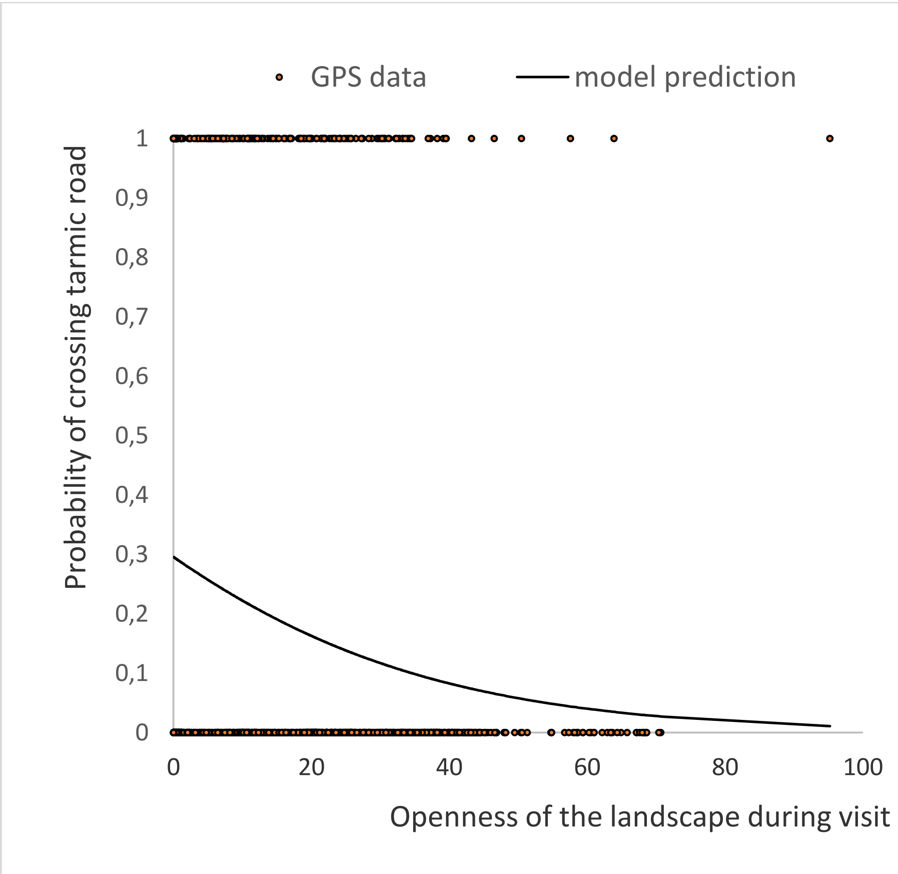

Figure 1 Change of visitors crossing tarmic roads in relation to openness of the landscape.

Discussion

For this study we used an already available dataset of GPS tracks. We used this set to understand what drives visitor patterns and densities in nature areas (Beeco et al. 2014). Understanding these drivers is important to derive rules of thumb for mangers to predict the impact of their actions.

The model showed that openness is important to predict visitor densities as well as the probability of visitors to cross roads. For managers this information can be used to guide visitor patterns depending on the sensitivity of nature values. Designing crossings of the path network and road network in an open landscape will result in lower visitor densities on the other site of the road than designing these crossings in a closed landscape.

Another factor that is important for managers is the so-called penetration distance of visitors into the area (see Hornigold et al. 2016). In our dataset we tried to find a relationship between path density and the penetration distance. This was not significant, so visitors tend to go into a certain direction regardless the number of crossings with other paths. However, our dataset did show a difference in penetration distance between dog-walkers and walkers. Further analyses are needed to provide guidelines with respect to the impact of the openness of the landscape on the distance people enter the area.

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