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Managing the timing and speed of vehicles reduces wildlife-transport collision risk

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ABSTRACT

Understanding wildlife-vehicle collision risk is critical to mitigating its negative impacts on wildlife conservation, human health and economy. Research often focuses on collisions between wildlife and road vehicles, but collision risk factors for other types of vehicles, less examined in the literature, may also be informative.

We studied spatial and temporal variation in wildlife-train collision risk in the State of Victoria, Australia. We quantified train movements in space and time, and mapped species occurrence likelihood, across the railway network. Using spatially- and temporally-resolved collision data, we fitted a model to analyse collisions between trains and kangaroos; accounting for time of day, train frequency and speed, and kangaroo occurrence. We then predicted collision rates on the passenger railway network under three management scenarios relating to train speed and occurrence of kangaroos near the railway lines.

Temporal variation in animal activity was the strongest predictor of collision risk. Train speed was the second most influential variable, followed by spatial variation in likelihood of species occurrence. Reducing speeds in areas of high predicted species occurrence and during periods of peak animal activity (early morning and evening for kangaroos) was predicted to reduce collision risk the most.

Our results suggest mechanisms that might improve existing wildlife-transport collision analyses. The model can help managers decide where, when and how best to mitigate collisions between animals and transport. It can also be used to predict high-risk locations or times for (a) timetable/schedule changes (b) proposals for new routes or (c) disused routes considered for re-opening.

1. Introduction

Wildlife collisions with transport vehicles pose a serious global problem (Litvaitis and Tash, 2008) and inspire research to investigate causes and propose solutions. For example, deer-vehicle collisions on roads are common and well-studied in North America (Huijser et al., 2007; Romin and Bissonette, 1996) and Europe (Sáenz-de-Santa-María and Tellería, 2015; Seiler, 2004). In addition to concerns about animal welfare (Sainsbury et al., 1995) and conservation status of threatened species (Dwyer et al., 2016; Jones, 2000), collisions with large animals pose direct risks to the life of humans (Langley et al., 2006; Rowden et al., 2008). Moose, for instance, are one of the largest animals struck by vehicles in North America and Europe, causing significant damage and injuries

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(Huijser et al., 2007; Hurley et al., 2009). Vehicle collisions with deer, although smaller than moose, frequently kill humans in North America (Williams and Wells, 2005). Collision events disrupt transportation services, and are therefore also an economic burden. Management of wildlife-vehicle collisions will become increasingly important as new transportation networks are constructed and existing networks are expanded.

Information about the spatial and temporal distribution and magnitude of wildlife-vehicle collisions is useful to managers because it can more effectively help mitigate impacts (Mountrakis and Gunson, 2009). For example, identifying a collision hotspot along a transportation network for a particular species can inform the most appropriate form of mitigation (e.g. animal exclusion or change in vehicle speed – see Visintin et al., 2016). Collision data can also be used in statistical modelling which helps to predict the probability of wildlife-vehicle collisions (Gunson et al., 2011).

The majority of wildlife-vehicle collision modelling deals with roads and traffic (Popp and Boyle, 2017; van der Ree et al., 2015), yet, the problem extends to other forms of vehicular transportation such as air (van Belle et al., 2007), railway (Belant, 1995; Onoyama et al., 1998; Wells et al., 1999) and shipping (Laist et al., 2001) operations. Regardless of the mode of transport, the modelling of collisions share some common attributes (Forman et al., 2003). The movements or presence of animals are often considered in the models and may include species-specific habitat variables (Roger and Ramp, 2009) or behavioural traits (Lee et al., 2010). Vehicle presence or movements are also considered and may be grouped into a larger category of human behaviour as humans ultimately control speeds and trajectories of vehicles (Ramp and Roger, 2008).

Some drawbacks of existing road ecology studies are that the time of collision is often not known precisely, the volume of traffic varies temporally and is difficult to accommodate in analyses (especially when time of collision is not known), and collisions might be under-reported or temporally and spatially biased. These drawbacks might obscure drivers of collision risk or provide inaccurate predictions of risk upon which mitigation might be implemented. These considerations are especially important for studies that explore temporal variation in animal activity (e.g. Dussault et al., 2006, Thurfjell et al., 2015) as reporting errors in collision times may produce spurious correlations (or lack of).

Wildlife-train collisions provide a different dataset for considering factors that influence collision risk that are often difficult to obtain. Firstly, the timetabling of trains means that their movements are much more precisely documented than those of cars. Secondly, collisions with large animals are more consistently reported for trains than cars – although under-reporting is still an issue (Dorsey et al., 2015). And thirdly, the time of collision is also reported more precisely. These benefits mean that examining factors that influence wildlife-train collision risk may help uncover factors that influence wildlife-vehicle collisions more generally.

Herein, we develop a modelling framework to predict the rate of wildlife-train collisions across a large railway network. We use kangaroos and a regional passenger railway network in south-east Australia as an example to demonstrate our methods. In addition to informing railway operators in Australia of potential kangaroo collision risks, our approach can be generalised to other species (e.g. deer) and transportation modes (e.g. road vehicles, watercraft) elsewhere in the world by incorporating parameters that accommodate patterns of species activity.

2. Materials and methods

2.1. Study area

Our study area encompassed a 1712-kilometre passenger railway network from regional Victoria, Australia (operated by V/line, a government-owned corporation) in south-east Australia (Fig. 1). Trains operate on all sections of the network between 4 a.m. and 2 a.m. (the following day), with the largest volume occurring Monday through Friday between 7 a.m. and 9 a.m., and 4 p.m. and 6 p.m. Most trains operate at speeds of 100 $km\,h^{-1}$ or less, however, on some sections of track commuter trains operate at maximum speeds of 160 $km\,h^{-1}$. Due to limited data available, we did not include freight operations in our study.

2.2. Data preparation

To organise our data and modelling, we overlaid a 1-km^2 cell grid on the railway network (Fig. 2). In each grid cell we modelled kangaroo occurrence and quantified train movements and speeds to generate predictor variables (Table 1); each is described in more detail in subsequent sections.

Collisions with large mammals (e.g. domestic livestock or kangaroos) must be reported by train drivers to allow trains to be inspected and maintenance performed as required. Eastern grey kangaroos (*Macropus giganteus*, Shaw, 1790; "kangaroos" hereafter) are frequently struck in regional Victoria and large enough – up to 85 kg – to cause noticeable damage to composite body panels or require the train to be removed from service for cleaning. In this study, we assumed that 'kangaroos' reported by train drivers could also include other large macropods (two other kangaroo species), albeit these would be rare due to the limited overlap of the train network on these species' ranges. We also assumed that collisions were perfectly detected at all times of the day, however, visibility issues during non-daylight hours may have affected reporting rates.

V/line provided records of all driver-reported collisions with kangaroos spanning a seven-year period between 1 January 2009 and 31 December 2015, a total of 439 collisions. These were reduced to 404 when spatial and temporal duplicates were removed. Whilst 404 collisions over a seven-year period suggests rarity, issues with data availability suggested that this number under-represented actual collision numbers. For example, not all records were available in electronic format (V/line, personal communication), therefore we only received records that were entered into, and could be queried from, a train operator database. Nonetheless, we considered this dataset useful to test our model and its sensitivity to operational changes on the train network. Each record