Frequency of animal-vehicle collisions in NSW

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ABSTRACT

Animal-vehicle collisions occur daily on roads around the world, putting drivers and passengers at risk of trauma and death. There is limited routine information about the incidence of such collisions and their resultant trauma and healthcare burden in Australia. Without this information it is difficult to quantify the magnitude of the problem, identify contributing factors or prioritise potential solutions. One source of data is the Traffic Accident Database System of NSW that is maintained by the NSW Roads and Traffic Authority. We queried this database for crashes involving animals in NSW over ten years from 1996 to 2005. In this paper we summarise the temporal and spatial patterns that emerge from these crashes and use the findings to highlight the ramifications for those seeking preventative solutions. We advocate a strategic cross-sectoral approach to understanding animal-vehicle crashes, particularly for improving the health status of our rural communities.

Key words: roadkill, hotspots, spacial and temporal patterns, human injury, traffic accident database, animal-vehicle crashes

Introduction

Road trauma is a significant public health problem, particularly on rural roads. With an increase in the number of vehicles and our greater reliance on the road transportation network over the past 30 years, collisions between animals and vehicles have become a concern for health agencies, environmentalists, animal welfare groups and road safety agencies. The significance of animal-vehicle related trauma is highlighted when the potential costs of treating and managing the resultant road trauma are added to the costs associated with a reduced quality of life (due to physical and psychological trauma), indirect costs (e.g. productivity absences), property damage (and resultant increases in insurance costs), and ecological damage (and resultant economic costs, e.g. to the tourist industry). While there is considerable literature on the magnitude of the animal-vehicle trauma problem in Australia and elsewhere (Groot Bruinderink and Hazebroek 1996; Putman 1997; Ramp 2005), the data used to assess the human trauma associated with animal-vehicle crashes and their causal factors are limited. These limitations must be addressed so that the road trauma toll, particularly in rural areas, can be reduced.

Information on animal-vehicle crashes is largely from the USA and Europe. In the USA in 1991, 538,000 deer-vehicle collisions on public highways resulted in deer fatalities, killed 100 motorists and injured a further 7,000 people (Romin and Bissonette 1996). More recently, it has been estimated that more than 1,500 people were killed in animal-vehicle collisions in the USA over the last ten years (Khattak 2003; Williams and Wells 2005). A decade later, police in the USA received reports of 247,000 animal-vehicle crashes during 2001-2002, described 26,647 vehicle occupants being treated for non-fatal injuries (Conn *et al.* 2004). Cook and Daggett (1995) estimated the total cost of animal-vehicle collisions in the USA to be around US$1.2 billion per year. Animal-vehicle collisions are also a problem in Australia where there is an extensive network of rural roads, and large wildlife (particularly kangaroos) and livestock (sheep and cattle) within the vicinity of these roads.

Unfortunately, data on the incidence of trauma resulting from animal-vehicle collisions are not recorded systematically by any particular organisation. The only Australian study to date examined traumatic injuries in 46 patients who presented to Royal Perth Hospital from collisions with kangaroos between 1994 and 2000 (Abu-Zidan *et al.* 2002). Vehicle accidents related to the presence of an animal on a road are significantly underreported. Often, drivers swerve to miss animals only to hit roadside obstacles such as trees and poles or oncoming vehicles. These instances are often missed in routine data collections because they would not be coded as having animal involvement. Some information on property damage associated with these collisions is available from vehicle insurance bodies such as the National Roads and Motorists' Association in Australia which estimates that for those collisions reported to insurance agencies, vehicle damage from collisions with animals cost an average of $3,000 per incident (NRMA 2003).

One source of data that contains information on the human side of animal-vehicle collisions is the Traffic Accident Database System of NSW. We queried this database for crashes involving animals in NSW over ten years from 1996 to 2005. Our aims were to (i) summarise the temporal and spatial patterns that emerge from these crashes, (ii) identify data quality issues surrounding the collection of information stored in the database, (iii) make recommendations for improvement in data collection and (iv) use the findings to highlight the ramifications for those seeking preventative solutions.

Pp 118 - 126 in *Too close for comfort: contentious issues in human-wildlife encounters,* edited by Daniel Lunney, Adam Munn and Will Meikle. 2008. Royal Zoological Society of New South Wales, Mosman, NSW, Australia.

Methods

Data for this study was provided by the NSW Roads and Traffic Authority (RTA) who maintain the Traffic Accident Database System of NSW (TADS). TADS is a computer system which is used to enter and produce statistics on road traffic accidents in New South Wales. Data are gathered and included in TADS only when road crashes are reported to NSW Police. The TADS Data Manual (NSW Roads and Traffic Authority 2003) describes the circumstances where this comes about. Prior to 2000, section 8 (3) of the Traffic Act 1909 required a road accident in NSW to be reported to police when any person was killed or injured or property damage over $500 was sustained. Post 2000, the Traffic Act was replaced by new traffic legislation, including the adoption of the Australian Road Rules. Rule 287 (3) of the Australian Road Rules requires an accident to be reported to police when any person is killed or injured; when drivers involved in the accident do not exchange particulars; or when a vehicle involved in the accident is towed away. NSW police maintain the Computerised Operational Policing System (COPS) which records all police attendance of accidents. Accidents that also fulfil the police attendance requirements but attendance does not occur are also recorded on COPS. Other minor accidents (Self Reporting accidents) can also be recorded on COPS. Data are entered into TADS for all accidents in which a person was killed or injured or at least one motor vehicle was towed away. Typically, 50,000 crashes are recorded annually in NSW, with approximately 500 of those recorded as involving an animal in some way.

Following submittal of a request to the RTA, RTA staff queried TADS for all instances of crashes involving animals for the ten years between 1996 and 2005. This query resulted in 5,119 geolocated data points. Temporal patterns were explored graphically using a database of the extracted data. These data were exported into ArcGIS 9.1 (ESRI 2004) for spatial analysis. Spatial clustering of the three most prominent species groups recorded as being involved in crashes with vehicles was conducted using kernel density transformation, a Spatial Analyst tool in ArcGIS. For each species group, a series of kernel densities were run using varying bandwidths and input into Cell Stat. The Cell Stat function allows for the discrimination of the highest value in which density is maximized. For each of the three species groups the selected bandwidth value was a search radius of 40 km^2.

In this paper we make reference to terms used in the TADS database. Where these terms are used they are reported in inverted commas. Exact definitions can be found in the TADS database manual (NSW Roads and Traffic Authority 2003). The recording of information using these terms gives us the ability to query the database and infer patterns yet the definition and precision of these terms create uncertainty and limit the scale of analyses.

Results

As the primary object of collision, the three most commonly collided with animals were 'kangaroos or wallabies' (41.2 %), 'straying stock' (31.4 %) and 'dogs' (10.4 %) (Table 1). A second object was recorded as being hit in (11.9 %) of accidents. The three most commonly collided with secondary objects were 'trees or bushes' (32.3 %), 'guardrails or fences' (18.8 %) and 'embankments or rocky outcrops' (12.1 %). 'Straying stock' were also often hit as secondary objects (8.9 %).

Where crashes involved animals, 22 human fatalities were recorded in TADS between 1996 and 2005 in NSW (Figure 1). By far the most frequently involved animal in these crashes were 'kangaroos or wallabies' (13 or 59.1 %). 'Straying stock' and 'riderless horses' were both responsible for four human fatalities each (or 18.2 % each), while the common wombat was responsible for one fatality. Secondary objects were involved in six of the crashes that resulted in human fatalities, although the database does not identify whether the primary or secondary object was ultimately responsible for the severity of the crash. Of the six, 'trees or bushes' accounted for four of the crashes (Table 1).

A total of 1,462 crashes involving animals resulted in human injuries were recorded in TADS between 1996 and 2005, resulting in injuries to 1,708 people. The worst crash saw seven people injured, although 86.3 % of crashes only saw injuries to one person. Querying the database for 'degree of accident', 24 crashes are listed as resulting in fatalities, 1,487 resulting in injuries and 3,608 resulting in non-casualty tow-away. These values differ slightly from data obtained by querying 'number killed in this traffic unit' and 'number injured in this traffic unit' due to data entry errors. Two additional fatality causing crashes are listed in 'degree of accident', one to a 'kangaroo or wallaby' and one to a 'riderless horse'. It is not possible to say whether the error reflects actual fatalities or not. Likewise, a number of crashes listed as resulting in injuries in 'degree of accident' do not have injured listings in 'number injured in this traffic unit'. Injuries also occurred in accidents listed as 'fatalities' that would not be picked up in 'degree of accident'. Most injury causing crashes resulted from colliding with 'kangaroos or wallabies' (37.5 %), followed by 'straying stock' (24.5 %) and 'dogs' (17.4 %).

Temporal patterns

An average of 511.9 ± 32.2 (mean ± 95 % confidence interval) crashes involving animals and recorded in TADS in NSW occurred over the ten years between 1996 and 2005 (Figure 2a). This resulted in average of 2.75 ± 0.98 human fatalities per year reportedly attributed to crashes involving animals.

Crashes involving animals did not occur evenly throughout the year, with significantly more crashes occurring in the middle of year ($df = 11$, $F = 16.401$, $p < 0.001$) (Figure 2b). The number crashes in April, May, June, July and August (mean = 52.84), almost two per day, were significantly higher than those in all other months (mean = 35.39), just over one per day.

Crash rates on weekends (mean = 83.5 per day) were significantly higher than on weekdays (other than Friday) (mean = 66.5) ($df = 6$, $F = 6.894$, $p < 0.001$) (Figure 2c).

Table 1. The number of crashes involving animals recorded in the TADS database between 1996 and 2005 in NSW.

Type of first object impacted	Damage	Human fatalities	Type of second object impacted	Damage	Human fatalities
Kangaroo or wallaby	2097	13	Trees or bushes	178	4
Straying stock	1605	4	Guardrail or fence	105	1
Dog	533		Embankments / Rocky outcrops	68	
Riderless horse	360	4	Straying stock	50	
Other large animal	177		Drain or culvert	31	
Wombat	149	1	Riderless horse	27	
Other small animals	83		Utility pole	19	
Emu	30		Kangaroo or wallaby	18	1
Stock driven or led	26		Guide post	11	
Cat	21		Signpost or parking meter	11	
Guardrail or fence	7		Other large animal	7	
Rabbit	7		Dog	7	
Trees or bushes	1		Traffic island / Median strip	6	
Roadwork / Temporary signs	1		Other non-fixed objects	5	
			Any other fixed objects	4	
			Wombat	2	
			Body of water	2	
			Other small animals	2	
			Bridge railing	2	
			Stock driven or led	1	
			Unknown / Not stated	1	
			Vehicle interior	1	
Grand Total	5097	22	Grand Total	558	6

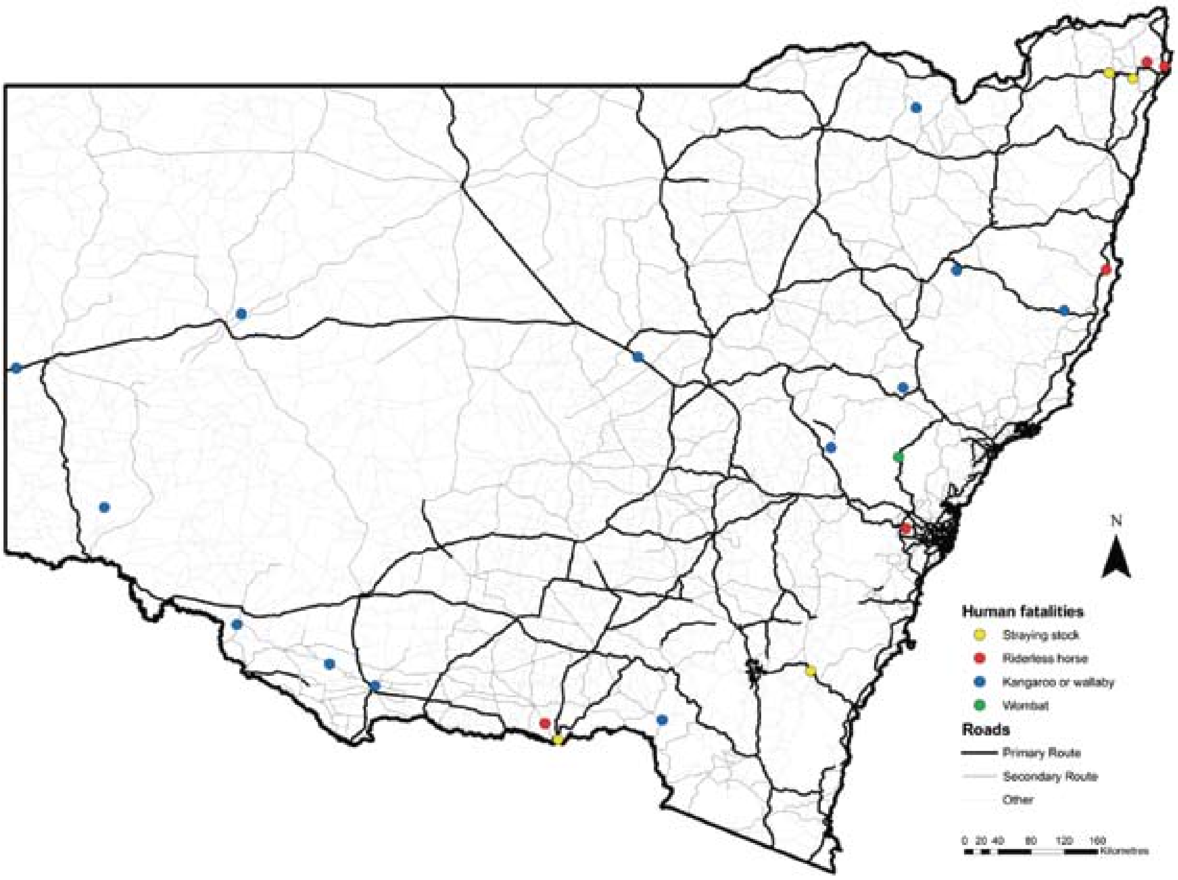

Figure 1. Distribution of the 22 crashes involving animals recorded in the TADS database between 1996 and 2005 in NSW where human fatalities occurred. The species involved in the crash is listed next to the location point.

Not surprisingly, by far the greatest temporal variation occurred diurnally (Figure 2d). Crashes occurred mainly from the evening to dawn, with 57 % of crashes in the evening from 5 pm to midnight, and 13 % in the peak period from 6 pm to 7 pm.

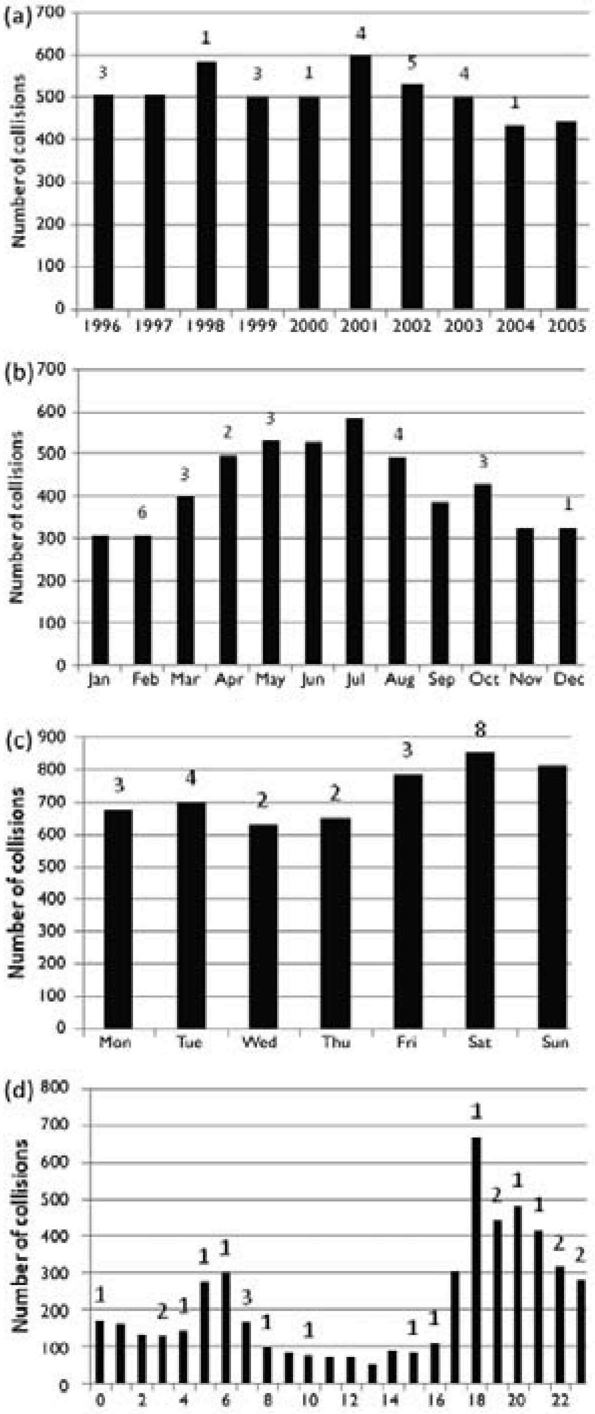

Figure 2. Temporal distribution of crashes involving animals reported in the TADS database between 1996 and 2005 in NSW. Figures represent (a) annual collision numbers, (b) monthly averages, (c) daily averages and (d) hourly averages. Value labels above bars represent the number of human fatalities reported.

Weather conditions at the time of the crash indicated that 81.7 % of crashes involving animals occurred when the conditions were classed as 'fine', including 95.5 % of crashes resulting in human fatalities, while 14.8 % of crashes occurred when conditions were either classed as 'overcast' or 'raining'. These crashes did not result in any human fatalities. The only time fatalities occurred when the conditions were not 'fine' was during 'fog or mist' (responsible for 3.0 % of reported crashes). Likewise, 86.7 % of crashes occurred when the 'surface condition' of the roads was considered 'dry', with only 12.8 % of crashes reported in 'wet' conditions. Identical proportions in 'surface conditions' were reported when crashes were severe enough to cause injuries. Twenty of the human fatalities reported occurred when 'surface conditions' were 'dry'.

Reporting of 'natural light' conditions at the time of crash identified 67.5 % of crashes occurred in 'darkness' and 20.7 % in 'daylight'. Surprisingly, only 11.8 % of crashes occurred in either 'dawn' or 'dusk' conditions. For crashes that resulted in human injuries, the proportion of crashes in 'darkness' was less (55.1 %) while the proportion in 'daylight' was greater (31.9 %).

Given that poor weather conditions are not responsible for the increase in crashes in the winter months, we compared temporal variation in the length of darkness with monthly variation in crashes (Figure 3). Variation in the length of darkness explained 88.8 % of the variation in crash rate.

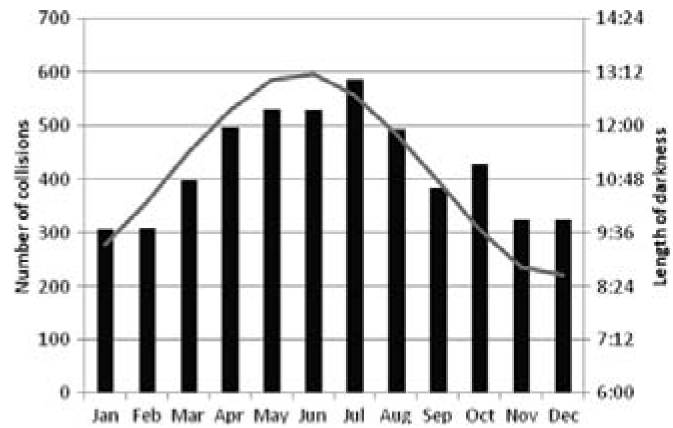

Figure 3. Monthly average number of collisions involving animals recorded in the TADS database between 1996 and 2005 in NSW. The grey line represents the mean length of time between sunrise and sunset for 2005 for NSW.

Spatial patterns

The 2,097 crashes involving 'kangaroos or wallabies' were spread across NSW but a number of clustered hotspots were identified along the eastern coast (Figure 4). Hotspots were concentrated along the Hume, Barton and Federal highways, with peaks around the intersections, particularly those at Canberra and Yass (Figure 5). Other hotspots were located near Dubbo, Newcastle and Byron Bay. Clustering of crashes involving 'straying stock' were greatest at Lismore, Newcastle and the foothills of the Blue Mountains (Figure 6). The Sydney and Newcastle hotspots are presented in more detail in Figure 7. For 'dogs', the foothills of the Blue Mountains accounted for the vast majority of crashes (Figure 8).

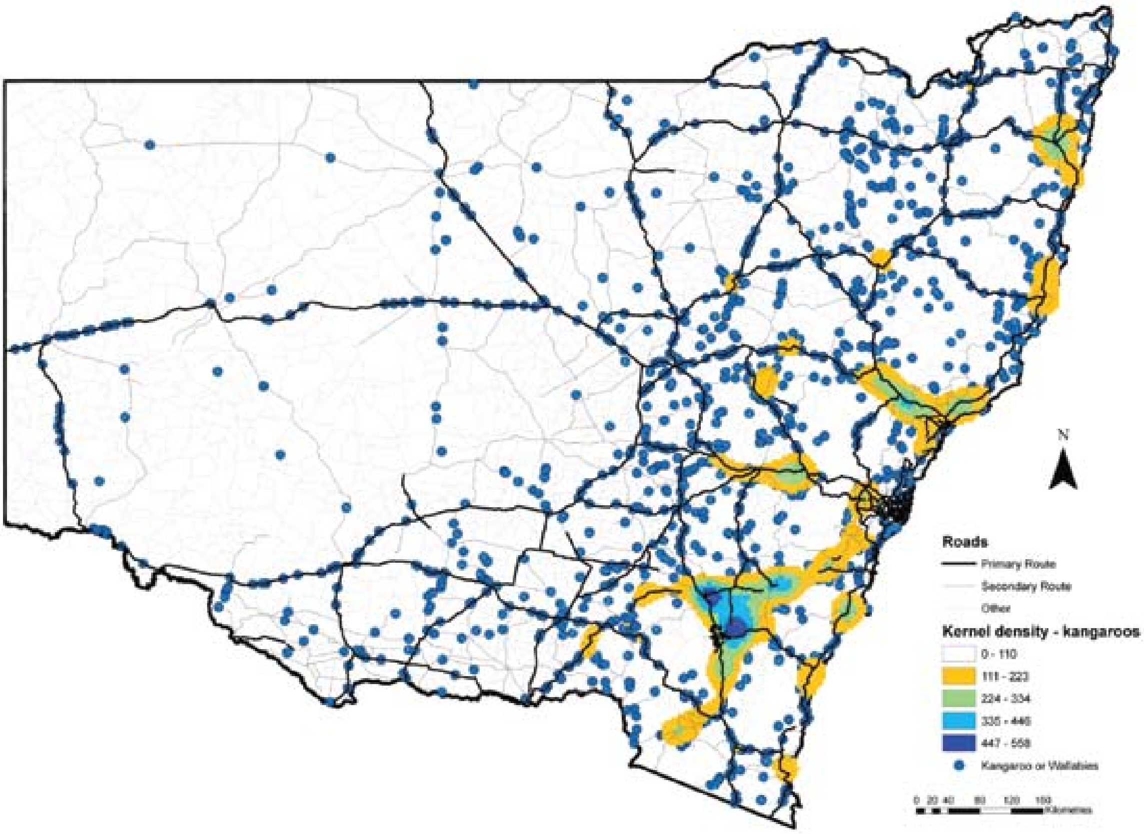

Figure 4. Distribution of crashes involving 'kangaroos or wallabies' recorded in the TADS database between 1996 and 2005 in NSW. Kernel density hotspot locations are highlighted using four categories ranging from high density to low density clusters (dark blue, light blue, light green and yellow respectively). Crash locations within hotspots have been removed for clarity.

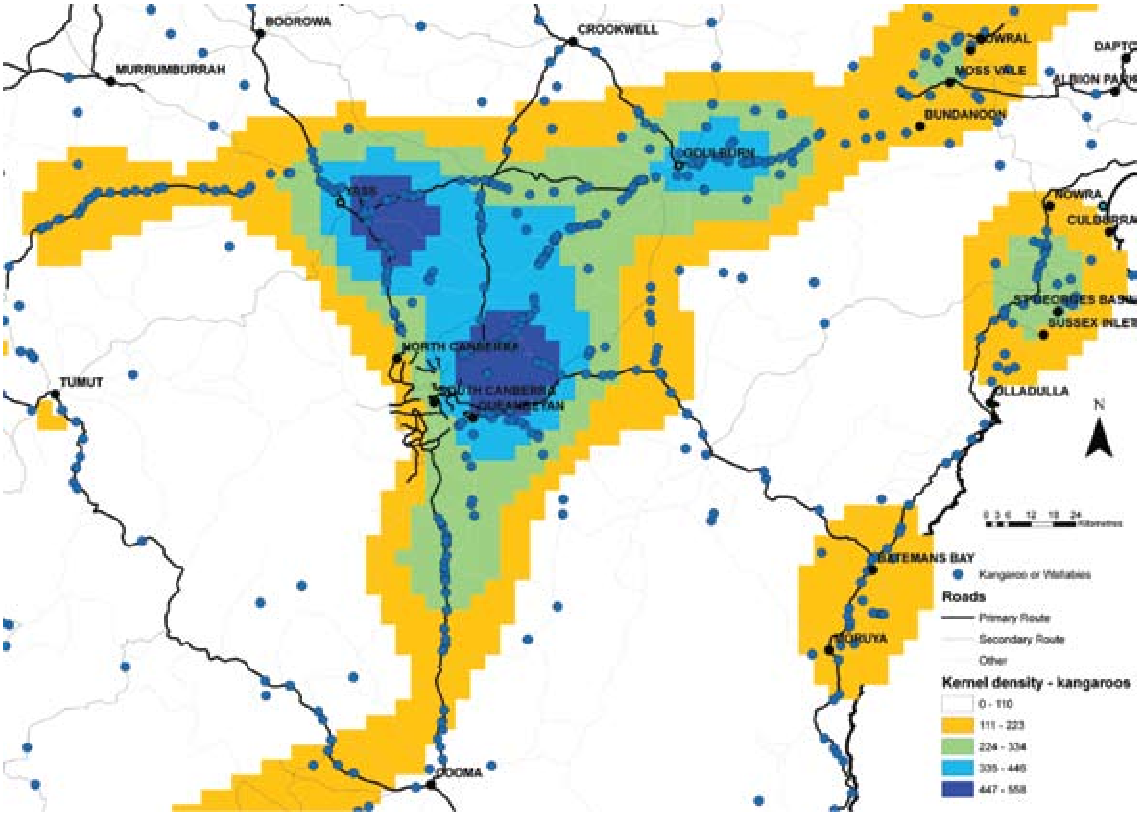

Figure 5. Crash hotspot centred on Canberra involving 'kangaroos or wallabies' (blue circles) recorded in the TADS database between 1996 and 2005. Kernel density hotspot locations are highlighted using four categories ranging from high density to low density clusters (dark blue, light blue, light green and yellow respectively).

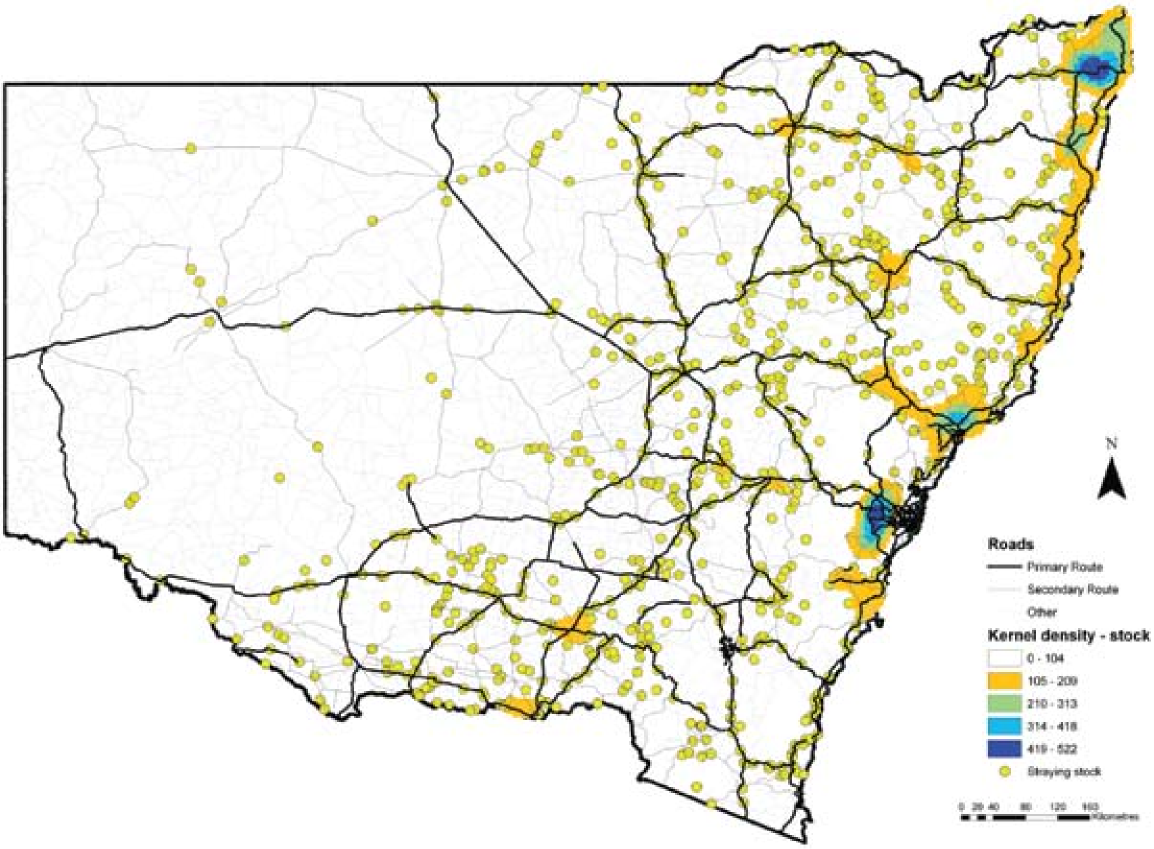

Figure 6. Distribution of crashes involving 'straying stock' recorded in the TADS database between 1996 and 2005 in NSW. Kernel density hotspot locations are highlighted using four categories ranging from high density to low density clusters (dark blue, light blue, light green and yellow respectively).

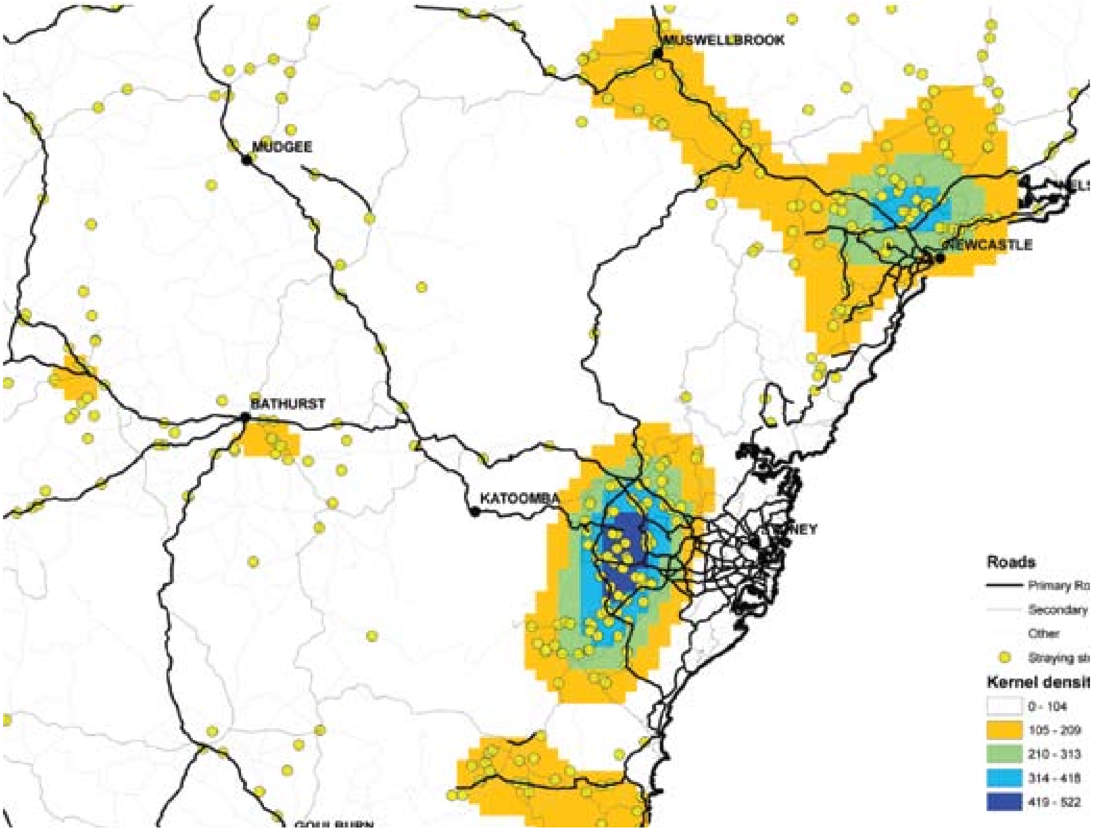

Figure 7. Crash hotspot centred on Sydney involving 'straying stock' (yellow circles) recorded in the TADS database between 1996 and 2005. Kernel density hotspot locations are highlighted using four categories ranging from high density to low density clusters (dark blue, light blue, light green and yellow respectively).

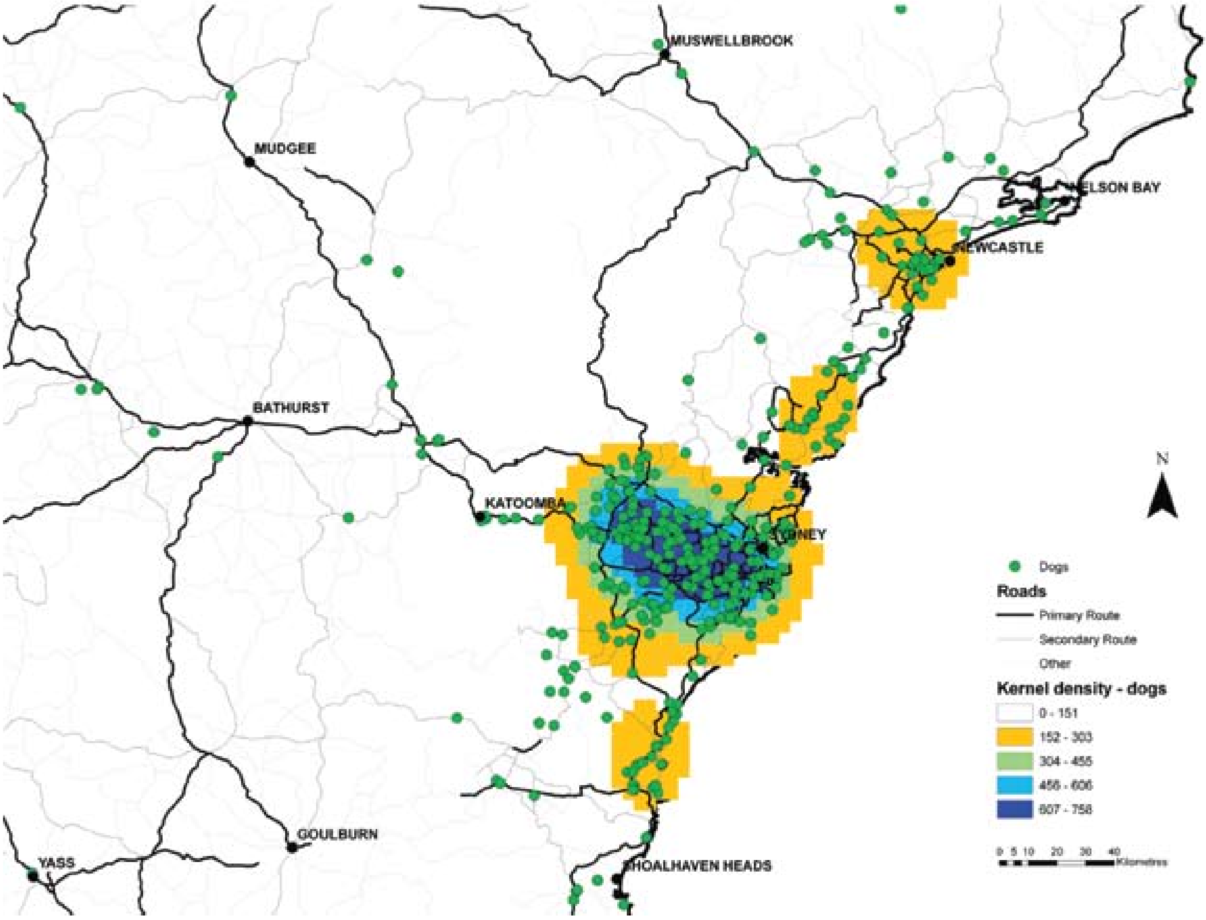

Figure 8. Crash hotspot centred on Sydney involving 'dogs' (green circles) recorded in the TADS database between 1996 and 2005. Kernel density hotspot locations are highlighted using four categories ranging from high density to low density clusters (dark blue, light blue, light green and yellow respectively). There were no other hotspots for 'dogs' in NSW.

Discussion

In this paper we have quantified the frequency of animal-vehicle collisions as recorded in the TADS database in NSW. Rather than focus on trauma to individual animals, animal populations and subsequent impacts on biodiversity, our intention was to quantify temporal and spatial patterns of crashes involving animals and the associated healthcare burden this causes. In the past ten years, reported crashes involving animals have resulted in 1,708 injuries and 22 fatalities to vehicle occupants. Data on the severity of the injuries are not recorded in the TADS database. Neither are data on the cost of vehicle damage, although these data are available from insurance companies.

The identification of crash hotspots is a vital tool in describing and managing collisions between animals and vehicles. We have identified several major hotspots for crashes involving animals throughout NSW. The knowledge that these hotspots are species specific should enable road managers and road safety engineers to focus their efforts on those species at those locations, thereby minimising the costs associated with installing multi-species road safety infrastructure. Clear seasonal variation in collision rates also suggests that the peak time for implementing any preventative strategy would be during winter when the period of night darkness is longest.

Data reliability

Research into animal-vehicle collisions will not be able to accurately determine the magnitude of the animal-vehicle trauma problem, nor will it be able to identify potential preventive strategies, until the development of good quality information about the crashes, their casual factors and their traumatic consequences. The TADS database, while a vital source of information as shown by this study, is by no means the perfect tool. As with the collation of any database, reporting error can have a significant impact on the accuracy of the information held. The recording of animal involvement in crashes is not typically perceived as a vital piece of information and may go unreported. Crashes are also likely to underestimate animal-vehicle collisions in rural areas because police reporting is not mandatory in all cases. Biases may also appear in the reporting of crashes depending upon the animal involved. Failure to report crashes with domestic and livestock animals is likely to be lower than for crashes with native fauna as (i) drivers use crash reporting as a mechanism to inform animal owners, (ii) crashes with native fauna often do not cause significant damage and (iii) drivers exhibit less concern over the welfare of native animals. In addition, the involvement of animals may sometimes be contrived; anecdotal evidence suggests that drivers may sometimes use animals (e.g. 'a large black dog') to abdicate responsibility for crashes in order to make insurance claims.

Proper evaluation of the healthcare burden is vital to properly assess the cost of animal-vehicle crashes. Trauma-related hospital admission and mortality databases currently use the International Statistical Classification of Diseases (ICD) to identify cases but this does not distinguish between crashes with pedestrians or animals. These limitations apply internationally, with Conn *et al.* (2004) highlighting a lack of coordination among national and state agencies in the USA, the exclusion of some vehicle types (e.g. motorcycles) and data only available for hospital presentations.

In contrast to reported crashes in the TADS database, our best estimates of wildlife killed on roads suggest that animal fatalities, in Australia alone, are likely to be in the millions annually, not including reptiles, amphibians or livestock (Ramp *et al.* 2005). These data suggest that many collisions with vehicles occur without them being reported to relevant agencies because they do not result in significant damage to the vehicle or its occupants.

To rectify the deficiency in reporting on animal-vehicle collisions, a rigorous assessment and review of the reported of such collisions and the resultant trauma must be a priority. This will identify specific weaknesses in current databases and recommendations on how data collection and management can be improved and how road safety policy could be better influenced.

Finding solutions

Despite the lack of available evidence to date, it is likely that the solutions will come from a combination of behavioural and vehicle design approaches. There is a particular need to understand driver reactions to animals on roads and their attitudes to the risk of collisions with them. Previous studies investigating driver behaviour and attitudes to animal-vehicle crashes have been minimal (Morrissey 2003). Nonetheless, it is known that drivers can effectively reduce the likelihood of animal-vehicle crashes by reducing their driving speed and remaining alert while driving through areas where animals are more abundant (Haikonen and Summala 2001; Khattak 2003). Information on driver responses to animals on the road, differences in behaviour for different animal types (e.g. cattle versus native fauna), and left-right preferences when swerving to avoid animal collisions is necessary to identify potential preventive strategies.

Driver attitudes are also an important consideration for understanding the aetiology of animal-vehicle crashes. Illusory invulnerability and risk propensity are two attitudinal factors potentially related to such crashes (Weinstein 1989), but how they affect driver behaviour when faced with animals on roads is currently unknown. The quantification of these attitudes will clearly contribute to our knowledge of the animal-vehicle collision moment, and assist with the development of countermeasures targeted towards drivers.

How the behaviour of different animal species to approaching vehicles influences the likelihood of a collision and resultant trauma is also an important consideration when designing preventative measures for crashes. While there is much anecdotal evidence on how different species react to approaching vehicles (e.g. kangaroos often jump into the sides of vehicles), little quantitative data currently exists. A recent study by Lee *et al.* (In Review) found that different species of kangaroo responded differently to oncoming vehicles, thereby influencing the likelihood of a collision.

In addition to driver and animal behaviours, it is very likely that engineering solutions, such as better designed cars, will be critical. Considerable debate has ensued over the past decade regarding the fitment of bullbars to the fronts of cars as trauma reduction devices for crashes with animals (Attewell and Glase 2000). However, road safety advocates point out that bullbars, because of their high stiffness, unyielding characteristics (not energy absorbing) and small contact areas, are the antitheses of designs aimed at reducing injury risk (Rechnitzer and Grzebieta 1999; Grzebieta and Rechnitzer 2001). Furthermore, they have been identified as significantly exacerbating the injury risk to pedestrians, cyclists and vehicle occupants and this, on a population-basis, may outweigh any benefits they confer in animal-vehicle crashes. The influence of bullbars and other vehicle safety measures on driver behaviour must also be evaluated. Clearly, if drivers believe they lead to invulnerability then risk propensity will increase.

Summary

- The TADS database contains 5,119 reported crashes involving animals over the 10 years between 1996 and 2005 in NSW, at an average of 1.4 per day.
- Of these, macropods, livestock and domestic animals most responsible for reported crashes.
- A total of 1,708 people were treated for injuries resulting from these crashes at roughly one person treated every three days.
- A total of 22 (perhaps 24) died as a result of crashes involving animals.
- Collisions with macropods were responsible for nearly 60 % of human fatalities, although 'straying stock' and 'riderless horses' together accounted for 36 % of human fatalities.
- The involvement of secondary objects in crashes (11.9 % of the time) had a disproportionately large impact on the likelihood of a human fatality (27.2 % of fatalities).
- Most crashes occurred between the hours of 5 pm and 10 pm and the rate of crashes was significantly higher from late autumn through winter.
- Poor weather conditions do not play a role in causing collisions.
- Seasonal variability in crash rate was correlated with the length of darkness.
- Hotspots for collisions were identified for the three main groups of species involved in collisions but the locations were species specific.
- Clear that only a small fraction of crashes with animals get reported to police.

Recommendations

Despite our increasing dependence on road transport, a strategic cross-sectoral approach to assessing the clashes between animals and vehicles on roads and their traumatic consequences is currently lacking, with rural and regional communities bearing the brunt of this problem. We need to increase our efforts in quantifying the extent of the trauma and healthcare burden, in developing an understanding of why collisions occur with such frequency, and in devising and implementing preventive strategies appropriate to road conditions and animal species as they vary in space and time. We call on those agencies responsible for managing roads, road safety, wildlife and livestock to develop a cooperative approach to address this serious issue.

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