Current and probable past wildlife fatality hotspots on the Thousand Islands Parkway, Ontario, Canada

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1. Introduction

The impacts of roads on natural environments are varied and complex, but one of the most obvious impacts on wildlife populations is elevated mortality from collisions between vehicles and animals. Improved and efficient investment in mitigation requires knowledge of where (and why) roads have particularly high impacts on wildlife populations.

We report on an animal road kill study on the Thousand Islands Parkway, near St. Lawrence Islands National Park, Canada. The objectives were to, for each taxon: (i) identify current vertebrate wildlife mortality hotspots; (ii) test for effects of traffic volume; and (iii) relate the road kill abundance to hypothesized landscape predictor variables related to wildlife habitat requirements. This was accomplished using a combination of intensive field data collection, visualization of kill densities, evaluation of the significance of spatial clustering of road kill using the network K-function, and a roving window regression analysis to model associations of kill zones with the surrounding landscape.

1.1 Study Area

The Thousand Islands Parkway is a 37km two-lane highway, which crosses the Algonquin to Adirondacks conservation corridor at its narrowest point. It is also within the greater park ecosystem of, and is often bordered on both sides by, Saint Lawrence Islands National Park. Parks Canada is mandated to improve ecological integrity of the park and its surrounding ecosystem, and thus seeks to mitigate against wildlife mortality on the roads in this important corridor.

2. Methods

The 37km survey route was travelled by bicycle over 80 days between April 14 and October 16, 2008. Animals killed on the road were identified as best possible, recorded on a hand-held computer with integrated GPS, and removed or flagged. 6 682 kills were located of 63 unique species, of which 3 were of special concern and 2 were threatened as designated by the Committee on the Status of Wildlife in Canada (COSEWIC).

Kernel density and network K-function analyses were used to visualize and assess statistical significance of taxon-specific spatial clusters of road kill. The network K-function was used because it uses distances along a network (in this case the road) rather than Euclidean distance across the landscape, removing a source of potential error that is exacerbated where roads intersect or curve back on themselves. Analysis was conducted using Spatial Analysis on a Network (SANET) software (Spooner et al. 2004), using 1km radii. A Monte Carlo approach to generate expected random distributions of the K-function on this network allowed significance testing of spatial clustering or dispersal.

Models were developed to predict areas of high taxon-specific mortality by examining associations between locations of kills with potential habitat-related variables. These landscape variables originated primarily from the Southern Ontario Land and Resource Information System (SOLRIS ver. 1.2), a provincial land cover database with a resolution of 15m but a positional accuracy of 30m (Smyth 2008). This was used to provide estimates of built-up area, building density, forest area, “vacant” land, water area and edge perimeter, and wetland area. Ontario Base Map data at a 1:10 000 scale provided an elevation model for the site. Since existing data clearly under-represented culverts under the road, extra information about the locations and characteristics (size, shape, integrity, and presence of water) of all 195 existing culverts was collected in the field. Traffic volumes were captured using Trafx Gen III magnetic counters (Trafx Research, Canmore, Alberta), to check for differences in traffic conditions along the route.

Correlations between kills and the landscape variables identified above were developed using a roving window analysis. From a total of 1481 possible 25m sites, over 600 random non-overlapping sites were randomly chosen in 10 iterations, yielding 10 subsets of the road kill data with no spatial overlap. Logistic regression was performed on each of these 10 subsets, using presence/absence of kills in each 25m site against landscape data from 500m windows around the site. Average regression slopes from the 10 subsets were tested for significant differences from zero, yielding an aggregate model for each taxon (c.f. Holland et al. 2004).

Initial analysis showed a consistent negative association between traffic volume and frog and toad kills, implying that populations have been already been depressed (Fahrig et al. 2005). We reasoned that mitigation efforts should consider both current hotspots and areas that may have good potential habitat but low populations due to past and continuing road mortality pressure. Therefore we extended our moving window approach, controlling for traffic volume by developing models without the traffic variable in low traffic densities, then applying them to the entire study area, to include potentially good future habitat with appropriate mitigation.

3. Results and Discussion

The road kill data were aggregated into eight taxon groups including: frogs (5416 kills), salamanders (11 kills), toads (52 kills), birds (212 kills), large mammals (27 kills), small mammals (165 kills), snakes (244 kills), turtles (128 kills) and unknown. The largest road kill group was frogs which represented 81% of all kill points, followed by snakes which accounted for 4% of kills. Due to space constraints, only highlights of the results are presented here.

Kernel density maps demonstrated that there are distinct clusters of kill zones, and that these zones differ between taxa. East of both the communities of Rockport and Mallorytown Landing were high road kill zones for seven of the eight taxa. High frog kill density areas were all located in the eastern part of the study area (fig. 1). Toads and salamanders exhibited similar patterns. Bird kills were much more distributed along the route, whereas large mammal kill zones were in relatively compact patches and small mammals had small clusters across the region.

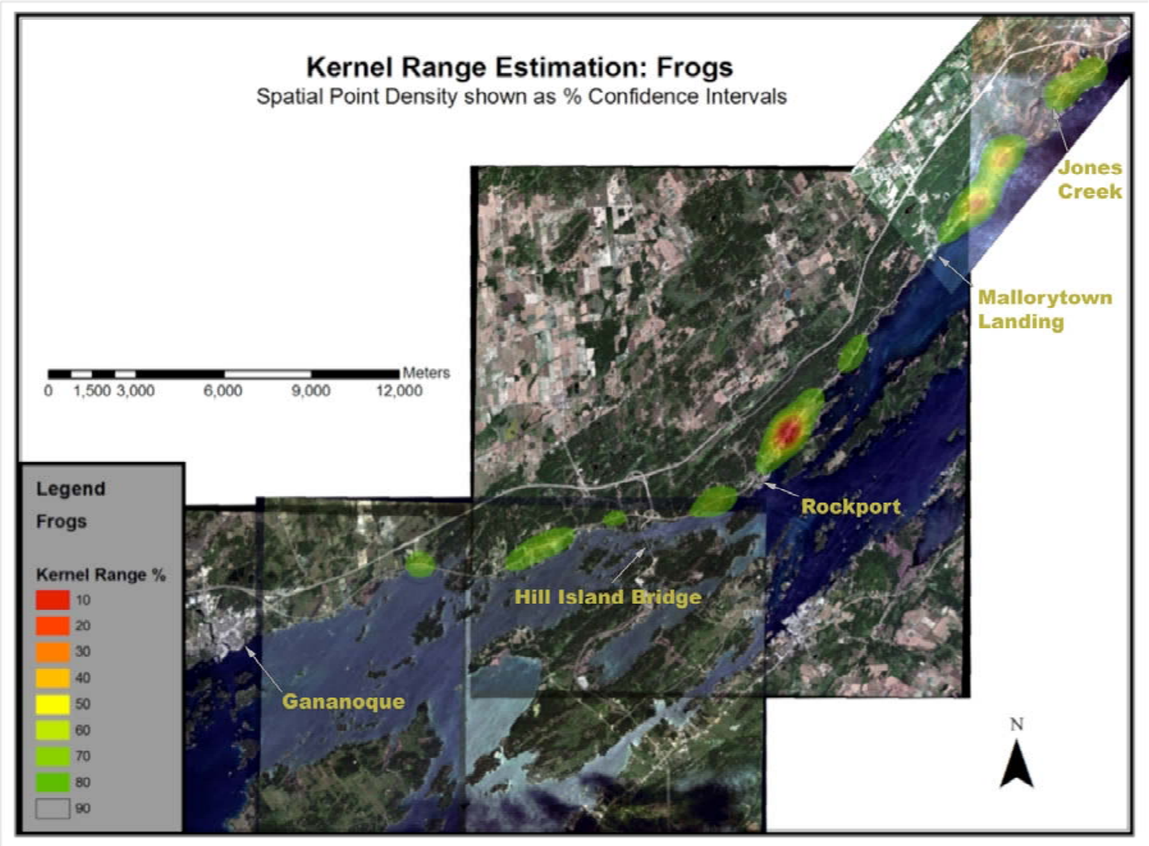
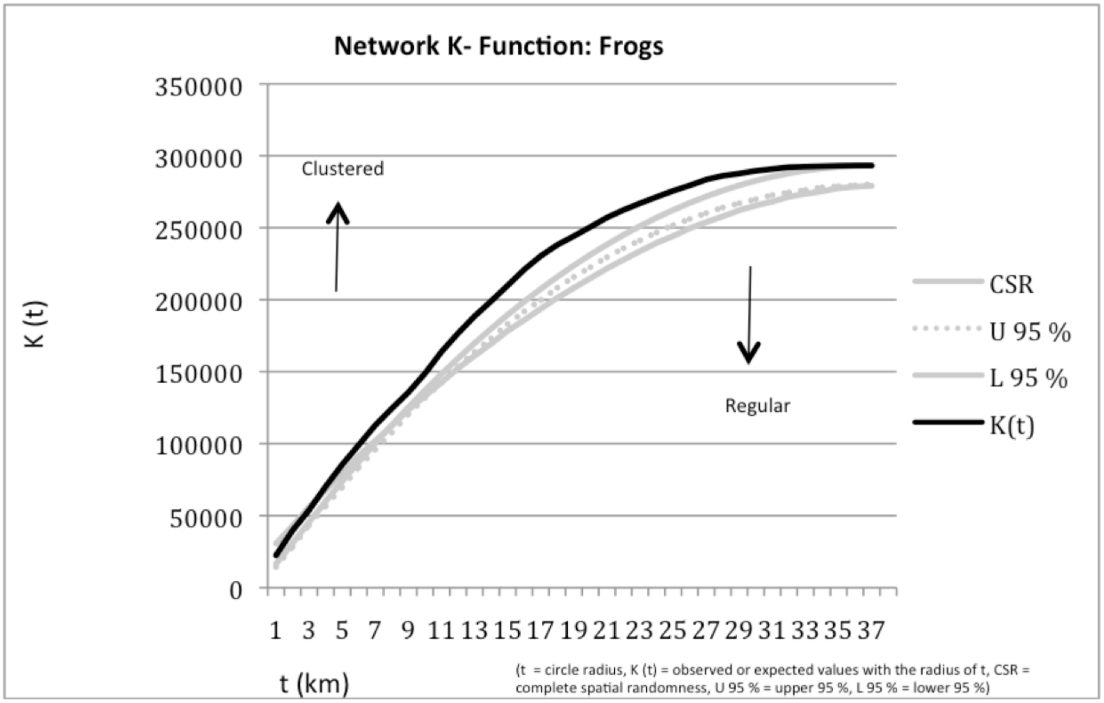


Figure 1. Density of frog kills using kernel range estimation, divided into deciles, such that the 10% range identifies the **highest** category of road kill density.

These patterns were tested for significance by comparing the network K-statistic to a random distribution; not all taxa exhibited significant kill clustering, and the patterns varied. Frog (fig. 2), toad and snake kills were clustered at all scales, birds were only clustered up to 5km, turtles were clustered up to 7km, but large and small mammal kills were randomly distributed. These results provide guidance on relevant scales for further analysis and mitigation efforts, especially for reptiles and amphibians, and show relatively constant mortality patterns for mammals.



(t = circle radius, K (t) = observed or expected values with the radius of t, CSR = complete spatial randomness, U 95 % = upper 95 %, L 95 % = lower 95 %)

Figure 2. Spatial clustering of frogs with respect to scale (t) and complete spatial randomness (CSR).

The moving window regression analysis created separate models for each taxon, with varying numbers of explanatory variables. Mammals did not show any significant relationship with any of the landscape variables. Bird kills were positively associated with traffic and negatively associated with surrounding forest and water areas. The frog data allowed the most robust analysis, and showed significant relationships between frog kills and decreasing traffic, and increasing water edge. As noted above, the negative association between traffic and road kill implies that in areas of high traffic, lower kills occur because populations have already been depressed. Therefore the analysis was repeated controlling for traffic, which lead to a model in which frog road mortality was negatively associated with number of buildings and proportion of built-up area, and positively associated with the surrounding number of wet culverts. Mapping the results of this model provides guidance for promising areas for future mitigation (fig. 3) in areas of both low and high current road kill densities.

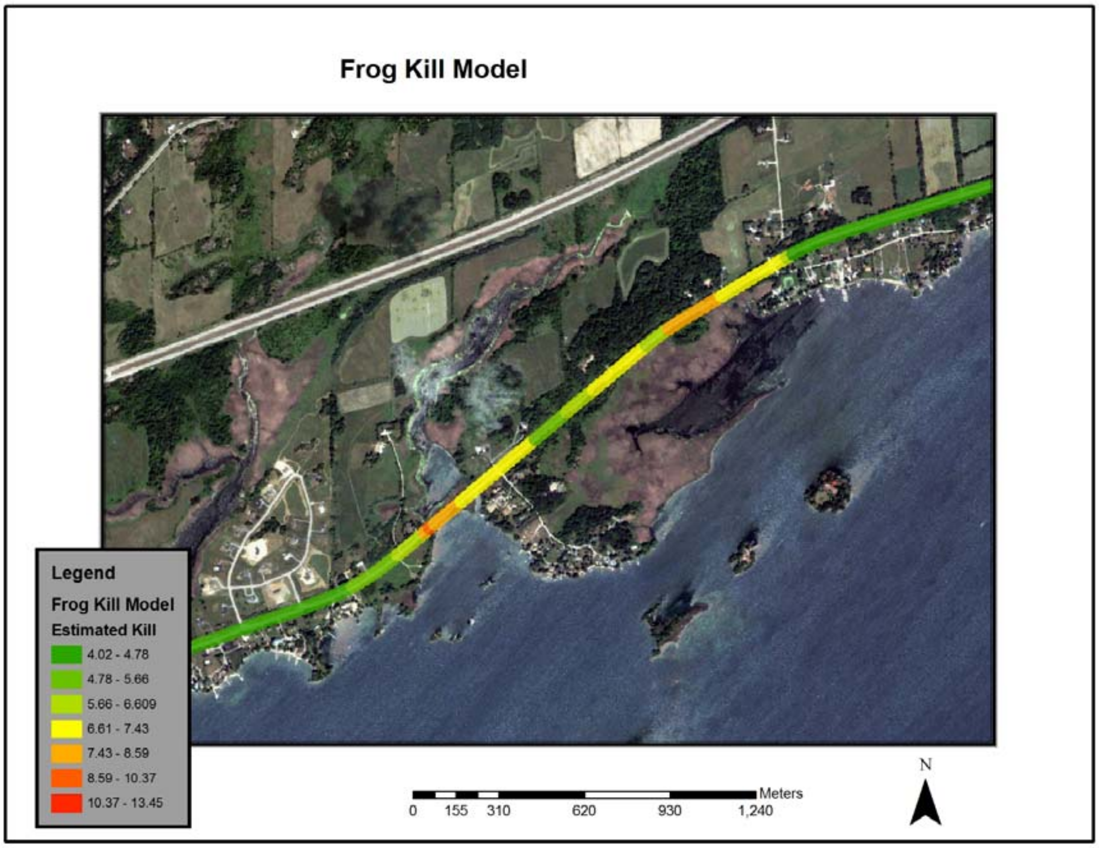


Figure 3. Predicted kill zones for frogs in a region that currently has low rates, based on modelled landscape associations from areas with higher kill rates.

4. Conclusions

Careful intensive data collection combined with spatial density and regression analysis allowed identification and prediction of wildlife road mortality hotspots. Network-aware methods are important for this analysis. Road kill patterns with respect to traffic must be examined carefully, because continued exposure to high traffic eventually decreases source populations.

5. Acknowledgements

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6. References

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