How Effective Is Road Mitigation at Reducing Road-Kill? A Meta-Analysis

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INTRODUCTION

There are more than forty types of road mitigation measures available that aim to reduce wildlife mortality on roads (road-kill). For road planners, deciding on what mitigation method to use has been problematic because there is little good information about the relative effectiveness of these measures in reducing road-kill, and the costs of these measures vary greatly.

The purpose of our study was to conduct a comprehensive analytical review of the studies that quantified the relationship between road-kill and a mitigation measure that was installed, at least in part, to reduce wildlife road mortality, using well-described meta-analysis methods. Specifically we asked:

(1)To what extent does road-kill mitigation effectiveness differ among measures?

(2) To what extent do taxa differ in the effectiveness of particular road mitigation measures?

(3) To what extent does study design influence the estimated effectiveness of road mitigation measures?

METHODS

We conducted a comprehensive search that included both primary and grey literature with no date, language, or format restrictions. Studies included employed one of three study designs: (1) Before-After (BA); (2) Control-Impact (CI), or (3) Before-After-Control-Impact (BACI).

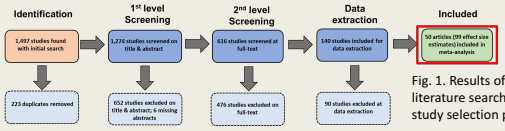
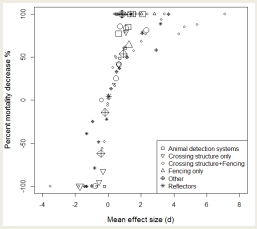


Fig. 1. Results of the literature search and study selection process.

Outcomes of each of the 50 studies were then converted into a common measure, the standardized mean difference (or Hedge's d). A positive *d* indicates a reduction in road-kill with the road mitigation and a negative *d* indicates an increase in road-kill with the road mitigation. To address our research questions, we investigated a set of candidate predictor variables from four broad categories: attributes of (a) planning and management; (b) wildlife; (c) fencing; and (d) study design. We used mixed-effects meta-regression to examine associations between effect size and candidate predictor variables using restricted maximum-likelihood to estimate heterogeneity.

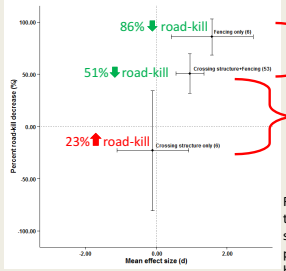
RESULTS



Overall, mitigation measures reduce road-kill by approximately 40% compared to controls.

Fig. 2. Relationship between mean effect size and the percent road-kill decrease (n = 99 effect sizes). Symbol size is proportional to the weight (inverse of the sampling variance) of the effect size; smaller symbols correspond to effect sizes with lower weights.

1. To what extent does road-kill mitigation effectiveness differ among measures?
   a) Are fences with crossing structures more effective than fences or crossing structures alone?

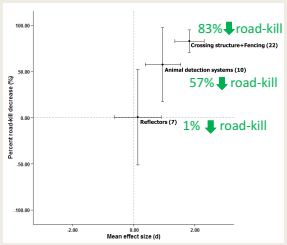


No detectable additional reduction in road-kill afforded by adding crossing structures to fencing.

Additional reduction in road-kill afforded by adding fencing to crossing structures

Fig. 3. Relationship between weighted-mean effect sizes and the weighted-mean percent road-kill decrease for crossing structures and fencing alone and in combination. Values in parentheses are the number of effect size estimates. Error bars indicate 95% confidence intervals.

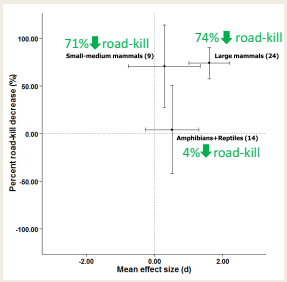
1. To what extent does road-kill mitigation effectiveness differ among measures?
   b) What mitigation measures are most effective for a given taxon?



Crossing structures with fencing and animal detection systems reduced large mammal road-kill much more than wildlife reflectors.

Fig. 4. Relationship between weighted-mean effect sizes and the weighted-mean percent road-kill reduction for three different types of mitigation measures, based on a sample of n = 39 large mammal effect sizes. Values in parentheses are the number of effect size estimates. Error bars indicate 95% confidence intervals.

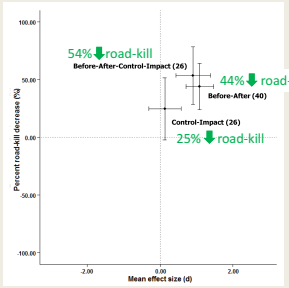
2. To what extent do taxa differ in the effectiveness of particular road mitigation measures?



Crossing structures with fencing were most effective at reducing road-kill for large mammals than for other taxa.

Fig. 5. Relationship between weighted-mean effect sizes and the weighted-mean percent road-kill reduction for different taxa, based on n = 47 effect sizes from studies involving crossing structure and associated fencing. Values in parentheses are the number of effect size estimates. Error bars indicate 95% confidence intervals.

3. To what extent does study design influence the estimated effectiveness of road mitigation measures?



BA and BACI studies are much better able to detect effectiveness of mitigation measures on road-kill than CI studies.

Fig. 6. Relationship between weighted-mean effect sizes and the weighted-mean percent road-kill reduction for study design, based on n = 92 effect sizes. Values in parentheses are the number of effect size estimates. Error bars indicate 95% confidence intervals.

IMPLICATIONS

Our meta-analysis highlights the fact that there are insufficient data to answer many of the most pressing questions that road planners ask about the effectiveness of road mitigation measures, such as whether other less common mitigation measures (e.g., measures to reduce traffic volume and/or speed) reduce road mortality, or to what extent the attributes of crossing structures and fences influence their effectiveness (e.g., presence of dig barriers, fence-end treatments, mesh size, height, numbers and spacing of crossing structures and fenced sections etc.).

Key points of consideration when at least one of the goals of mitigation is to reduce road-kill:

1. Mitigation for road-kill should include wildlife fencing.
2. For large mammals, current animal detection systems can reduce road-kill, though not as effectively as wildlife fencing.
3. If the goal of a crossing structure includes reducing road-kill, fences must be included.
4. There is little evidence that other measures aimed at affecting driver or animal behaviour (e.g., reflectors) reduce road-kill.
5. Studies should incorporate data collection before the mitigation is applied, and we recommend a minimum study duration of 4 years for BA, and a minimum of either 4 years or 4 sites for BACI designs.

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