Collaboration for Environmental Evidence

Systematic Review No. 68

ARE MAMMAL AND BIRD POPULATIONS DECLINING IN THE PROXIMITY OF ROADS AND OTHER INFRASTRUCTURE?

Review Summary

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Benítez-López, A., Alkemade, R. & Verweij, P.A. 2009. Are mammal and bird populations declining in the proximity of roads and other infrastructure? Systematic Review No. 68. Collaboration for Environmental Evidence.

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COVER SHEET

Title	**Are mammal and bird populations declining in the proximity of roads and other infrastructure?**
Systematic review	Nº 68
Reviewers	Ana Benítez López, Rob Alkemade and Pita Verweij
Date draft protocol published on website	9/02/2009
Date final protocol published on website	06/03/2009
Date draft review published on website	11/03/2009
Date final review published on website	25/02/2010
Date of most recent amendment	21/01/2010
Date of most recent SUBSTANTIVE amendment	-
Details of most recent changes	-
Contact address	Netherlands Environmental Assessment Agency (PBL) PO Box 303 3720 AH Bilthoven The Netherlands
Sources of Support	Netherlands Environmental Assessment Agency (PBL), Copernicus Institute (Utrecht University), UNEP-Grid Arendal, Alterra
Conflicts of interest	None reported

Summary

1. Background

Biodiversity is being lost at an increased rate as a result of human activities (Vitousek, 1994; Pimm et al., 1995; Sala et al., 2000; MEA, 2005). One of the major threats to biodiversity is infrastructural development (UNEP, 2001; Sala et al., 2000; Sanderson et al., 2002; Alkemade et al., 2009). The most commonly reported impacts from roads and utility corridors include habitat loss, intrusion of edge effects in natural areas, isolation of populations, barrier effects, road mortality and increased human access (Andrews, 1990; Forman and Alexander, 1998; Spellerberg, 1998; Trombulak and Frissell, 2000; Forman et al., 2003). Besides roads, other types of infrastructure, such as railways, powerlines, pipelines, hydroelectric developments, oil wells, seismic lines and wind parks, have an impact on wildlife populations (Dunthorn and Errington, 1964; McLellan and Shackleton, 1989; Cameron et al., 1992; Van Dyke and Klein, 1996; Mahoney and Schaeffer, 2002; Nellemann et al., 2003a; Barrios and Rodriguez, 2004). All these impacts may influence the long-term viability of populations and, eventually, biodiversity. In this study, we aim at estimating the decline of animal populations, in particular bird and mammal species, in relation to proximity to infrastructure by using a meta-analytical approach.

2. Objectives

To systematically collect and synthesize the available published and unpublished evidence in order to answer the questions:

- What are the impacts of roads and infrastructure on mammal and bird populations? What are the disturbance distances at which mammal and bird populations are significantly reduced?
- Do traffic volume, habitat, infrastructure type have an effect on the decline of mammal and bird populations in the proximity of roads?
- Are there any differences in the response of birds and mammals to infrastructure due to the study of different species populations?

3. Methods

Multiple electronic databases and web sites were searched using key words such as “road effects, infrastructure distance, road avoidance, etc”. Bibliographies of articles viewed at full text were searched for relevant additional articles. Researchers and experts were contacted to retrieve relevant material. One reviewer selected articles that met the selection criteria regarding subject, intervention, outcome and comparators. A second reviewer checked studies whose data suitability for the meta-analysis was unclear for the first reviewer. Disagreement regarding inclusion or exclusion of a certain study was resolved by consensus. Additionally, a statistician helped to solve problems regarding data extraction and variance inference for studies with insufficient information on standard deviation, standard error and/or sample size.

We selected studies included sufficient data to derive ratios by comparing bird and mammal species abundances at disturbance distances and at control distances. These ratios were combined in the indicator mean species abundance (MSA), used as the effect-size measure. The impact of infrastructure distance on MSA was studied by using meta-analysis in R 2.9.1. Possible reasons for heterogeneity in the results were explored by performing meta-regression of mixed effects (GLMM) in S-Plus 7.0. In these analyses MSA values were weighed by the inverse of their variances.

4. Main results

More than 600 references were reviewed at full text and identified as relevant for assessing the impacts of infrastructure on biodiversity. Of these references, a number of studies were left out of the analysis: studies on other taxa (reptiles, plants…), studies not reporting on densities or abundance of bird and/or mammal species, studies not containing proper comparators or control distances, studies whose data was not suitable for the calculation of the effect size and studies reporting on the impacts of human access and human activities from infrastructure. Finally we selected 49 studies from which we extracted 86 datasets on 234 mammal and bird species that were suitable for the meta-analysis. In these studies, the main response by mammals and birds in the vicinity of infrastructure was either avoidance or a reduced population density.

Mammal and bird population densities significantly declined with their proximity to infrastructure. Bird populations were reduced at a shorter distance to infrastructure than mammal populations. Mammals and birds seemed to avoid larger distances from infrastructure in open areas compared to forested areas, which could be related to the reduced visibility of the infrastructure in forested areas. We could not find a significant effect of traffic intensity on the MSA of birds. Species populations responded differently to infrastructure. Raptors were found to be more abundant in the proximity of infrastructure whereas the other bird taxa avoided it. Small-sized mammals were affected within few meters from infrastructure while abundance of large-sized mammals was reduced up to several hundred meters from infrastructure.

5. Conclusions

The available evidence from the meta-analyses and the meta-regression suggests that mammal and bird populations are displaced from infrastructure, and that displacement distance depends on the habitat type and on the species population. The findings of our analysis represent a step forward in the field of road (and infrastructure) ecology research that may contribute to the understanding of the magnitude of the pernicious effects of infrastructure development on animal populations.

Our findings show the importance of minimizing infrastructure development for wildlife conservation in relatively undisturbed areas. By combining actual species distributions with the effect distance functions we developed, regions sensitive to infrastructure development may be identified. Additionally, the effect distance functions can be used in models in support of decision making on infrastructure planning.