CEE review 09-007

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

Systematic Review Protocol

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1. BACKGROUND

Global biodiversity is changing at an unprecedented rate, as a result of several human-induced changes in the global environment (Vitousek, 1994; Pimm *et al.*, 1995; Sala *et al.*, 2000; MEA, 2005). The process of biodiversity loss at the species level is generally characterised by a decrease in the abundance of many species, resulting in an increase in the number of threatened species and in the extinction of others. A simultaneous increase in the abundance of some species results in the so-called homogenisation process (Lockwood and McKinney, 2001). The main drivers of biodiversity change are land-use and land-cover change, climate change, pollution, fragmentation and infrastructural development (UNEP, 2001; Sala *et al.*, 2000; Sanderson *et al*., 2002).

The ubiquity of road networks and the growing body of evidence of the negative impacts that roads and other linear infrastructure have on wildlife and ecosystems suggest that infrastructure represents a major driving factor of biodiversity loss. 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). Road construction leads to habitat destruction and creates open spaces in otherwise closed forests (Gullison and Hardner, 1993; Reed *et al*., 1996; Santos and Tabarelli, 2002). The open spaces may fragment populations (barrier effect), serve as corridor for spread of invasive species, attract light-demanding or predator species and may be avoided by others (edge effect) (Kroodsma, 1984; Vos and Chardon, 1998; Bolger *et al.*, 1997; Ortega and Capen, 1999, Meunier *et al.*, 2000, Gelbard and Harrison, 2003). Additionally, the use of infrastructure by cars or trains increases the risk of collisions with wildlife and stress on (breeding) individuals (due to noise disturbance and visual stimuli), both of these risks affecting reproductive success and population maintenance (Zande *et al.* 1980; Reijnen *et al.*, 1996; Romin and Bisonette, 1996; Mumme *et al.,* 2000; Boarman and Sazaki, 2005).

Besides roads, other types of infrastructure, such as railways, powerlines, pipelines, hydroelectric developments, oil wells and seismic lines, also 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). All these impacts may influence the long-term viability of populations and, eventually, biodiversity.

Qualitative reviews provide a broad understanding of the ecological effects of infrastructure that affect a range of taxa and ecosystems, but lack quantitative evidence (Forman and Alexander, 1998; Spellerberg, 1998; Trombulak and Frissell, 2000; Forman *et al.*, 2003). However, the few attempts to quantify the effects of infrastructure (UNEP, 2001; Nellemann *et al.*, 2003b), or to model the vulnerability of animal populations to road effects (Jaeger *et al.*, 2005), did not follow the guidelines for systematic reviews and did not apply meta-analysis − which is the statistical procedure for combining the results of independent studies in a quantitative way (Arnqvist and Wooster, 1995). In this study, we aim at estimating the decline of animal populations due to infrastructural development by using a systematic review and meta-analytical approach.

Among all animal taxa, mammal and bird populations were chosen for our analysis since both have been widely reported to be declining in relation to their distance from infrastructure. However, large differences in disturbance sensitivity seem to exist between and within these groups. Bird populations seem to be affected within a few hundred metres from infrastructure, whereas a reduction in mammal populations has been found at distances of a few hundred metres up to several kilometers from infrastructure (McLellan and Shackleton, 1989; Cameron *et al*., 1992; Ortega and Capen, 1999; Nellemann *et al.,* 2003a). Additionally, traffic volumes seem to play a role in the decline of both bird and mammal populations close to roads (Zande *et al*., 1980; Reijnen *et al.*, 1995; Reijnen *et al.*, 1996; Dyer *et al.*, 1999; Rheindt, 2003).

To quantify the patterns of reduced population densities in relation to infrastructural development, we will search the scientific literature for quantitative data on mammal and bird populations at varying distances from infrastructure and for varying traffic volumes. Subsequently, we will synthesize the data by using a biodiversity indicator as effect size, mean species abundance, MSA (Alkemade *et al.*, in press). Finally we will apply meta-regression to estimate the relationship between distance to infrastructure and MSA for birds (MSA_B) and mammals (MSA_M) (infrastructure−distance effect). In addition, we will also test the role of traffic volume (traffic volume effect) in this relationship. The outcome of our review will serve to estimate biodiversity loss of mammal and bird populations due to current infrastructural development. It will also be useful in forecasting the impacts of future developments and therefore, it will serve policy makers, infrastructure planners and conservation planners when designing future infrastructural development plans aiming at reducing the impact on biodiversity.

2. OBJECTIVE OF THE REVIEW

2.1 Primary question

Are mammal and bird populations declining in the proximity of roads and other infrastructure? At which distance are mammal and bird populations unaffected by roads and other infrastructure?

2.2 Secondary questions

Are mammal and bird populations affected similarly in the proximity of infrastructure?
Do environmental and geographical factors (e.g. biome, land use, vegetation cover…) have an effect in the disturbance distances of mammal and birds?
Does traffic volume affect the abundance of birds in the proximity of roads?

Table 1. Definitions of components of the systematic review questions

				Outcomes	
Subject	**Interventions**	**Comparators**	**Primary**	**Secondary**	**Tertiary**
Mammal and bird populations affected by road construction and infrastructure development	Proximity to infrastructure (Disturbance distance)	Large distances from infrastructure (Control distance)	Change in abundance of mammal and bird species related to distance to infrastructure	Impact of traffic volume on bird species abundance	Impact of infrastructure on mammal and bird populations in forested and non-forested areas

3. METHODS

3.1 Search strategy

3.1.1 General sources

The following electronic or computerised databases and catalogues were searched:

1. ISI Web of Knowledge (inc. ISI Web of Science and ISI Proceedings)
2. Science Direct
3. Scopus
4. Omega (Utrecht University Digital Library)
5. Ebsco
6. JSTOR
7. Wiley InterScience
8. Springer Link
9. BioOne
10. Picarta
11. CAB Abstracts
12. Encyclopedia of Biodiversity
13. Dissertations Utrecht University
14. Wildlife & Ecology Studies Worldwide
15. Other databases and catalogues deemed relevant by experts

One reviewer will search the electronic or computerised databases and catalogues, and the number of citations retrieved from each search will be recorded within an Access database.

An Internet search will also be performed using the meta-search engine Google Scholar and WebPlus. The first 50 hits (Word and/or PDF documents where this can be separated) from each data source will be examined for appropriate data.

The search strategy will cover worldwide literature for the purposes of collecting the broadest scope of information possible. Searches will include the following English language search terms (* indicates a wildcard):

1. Road* AND impact* AND biodiversity OR mammal, bird

2. Infrastructure* AND impact* AND biodiversity OR mammal, bird

3. Road* AND distance* AND biodiversity OR mammal, bird

4. Infrastructure* AND distance* AND biodiversity OR mammal, bird

5. Road * AND biodiversity* AND mammal, bird

6. Infrastructure AND biodiversit* AND mammal, bird

7. Road-effect zone AND mammal abundance OR bird abundance

8. Traffic* AND impact* AND biodiversity OR mammal, bird

9. Traffic volume AND mammal abundance OR bird abundance

10. Road* AND disturbance* AND biodiversity OR mammal, bird

11. Road* AND disturbance* AND mammal abundance OR bird abundance

12. Infrastructure* AND disturbance* AND biodiversity OR mammal, bird

13. Infrastructure* AND disturbance* AND mammal abundance OR bird abundance

14. Road* AND avoidance* AND biodiversity OR mammal, bird

15. Infrastructure* AND avoidance* AND biodiversity OR mammal, bird

16. Highway AND impact* AND biodiversity OR mammal, bird

17. Highway* AND distance* AND biodiversity OR mammal, bird

18. Highway* AND biodiversit* AND mammal, bird

19. Railway* AND biodiversit* AND mammal, bird

20. Railway* AND distance* AND biodiversity OR mammal, bird

3.1.2. Specific key authors

Our previous collective examinations of the literature have identified a number of potential key authors (listed below). We will search Scopus for each of these authors using the author field tag (i.e. to exclude multiple citations).

Cameron, R.D.

Fahrig, L.

Forman, R.T.

Erritzoe, J.

McLellan, B.N.

Meunier, F.D.

Nellemann, C.

Reijnen, R.

Shackleton, D.M.

Van der Zande, A.N.
Vistnes, I.

3.1.3 Specialist sources

Bibliographies of articles viewed at full text will be searched for relevant secondary articles. Authors and recognised experts in the field of infrastructure development, road establishment and effects on biodiversity (Christian Nellemann, UNEP-Grid Arendal and Rien Reijnen, Alterra) will also be contacted for further recommendations, and for provision of any unpublished material or missing data that may be relevant (grey literature). Foreign language searches will be undertaken by using cross-reference.

3.2 Study inclusion criteria

One reviewer will filter the most relevant studies by including only those studies whose title and keywords are associated to the objective of this review. Subsequently, all the abstracts from the selected studies will be revised and only those satisfying the review criteria will be considered. Finally, all the studies selected above will be read in full to determine which are suitable for data extraction. A second reviewer will check the studies whose suitability is unclear for the first reviewer. Disagreement regarding inclusion or exclusion of studies will be resolved by consensus.

• **Relevant subjects:** Populations of any mammal or bird species. Studies will be included irrespective of habitat or spatial scale; however, the biome and/or ecosystems will be recorded in order to interpret any patterns of variation in the results.
• **Types of intervention**: Disturbance distances or distances close to infrastructure at which mammal and bird populations might be reduced compared to larger distances or control distances (see Types of comparator).
• **Types of comparator:** Control distances or distances at which mammal and bird populations are unaffected by infrastructure and roads.
• Types of outcome: Changes in abundance of mammal and bird populations in the proximity of infrastructure. Differences in the relationships between infrastructure distance and mammal or bird species abundances as a result of vegetation cover. Influence of traffic volume on the response of birds in the proximity of roads.

• **Types of study:** All studies that report on the impacts of infrastructure on mammal and bird populations as long as they present primary data about the relevant subject, such as abundance or density, intervention (varying distances from infrastructure) and comparator (control distance or a distance far enough from infrastructure to be considered as a control distance).

• **Potential reasons for heterogeneity:** Variation in the response of mammal and birds to different types of infrastructure (highways, secondary roads, oil wells, hydroelectric development, power lines…).

Variation in the response of birds to infrastructure due to different levels of traffic on the road.

Variation in the type of effect: edge effect, habitat loss, habitat degradation.

Variation between species in the response to infrastructure: some of them might be more sensitive to infrastructure than others.

3.3 Study quality assessment

The selected studies to be viewed at full text will be considered by one reviewer, excluding them from the review or admitting them to different categories of information quality. Study quality will be assessed by one reviewer with reference to a second reviewer in cases of uncertainty. Disagreement regarding study quality will be resolved by consensus.

Only papers containing quantitative data on mammal and bird species density or abundance at different distances from linear infrastructure will be selected. This implies that each study should report on the abundance or density of birds and /or mammal species at distances close to infrastructure (Disturbance distances) and at distances far from infrastructure or control distances. Studies on the effects of human access, like hunting or tourism, will be rejected, in order to limit the systematic review to direct effects of infrastructure.

3.4 Data extraction strategy

No qualitative data will be used. Quantitative data will be extracted by one reviewer, and a subset of the selected studies will be checked by a second reviewer to check data hygiene and verify the robustness and repeatability of the data extraction. The available data will be extracted and stored in a database. The data will include density or abundance of each species at different distances from infrastructure, the sample size and the variance, standard deviation or standard error, depending on the study. This data will be used to estimate an effect size and its variance needed in the meta-regression (Osenberg *et al.*, 1999). Additional data, for example, on location and corresponding biome, type of effect, and traffic volumes will also be recorded.

3.5 Data synthesis

We will use a biodiversity indicator, the mean species abundance (MSA), close to infrastructure relative to their abundances at larger, undisturbed distances, as the metric for effect size (Alkemade *et al.*, in press). The MSA will be derived from the data found in peer-reviewed papers on both mammals and birds. Subsequently, meta-regression will be applied to estimate the relationship between distance to infrastructure and MSA for birds (MSA_B) and mammals (MSA_M) (infrastructure−distance effect). Furthermore we will test the infrastructure−visibility effect by comparing the estimated relationships for open vegetations (e.g. grasslands) and closed vegetations, such as forests. In addition, we will test the role of traffic volume (traffic volume effect). The meta-regressions will be done by applying logistic regression (GLMM), using each study as a random effect and therefore accounting for heterogeneity between studies. Additionally, each MSA value (effect size) of each study will be weighed by its variance (Gurevitch and Hedges, 1993).

4. POTENTIAL CONFLICTS OF INTEREST AND SOURCES OF SUPPORT

There are neither conflicts of interest nor sources of support to be recorded.

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