Improving EIA for roads at the landscape-scale

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1. Introduction

Wildlife populations are increasingly threatened by the expansion of road networks and built-up areas worldwide. However, ecological effects of roads and traffic at the level of landscape functions, communities, and ecosystems are complex and potentially unexpected. They are usually not well studied and not considered in environmental impact assessments (EIAs) and road planning. Major efforts are necessary to improve the quality of project-specific EIAs, landscape-scale cumulative effect assessments (CEA), strategic environmental assessments (SEA), road planning, and land-use planning. I draw 12 lessons from recent advances in Road Ecology science that are important for EIA at the landscape-scale (based on Jaeger 2015).

2. Twelve lessons from Road Ecology for improving EIA

2.1 EIAs of road projects are generally poor and require substantial improvements

Recent reviews of EIAs from Europe, the UK and USA (e.g. Gontier et al. 2006; Tennøy et al. 2006; Karlson et al. 2014) have concluded that many EIAs were deficient, for example:

- It was generally unclear whether reasonable searches had been carried out to detect rare or protected species;
- Fragmentation and barrier effects were seldom considered.

Thus, the assessment of impacts related to biodiversity is still far from meeting its goals (Gontier et al. 2006; Karlson et al. 2014). For example, the width of corridors investigated in EIAs is often only a few hundred meters. Thus, they will miss many effects of roads, since declines in species abundances range between 40 and 2800 meters from the road for birds, between 250 and 1000 meters (and possibly more) for amphibians, and up to 17 kilometers for mammals (Benítez-López et al. 2010). The road-effect zone for mammals is about 6 km wide on average on either side of the road. This means that the usual width of the corridors in road EIAs does not even cover the road-effect zone.

EIA needs to link much more closely to recent advances in science and needs to be combined with research, using experimental designs as proposed by Rytwinski et al. (2015). Each road is an experiment that we can learn from, it needs to be monitored well according to a study design that will allow us to draw meaningful conclusions.

Cumulative effects deserve particular attention because they constitute the most relevant effects worth assessing in most EIAs. However, CEA has largely failed to deliver on its promises (Dunker and Greig 2006). Fundamental improvements are required, for example through regional environmental assessments in combination with regional land-use planning, in addition to more rigorous CEA within project EIAs.

The poor quality of EIAs poses a significant concern considering that guidelines on biodiversity/ecological assessment issues have been available for two decades now. These guidelines are not effectively applied, probably because many consultants depend on continued support from their clients. Concluding that there are significant environmental effects might result in being cut off from the preparation of EIAs in the future, which is not in their interest. This is a structural flaw of the current EIA system that needs to be fixed, e.g. through independent peer review.

2.2 Landscape-scale effects of road networks are neglected in EIAs

Even though landscape-scale effects are highly important for wildlife populations, they have not yet been studied very well (van der Ree et al. 2011) and are usually not covered in EIAs. For example, long-distance dispersal of animals is ecologically important for re-colonizing empty habitats (e.g. in meta-population dynamics), allowing range shifts of populations in response to climate change. However, data on long-distance movements are difficult to collect, and studying populations across multiple sites requires longer time scales and greater investments than studies at individual sites.

2.3 There is a lack of knowledge of thresholds in the cumulative effects of landscape fragmentation and habitat loss on the size and viability of wildlife populations

There are thresholds in the effects of increasing road density on the viability of wildlife populations, after which there is a dramatic decline (Jaeger and Holderegger 2005). For example, roads are a primary cause of the decline of endangered brown hare populations in Switzerland. Roads have made the hare populations much more vulnerable to unfavourable weather, to the intensification of agriculture, and to habitat loss (Roedenbeck and Voser 2008). However, little information is available about these thresholds (Robinson et al. 2010), which implies that nobody knows how close wildlife populations already are to their thresholds: The next new road may cause extinction. Long-term studies would be required to elucidate these thresholds. As a consequence of the current practice of considering only endangered species in EIAs, many species that are not (yet) endangered are pushed closer and closer to their threshold.

2.4 Wildlife populations often have long response times to increases in landscape fragmentation ('extinction debt')

Wildlife populations react to the fragmentation of their habitats with variable response times. Their responses may take several decades (e.g. Findlay and Bourdages 2000). Their response times to the main four mechanisms affecting a population may differ: The effect of (i) habitat loss is almost immediate, while the effects of (ii) reduced habitat quality and (iii) traffic mortality may take longer, and (iv) reduced connectivity even longer still. After this time lag, the population is smaller and more vulnerable to extinction. The response times are not known for most species. The term "extinction debt" denotes the number of populations that will go extinct because of changes that have already occurred (Tilman et al. 1994) and should be taken into account in EIAs.

2.5 There are large uncertainties about many potential ecological effects of roads; they need explicit consideration in EIA, and decision-makers should more rigorously apply the precautionary principle

Examples of uncertainties about the landscape-scale effects of roads include the influence of the configuration of the road network on wildlife populations, effects of roads on source-sink dynamics, predator-prey dynamics, changes in food chains, and cascading effects. In general, the bundling of transportation infrastructure to leave other parts of the landscape unfragmented decreases the impact of road networks (Jaeger et al. 2006). Even though the barrier effect of a bundle of transport routes will be higher than the barrier effect of a single transport route, bundling is preferable because more core habitat remains unaffected by barriers and by edge effects. Research about the role of road network configuration is lacking, even though it is urgently needed to inform EIA and landscape-scale road planning. Since we do not know the thresholds in road density, etc., these uncertainties need to be explicitly incorporated into decision-making. We cannot wait another 40 years for research to identify thresholds and response times before they will be considered in EIA. This requires a shift from a reactive to a proactive mode of mitigation and a more rigorous application of the precautionary principle (EEA 2001). This shift is supported by the insight that the failure of detecting environmental impacts that exist (Type II error) usually has more detrimental consequences than the erroneous detection

of impacts that do not exist (Type I error) (Kriebel et al. 2001). In addition, EIA practitioners should be more explicit about their assumptions and knowledge gaps and disclose uncertainties such that decision-makers can make more informed decisions (Tennøy et al. 2006).

2.6 Landscape fragmentation should be monitored because it is a threat to biodiversity and a relevant pressure indicator

Many countries monitor their biodiversity, and some monitoring systems already include an indicator to measure the pressure on landscapes caused by fragmentation due to transportation infrastructure and urbanisation. It can be calculated using the method of effective mesh size and effective mesh density (Jaeger et al. 2008). Further increases in the level of landscape fragmentation need to be avoided because it is a threat to biodiversity and many ecosystem functions and services. Monitoring landscape fragmentation reveals if and how fast landscape fragmentation is increasing, and it can detect any changes in the trends (EEA & FOEN 2011).

2.7 Limits to control landscape fragmentation are needed

In 1985, the German Federal Government declared the goal to 'reverse the trend in land consumption and landscape fragmentation' (BdI 1985). There is also an explicit intention to preserve large, un-fragmented spaces with little traffic, which is a central principle of regional planning in Germany. However, landscape fragmentation has continued to increase unabatedly since 1985. Therefore, the German Environmental Agency has proposed to establish limits to the rate of increase of landscape fragmentation (Penn-Bressel 2005). Targets and limits can be evaluated to assess whether or not they have been achieved and they provide a regulatory ground for administrative action for curtailing fragmentation when the targets are exceeded.

2.8 Maintaining ecological corridor networks is less costly than paying for their restoration at a later date

In Switzerland and in the Netherlands, the restoration of wildlife corridors of national importance has required a large amount of money (van der Grift 2005). Therefore, it is a good strategy to map ecological corridors and keep them sufficiently wide and free from development from the very beginning. Countries can save a lot of money by addressing the issue of landscape fragmentation now rather than ignoring the need for mitigation measures during road construction and having to deal with the increased costs of adding them later.

2.9 Caring about the quality of the entire landscape is essential, not just protected areas and wildlife corridors

Many wildlife species suffer from high mortality when moving outside of protected areas. This implies that we should *always* be concerned about the ecological effects of roads and about how to improve the ecological quality of the landscape – inside and outside of protected areas.

2.10 Make use of the road-effect zone for assessing large-scale effects of road networks

A new method for assessing the impacts of road networks on wildlife has recently been proposed by Torres et al. (2016), based on road effect zones of birds and mammals. This approach should be applied for cumulative impact assessment when new roads are planned, for different types of habitat and for different groups of species. Torres et al. (2016) propose an internationally coordinated a network of studies about road effect zones across ecosystems and geographical areas.

2.11 Increases in the populations of species that are positively affected by roads and traffic are not desirable, either

Many small mammals benefit from higher densities of roads, for example through predation release. However, these increases in population density are *not desirable* either. Therefore, we

should prevent community shifts towards more road-tolerant species in the first place by protecting the predators from the effects of roads.

2.12 We need an experimental approach to road mitigation and better long-term collaboration between transport agencies and road ecologists

The only way to achieve "environmental sustainability" is to support long-term and credible scientific research. Road mitigation experiments are the most informative and most efficient approach because they can more reliably reveal the effects of important design and landscape parameters on mitigation effectiveness.

3. Conclusion

It is dangerous to think that roads could be built anywhere if they come with wildlife crossing structures and fences. Crossing structures and fences mitigate only *some* of the effects of roads, but not all. A central database of road EIAs should be established to enable learning from previous studies and share experiences in a more systematic way. It is necessary to establish long-term collaborative links between ecologists and transportation agencies and to modify our approach to evaluating the effectiveness of mitigation measures. Multiple road projects in different regions can be combined and studied as part of integrated and well-replicated larger research projects (Rytwinski et al. 2015).

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PROCEEDINGS - FINAL PAPERS

IAIA17 presenting authors were invited to participate in the Paper Review Process: participation was optional. Below are the final papers of the contributing authors.

Adusei-Asante, Kwadwo - On the Brink of Politicisation, Public Policy IA Practice (final-papers/Adusei-Asante, Kwadwo - On the Brink of Politicisation, Public Policy IA Practice.pdf)

Adusei-Asante, Kwadwo - Towards Developing Policy Impact Assessment Framework (final-papers/Adusei-Asante, Kwadwo - Towards Developing Policy Impact Assessment Framework.pdf)

Amaya, Andres - Social Dynamics Prevent 400 MW Hydropower-Porce IV (final-papers/Amaya, Andres - Social Dynamics Prevent 400 MW