Fauna overpasses increase habitat connectivity and road permeability

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Roads and their impacts

Roads are among the most pervasive features of human presence on our planet. As with many other aspects of anthropogenic activity, however, the ecological impacts of roads has been recognised only relatively recently. Although the direct impact of roads is most conspicuous as road-kill, it is the less obvious indirect influences that are proving to be the most significant. Roads may represent a variety of impediments to the movements of animals, from minor or partial filter to a complete barrier, depending on a range of features of the road and the species involved.

But the influence of the road may extend well beyond its physical structure and the traffic it carries. One of the central concepts of road ecology is the 'road-effect zone', an area in which the cumulative effects of noise, pollution, vibration, disturbance associated with the construction of the road, and abrupt ecological change (Beckmann *et al.* 2010). Numerous studies, which have attempted to define and quantify this zone for a variety of taxa, have found dramatically different responses at the population level. While some species are attracted to the road verge, the huge majority, including many amphibians, reptiles, ungulates and birds, are negatively impacted and have reduced abundances closer to roads.

Overcoming the 'road barrier effect' has, therefore, becoming a primary aim of the field of road ecology. Many early construction solutions to this issue were highly specific, often focussed on particular species in single locations. Among the earliest examples of purpose-built wildlife crossing structures were the underpasses constructed during the 1950s for the Florida panther (*Puma concolor coryi*) and the 'tunnels of love' built in the 1960s to reconnect populations of the Mountain pygmy possum (*Burramys parvus*) severed by a road in the Victorian Alps. Since then, many wildlife passages have been constructed throughout the world (Taylor and Goldingay 2010). While various forms of wildlife underpasses have been installed for species of all sizes, existing culverts designed as conduits for water are increasingly being retrofitted with dry ledges for smaller species.

While interest in such engineering solutions to mitigating the impact of roads is spreading steadily, its most consistent and dynamic manifestation has been in Europe where strong European Union environmental protection legislation has required high standards of compliance for infrastructure developments. Indeed, the maturity of the field in the EU, in terms of the levels of planning, design, engineering standards and the exchange of information (see http://iene) appear to be well ahead of most of the rest of the world (Jones 2010).

This claim is supported by consideration of the scale of construction and level of innovation seen in wildlife overpasses from different regions. Australia, for example, now has five purpose-built wildlife overpasses, constructed between 2002 and 2010, all in coastal southern Queensland and northern New South Wales. The first North American overpass appeared in 1978 but only five more have since been constructed in that continent (Beckmann *et al.* 2010). In contrast, Europe has hundreds of wildlife overpasses: France alone has more than 130, Germany and Switzerland over 30 each, Poland 25 and the Netherlands 15 (Corlatti *et al.* 2009) with most European Union countries actively rolling out many crossing structures along all new motorways (www.IENE 2010).

Why Europe?

The reasons for the remarkable scale of fauna passage construction in Europe are complex and well beyond the aims of this article (see Trocmé *et al.* 2002). However, the international implications of these developments are such that a brief contextual summary is instructive. First, the rapid post-war expansion of the road network, in France especially, was seriously challenged, not only by environmentalists but also by the politically powerful hunting lobby. These hunters saw the populations of their target species (mainly deer) being progressively isolated and demanded a solution. The result was the world's first wildlife overpasses, constructed during the 1950-60s.

Second, the promulgation of a series of major European Council Directives aimed at environmental protection of key sites and species had profound implications for linear transportation infrastructure. The 'Habitats' Directive of 1992 required EU member states to identify sites of National Interest and obliged them to protect these sites from adverse development impacts. In all, these locations numbered over 22,000 and occupied 17% of the land area of Europe. With many of these sites concentrated in some of the most densely populated areas of Western Europe, the challenge for the expansion of transportation infrastructure was immense (Trocmé *et al.* 2002). To address this critical challenge, an international group of scientists, ecologists and engineers met in 1995 and formed the Inter Eco Network Europe (IENE) to facilitate the exchange of information and ideas.

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Moreover, with the ecological imperatives associated with 'de-fragmentation' generally accepted by European infrastructure agencies, structures that increase road permeability are now standard components of road design throughout Europe. Having become 'main-streamed', innovation in design has been enhanced and encouraged, a trend especially evident in the overpass construction.

What are wildlife overpasses?

Wildlife overpasses (often called ecoducts in Europe) are large structures at least 30-50m wide with a soil surface and some level of vegetation contiguous with the landscape on either side. Most are a sweeping convex design with slopes on either side leading to a relatively flat surface above the road. Their length is related to the local terrain and the width of the transport corridor, but may also be relatively short when crossing a road above a steep-sided cutting. Indeed, the largest form of wildlife overpass, the landscape bridge, is usually positioned in a relatively narrow cutting. These remarkable structures are typically over 100m in width but may be much larger; landscape bridges up to 1700m have recently been constructed in Spain and Switzerland.

Reflecting their origins as game bridges, most wildlife overpasses have been designed primarily to allow the passage of larger species of mammal, and the reconstructed vegetation on the surface tends to be open in structure, allowing an unhindered line of sight. More recently, however, numerous wildlife overpasses have been designed to attract a much broader diversity of taxa. Lines and dense clumps of trees have been shown to be effective in assisting the passage of songbirds while continuous rows of logs and stumps retained following construction are now widely employed to attract reptiles and amphibians.

But do they work?

A persistent response by road engineers to demands for the inclusion of wildlife overpasses in the design of new roads has been a request for reliable evidence demonstrating that "they actually work". This is not only a legitimate query; until relatively recently, such information was not easy to provide. Over the last decade or so, however, there has been an explosion of publications into all aspects of road ecology (see Beckmann *et al.* 2010), including several important meta-analyses of very large data sets (e.g., see Fahrig and Rytwinski 2009, Benítez-López *et al.* 2010). As well as providing detailed information on the effects of roads on a wide variety of species, evaluations of the effectiveness of many structures have also been undertaken, though longer-term genetic studies remain rare.

The studies that do exist provide increasingly detailed information on various features of overpasses directly relevant to improving design. For example, large mammals used wider overpasses significantly more often than those 20m wide or less. It is worth noting that while none of the Australian overpasses are wider than 40m, IENE recommends a minimum width of 50m.

Although primarily designed and constructed with large mammals in mind, well-designed and appropriately vegetated overpasses may also be the most comprehensively effective form of wildlife passage structure, with a wide range of taxa using them including small mammals, reptiles, amphibians, many insects and even small forest birds (Jones and Bond 2010). Particularly successful overpasses tend to be wide – at least 50m – and provide effectively a seamless connection with the habitat adjoining the road. Moreover, overpasses that are used by wide ranges of taxa represent a continuation of local habitat structure and plant diversity, providing a broad and apparently undisturbed passageway through the immediate landscape. In other words, a successful wildlife overpass will have been sited, planned and designed to provide effective landscape connectivity despite the presence of the road.

Conclusion

While they appear to be the most important structures associated with the mitigation of the ecological impacts of roads, they are, needless to say, also the most expensive. The inclusion of such a significant structure in a road design plan will always be the result of intense discussion among a diverse group of road engineers and designers, landscape ecologists and consultants, along with the funding agencies seeking to ensure the best value for money. For such reasons, road engineers and designers have often been understandably reticent about the inclusion of wildlife overpasses in the planning for new roads. Furthermore, a common justification for declining the inclusion of an overpass has been an apparent lack of reliable information, both of the technical details associated with design and construction, as well as convincing ecological data. With the explosion of recent studies and reviews addressing these issues, and the maturity of the field in Europe especially, but increasingly in Australia, such reticence is no longer credible. As stated by Anders Jansson, a leading IENE road ecologist almost a decade ago, "A lack of knowledge can no longer be seen as a valid motive for not taking the necessary action." (Trocmé *et al.* 2003).

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Australia's latest wildlife overpass, recently completed near Bonville in northern NSW.

The famous Groene Woud overpass in the Netherlands, constructed primarily to aid the movement of amphibians.

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