

# **Why Did the Turtle Cross the Street? An examination of herpetofauna habitat road fragmentation**

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## **Abstract**

Roads and urban development cause severe herpetofauna habitat fragmentation. The objective of this study is to analyze the road ecology problem of herpetofauna habitat fragmentation. It is argued that most wetland systems have high biodiversity conservation value and that their herpetofauna habitat fragmentation requires the implementation of adequate road crossing mitigation strategies. The research methods comprised mostly literature reviews on road ecology, habitat road fragmentation and mitigation, and roadway redesign measures. The key finding discovered was the urgent need for more continuous habitats, uniform underground crossings, and the elimination of reptile and amphibian road crossing deaths in (sub)urban settings. The study identifies the following five management recommendations: (1) Updating the existing knowledge on herpetofauna populations; (2) Engaging community constituents with road ecology and biodiversity activities; (3) Implementing various habitat mitigation measures; (4) Monitoring herpetofauna crossings in areas of need and maintaining the integrity of the protective measures; and (5) Disseminating research results through the creation of brochures, press-releases, newspaper, scientific articles, and presentations at conferences.

Keywords: Road ecology; herpetofauna; habitat fragmentation; mitigation measures.

## **Introduction**

Roads and urban development cause severe herpetofauna habitat fragmentation (Glista et al., 2009; Koemle et al., 2018). Some herpetofauna is at risk from a biodiversity conservation perspective, being even utilized in popular media for uses not conducive with needed conservation goals. This phenomenon is simultaneously a road ecology (D'Amico et al., 2018) and a public health problem (Schwartz et al., 2018), since it decimates biodiversity and it also potentially spreads diseases from the herpetofauna carcasses on the side of the road. It is argued that many wetland systems have high biodiversity conservation value and that their herpetofauna habitat fragmentation requires the implementation of adequate road crossing mitigation strategies. The objective of this study is to analyze the road ecology problem of herpetofauna habitat fragmentation.

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The study consists of four parts. Following this introduction, Part One places herpetofauna and biodiversity conservation in the broader context of road ecology and greenway planning. Part Two discusses a set of professional practice implications (i.e. on-the-ground restoration, environmental outreach, education and training, community partnerships, measurable results, and sustainability) needed to help eradicate increasing levels of herpetofauna mortality. Part Three proposes a set of future research advancements (i.e. knowledge, engagement, implementation, monitorization, dissemination) aimed at expanding the reach and impact of this study. And finally, part Four is the conclusion.

### **Greenways, wetlands and road ecology**

The main motivation for this review was the observed presence of many amphibians and reptiles in and around wetlands in many greenways and wetlands throughout the United States and Canada. Herpetofauna habitat fragmentation is a serious biodiversity and road ecology problem in the Northeast (Mitchell, Breisch and Buhlmann, 2006) and throughout the world (Elton and Drescher, 2018; Santos et al., 2017). There have been multiple attempts by individual scholars (Soulé, 1991; Coffin, 2007) and organized groups of researchers (e.g. Forman et al., 2003; Van der Ree et al., 2011; Lesbarreres and Fahrig, 2012; Andrews et al., 2015; Langton, 2015) at raising awareness to this road ecology problem.

Various aspects of road ecology have been studied over the years, ranging from an estimate of the area affected ecologically by the road system (Forman, 1998; 2000), turtle population inventories (Conant and Collins, 1991; Gibbs, 2007; Macdougall, 2016), herpetofauna behavioral patterns (Steen et al., 2006; Steen and Gibbs, 2004), and multiple habitat fragmentation and mitigation measures (Fitzsimmons and Breisch, 2015; Kintsch et al., 2015).

It is our conviction that new constructions and urbanization (Johnson and Klemens, 2005) tend to further bisect herpetofauna habitats if no mitigation plans are advocated for by concerned citizens and subsequently devised, implemented and monitored by regulatory and enforcement entities. Although the probability of getting killed when crossing the road (Grgurovic and Sievert, 2005) varies by species, local context, number of vehicles and speeds, time of the day and weather conditions, Hels and Buchwald (2001: 331) have concluded that “the probability of amphibian(s) getting killed ranged from 0.34 to 0.61 when crossing a road with a traffic load of 3207 vehicles/day, and from 0.89 to 0.98 when crossing a motorway”. Researchers have concluded that directing herpetofauna toward safe crossings (most commonly via underground passageways) is an important technique to reduce herpetofauna road crossing mortality.

Advances in ecological thought (Wals and Jickling, 2002), sustainable urbanism (Farr 2011; Roggema 2016), and sustainability science (Kates, 2011) enhanced our collective awareness and contributed to the construction of a limited number of LEED certified buildings surrounded by sound green

infrastructure in various communities throughout the United States. Most of these certified buildings were built with smart materials, help conserve energy, and preserve the environment (Torres-Antonini and Dunkel, 2009).

Although, parking space is also a requirement of the roadway system (Livingston and Mehlem, 2004), we note that it is possible to redesign roads and suburban parking in ways that enhance adjacent flora and fauna habitats, while fulfilling the goals of biodiversity conservation and enabling higher levels of ecological literacy (Levy and Marans, 2012).

Greenways, parks and Arboretums with a variety of trees and a myriad of gardens (e.g. botanical, classical, Japanese, community) can be found in all sorts of communities throughout the United States (Fábos and Ahern, 1996). These spaces enable active learning outside of traditional classroom environments. It is our conviction that most wetlands can be further utilized to foster stronger senses of ecological engagement and hands-on understanding of unique ecosystem functioning, and habitat conservation measures, such as safe crossings for herpetofauna.

We believe that wetlands are sensitive ecosystems in need of protection (Edinger et al., 2002; Smardon, 2009) and this requires the deployment of conservation policies aimed at restoring and enhancing their sensitive fauna and flora (Kleppel et al., 2004). A central component of the mitigation of habitat fragmentation is the analysis of existing herpetofauna habitat and the identification of mitigation measures such as the installation of protective barriers and the construction of underpasses, and or the replacement of existing pluvial pipes and wider tunnels to facilitate habitat connectivity. By identifying these measures, we are aware of a critical conservation puzzle where raising awareness of fragile endangered species through the installation of conservation measures to improve their habit continuity may also expose those populations to potential human and animal predators (Geller, 2012).

### **Professional practice implications**

It is recognized that wetland systems have high biodiversity conservation value and that their herpetofauna habitat fragmentation requires the implementation of adequate road crossing mitigation strategies. These are important professional practice implications:

***On-the-ground restoration*** – Wetland biodiversity through species and habitat inventories ought to be an integral part of watershed and conservation plans (Benson et al., 2017). We are particularly concerned with the conservation of various endangered species of turtles. However, we also recognize that other herpetofauna (including salamanders) can potentially also benefit from the biodiversity conservation measures identified in this review.

***Environmental outreach, education and training*** – The engagement of the public, particularly youth, in hands-on, outdoor conservation programs that create awareness of the importance of protecting and recovering at-risk species and their habitats and promote ecological stewardship is a very important road ecology goal (Wals and Jickling, 2002). Multiple publics from the community, including students and teachers from school districts, and environmental scientists and volunteers can perform very important roles in researching road ecology further, such as identifying species and proposing various habitat conservation and mitigation measures.

Furthermore, this review claims that the improvement of citizen understanding of damaging trash and litter impacts in local waterways may create positive awareness of road ecology problems. Neighborhood clean-up efforts within the context of community service campaigns and town-gown collaborations with off-campus communities can also increase communities' understanding of watershed planning, stormwater management, habitat restoration, and biodiversity conservation.

***Community partnerships*** – There is potential for the direct engagement of a diverse group of community partners to achieve ecological and specific educational outcomes, including partnerships among adjacent upstream and downstream communities. Garnering support from various on- and off- campus local and regional non-profit leaders is likely to help strengthen herpetofauna conservation awareness and the implementation of measures aimed at mitigating herpetofauna habitat fragmentation. Educational partnerships involving city administrations, universities, schools and non-profit organizations can be developed through innovative curriculum development, mentoring and tutoring activities. After school programs with an ecological focus are likely to create a stronger interest in helping to resolve this problem (Benson et al., 2017). Volunteering efforts can also expand weak sense of ecological literacy and understanding of habitat conservation measures among high-income and under-served populations.

Furthermore, this review also claims that it is possible to enhance existing local watershed and conservation plans and to foster diverse stakeholder partnerships, which can further lead to the development and implementation of more ecologically sensitive conservation plans. Regulatory environments have traditionally neglected wildlife conservation policies and measures (Ahern et al., 2009). Therefore, we anticipated an opportunity to develop and implement new biodiversity conservation, site and urban design, and road ecology plans (Carmona et al., 2010; Barrella et al., 2017). These plans can potentially strengthen and help to coordinate the actions of various constituencies with broad interests in stormwater management, wetland regeneration, and the mitigation of habitat fragmentation, among others.

***Measurable results*** – Measurable activities and conservation metrics, which clearly link watershed to positive community outcomes are critical to resolving the problem of habitat fragmentation. Initial conservation activities can serve to motivate, demonstrate progress, and help leverage additional resources. Those activities may range from studies and research on land and wetland restoration, the implementation of best management practices through protective fencing and green infrastructure for resolving stormwater runoff issues, to institutional capacity building, outreach, education, technical assistance, and volunteer participation, and monitoring. Community engagements can also demonstrate support for wildlife habitat, urban forestry, community gardening, and water quality-related recreational activities, and help to enhance the understanding across diverse communities of how wildlife conservation, clean water, and healthy forests can contribute to more resilient community wellbeing.

***Sustainability*** – This review establishes a commitment to strengthening a sense of community through capacity building for various partners. We are hopeful that individuals who pursue this research avenue will learn valuable sustainable development knowledge and skills, likely to make them feel motivated to advance their careers in various fronts. We also hope that students who volunteer or become familiar with road ecology will develop a stronger sense of ecological understanding, which may entice them to further their education by enrolling in biodiversity and sustainability programs (Barrella et al., 2017). Furthermore, the needs of priority and at-risk species, together with habitats and conservation actions need to be incorporated more fully and expeditiously into conservation plans. Even though greenways and

wetland resources are quite sensitive and range in location, size, complexity and biodiversity richness, which endows them with various levels of recognition at state and or federal levels, a proactive and anticipatory perspective on their immense value to society ought to lead to more thorough road ecology conservation strategies.

### **Future Research Activities**

Future research activities involving road ecology and the mitigation of herpetofauna habitat road fragmentation ought to discuss the following themes:

**Knowledge:** Updating the existing knowledge on herpetofauna populations at the local and regional levels is a must do in most communities throughout North America. Given the preeminence of specific ecological resources in distinct communities, we believe that it is quite opportune to also dedicate attention to less well known floristic and faunistic resources in need of conservation measures.

**Engagement:** Engaging a wide range of constituencies in road ecology and the mitigation of habitat fragmentation provides numerous opportunities for encouraging biodiversity conservation. In the past, collaborative partnerships among individuals and various types of entities have proven to be successful in multiple occasions (Kintsch et al., 2015).

**Implementation:** Best practices recommend the implementation of various habitat mitigation measures through the installation of barriers and fences, and the potential construction of underpasses. Once additional knowledge on the characteristics and behaviors of the herpetofauna species in various regions is more fully understood, the feasibility of implementing measures (vertical and/or electric fences, culverts, signage) aimed at mitigating these species' habitat fragmentation will also increase (Geller, 2012).

**Monitorization:** Monitoring herpetofauna crossings in pilot areas and maintaining the integrity of the protective measures is critical to the success of mitigating habitat fragmentation. Future monitoring activities of herpetofauna crossings can be conducted by a wide variety of constituencies ranging from community members, students and volunteers. Catch and release, and radio telemonitoring of herpetofauna movements are standard practices in biodiversity conservation programs (Michell and Michell, 2015).

**Dissemination:** Disseminating research results comprise the creation of brochures, fliers, press-releases, newspaper, magazine and journal articles, as well as presentations at scientific meetings and conferences.

### **Conclusion**

This review analyzed a broad panoply of literature on road ecology, wetlands and herpetofauna habitat fragmentation mostly in North America. It also identified potential mitigation measures such as the installation of protective fencing and the construction of underpasses on roads surrounding wetlands in sensitive greenway areas. We believe that this review has helped to advance the field of road ecology by demonstrating the opportunity to enhance conservation goals while fostering service collaborations. The key finding discovered was the urgent need for more continuous habitats, uniform underground crossings, and the elimination of reptile and amphibian road crossing deaths in (sub)urban settings.

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