

**ECOLOGICAL INFRASTRUCTURE: HOW TO PLAN FOR LOW PROFILE  
ANIMALS AND MINIMIZE HIGH PROFILE PROBLEMS**

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**ABSTRACT**

Small animals are considered low profile on roads because they are: literally small and therefore less visually obvious to drivers; present a reduced human safety or economic damage risk; more vulnerable to being struck on the road; and less apparent when they are declining in populations. For these reasons, assessments of road effects on small vertebrates and amphibians and reptiles in particular have demonstrated a pressing issue, yet these taxa receive little attention in the transportation planning process, even where quantified mortality rates exceed those of other vertebrate species. Part of the problem is that current transportation planning cycles and decision-making processes are focused around human infrastructure needs. However, by considering also **ecological infrastructure**, i.e., the connections among the habitat components (nesting, foraging, overwintering) that are necessary across life history processes (breeding, dispersal) to prevent interruptions in ecosystem function, we can proactively ensure that human infrastructure will do no harm to this existing ecological infrastructure. Further, negative attention, either in support of (due to threatened or endangered species concerns) or against a mitigation project (due to concerns of economic waste) can also greatly affect funding to address the problem. Thus, proactive and collaborative solutions to address low profile animals can minimize high profile problems. We provide examples and information from our upcoming book that addresses these problems and considerations for small animals, including expert guidance and recommendations for mitigation concepts and applications.

**BODY**

Small animals are considered low profile on roads for several reasons. Literally, small animals are physically small or short in stature and therefore, are less visually obvious to drivers in addition to presenting a reduced risk in terms of human safety and economic property damage. They are more vulnerable to being struck on the road, and it is also less apparent when they are declining in populations. Further, wildlife taxa, such as snakes, are not popular in today's society and do not raise public concern to the same extent as large vertebrates when there are elevated road effects. For these reasons, assessments of road effects on small vertebrates and amphibians and reptiles in particular have demonstrated a pressing issue, yet these taxa receive lagging attention in the transportation planning process (Andrews et al. 2008), even where quantified mortality rates exceed those of other vertebrate species. Increasingly, small animals are being studied by the scientific and wildlife management community, and more and more of these animals are being determined to be at risk due to habitat fragmentation (i.e., prevention of movement and greater isolation) as well as due to climate change. Thus, concepts and considerations of "safety" for these animals go beyond roadkill impacts and can mean ensuring population and metapopulation health.

Mainstream mitigation practices targeting single species in a local area or region may not be effective in maintaining biodiversity nor in contributing to the economic value of ecosystem services (MEA 2005). The costs of adding mitigation measures as a result of a threatened, endangered, or declining species concern or legal determination, as well as the costs of species recovery, far exceed the costs of proactive planning. Further, negative media attention, either in support of or against, a mitigation project, can greatly affect funding to address the problem. By proactively and collaboratively addressing these low profile animals, we can minimize high profile problems.

Best practices for design and mitigation to improve driver safety as well as to avoid wildlife conflict, especially in instances where roads are adjacent to or bisecting aquatic habitats, are sorely needed. Part of the problem is that current transportation planning cycles and decision-making processes are focused around human infrastructure needs. However, by considering also *ecological infrastructure*, i.e., the connections among the habitat components (nesting, foraging, overwintering) that are necessary across life history processes (breeding, dispersal) to prevent interruptions in the ecosystem, we can proactively ensure that human infrastructure will do no harm to this existing ecological infrastructure. To address these needs, we have developed a book that provides expert guidance and recommendations for concepts and applications for small animals.

Along with providing background on transportation planning processes, funding, and public engagement, we present information on the natural history of small animals. In particular, we have summarized what makes them vulnerable to roads and road-related impacts using an ecosystem perspective for considerations where land-to-land, land-to-water, or water-to-water passage, mitigation, retro-fitting, or other enhancement is concerned. This book encompasses the suite of both direct and indirect effects of roads on small animals with attention to minimizing costs and conflicts while maximizing connectivity and natural ecological functions. The ecosystem perspective will also allow for species groupings beyond taxonomic similarity and into habitat-based similarities and specializations (e.g., fully aquatic species vs. aquatic breeders, or fully terrestrial species vs. terrestrial breeders), or movement guilds (Kintsch and Cramer 2011).

We provide recommendations to facilitate improved (adaptive) approaches where new, targeted objectives are specified, as well as when a need arises to enhance an existing approach. We offer summaries of practical planning and design guidance, including real-world case studies; the opportunities to minimize regulatory burdens and costs; the relationship of these ideas with the maximization of small animal connectivity with new or expanded human corridor (transportation) needs; and addresses emerging issues, such energy development, and related considerations. Integrating ecological infrastructure into human infrastructure planning, design and delivery (environmental analysis and decision support) offers a better, and cheaper, way of doing business. The book is currently in press with Johns Hopkins University Press and will be the second in The Wildlife Society book series.

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### **BIOGRAPHICAL SKETCH**

**Priya Nanjappa** holds a M.Sc. in Biology from Ball State Univ. (2000) and a B.Sc. in Biology from Iowa State Univ. (1996). She leads the Association of Fish and Wildlife Agencies' (AFWA) national amphibian and reptile conservation and policy efforts. She provides executive staff assistance to the AFWA Amphibian & Reptile Subcommittee (reporting to the AFWA Wildlife Resource Policy Committee), and coordinates activities with and for the States through Partners in Amphibian and Reptile Conservation (PARC). As such, she has an in-depth working knowledge of the state wildlife agencies at the national level. In addition, she is the Conservation Section Editor for the journal, *Herpetological Review*. She was involved previously in regional- and national-scale amphibian and reptile research, monitoring, and conservation activities including the USGS Amphibian Research and Monitoring Initiative (ARMI), Northeast Region (2001-2005), and also assisted in the development and national coordination of the National Amphibian Atlas distribution maps website and database (1998-2005). The latter was initiated with her graduate work, in association with the book project, *Amphibian Declines: Status and Conservation of United States Species* (edited by Michael J. Lannoo, Ph.D.), in which she co-authored the Introduction and several species accounts.

**Kimberly Andrews** earned her Ph.D. in Ecology (2010), a M.Sc. in Conservation Ecology and Sustainable Development (2004), and a B.Sc. in Ecology (1999) from the University of Georgia (UGA) Odum School of Ecology. Kimberly has a joint position as the Research Coordinator on Jekyll Island and as a staff researcher at the UGA Savannah River Ecology Lab. She moved to the Jekyll Island Authority's Georgia Sea Turtle Center in 2011 to establish a research and graduate student lab that focuses on spatial ecology, human-wildlife interactions, road effects, the assessment of wildlife-compatible designs for small vertebrates, developing approaches for retaining ecological viability and permeability in urbanizing landscapes, and advancing ecological studies through the integration of wildlife health. Kimberly works with coastal projects to address effects of development designs on wildlife movement patterns and human-wildlife conflict assessment and reduction. Additionally, she uses ecological modeling assessments to assess sensitive species on federal lands that are vulnerable to local and global human changes. She is also the national chair of the PARC Roads Task Force group whose objective is to disseminate information, form collaborations, and develop products that inform wildlife enhancement components of transportation projects.

**Seth Riley** graduated in 1988 from Stanford University with a B.A. in Human Biology, concentrating in Animal Behavior and Ecology and obtained his Ph.D. in Ecology in 1999 from the University of California, Davis. Since his first professional experience with the National Park Service in Washington, D.C. in 1987, Seth has been interested in wildlife in urban areas and the effects of urbanization and habitat fragmentation on animal ecology and behavior. At the beginning of 2000, Seth began in his current position with the National Park Service as Wildlife Ecologist Santa Monica Mountains National Recreation Area, and he also has an adjunct position with the Department of Ecology and Evolutionary Biology at UCLA where he advises students and teaches graduate seminars. His current projects, all related to the impacts of urbanization and

fragmentation on wildlife, include a bobcat telemetry study, a mountain lion GPS telemetry study, stream surveys for amphibians, pitfall/drift fence trapping to determine terrestrial reptile and amphibian distribution and abundance, projects with California Department of Transportation to determine road impacts on wildlife, and evaluation of the effects of rodenticides on non-target wildlife. He recently co-edited the book, *Urban Carnivores*, in which he also co-authored seven chapters.

## REFERENCES

- Andrews, K.M., J.W. Gibbons, and D.M. Jochimsen. 2008. Ecological effects of roads on amphibians and reptiles: a literature review. Pp. 121-143 in *Urban Herpetology*, J.C. Mitchell, R.E. Jung Brown, and B. Bartholomew, editors. Society for the Study of Amphibians and Reptiles, Herpetological Conservation Volume 3, Salt Lake City, UT.
- Kintsch, J., and P.C. Cramer. 2011. Permeability of existing structures for wildlife: developing a Passage Assessment System. Final Report to Washington Department of Transportation, Report WA-RD 777.1, Olympia, WA. URL:  
<http://www.wsdot.wa.gov/research/reports/fullreports/777.1.pdf>
- Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington. 155pp.