



# Do California Highways Act as Barriers to Gene Flow for Ground-Dwelling Mammals?

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## Issue

The principle of sustainable transportation suggests that impacts to environmental processes and patterns will be limited as much as possible during construction and operation of the transportation system. Wildlife populations are affected by transportation in various ways, including individual animal deaths due to collisions with vehicles, animal aversion to roads due to light and noise, habitat fragmentation, and human access for recreation and hunting<sup>1</sup>. If individual animals of a species have limited movement in part or all of their range, then divided populations can become genetically different from each other, which can jeopardize survival of populations and even whole species. This population subdivision can happen even in the relatively short time since California highways were constructed. For example, U.S. 101 in Southern California has been found to be a physical and social barrier to gene flow in carnivores<sup>2</sup>, which suggests a current and possibly widespread effect of transportation infrastructure on wildlife genetic diversity. Carnivores are especially vulnerable to population division by highways because they have large movement requirements as they seek prey and disperse.

## Key Research Findings

Although research has shown Southern California highways can significantly impede gene flow of numerous taxa<sup>3</sup>, few studies have investigated the effect of Northern California highways. A new study from the

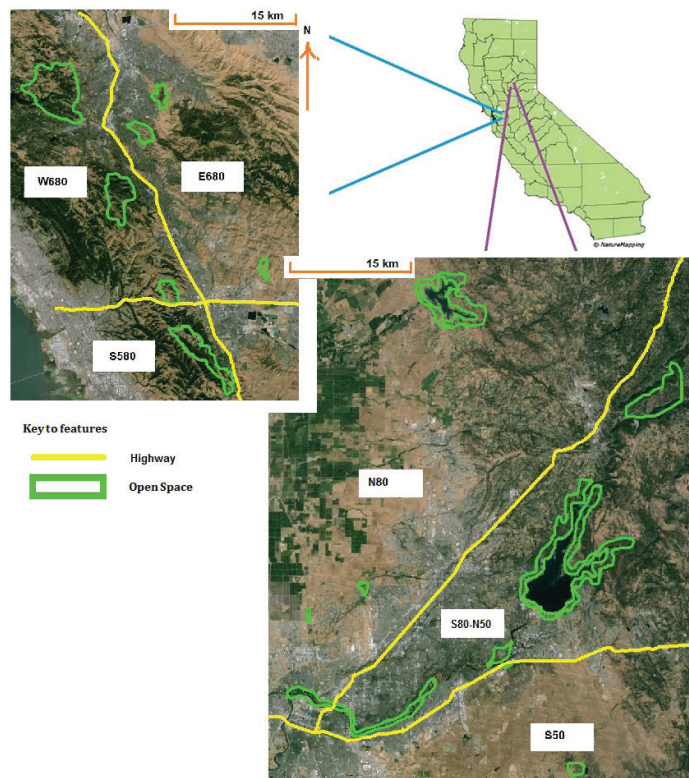


Figure 1: Study areas in the Bay Area and Sierra Nevada foothills in which coyote sampling occurred.

University of California, Davis (UC Davis), examined the potential population division effect of highways on coyote populations in the Bay Area and Sierra Nevada foothills (Figure 1). The coyote was chosen because it is abundant, wide-ranging in California, uses many habitat types, and is easy to sample through collection of scat. If genetic effects were found among the coyote populations in these two regions, then it would be reasonable to expect that similar effects would be found for other wide-ranging carnivores and non-carnivores.

Results from the study found high levels of genetic diversity in coyotes in both regions. These results are comparable to other similar studies. Little evidence was found of genetic structuring across highways in the Bay Area or Sierra Nevada

foothills suggesting highways in these two regions are not currently limiting gene flow in coyotes on either side. When structuring is discovered in wildlife populations, it means that there is some barrier to gene flow separating subpopulations. Though this study did not find genetic structuring among coyotes due to the presence of a highway does not mean it is not occurring among other species, most notably endangered species with low genetic diversity or small-bodied wildlife less capable of successful road crossing.

These results contrast with the findings of a previous study examining coyote movements and gene flow across U.S. 101 in Southern California<sup>4</sup>. In the Southern California study, two populations were detected and corresponded to the north and south sides of the highway and although migration across the highway occurred, there was little gene flow because migrants could not reproduce successfully. There are two alternative explanations for why results differ between the two studies. In the UC Davis study, highways may be permeable to coyote movement due to successful road crossings or use of crossing structures. Although coyotes have not been observed using culverts or underpasses to cross S.R. 50 and I-80 in the two regions studied, coyotes do use crossing structures on these highways at higher elevations<sup>5</sup>. Alternatively, the highways within the two study areas may not have been in place long enough to produce detectable signals of genetic structure in a genetically diverse, large bodied, and wide-ranging species like coyote. Other studies have shown there can be

a time lag between introduction of a barrier and development of detectable genetic structure<sup>6</sup>.

### Policy Implications

State and federal environmental and transportation statutes support and require actions that minimize impacts from construction and operation of transportation systems, including disruption of wildlife gene flow. The UC Davis findings suggest that certain existing structures (i.e., undeveloped under crossings) are being used by wildlife to safely cross highways. Therefore, use of these structures should be protected and for areas where genetic structuring is evident or likely, new structures should be built to increase the overall sustainability of the transportation network.

To effectively plan these and other mitigation activities, transportation agencies must determine which roads to target and which species are most affected. Wildlife movement and gene flow will vary by road and species. Physical characteristics of roads (e.g. width, gradient, traffic volume) can affect their permeability to different species<sup>7</sup>. In addition, a single road can affect different species to varying degrees due to species-specific behavior patterns. As an example, the Trans-Canada Highway was a significant dispersal barrier for grizzly bears but not for black bears<sup>8</sup>. Therefore, mitigation solutions must be context-sensitive given that the impacts of roads on wildlife gene flow cannot be generalized in space or among species.

<sup>1</sup> van der Ree, R., D.J. Smith, and C. Grilo. 2015. Handbook of Road Ecology. Chichester, West Sussex: John Wiley & Sons Ltd.

<sup>2</sup> Riley, S. P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C. Bromley, T.K. Fuller, and R.K. Wayne. 2006. A southern California freeway is a physical and social barrier to gene flow in carnivores. *Molecular Ecology* 15:1733–1741.

<sup>3</sup> Riley, S.P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C.Bromley, T.K. Fuller, and R.K. Wayne. 2006.

<sup>4</sup> Riley, S.P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C.Bromley, T.K. Fuller, and R.K. Wayne. 2006.

<sup>5</sup> Shilling, F. Unpublished data.

<sup>6</sup> Holzhauer S. I. J., K. Ekschmitt, A. C. Sander, et al. 2006. Effect of historic landscape change on the genetic structure of the bush-cricket *Metrioptera roeseli*. *Landscape Ecology* 21:891–899; Schreier A. D., B. Mahardja, B. May. 2013. Patterns of population structure vary across the range of the white sturgeon. *Transactions of the American Fisheries Society* 142:1273–1286.

<sup>7</sup>Gerlach and Musolf 2000, Marsh et al. 2005, Charry and Jones 2009.

<sup>8</sup> *Ursus americanus*; Sawaya et al. 2014.

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