National Center for Sustainable Transportation

POLICY BRIEF

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

Andrea Schreier, Fraser Shilling, and Amanda Coen
University of California, Davis

For more information, contact:
Andrea Schreier - amdrauch@ucdavis.edu

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[1]. 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 genetic effect can happen in the lifetime of California's highways. For example, U.S. 101 in Southern California has been found to be a physical and social barrier to gene flow in carnivores[2], suggesting that this is a current and possibly widespread effect of transportation infrastructure. Carnivores are especially vulnerable to population division by highways because they have large movement requirements as they seek prey and disperse.

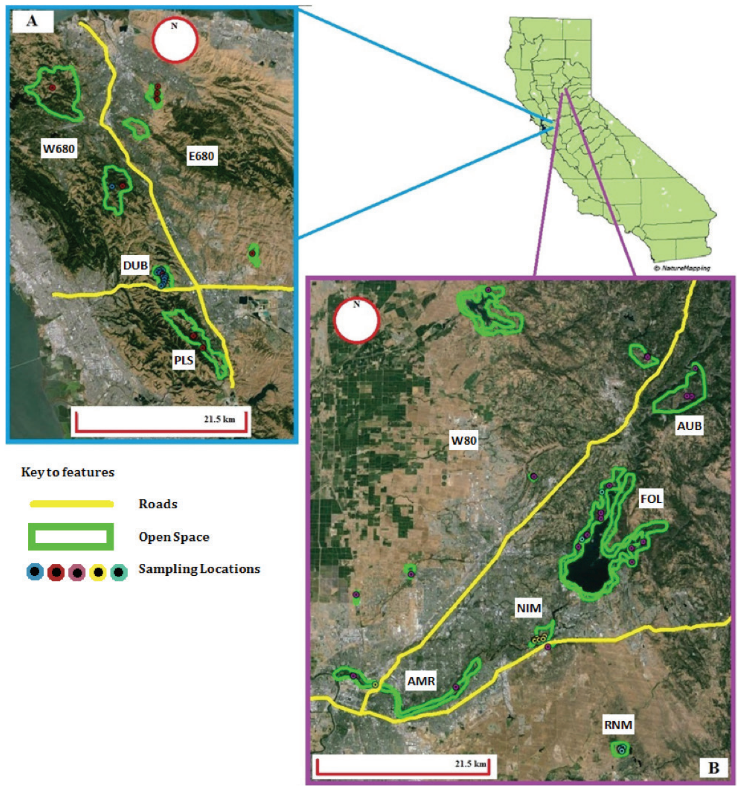

Figure 1: Study areas in the Bay Area (A) and Sierra Nevada foothills (B) in which coyote sampling occurred

Key Research Findings

Although research has shown that Southern California highways can significantly impede gene flow of numerous taxa[3], few studies have investigated the effect of Northern California highways. This study 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 population 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.

In both regions, significant genetic structuring was found among the coyote populations. When structuring is discovered in wildlife populations, it means that there is some barrier to gene flow separating subpopulations. In this case, structuring across highways would suggest that the highways act as barriers to coyote movement although it is unclear to what degree highways are impeding coyote gene flow versus other factors. For example, the most genetically divergent population in the Sierra Nevada study area was separated from all other sampling locations by one or two highways. However, it was also the most geographically distant population suggesting that isolation by distance may play a factor in its genetic divergence.

Our results contrast with the findings of a previous study examining coyote movements and gene flow across U.S. 101 in Southern California[4]. 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. The coyote populations found in our study in Northern California didn't necessarily correspond to sides of a highway although we also identified possible instances of migration, which may be facilitated by crossing points such as culverts and underpasses. Although coyotes have not been observed using culverts or underpasses to cross S.R. 50 and I-80 in our study areas, coyotes do use crossing structures on these highways at higher elevations[5]. We hypothesize coyotes are crossing S.R. 50 and I-80 at higher elevations and moving down into lower elevation areas.

The sample size on which our preliminary results is based is small (N=59) and additional work is required to clarify how often coyotes and other mesocarnivores are moving across highways in the Bay Area and Sierra Nevada foothills. Increasing our sample size will help us better understand how highways contribute to genetic structuring in these regions. In addition, in both regions, busy secondary roads and presence or absence of structures across them may contribute to or prevent animal movement and gene flow, independent of highways.

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. Our findings suggest that existing structures (i.e., overpasses and under crossings) are being used by wildlife to safely cross highways. Therefore, 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[6]. 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[7]. 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.

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

[2] 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.

[3] Riley, S.P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C.Bromley, T.K. Fuller, and R.K. Wayne. 2006.

[4] Riley, S.P.D., J.P. Pollinger, R.M. Sauvajot, E.C. York, C.Bromley, T.K. Fuller, and R.K. Wayne. 2006.

[5] Shilling, F. Unpublished data.

[6] Gerlach and Musolf 2000, Marsh et al. 2005, Charry and Jones 2009.

[7] Ursus americanus; Sawaya et al. 2014.