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Modeling Traffic Noise and Light on Natural Landscapes at the State Scale

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16. Abstract

Anthropogenic noise and light have been shown to impact wildlife behavior, distribution, movement, and population fitness and survival. Traffic noise and light can inhibit wildlife use of areas adjacent to roads, impair wildlife perception of traffic risks, and cause a barrier effect to wildlife occurrence and movement well beyond road edges. A critical action being taken by states to repair wildlife movement across roadways is construction of wildlife crossings, theoretically providing a safe passage across roads. Planning the location of theses crossings and to some degree their design currently does not take into account traffic noise and light impacts on wildlife approaching the structures. The authors developed statewide models of traffic noise and light intrusion into areas adjacent to state highways to aid understanding of wildlife responses to noise and light and to aid locating and designing crossings to maximize wildlife approach and use. These models have the added benefit of estimating traffic impacts as part of environmental analysis associated with delivering transportation projects. The authors used the NoiseModeling software in QGIS and novel light-modeling tools developed in ArcGIS to model the "noise-scape" and "light-scape" at high-resolution around California state highways. They used different putative sources of traffic noise and light and model propagation (depending on traffic volumes) of both across adjacent landscapes out to at least 1 kilometer. The authors tested the models in the field using transects of noise and light measurements. The outputs were digital (raster) maps that showed the high and low impact areas.

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Disclaimer

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Executive Summary

Anthropogenic noise and light can significantly alter animal behavior and well-being, including in humans. Road traffic is an extensive source of noise and light which occurs in most landscapes and is likely to negatively impact wildlife movement through adjacent landscapes and in relation to roads. Variation in noise and light during the day-night cycles and in relation to each other could alter impacts within a single species. Variation in sensitivity to noise and light among species could change their ability move relative to each other and therefore alter natural wildlife communities and dynamics. Roadway crossings, including those built for other purposes (e.g., drainage) and for wildlife (e.g., wildlife crossing structures (WCS)) are locations where it is highly desirable that wildlife traverse highways. Traffic noise and light impacts on wildlife use of these structures could have serious repercussions for individual species and ecosystems.

We modeled traffic noise and illumination for areas adjacent to (out to one kilometer) California highways, the first time that this has been carried out at this extent. The models were high-resolution (30-meter raster), which means they can be used for planning. We also compared modeled noise and light to field measurements. The noise model generally performed well (had low uncertainty) predicting noise levels, with some exceptions. The light models performed well predicting dark and light locations, but less well predicting the relative intensity of illumination. We are continuing to work on these to improve performance.

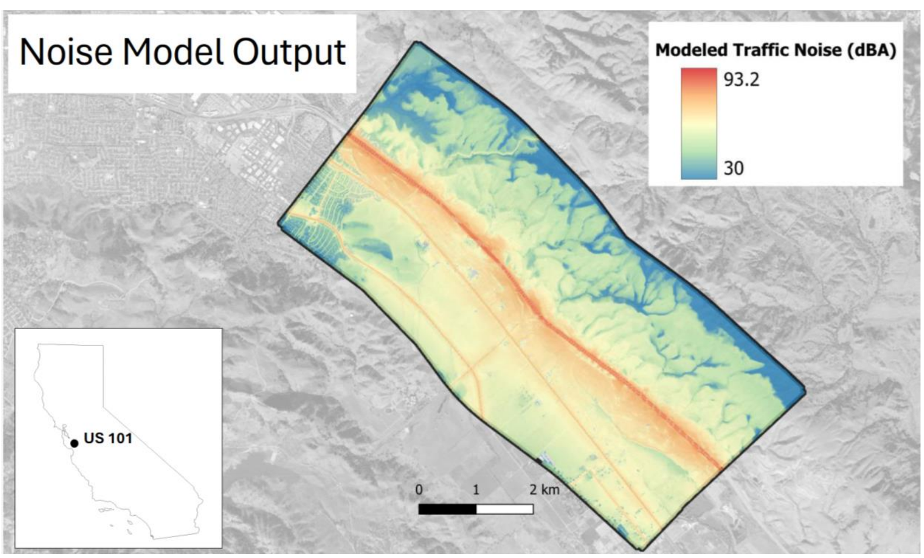

Figure E1. Modeled traffic noise around U.S. 101 and local roads in Coyote Valley, Santa Clara County, CA.

The models were used to calculate noise and light conditions around proposed WCS at several locations across state highways (State Route 152 and United States Route 395). These proposed WCS are being planned and designed by engineering firm Mark Thomas with support from the California Wildlife Conservation Board. Preliminary engineering designs were available for several locations and were used to model noise and light conditions. Under typical construction scenarios, noise and light conditions would have been intolerable for many wildlife species on at least one side of the proposed WCS and often on the deck of the WCS itself. In modeling space, we added noise walls (three meters and four meters in height) adjacent to the right-of-way to inhibit noise and light penetration into the surrounding landscape.

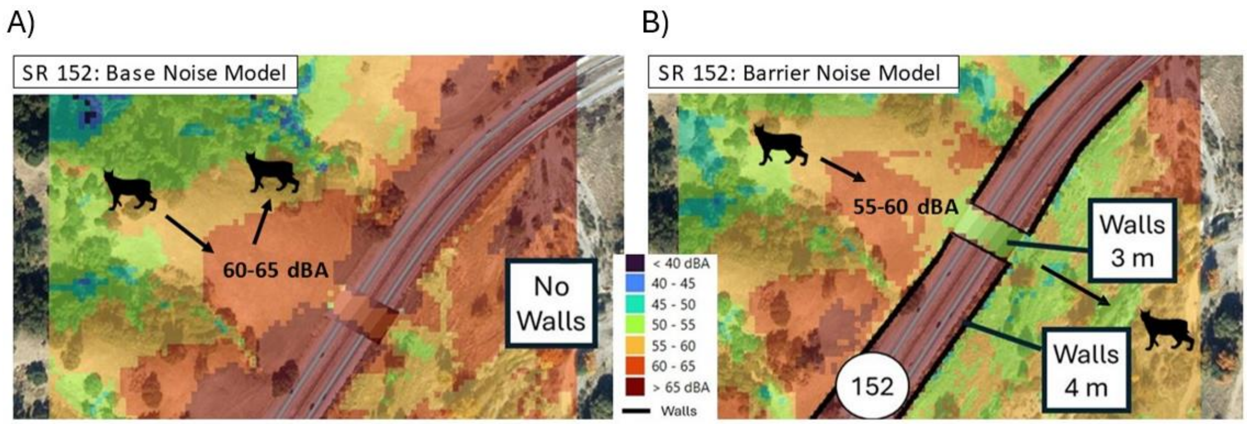

Figure E2. Noise conditions around a proposed WCS across SR 152 in the (A) absence and (B) presence of noise walls.

We are currently sharing these statewide traffic noise and illumination models, which we consider to be roughly beta versions, through our data-sharing platform "CROSPlan" (https://crosplan.wildlifecrossings.net). This means that others can download the model products for their study area when planning WCS. Although we are unlikely to change the noise model much, we are continuing to develop the illumination model to try and improve its prediction of landscape illumination conditions.

In summary, we created and are sharing statewide traffic noise and light models. We have tested these using field measurements and used them to evaluate and help plan WCS. We are continuing to improve the models and will share updated versions through our web platform.

Introduction

Wildlife are sensitive to a similar range of sound levels as humans are. Vehicle noise can affect wildlife communication (Parris and Schneider, 2008; Owens, 2013), habitat occupancy (Davies et al., 2013; Goodwin and Shriver, 2010), vigilance (Shannon et al., 2014; Li et al., 2009), predation efficiency (Siemers and Schaub, 2011), predator avoidance behavior (Meillere et al., 2015), and various other behaviors (Longcore and Rich, 2004; review: Francis and Barber, 2013; Ware et al., 2015). Anthropogenic noise from various sources, including transportation, are pervasive throughout the U.S., including in protected areas that theoretically provide sanctuaries for wildlife (Buxton et al., 2018). Wildlife crossing structures (WCSs) are often located and designed to optimize wildlife use. Despite the widespread recognition that artificial light and noise can affect wildlife in various ways, available location and design guidance for wildlife crossing structures does not consider the existence of or mitigation treatments for traffic noise and light as wildlife approach highways and proposed or existing WCSs (e.g., Clevenger and Hujser, 2011).

Anthropogenic noise and light propagate through landscapes differently and areas may be bright and quiet, or darker and noisy, depending on roads and nearby development (Buxton et al., 2020). Both traffic noise and illumination theoretically change at rates inversely proportional to the square of the distance from the road edge, but may be separately reflected and absorbed by structures, vegetation, and geological formations. This means that as animals approach highways and wildlife crossing structures, they will encounter increasing and variable light and noise conditions. This heterogeneity at fine scales has not been characterized at the U.S. state scale.

Given the sensitivity and responsiveness of many wildlife species to anthropogenic noise and light, an increase in traffic volume and resulting traffic noise and light would likely reduce the habitat and WCS use by sensitive species. Identifying the anthropogenic noise and light conditions that would and would not interfere with the approach of wildlife to WCSs would be useful for transportation and conservation organizations engaged in environmental mitigation planning. We have previously quantified the traffic disturbance (noise and glare) conditions that can affect wildlife presence and behavior approaching highways and at wildlife crossing structures (Shilling et al., 2018 & 2020; Collins et al., 2022; Barrientos et al., 2023). We have also used field-measurements and modeled light/soundscapes to describe possible opportunities and barriers to reduced-disturbance approach zones to existing and proposed crossing structures (Shilling et al., 2022). Our goal is to model the artificial noise and light conditions in the “approach zone” to highways and WCSs would help with designing future mitigations that are more broadly effective, including informing where to place these multi-million-dollar structures. In the case of existing WCS in natural areas, modifications to the approach zone, or the bridges themselves to reduce noise and glare could cost-effectively increase wildlife use.

Methods

Traffic Noise Modeling

Landscape noise levels were calculated using the Geographic Information Systems (GIS) sound mapping program, NoiseModelling. NoiseModelling is a deterministic sound level simulation tool that allows users to calculate initial sound emissions from traffic sources and model sound propagation from sources to receivers across a landscape. The propagation model uses attenuation and diffraction algorithms to simulate sound wave interactions with terrain and structures, allowing users to calculate noise levels in complex geographies. The model implements the European noise standard, Common Noise Assessment Methods in Europe (CNOSSOS-EU) (Kephalopoulos et al., 2012), computes sound emission from traffic, and simulates noise propagation over landscapes.

The program requires data for sound emission sources (roads), receivers, and local geography to produce landscape traffic noise levels. Data for road network geometry, hourly traffic flow, vehicle type, and average speed were compiled from the U.S. Department of Transportation's Highway Performance Monitoring System and from estimates based on select traffic census stations within the California Department of Transportation's Performance Measurement System. A grid of receiver points was created for each study area using GIS software. Topographical data were obtained from U.S. Geological Survey's digital elevation models. Building geometry data were compiled from the Microsoft U.S. Building Footprints dataset. Ground cover data were obtained from the National Land Cover Database. The data were loaded into a GIS program (QGIS) and standardized for model compatibility using "H-RISK with NoiseModelling," a tool that allows users to execute NoiseModelling calculations within a GIS environment. Model results of A-weighted decibels during day, evening, and night periods were converted to landscape noise maps.

Comparison with Other Noise Modeling Programs

Simulated noise levels produced by NoiseModelling were compared to simulated levels produced by the U.S. Federal Highway Administration's Traffic Noise Model (TNM) program. Noise levels were simulated over flat terrain. Due to technical limitations and ease of use concerns, NoiseModelling was preferred over TNM at large and small mapping scales.

Traffic Illumination Modeling

The illumination models were built by combining several data sources, geospatial tools, and analytical methods to represent the overall light coverage and intensity across the landscape. A digital elevation model (DEM) was used to represent the terrain. For crossing structures and local applications, we used a one-meter DEM while the statewide model used a ten-meter DEM. The DEMs were downloaded from the U.S. Geological Survey (USGS) National Map. For the analysis, we kept the projection in which the DEM was downloaded which was North American Datum of 1983 (NAD83) Universal Transverse Mercator (UTM) zone 10N (EPSG:26910) for the one meter and NAD83 North America (EPSG:4269) for the ten-meter. We used the QGIS Plugin “Visibility Analysis” to generate a viewshed of the region which determines what points across the landscape would be exposed to the highway headlights. For one viewshed model, we use the maximum value which generates a binary raster that shows which areas could be illuminated and which areas would be in the dark. We also built an additive model which, for every point on the landscape counts the number of highway illumination points that could be seen. This latter model provides an estimate of intermediate illumination.

We used the Highway Performance Monitoring System (HPMS) to represent the roads. The QChainage tool was used to generate sets of points at regular intervals on top of the road to mimic vehicle headlights and determine their visibility. While the concentration of points is based on the relative Annual Average Daily Traffic (AADT) values, a minimum number of points were required to ensure that the results provide a smooth set of values across the landscape. For the state scale model, we used a minimum of points at 20-meter intervals for interstate highways and 50-meter intervals for state highways. Points were set at one meter above the ground and a radius of 1,000 meters was analyzed around each point. A proximity matrix (distance raster) was generated where each cell included a value for distance from a light source. We used the inverse square law (rate of decay of light in a circle) against this proximity matrix to calculate the light intensity attenuation at all locations within the study region. The formula to calculate the light intensity (based on the inverse square law) is:

$$< \mathrm{viewshed\_value} > * \ 1 \, / \, (< \mathrm{proximity\_matrix\_value} >)\hat{}2$$

Field Testing Models

Noise and light models were tested using handheld meters adjacent to five highways: California State Route (SR) 152, U.S. Route 97, U.S. Route 101, Interstate 10 (I-10), and Interstate 8 (I-8) (Figure 1). Exact locations at which noise and light measurements were taken were first scoped using Google Earth imagery. Points were in areas that prioritized proximity to the road while remaining safe along busy highways. In the field, survey point locations were shifted depending on safety and access conditions.

Figure 1. Locations of field measurements to test models.

For U.S. Route 97, noise measurements were taken along five transects 100 meters apart from zero, 20, 100, and 500 meters leading away from the highway. For SR 152, noise transects were taken from zero to 1,000 meters away from the highway, depending on opportunistic side road features. Further noise measurements were taken at topographical low points adjacent to the road and in quiet areas at least 1,000 meters from SR 152. Light measurements along SR 152 were also taken at topographical low points adjacent to the road and at the road shoulder. Along U.S. Route 101 noise measurements were taken from zero to 2,000 meters away from the highway, again dependent on local side road access (Figure 2).

Noise measurements were taken using PCE-322A sound level meters (Figure 3A). Meters were always set on the tripod that came with the meters (approximately one foot tall) facing the highway of interest. Recording settings were set to "fast" meaning the time rating is 125 milliseconds and the sound level range was 30 to 130 A-weighted decibels (dBA). Measurements were recorded for at least ten minutes, and detailed notes for any noise disturbances (person talking, airplane passing, gunshots, etc.) were taken during the recording for later removal. Data clean up included removing data points when disturbances occurred. The average, 95th, and 99th percentile were calculated in Excel.

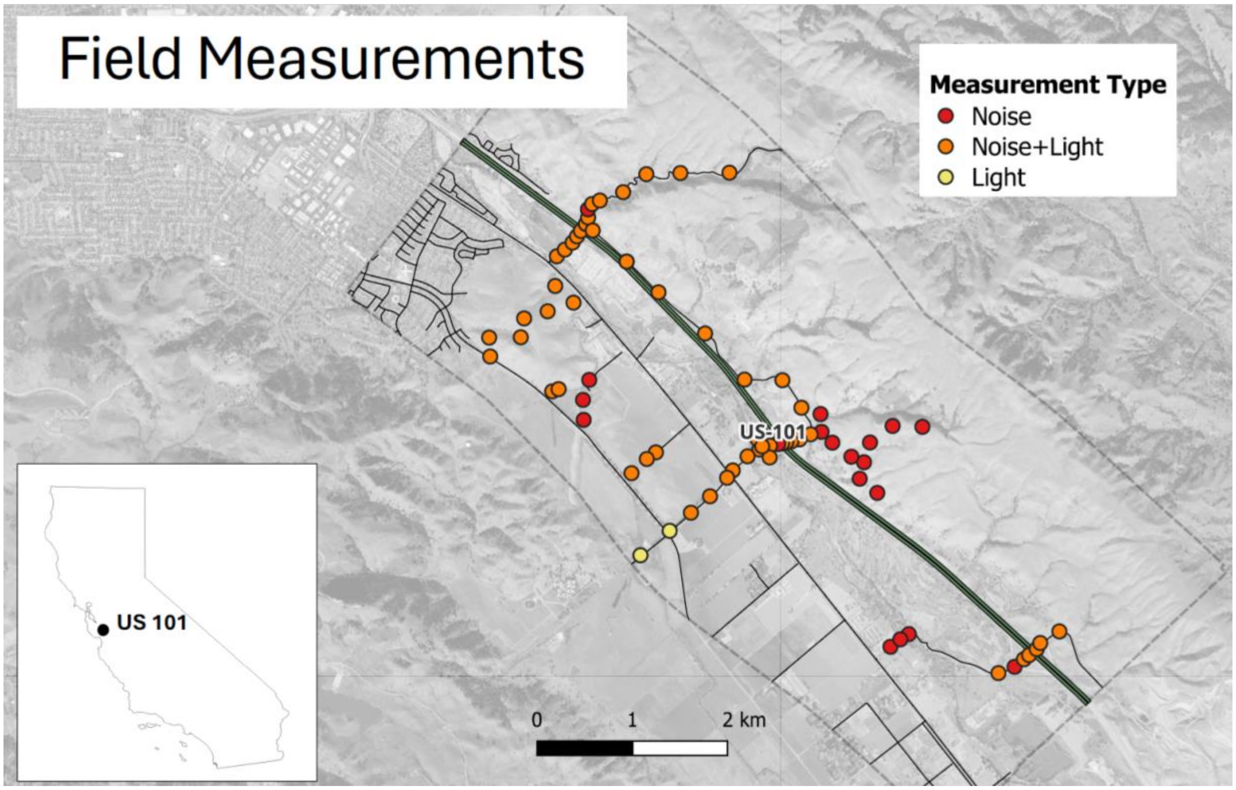

Figure 2. Locations of field measurements in Coyote Valley adjacent to U.S. Route 101.

Light measurements were taken using Gossen MavoMaster and Mavo Probe Light Sensor 5032 B (Figure 3B). The sensor was aimed towards the highway of interest at about human mid-section height. Light recordings collected the average, maximum, and minimum lux values from the duration of the recording. Measurements were taken when at least one vehicle was passing in front of the meter along the highway. Vehicle type and count (car, semi-truck, or other) was noted for each recording.

A) B)

Figure 3. A) PCE sound level meter. B) Gossen MavoMaster light meter. Illuminance Range: 0.001 lx – 199,900 lx. Sampling Rate: 2 measurements per second.

Comparison with Field Measurements

Simulated noise levels produced by NoiseModelling (LAEq) were compared to observed noise levels captured at select survey sites. Summary statistics of observed noise levels were calculated, and the 95th percentile value was compared with simulated noise. The 95th percentile value essentially includes all sound pressure values when vehicles are passing and ignores background. This is similar to the approach taken by the model, which assumes constant sound pressure. Association between simulated and observed noise was determined using statistics software (R), and model accuracy was assessed using regression coefficients and R-squared values.

Modeled illumination levels were compared to observed illumination in two ways: 1) Binary comparison: by measuring illumination adjacent to the travel lanes and beneath bridges adjacent to the highway (dark); and 2) Gradient comparison: by measuring illumination at varying distances from the travel lanes.

Results

Traffic Noise Modeling

Traffic noise propagation from all state highways was modeled at 30-meter resolution (Figure 4). The models were found to be accurate for multiple individual highways, with inaccuracies driven primarily by unaccounted for sources of noise. As far as we know, this is the first accurate statewide modeling of highway traffic noise in the U.S. Inclusion of minor roads in several areas (e.g., Coyote Valley, Santa Clara County; Figure 5), resulted in larger areas of noise impacts that were not present in the state highway-only model.

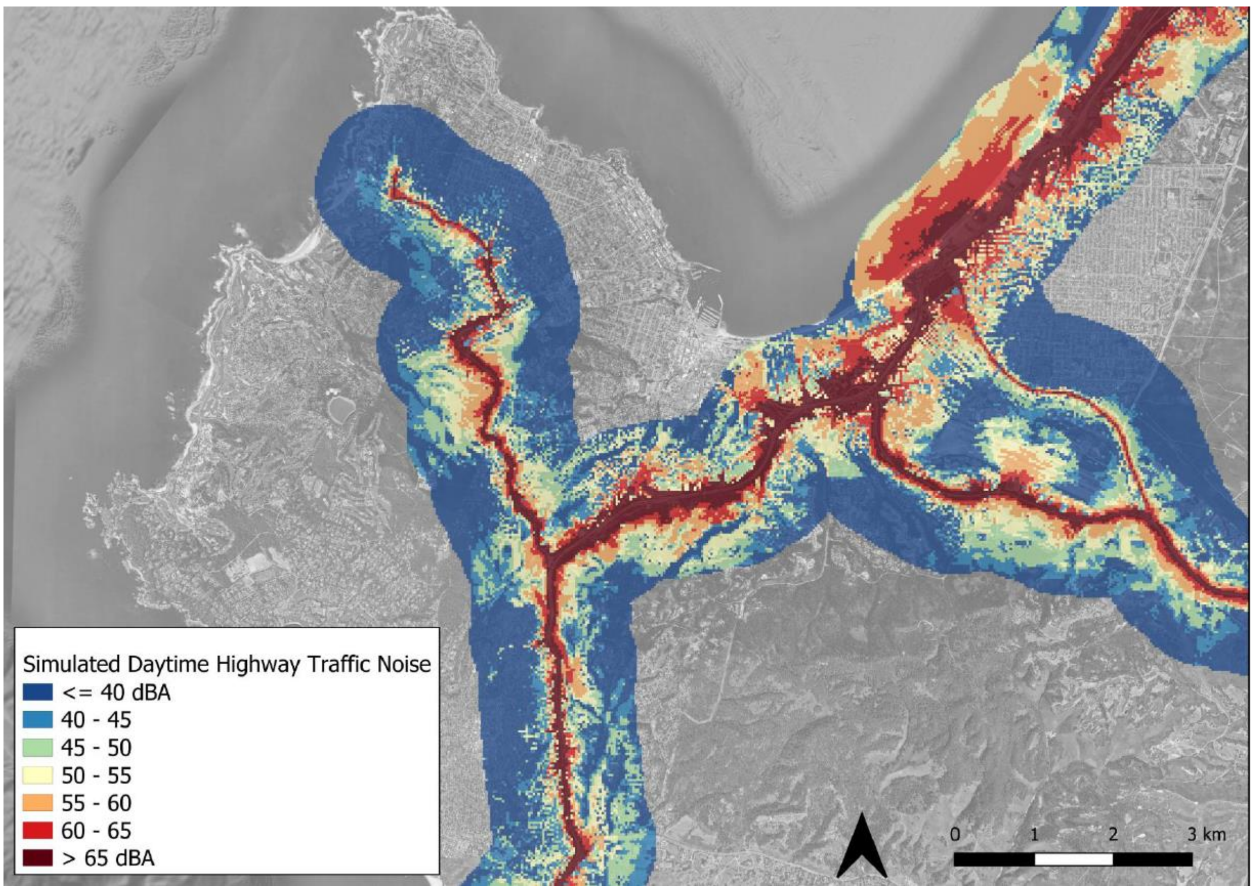

Figure 4. Modeled noise adjacent to state highways in the Monterey Peninsula area.

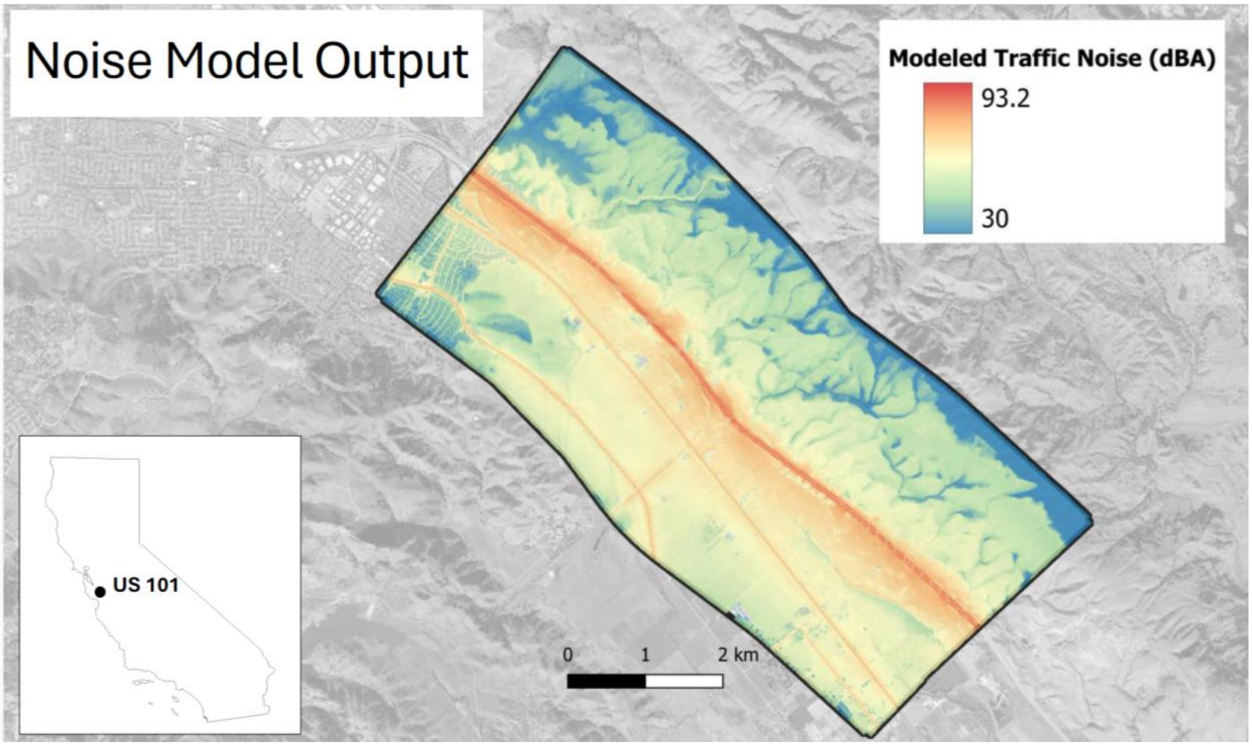

Figure 5. Modeled noise adjacent to state highways and minor roads in the Coyote Valley.

Traffic Illumination Modeling

Traffic illumination propagation from all state highways was modeled at ten-meter resolution in two ways. The first was as a binary “light/dark” model that shows areas that could be illuminated by traffic due to direct line of sight (“light”), or that could not be illuminated due to topography (“dark”; Figure 6). The second starting was a model estimating relative intensity of illumination by traffic from the highway, with illumination values measured originating from the highway and traveling perpendicular to the highway (Figure 7).

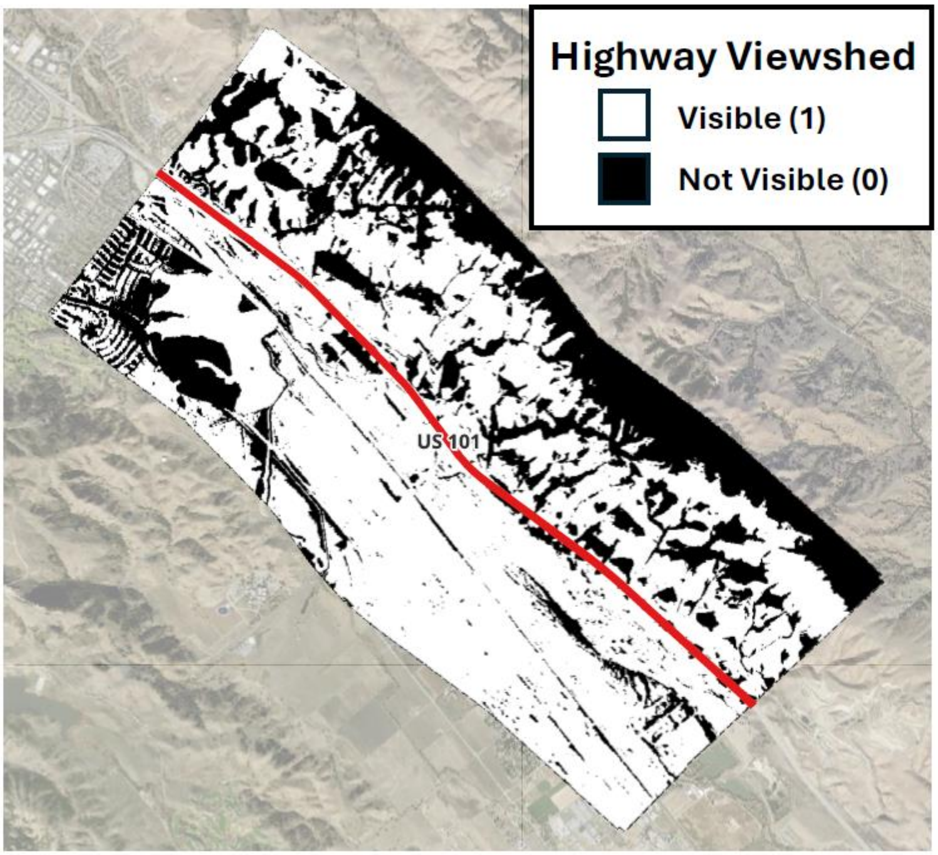

Figure 6. Modeled light/dark illumination adjacent to state highways and minor roads in the Coyote Valley.

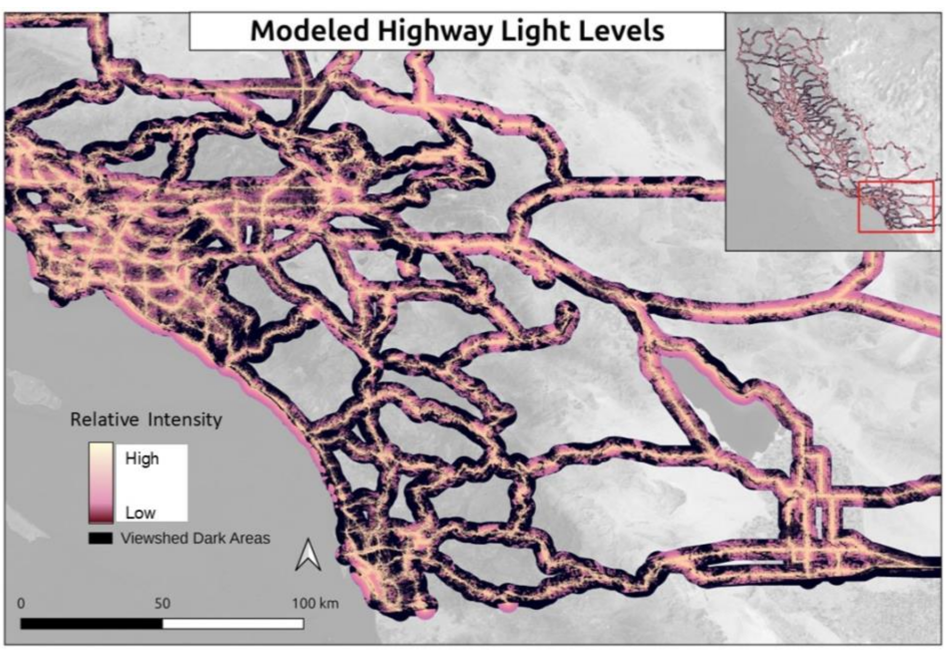

Figure 7. Modeled estimated illumination adjacent to state highways.

Field Measurement Comparison with Modeling

Noise Model

Field-measured traffic noise was compared to modeled noise at varying distances from five state highways and interstates. A linear regression model was fitted (simulated noise ~ measured noise) for each highway, and 95% confidence intervals were calculated and plotted using tools from several R packages ("dplyr", "ggplot2", "ggpmisc"). The R^2 value ranged from 0.30 to 0.78 and the slopes were all significant. The slopes varied in whether they were different from a 1:1 relationship between the two variables (modeled and measured noise; Figure 8). I-8 and I-10 measured values were significantly different from a slope of 1:1 (p<0.05), whereas values for SR 97, SR 152, and U.S. 101 were not significantly different from a 1:1 slope (p>>0.05). Individual modeled values differed by as much as 20 dBA from measured values in the same location. In general, the regression slope through the values did not vary more than five dBA from the 1:1 slope.

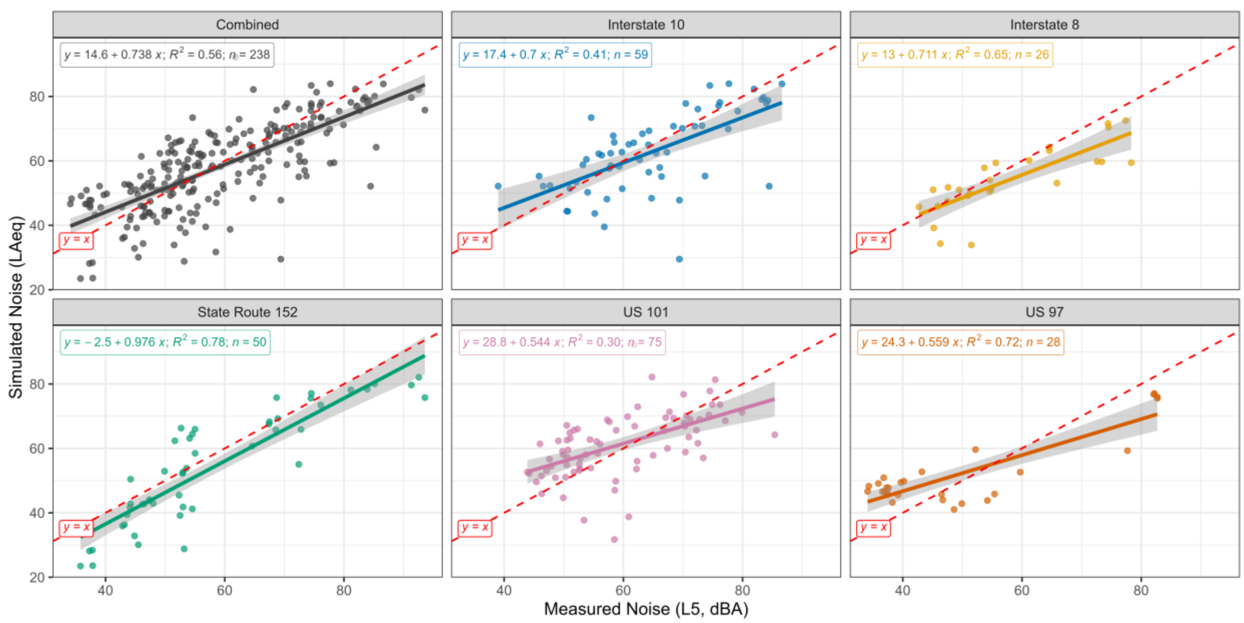

Figure 8. Comparison of modeled with measured noise at sampling points adjacent to state highways.

Illumination Model

We attempted to field test and validate the illumination model in the same way as the noise model. Overall, we were able to demonstrate that places our model suggested were dark had no measurable illumination from headlights and that illumination levels were high (>>1 lx) at the roadway. However, comparison of intermediate values of illumination obtained from the inverse-square law model with values measured in the field did not result in a good fit (Figure 9). The slope was significant (P<0.001) and was not significantly different from 1:1 (P>0.05). We think that the variation results primarily from the high degree of variation in perpendicular brightness of headlights among vehicle and light fixture types. In field conditions, we did not have a good way of measuring or controlling for this variation. This work is ongoing.

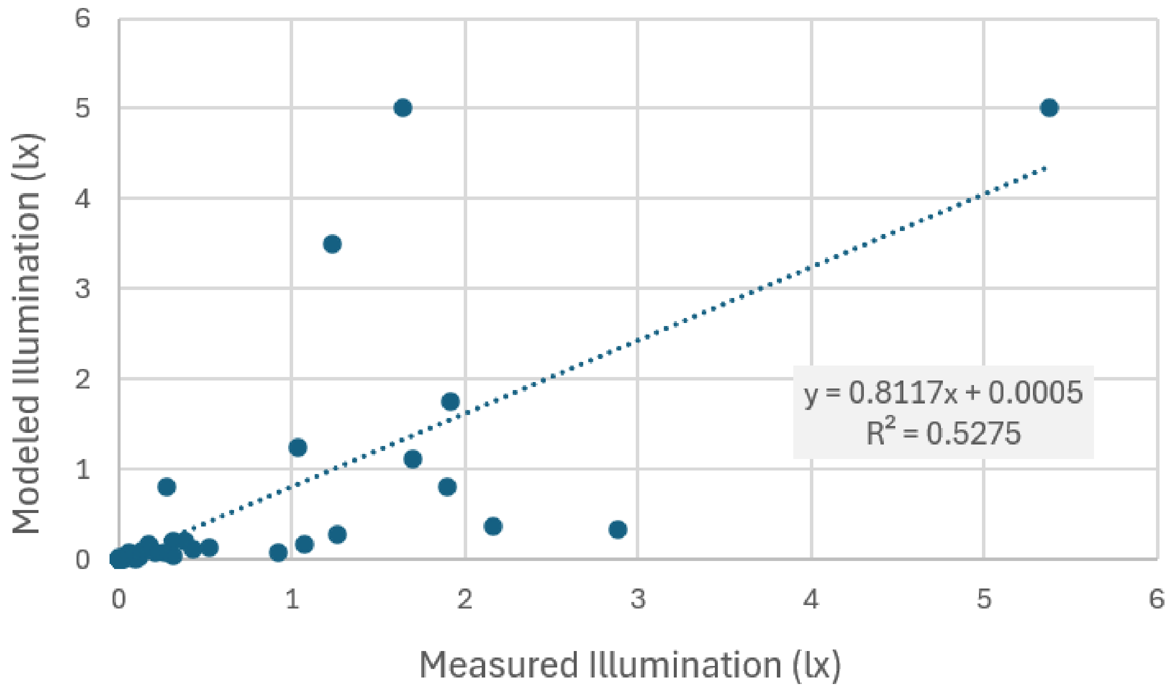

Figure 9. Comparison of modeled with measured illumination at sampling points adjacent to Interstate 8 and 10 (combined).

Model Performance

In order to assess noise model performance, the residuals from the measured-modeled noise comparison were calculated and compared using R (10). The mean and median differences for measured noise minus simulated noise were 0.869 dBA and 0.415 dBA, respectively. These are relatively small absolute differences, suggesting overall model accuracy. However, there were occasions (sampling locations) where differences were very large, suggesting that there were sources of noise that were not accounted for in the model (when measured > simulated) and when there was more noise attenuation than modeled (e.g., in dense vegetation).

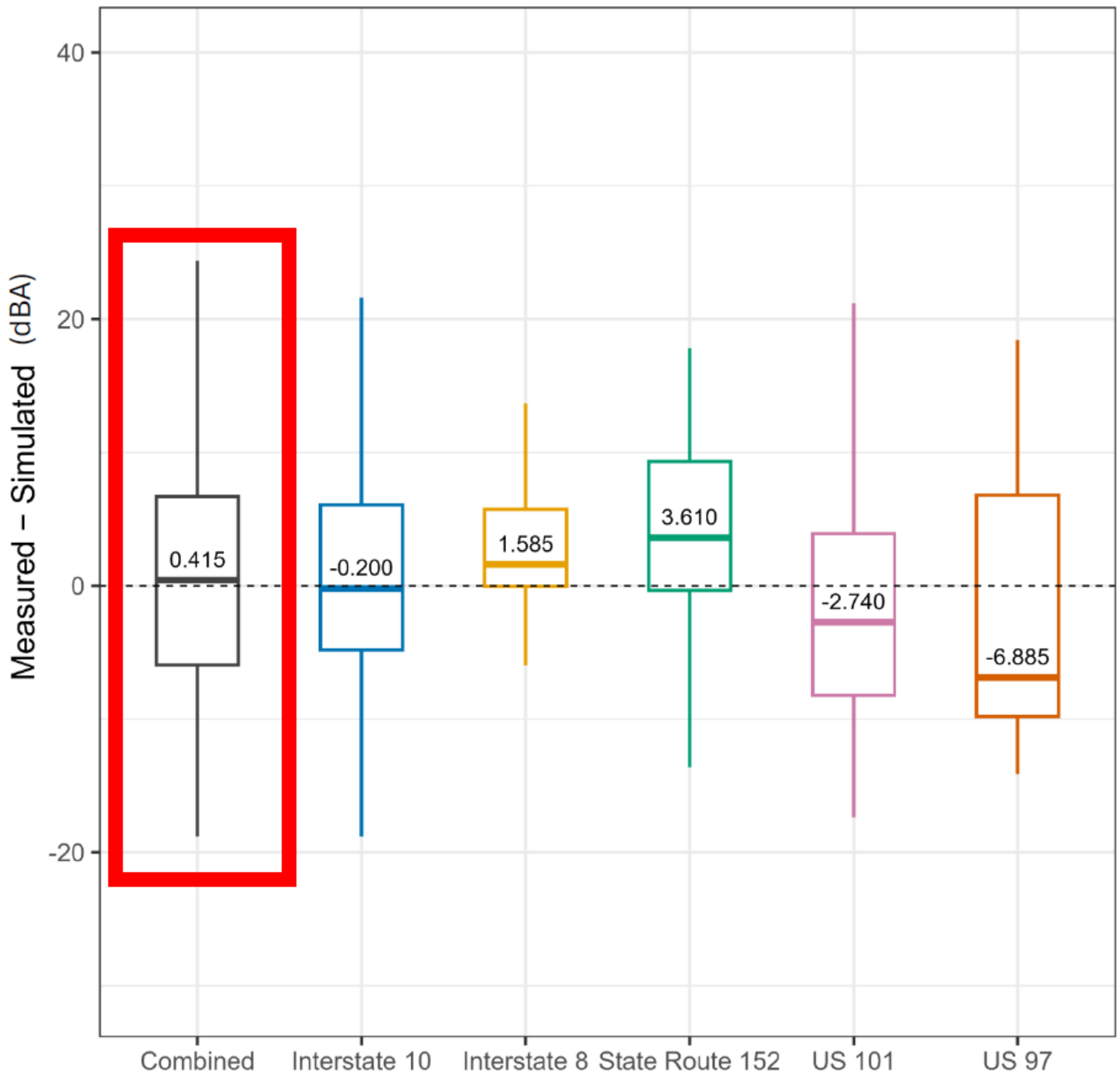

Figure 10. Residuals for comparison of measured and simulated noise adjacent to state highways.

Mitigating Modeled Noise at Proposed Highway Crossings

WCSs are a costly constructed solution to improving wildlife connectivity. Each structure is fixed in place and therefore must be encountered by wildlife on both sides of the structure to be successful. If wildlife are hesitant to approach or traverse the WCS they will not be effective. We modeled noise conditions associated with proposed/designed WCS across SR 152 without (Figure 11A) and with (Figure 11B) noise walls. The walls reduced modeled noise levels from 60 to 65 dBA to 55 to 60 dBA within the approach zone. This reduction is likely to aid sensitive wildlife in finding and using the WCS.

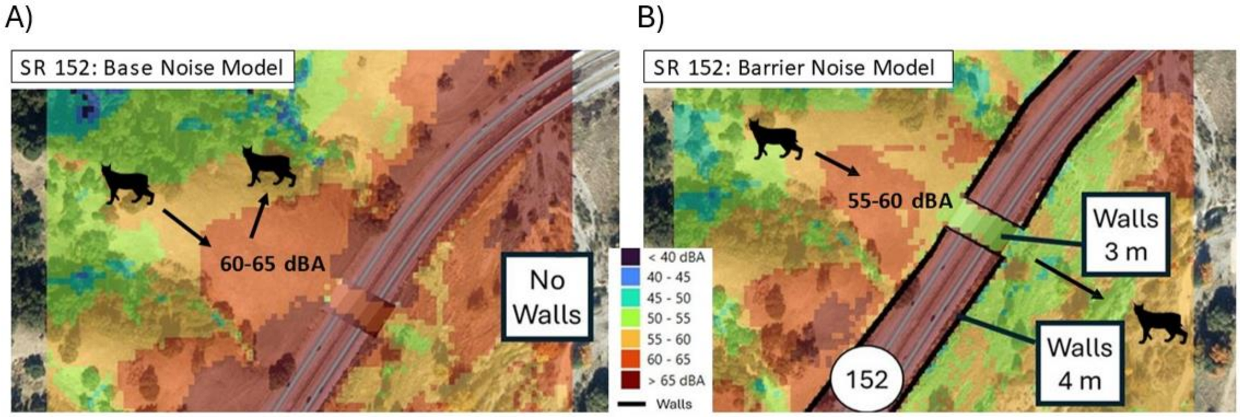

Figure 11. Noise conditions around a proposed WCS across SR 152 in the (A) absence and (B) presence of noise walls.

Mitigating Modeled Illumination at Proposed Highway Crossings

We also modeled light conditions associated with proposed/designed WCS across SR 152 without (Figure 12A) and with (Figure 12B) noise walls. The walls reduced modeled potential illumination levels within the approach zone. This reduction is likely to aid sensitive wildlife in finding and using the WCS

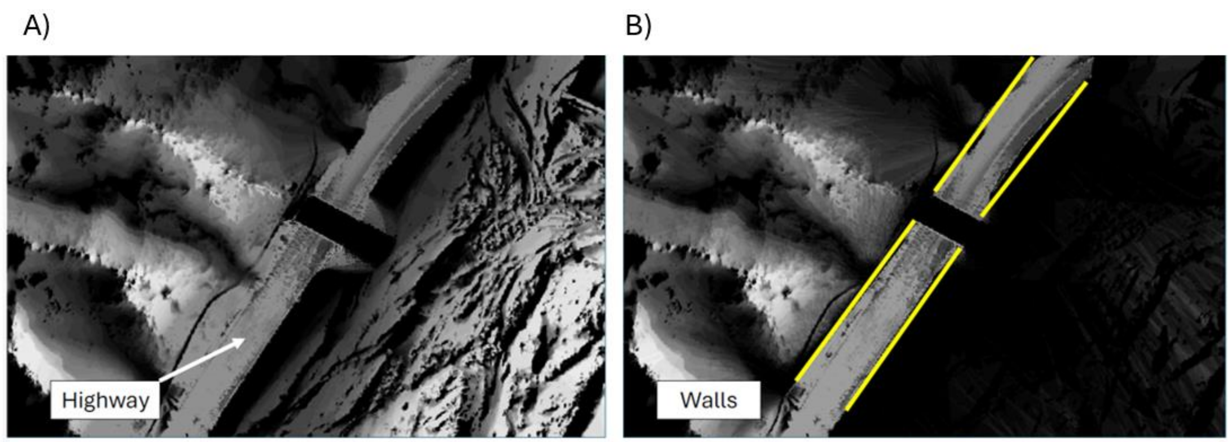

Figure 12. Light conditions around a proposed WCS across SR 152 in the (A) absence and (B) presence of noise walls.

Conclusion

We modeled traffic noise and light conditions adjacent to all state highways at 30-meter resolution. We also modeled noise conditions in certain regions, including both state highways and local roads. Within 100 meters of highways, the noise conditions were sufficiently high (greater than 60 dBA) that it is likely sensitive wildlife would not approach the highway. This means they would not find existing culverts and bridges or WCS (built for wildlife). There were similar findings for potential traffic illumination, except we had less confidence in the actual quantification of intermediate light conditions.

We further found that if approach zones and the deck surface of proposed WCS were protected by noise walls (three to four meters in height), then both noise and light effects could be mitigated to levels likely tolerable to most wildlife. This is an important finding as California has embarked on planning, design, and eventual construction of dozens of WCS throughout the state, none of which formally include noise and light protection (except those on which Shilling is working). To help WCS planners, we share our model data through https://crosplan.wildlifecrossing.net.

References

Barrientos, R., T.W. Vickers, T. Longcore, E.S Abelson, J. Dellinger, D.P. Waetjen, G. Fandos, and F.M. Shilling (2023) Nearby night lighting, rather than sky glow, is associated with habitat selection by a top predator in human-dominated landscapes. In Press.

Buxton, R. T., McKenna, M.F., Mennitt, D., Fristrup, K., Crooks, K., Angeloni, L., Wittemyer, G. 2017. Noise pollution is pervasive in US protected areas. Science 356: 531-533.

Clevenger, A. and M. Huijser. “Wildlife Crossing Structure Handbook: Design and Evaluation in North America.” (2011).

Collins, A., T.W. Vickers, and F. Shilling (2023) Behavioral responses to anthropogenic noise at highways vary across temporal scales. Frontiers in Ecology and Evolution. https://doi.org/10.3389/fevo.2022.891595

Davies, T. W., Bennie, J., Inger, R., Ibarra, N. H., and Gaston, K. J. 2013. Artificial light pollution: are shifting spectral signature changing the balance of species interactions? Global change Biology 19: 1417-1423. doi:10.1111/gcb.12166

Faghri, A., Boyle, P. and Lee, D., 2022. Review of social equity and environment in urban transportation. Current Urban Studies, 10(4), pp.556-574.

FHWA 2019 Technical Manual: Traffic Noise Model 3.0. FHWA-HEP-20-012. https://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v30/tnm3_tech_manual.cfm#toc19285279.

Francis, C. D., and Barber, J. R. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. Frontiers in Ecology and Environment 11(6): 305-313. DOI: 10,1890/120183

Goodwin, S. E., and W.G. Shriver. 2010. Effects of traffic noise on occupancy patterns of forest birds. Conservation Biology 25(2): 406-411.

Kephalopoulos, S., Paviotti, M., Anfosso-Lédée, F., Van Maercke, D., Shilton, S. and Jones, N., 2014. Advances in the development of common noise assessment methods in Europe: The CNOSSOS-EU framework for strategic environmental noise mapping. Science of the Total Environment, 482, pp.400-410.

Li, C., Jiang, Z., Feng, Z., Yang, X., Yang, J., Chen, L. 2009. Effects of highway traffic on diurnal activity of the critically endangered Przewalski's gazelle. Wildlife Research [serial online], 36(5):379-385.

Longcore, T. and Rich, C. 2004. Ecological light pollution. Frontiers in Ecology and the Environment 2, 191–198.

Meillere, A., Brischoux, F., Angelier, F. 2015. Impact of chronic noise exposure on antipredator behavior: an experiment in breeding house sparrows. Behavioral Ecology doi:10.1093/beheco/aru232

Neumann W., G. Ericsson, H. Dettki, N. Bunnefeld, N.S. Keuler, D.P. Helmers, V.C. Radeloff. 2012. Difference in spatiotemporal patterns of wildlife road-crossings and wildlife-vehicle collisions. Biological Conservation 145 (2012) 70–78. doi:10.1016/j.biocon.2011.10.011

Owens, J. L. 2013. Effects of traffic noise on the social behavior of tufted titmice (Baeolophus bicolor). PhD dissertation, University of Tennessee. http://trace.tennessee.edu/utk_graddiss/a767

Paksarian, D., Rudolph, K.E., Stapp, E.K., Dunster, G.P., He, J., Mennitt, D., Hattar, S., Casey, J.A., James, P. and Merikangas, K.R., 2020. Association of outdoor artificial light at night with mental disorders and sleep patterns among US adolescents. Jama Psychiatry, 77(12), pp.1266-1275.

Parris, K. M., and A. Schneider. 2008. Impacts of traffic noise and traffic volume on birds of roadside habitats. Ecology and Society 14(1): 29.

Shannon, G., Angeloni, L. M., Wittemyer, G., Fristrup, K. M., and Crooks, K. R. 2014. Road traffic noise modifies behavior of a keystone species. Animal Behavior 94: 135-141. http://dx.doi.org/10.1016/j.anbehav.2014.06.004

Shilling, F.M., Llevanos, R., and London, J.K. (2009). Marginalization by collaboration: Environmental justice as a third party in and beyond CALFED. Environmental Science and Policy, 12: 694-709.

Shilling, F., Collins, A., Louderback-Valenzuela, A., Farman, P., Guarnieri, M., Longcore, T., Banet, B., and Knapp, H. 2018. Wildlife-Crossing Mitigation Effectiveness with Traffic Noise and Light. UC Davis: National Center for Sustainable Transportation. Retrieved from https://escholarship.org/uc/item/8893d8zw

Shilling, F. M, Collins, A., Longcore, T., & Vickers, W. 2020. Understanding Behavioral Responses of Wildlife to Traffic to Improve Mitigation Planning. UC Davis: National Center for Sustainable Transportation. http://dx.doi.org/10.7922/G29S1P9Q Retrieved from https://escholarship.org/uc/item/72h3x0nk

Shilling, F., D. Waetjen, T. Longcore, W. Vickers, S. McDowell, A. Oke, A. Bass, and C. Stevens (2022). Improving Light and Soundscapes for Wildlife use of Highway Structures. Report of the National Center for Sustainable Transportation. https://doi.org/10.7922/G2V1233R.

Siemers, B. M., and Schaub, A. 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. Proceedings of the Royal Society, B 278: 1646-1652. doi:10.1098/rspb.2010.2262

U.S. Department of Transportation, Federal Highway Administration; Bureau of Transportation Statistics (BTS) [distributor]. (2021). Highway Performance Monitoring System (HPMS) 2006-Present [datasets]. https://doi.org/10.21949/1519108, https://doi.org/10.21949/1520767

U.S. Geological Survey, 2019, 3D Elevation Program 1-Meter Resolution Digital Elevation Model (published 20200606), accessed March 2, 2025 at URL https://apps.nationalmap.gov/downloader/

Ware H.E., C.J.W. McClure, J.D. Carlisle, and J.R. Barber. 2015. A phantom road experiment reveals traffic noise is an invisible source of habitat degradation. PNAS | September 29, 2015 | vol. 112 | no. 39 | 12105–12109. https://www.pnas.org/cgi/doi/10.1073/pnas.1504710112.

Data Summary

Products of Research

1. Noise model for all CA highways.
2. Light/illumination model for all CA highways.

Data Format and Content

Models are in raster format (30-meter resolution).

Models show noise levels OR relative light intensity.

Data Access and Sharing

The datasets are available through a Road Ecology Center web-system: https://crosplan.wildlifecrossing.net.

Reuse and Redistribution

There are no restrictions on data use. Citations for each of the datasets are:

1. "Road Ecology Center, 2026. Datasets of modeled noise associated with state highways. https://crosplan.wildlifecrossing.net."
2. "Road Ecology Center, 2026. Datasets of modeled illumination associated with state highways. https://crosplan.wildlifecrossing.net."