

2019



# Impact of Wildlife-Vehicle Conflict on California Drivers and Animals

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8/1/2019

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Using observations of reported traffic incidents and carcasses the Road Ecology Center has estimated the **total annual cost** of reported (large) wildlife-vehicle collisions for 2018 in California to be **at least \$232 million** and the cost to society over the last 4 years to be **>\$1 billion**. The cost is calculated using California Highway Patrol (CHP) reports of crashes with wildlife and US Department of Transportation equivalent values for different types of crashes (e.g., property damage vs. major injury). When including accidents that are claimed to insurance companies but un-reported to police, the estimated cost could be as high as \$500 million/year (estimated for 2017). This report provides an overview of wildlife-vehicle conflict (WVC) in general, including collisions with small and large animals and accidents resulting from drivers swerving to avoid colliding with an animal. We highlight WVC hotspots on California highways between 2015 and 2018, inclusive, based on a combination of >26,000 traffic incidents involving wildlife that were recorded by the CHP and >42,000 carcass observations reported to the California Roadkill Observation System (CROS, <http://wildlifecrossing.net/california>) between 2009 and 2018, inclusive. This report includes **maps of WVC hotspots**, discusses impacts to wildlife and people from WVC, addresses whether mapped “wildlife corridors & linkages” help explain where WVC occurs, and presents new tools to help organizations, state agencies and individuals collect and use this information. Projects to **reduce WVC** can be the most effective of any safety project, with effectiveness often >90%.

For the first time, we **statistically compared the location of WVC** with various computer **predictions of wildlife corridors/linkages** in California. In general, we found no significant correlation between the locations of WVC and these linkages. This may not be surprising because wildlife generally do not follow narrow or predictable paths through their habitat. California agencies have been looking for predictability in wildlife movement to help reduce the **cost of mitigation**. Fortunately, there are ample data available on wildlife movement from WVC databases and studies involving GPS-collared wildlife to identify mitigation locations.

**Data Sharing/Collaboration:** We receive requests from highway planners, fish and wildlife scientists, academic faculty, students, and non-governmental organizations on a weekly basis. We can typically meet data requests within CA for specific highways, counties, etc., but please keep in mind that this is an unfunded effort of the Road Ecology Center, so give us a few days.

We have developed 2 globally-unique web-tools to collect and to visualize WVC incidents in CA: 1) A re-vamped California Roadkill Observation System to support “one-click” reporting (<https://wildlifecrossing.net/california>) –take a picture of a roadkilled animal with your smartphone and upload with one click (which automatically creates a database record); and 2) A WVC hotspot tool that shows hotspot areas throughout CA and has a real-time display of WVC events, <https://roadecology.ucdavis.edu/hotspots>.

Cover photo credit. Female mountain lion killed by a vehicle on a county road near San Luis Obispo, 8/1/2019. Photo taken and provided by Kelly Kephart, wildlife biologist with PGE.

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## UC Davis Road Ecology Center: Sixth Annual Special Report on the Impact of Wildlife-Vehicle Conflict (WVC) on California Drivers and Animals

### **Top 4 Talking Points**

- 1) **We can help the state systematically collect and share data.** The data assembled here from the CHP were not collected with the purpose of studying WVC, the volunteer data were. California agencies should collect and share data about WVC to help inform decision-making about this important conservation and safety problem. Using our extensive datasets and decade of experience collecting and analyzing WVC data, we are open to partnering with Caltrans, California Department of Fish and Wildlife and others to accomplish this.
- 2) **Legislated support is needed for highway/road projects that that have net WVC benefit.** In the past, WVC-reduction projects (like wildlife crossings) were only occasionally considered and as part of partial mitigation for transportation impacts. There is currently a state program to allow “advance mitigation credit” for WVC-reduction projects where impacts are reduced now, but balanced by doing more harm later. Transportation agency planners and biologists are increasingly discussing wildlife-crossing structures and other projects as stand-alone safety and sustainability projects, providing a net benefit to drivers and wildlife, without the need for the projects to mitigate for further harm later.
- 3) **Build WVC-reduction projects at known hotspots.** Very few driver safety projects have the overall effectiveness that WVC reduction projects do. There are hundreds of places on state highways and major roads where WVC is a priority. Unfortunately, we can’t use “wildlife corridor/linkage” computer models to tell us where these places are. Fortunately, we have the WVC and other wildlife movement data to help show us where to act.
- 4) **Allocate sufficient funds to build needed WVC-reduction projects.** With the passage of SB1, California voters provided state legislators and transportation agencies with an increase in funding (>\$5 billion/year!) to protect driver safety and the environment. We know that doing nothing, or very little to reduce WVC is costly – to drivers and to the environment (~\$300 million per year). There are myriad excuses for why “nothing can be done”, lack of funding is not one of them.

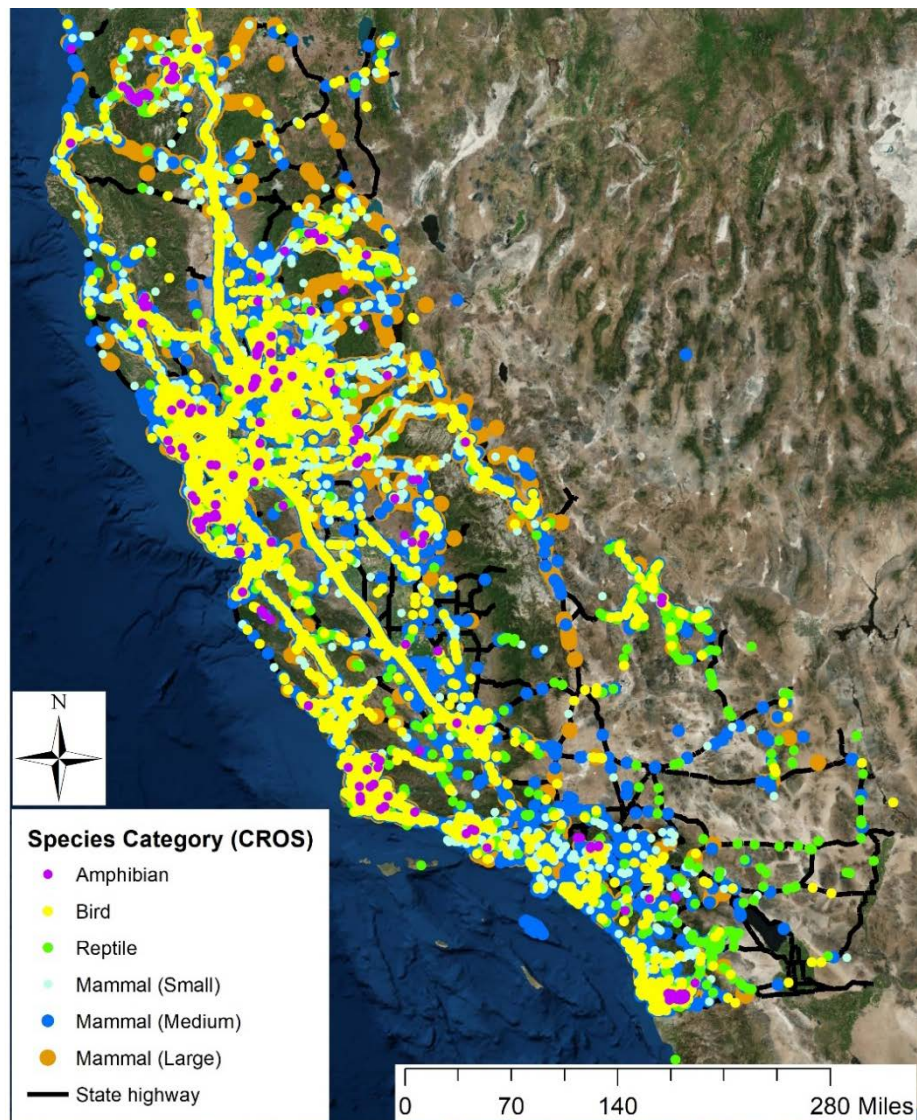
### **Introduction to Study**

Using California state data on traffic incidents and roadkill observations, the Road Ecology Center has mapped stretches of 15,160 miles of California highways that are likely to be continuing hotspots for wildlife-vehicle conflicts (WVC). Animals entering roadways are often killed and pose a hazard to drivers, who may collide with the animal, or try to avoid the animal



suffering vehicle damage, injury, and even death. Wildlife populations may suffer significant losses from highways with high rates of WVC, which may cause ripple effects into surrounding ecosystems up and down the food chain. In addition, animals are injured during collisions, which is damaging to the animal and traumatic and deadly to drivers.

By identifying stretches of highway where WVC are more likely to occur, the Road Ecology Center is assisting Caltrans and other responsible entities in developing mitigation to protect drivers and wildlife populations. Measures with proven effectiveness include 1) building fencing and over/under-passes along priority highways to allow the safe passage of wildlife across highways and 2) reducing speed limits in protected wildlife habitat. Using CHP data, we have found records of ~7,000 reported accidents per year on California highways involving deer and other large wildlife. We estimate that there are another few thousand with horses, cows, sheep and goats. Data from CROS allow state and local agencies to prioritize stretches of highway for mitigation of conflicts with particular species or groups (e.g., Ha and Shilling, 2017).



### Statewide Carcass Observations

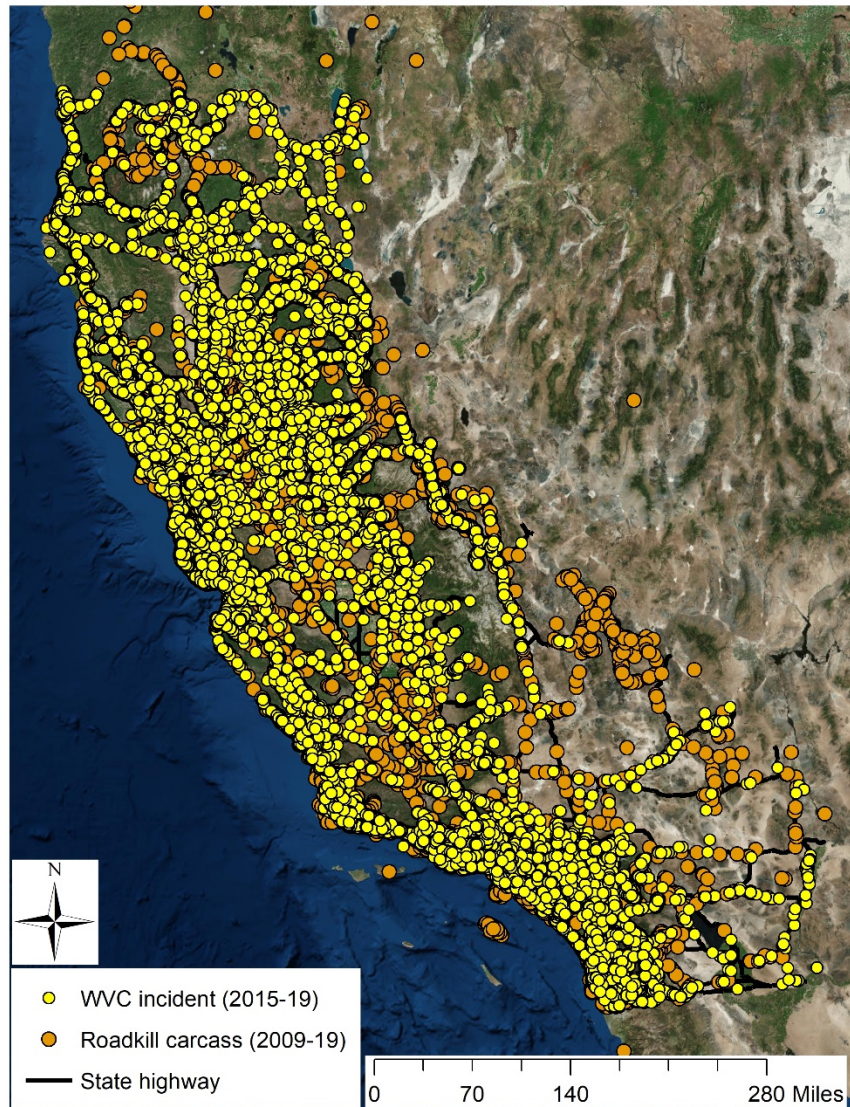
Members of the public, agencies, and others made >60,000 observations of animal carcasses on local roads and state highways (Figure 1). These are not the total roadkill that occurred, just the ones that expert observers saw and reported to CROS.

**Figure 1.** Carcass observations for amphibians, reptiles, birds, and mammals.



## Statewide Highway WVC Incidents

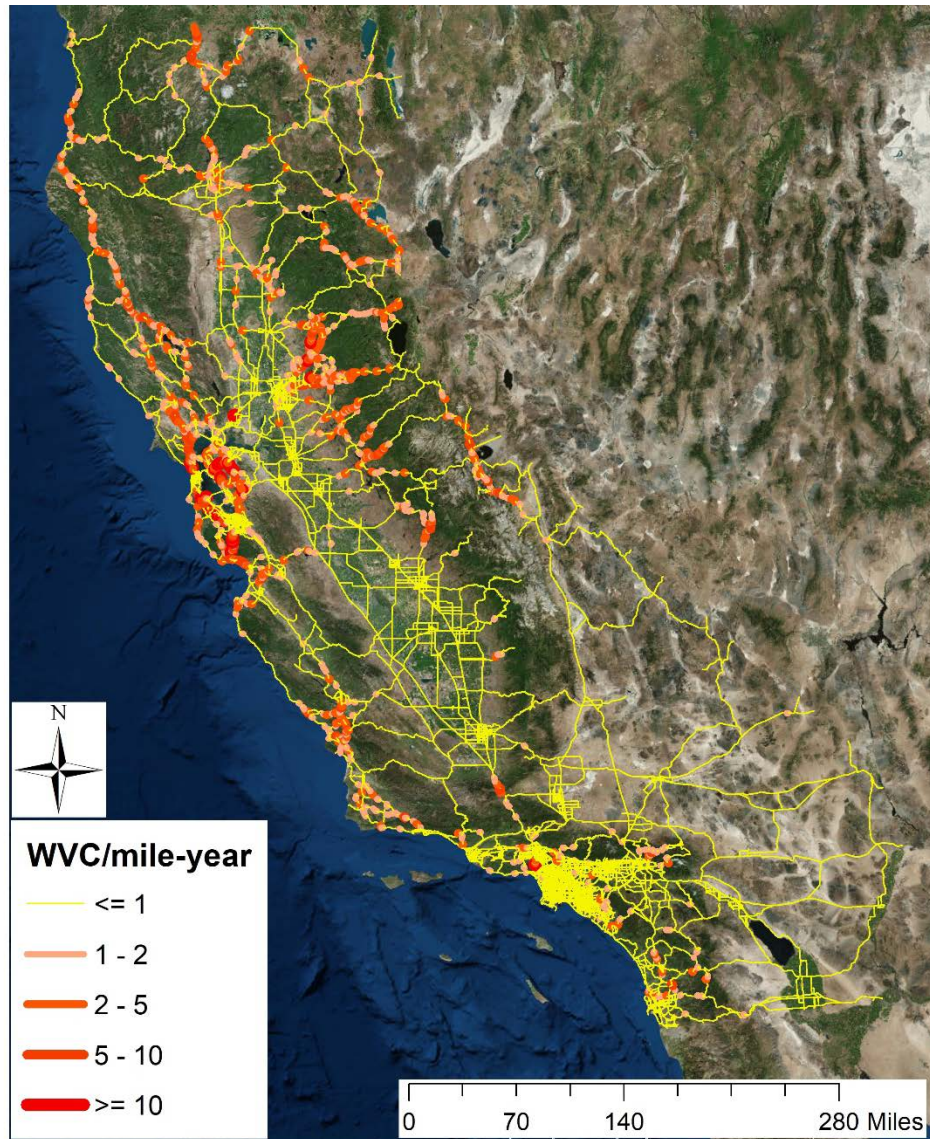
There were >2.5 million traffic incidents (of all types) across California reported to the CHP during 2015-2018. Of these, about half were collisions and 26,547 involved wildlife, including 1) reports of animals standing next to, standing in, or running across lanes (potential incidents); 2) collisions with large animals; and 3) swerving to avoid collisions, resulting in a crash (Figure 2).



**Figure 2.** Wildlife-vehicle conflict incidents on highways (2015-2018) and roadkilled animal observations on all roads (2009-2018).

Although WVC occurs on every major road and highway in California, the highest densities were reported in the San Francisco Bay Area (Caltrans District 4), Sierra Nevada Foothills (Caltrans Districts 3 & 10), North Coast (Caltrans District 1), and parts of the Central/South Coast (Caltrans Districts 5, 7, 11 & 12). These high-density areas are most likely where traffic volumes and wildlife populations are greatest, leading to more conflict. The map below shows the high-density clusters of collisions with large wildlife in California (Figure 3). There were 1,584 miles of state highway where  $\geq 4$  large animals were involved per mile per year in WVC incidents and 3,138 miles where  $\geq 2$  large animals were involved in WVC per year.



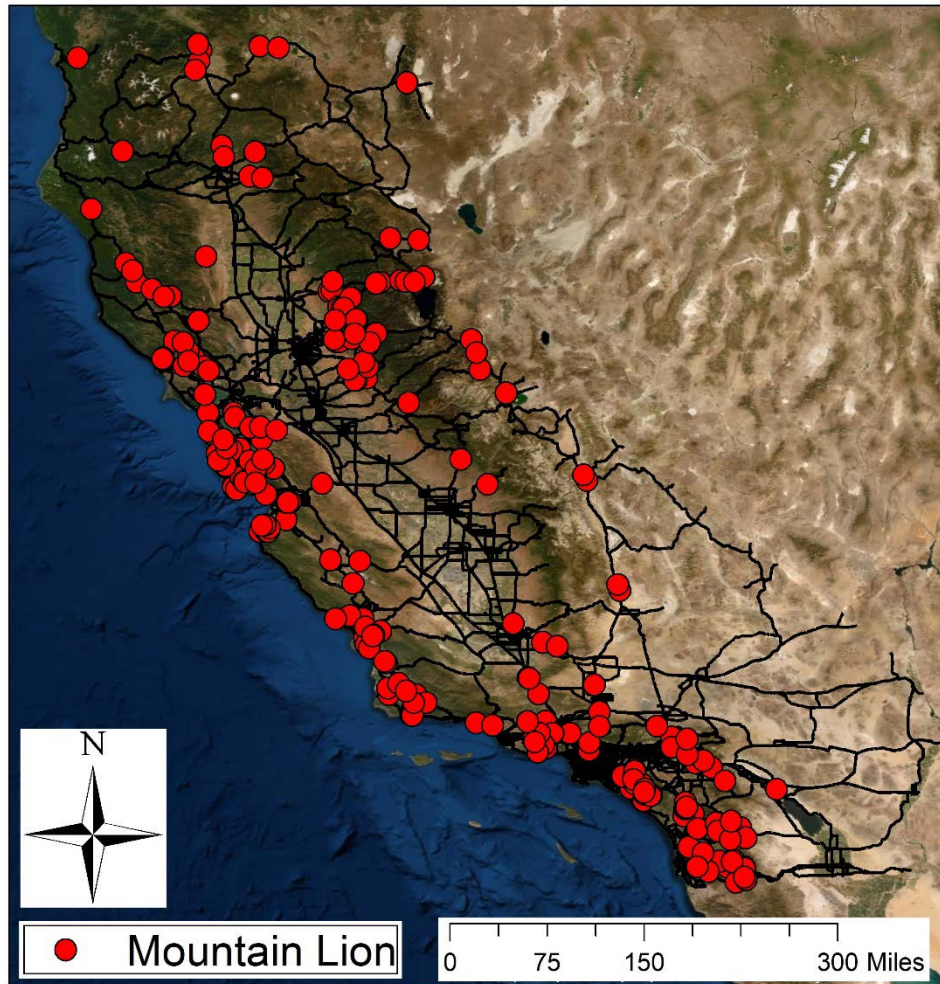


**Figure 3.** High-density WVC hotspots for 2015 to 2018. Hotspots can vary in length from 1 to several miles. Density is expressed as # incidents per mile per year. Greater than 2 WVC/mile-year is a recognized cost-benefit standard for transportation agencies to start planning for impact mitigation.

### Impacts to Specific Wildlife: Mountain Lions

Like most species at the top of the food web, mountain lions are especially vulnerable to WVC because they move around a lot and cross roads and highways. Mountain lions are important ecologically because they are the only large, widespread predator in most California ecosystems. They are also important socially, with great interest in their well-being in Southern California and Bay Area urban regions.

A critical problem for mountain lions in California is that there is no formal program, system or requirement to report when they are killed on roads, which happens frequently. As such, we only know the minimum killed each year on roads, when they are reported to CROS, and have



**Figure 4.** Mountain lions reported killed on roads, or involved in traffic incidents by the California Roadkill observation System, CDFW, CHP, or Winston Vickers and other biologists in Southern California (Vickers et al. 2015, and Vickers unpublished data).

no way of knowing the actual WVC impact to this important and charismatic species. Between 2015 and 2018, inclusive, 299 mountain lions killed on roads (~75/year) were reported by a combination of CROS volunteers, CHP, CDFW, and biologists in Southern California (Figure 4). The cover photograph for this report highlights the problem. It was taken by a wildlife biologist who happened upon the dead animal as part of her work. She reported the finding informally to colleagues in the

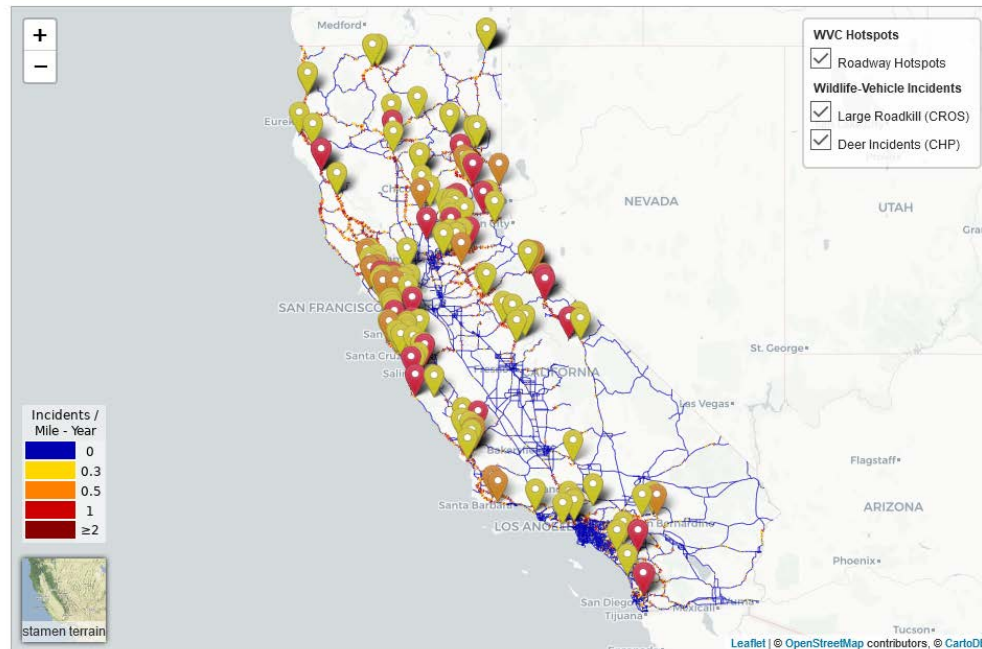
California Department of Fish and Wildlife, who similarly informally reported the observation to us. This story highlights the need in California for a systematic and legislated approach to reporting wildlife mortality on roadways in order that we can understand the distribution, impacts and risk to wildlife populations and species.

### Real-Time, Automated Web-Map of WVC

To provide more current information for California agencies and the driving public, we make our WVC data available in real time, the first tool of its kind in the world. You can see recent WVC events and WVC hotspots here: <https://roadeecology.ucdavis.edu/hotspots/map>. The map was developed with support from the National Center for Sustainable Transportation and can support automatic ingestion by web-systems or driver-assistance programs.



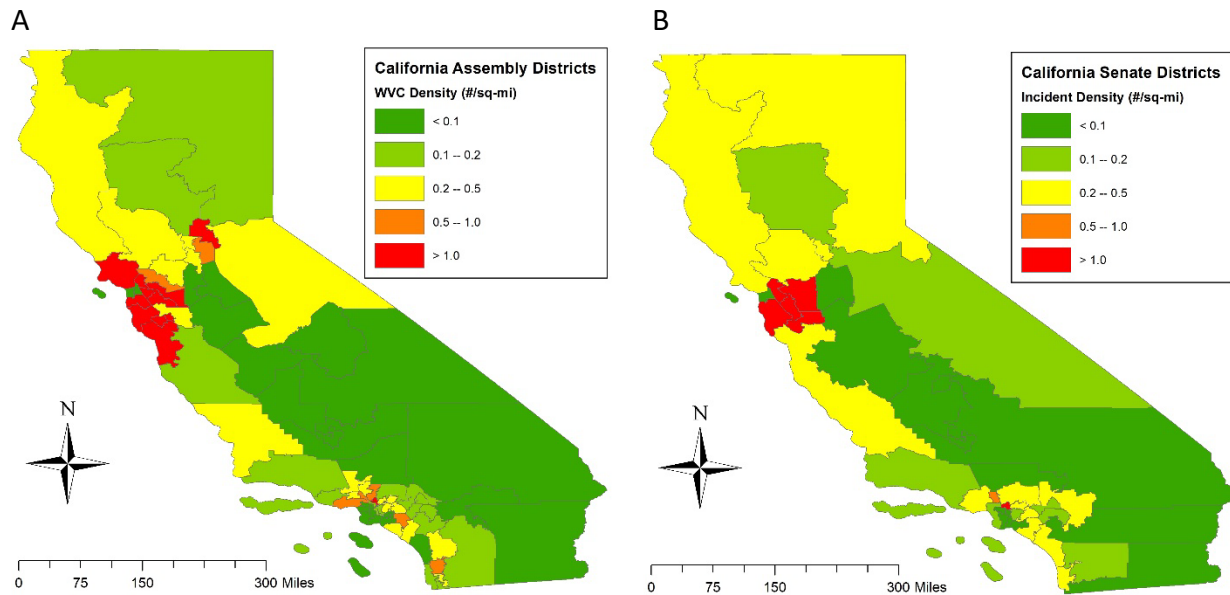
## Real-time Deer Incidents & Wildlife-Vehicle Conflict (WVC) Hotspots



**Figure 4.** Locations of recent (7/22/2019) WVC incidents and roadkill carcasses (points) overlaying WVC hotspots, defined by annual WVC density (lines). Map available at: <https://roadecology.ucdavis.edu/hotspots/map>.

### Impacts within Assembly & Senate Districts

The ultimate authority for legislating reporting and mitigating impacts to driver and wildlife safety from WVC lies with the state Assembly and Senate. They have the ability to require state agencies to report WVC (e.g., crashes and carcasses), to require analyses (such as the one you are reading), to mitigate impacts at an adequate rate, and to spend available funds (e.g., from the SB1 Fuel Tax). We calculated the total number of WVC with large mammals within Assembly and Senate Districts for the 2015-2018 time period. The total number of WVC varied between a low of 1 for Assembly District 66 (Palos Verde) to 6,466 for Senate District 1 (rural NE California). Because the Districts vary widely in size, we also calculated the density of WVC (#/square-mile). This calculation revealed that the highest-densities of WVC are in Assembly and Senate Districts around the edges of the urban regions of the Bay Area, Sacramento and Southern California (Figure 4). The 10 Assembly Districts with the highest WVC rates were politically-mixed, with 6 represented by Democrats and 4 by Republicans. Our calculations showed that WVC as a conservation and safety problem is not limited to one political party or type of region (rural vs. urban).



**Figure 4.** Density of WVC by (A) state Assembly and (B) state Senate districts for 2015-2018, inclusive.

## Cost to Society

Any type of collision involves risk and actual damage to drivers and their vehicles. It is no different for collisions involving wildlife, whether the collision is with the animal, or with another object after the driver swerved to avoid hitting the animal. As in previous years, we used cost coefficients from the US Department of Transportation (Harmon et al., 2018, Crash Costs for Highway Safety Analysis. FHWA-SA-17-071) to estimate the total cost to society from collisions involving wildlife. These costs include the expense of vehicle damage, injury treatment and recovery, emergency response, lost work, loss of the wildlife and other costs. We found that the total cost was lower in 2018 than in previous years: ~\$232 million in 2018 vs. \$307 million in 2017 (Table 1). This was in part due to a lower estimated property damage cost to vehicles and a lower estimated number of fatal collisions, which is only estimated because California does not release these statistics. The total number of collisions did not change very much from year to year.

**Table 1.** Impact to drivers and estimated cost to society of reported collisions with animals on CA highways and certain major roads in 2018. Equivalent costs for accident types were obtained from Harmon et al. (2018).

Type of Accident	Coefficient (cost as \$/event)	Number (2018)	Cost (2018)
Lost animal value (all animals)*			\$37,300,000
Collision/Swerve (property damage)	\$11,900	6,412	\$76,302,800
Injury (minor)	\$125,600	271	\$34,037,600
Injury (major)	\$655,000	43	\$28,165,000
Fatality	\$11,295,400	5**	\$56,477,000
<b>Total</b>			<b>\$232,282,400</b>

\* This value includes both reported and estimated un-reported carcasses, with an estimated 5 times as many total as reported. Others have reported under-reporting rates for carcasses from collisions of 5-10 fold.

\*\* This is an estimate as CA does not release annual rates of fatal collisions with wildlife

Another way to measure costs is according to a California jurisdiction. We totaled all types of injury and non-injury accidents within California Assembly Districts. Except for District 10 (Marin County), the top-5 highest costs were associated with rural Districts (1, 5, 2, 35). District 10 was also among the top-10 districts with the highest number of total WVC and density of WVC, primarily because of US 101. Besides Assembly District 10, other Districts with high total number of WVC, density, and cost were District 16 (San Ramon, I-680, I-580, SR 24) and District 24 (Los Altos, I-280). The total cost over a 4-year period (2015-2018) for the top 10 Assembly Districts was ~\$445 million.

**Table 2.** Estimated number of WVC, injury accidents (from collisions with wildlife) and cost to society of reported WVC between 2015 and 2018, inclusive, for the Assembly Districts with the most WVC impact.

Assembly District	Total Collisions	Injury Accidents	Total Cost (\$)
1	4969	226	\$105,308,820
5	4395	202	\$93,547,800
2	2804	141	\$61,660,480
10	1555	60	\$31,040,220
35	1505	86	\$34,786,980
29	1493	48	\$27,098,140
16	1102	36	\$20,043,740
24	1039	66	\$25,853,820
4	1018	57	\$24,364,640
3	1016	51	\$21,287,780
			\$444,992,420

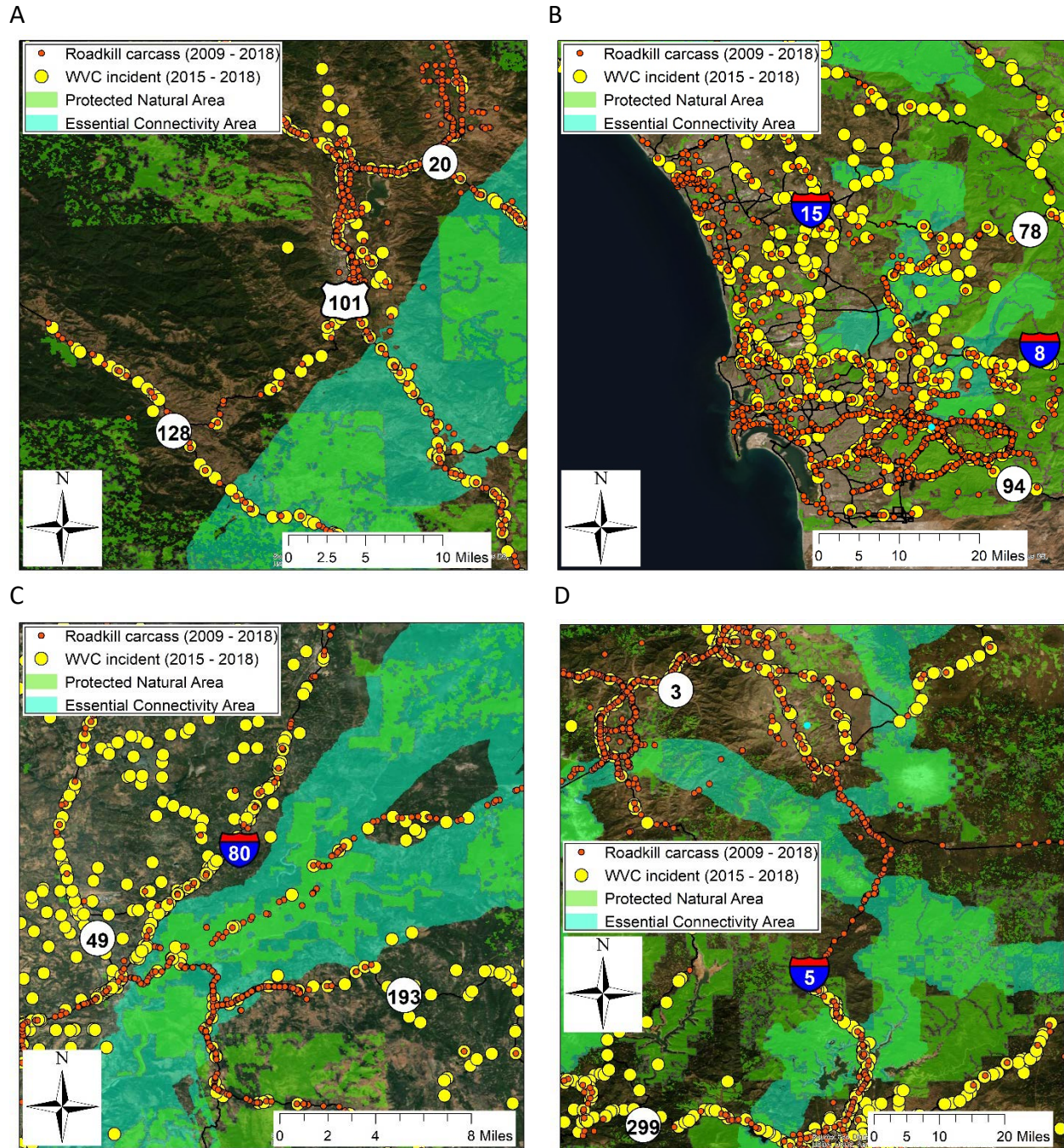


## Corridors, Linkages and Roadkill

Wildlife naturally move around their habitat, meeting daily, seasonal, reproductive, migratory, dispersal, and climate adaptation needs. A common misconception, even among conservation planners, is that wildlife will naturally follow “corridors” or “linkages” when roaming around on landscapes. This idea is related to the hypothesis that most species occupy “patches” of habitat and these patches are connected by corridors/linkages. Except for certain ungulates (e.g., mule deer in certain areas) there is little evidence that most or all of the roughly 180 mammal species in California (or anywhere else) follow predictable paths across landscapes, or only occupy mapped patches of habitat.

We compared densities of roadkilled animals on state highways with different connectivity values in the California Department of Fish and Wildlife’s Areas of Conservation Emphasis (ACE) and with the Essential Connectivity Areas in the California Essential Habitat Connectivity (EHC) project (Spencer et al., 2010). We tried all animals together and with different groupings (e.g., mammals). In all cases, we found no statistically significant relationship between location of roadkilled animals and linkage areas, or with connectivity values from ACE maps. Examples of the overlap between WVC/roadkill events and EHC linkage areas are shown in Figure 5. There were a few areas where concentrations of roadkill were associated with modeled linkages, which may indicate that these areas actually are important for wildlife movement. However, there were usually areas outside linkages that also had high concentrations of WVC/roadkill. The simplest explanation for these findings is that, in general, corridor and linkage maps don’t predict where animals are primarily moving and should not be used for mitigation planning that leaves out areas where animal movement is also provably occurring.

The importance of this finding is that many people in transportation and conservation planning use these maps as if they were related to wildlife connectivity movement and use the term “data” to describe the maps. In reality they are not data, nor are they based on data for all (or most) wildlife movement. In urban and agricultural regions, the “linkages” were more likely to seem related to locations of WVC, which is probably because these are the only natural habitat areas remaining in these regions. For example, if a stream with a healthy riparian area passes through an urban/residential area, then there tended to be a greater likelihood of predicted connectivity and concentration of WVC. The solution to the problem that our findings highlight is that maps of wildlife connectivity must be based upon where wildlife occur and are moving for them to have utility in wildlife conservation planning. Including additional areas where wildlife may occur after protection and restoration could also be useful.



**Figure 5.** Comparison of WVC/roadkill incidents and maps of essential connectivity areas and natural areas from the California Essential Habitat Connectivity project (Spencer et al., 2010). A) North Bay Area, B) coastal San Diego County, C) American River canyon, and D) Mt Shasta area.

## Summary

Monitoring wildlife movement and mortality is critical for improving wildlife connectivity and survival of wildlife species in the face of the combined threats they face, such as transportation systems, climate change, rodenticides, and habitat loss. We reported here on long-term,

successful methods for monitoring WVC in California, an annual (2018) analysis of locations and costs of WVC to wildlife and drivers and society. We provided key recommendations for ways to reduce WVC in California through support for a several-fold increase in mitigation projects with net benefit for wildlife and driver safety. Finally, we suggest that any WVC-reduction and wildlife connectivity mitigation be planned based on evidence-based connectivity design, not the current “linkage” models.

## **Acknowledgements**

We appreciate the support from the National Center for Sustainable Transportation (using USDOT funding) and the Institute of Transportation Studies (CA SB1 funding) for development of the automated wildlife-vehicle conflict hotspot tool and one-click reporting tool California Roadkill Observation System (CROS, <https://wildlifecrossing.net/california>). This and previous reports and the analyses contained within would not have been possible without the concerted and coordinated efforts of hundreds of volunteer roadkill observers over the last 10 years who contribute to CROS. Through their endeavors, they have so far (7/2019) collected >60,000 observations of >430 species, representing one of the largest and most comprehensive wildlife monitoring programs in California and the US. Their accuracy rate for species identification is >97% and have high locational accuracy (median <±13 meters). For the scientific article describing CROS, see citation below (you can paste the “doi” value below into a browser and access the papers). The report also benefited from the efforts of many unknown law enforcement personnel who described traffic incidents in enough detail that we could use their observations to help plan for reduced wildlife-vehicle conflict. Finally, we have partnered with other similar systems around the world in the Globalroadkill.net project (<http://globalroadkill.net>).

**Citation for CROS: Waetjen DP and Shilling FM (2017) Large Extent Volunteer Roadkill and Wildlife Observation Systems as Sources of Reliable Data. *Frontiers in Ecology & Evolution* 5:89. [doi:10.3389/fevo.2017.00089](https://doi.org/10.3389/fevo.2017.00089)**

**Additional CROS citation: Tiedeman, K., R.J. Hijmans, A. Mandel, D.P. Waetjen, F. Shilling (In Press) The quality and contribution of volunteer collected animal vehicle collision data in ecological research. *Ecological Indicators*. <https://doi.org/10.1016/j.ecolind.2019.05.062>**

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