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UC Davis Road Ecology Center

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Impact of Wildlife-Vehicle Conflict on Drivers and Animals

Using observations of reported traffic incidents and carcasses the Road Ecology Center estimates the total annual cost of wildlife-vehicle conflict (WVC) in California to be at least $225 million, maps out stretches of highway that are likely to be hotspots, and discusses impacts to wildlife and people from WVC. Since this cost is equal to ~2% of California's transportation budget, we suggest a strategy of "2% for wildlife and safety" to help reduce this impact to wildlife and drivers.

This report provides an overview of wildlife-vehicle conflict (WVC) hotspots on California highways, based primarily on traffic incidents involving wildlife that were reported to the California Highway Patrol between 2/2015 and 2/2016. It also puts these conflicts in the context of carcass observations (2009-2015) reported to the California Roadkill Observation System (http://wildlifecrossing.net/california). Analytical details are available from the report author upon request.

Photo acknowledgements

Mountain lion – Victoria Monroe
Live mule deer – Fraser Shilling
Dead mule deer – Kathryn Harrold

Data collection acknowledgements

Thanks to Kathryn Harrold for keeping track of wildlife-vehicle conflict data sources and for helping code traffic incidents. Thanks also to Pamela Flick, Kim Delfino (Defenders of Wildlife), Camille Fox (Project Coyote), and Alicia Falsetto for feedback on an earlier draft of this report. 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 7 years. Through their endeavors, they have collected >50,000 observations of >410 species, representing one of the largest and most comprehensive wildlife monitoring programs in California. Their accuracy rates for species identification are >93% and have measurably high locational accuracy (<±100 meters). The report also benefited from the efforts of many unknown law enforcement personnel who described traffic incidents in enough detail that we can use their observations to help plan for reduced wildlife-vehicle conflict.

The Authors

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UC Davis Road Ecology Center
Third Annual Special Report on the Impact of Wildlife-Vehicle Conflict on People and Animals

Using state data on traffic incidents, the Road Ecology Center has mapped stretches of California highway that are likely to be hotspots for wildlife-vehicle conflicts (WVC). Animals entering roadways pose a hazard to drivers, who may collide with the animal, or try to avoid the animal and have an accident suffering vehicle damage, injury, and even death. We estimated the total annual cost to society from WVC in California on state highways and a small proportion of major roads to be ~$225 million for 2015. **It is important to note that this report does not cover ALL incidents in California, just the ones reported to the CHP.** Wildlife populations may suffer significant losses due to collisions and highways with high rates of WVC may cause ripple effects into surrounding ecosystems. In addition, animals may be injured during collisions, which is damaging to both the animal and potentially traumatic to drivers.

The California Roadkill Observation System project (http://wildlifecrossing.net/california) includes past and current participation by over 1,000 volunteer-scientists, including several hundred academic, agency, and NGO biologists and natural historians. More than 50,000 WVC observations were contributed to the website by volunteers between August 2009 and the end of 2015 and by Caltrans Maintenance staff for the period 1987 to 2007. Records of traffic incidents between 2/2015 and 2/2016 were obtained from state databases of traffic incidents (e.g., emergency responses to crashes), included in our customized "California Highways Incident Processing system" (CHIPs), and coded according to severity of the incident for the drivers/vehicles and for the animals. The carcass observations and traffic incidents were used in a geographic information system (GIS) to find stretches of highway where WVC occur more frequently (high density) and places where there are statistically-significant clusters of WVC (hotspots).

By identifying stretches of highway where WVC are more likely, the UC Davis Road Ecology Center is assisting Caltrans and other responsible entities to develop mitigation to protect driver safety and wildlife populations. Effective measures include building fencing and under-passes along priority highways to allow the safe passage of wildlife across highways. According to Caltrans and California Highway Patrol statistics, there are >4,000 reported accidents per year on California highways involving deer, other wildlife, and livestock (in that order of importance). Despite the statewide collection of roadkill observations by CROS observers, we know that our ~7,000 observations per year represent only a small fraction of the total animals killed due to collisions with vehicles.

For the first time, we have analyzed the rates and locations of both animal carcasses (Report I) and reported traffic incidents (this report). These incidents could be reports of animals running across the road, collisions with animals (primarily deer), or accidents resulting from people swerving to avoid a collision with an animal in the road. Our analyses include identification of geographical hotspots and calculated costs to the public from vehicle damage, injury and even death. This information hopefully will show where we know there are problems and help in development of safety projects to fix these known problem areas.

The following maps show the distribution of WVC densities along select state highways. The densities of WVC reported are the minimum for each highway segment and do not represent actual rates, which are likely to be much higher. By significantly increasing the systematic treatment of these hotspots and stretches of highway with high rates of collisions, Caltrans and other entities can contribute to driver safety and improve the environmental sustainability of the state highway system.

Statewide Carcass Observations

The maps below shows >50,000 observations of animal carcasses on local roads and state highways. These are not all the roadkill that occurred, just the ones that people saw and reported in the California Roadkill Observation System (CROS) between 2009 and 2015, as well as older data from Caltrans' records. The observations are used to inform modeling of distribution of wildlife species and risks to wildlife and drivers from collisions.

A) B)

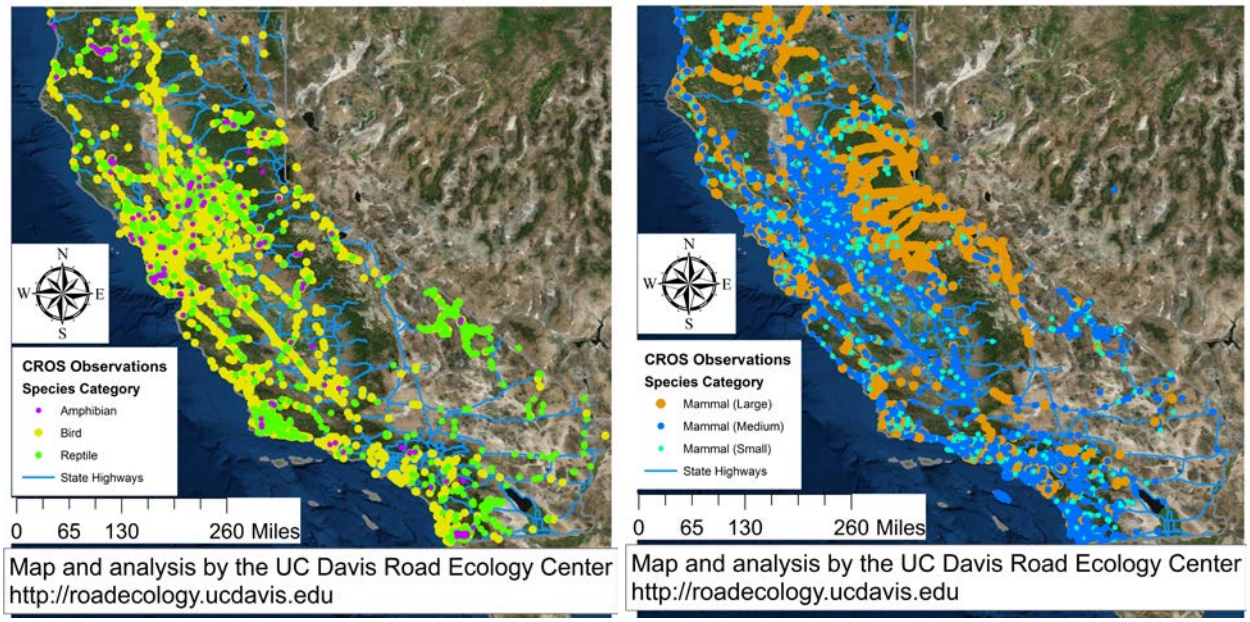


Figure 1. Carcass observations reported to the California Roadkill Observation System for (A) amphibians, reptiles, and birds; and (B) mammals of various sizes.

Statewide Highway Traffic Incidents

There were at least 563,496 traffic incidents of all kinds across California reported to the California Highway Patrol between 2/2015 and 2/2016 (Figure 2, "CHIPs (All)"). Of these, about half were collisions and 5,950 involved wildlife, including reports of animals standing next to or running across lanes, collisions with animals, and swerving to avoid collisions, resulting in a crash (Figure 2, "CHIPs (Animal)"). October was the most dangerous month for conflict, with about twice as many incidents as other months (inset graph). This may be because of increased movement related to mating season and seasonal migration.

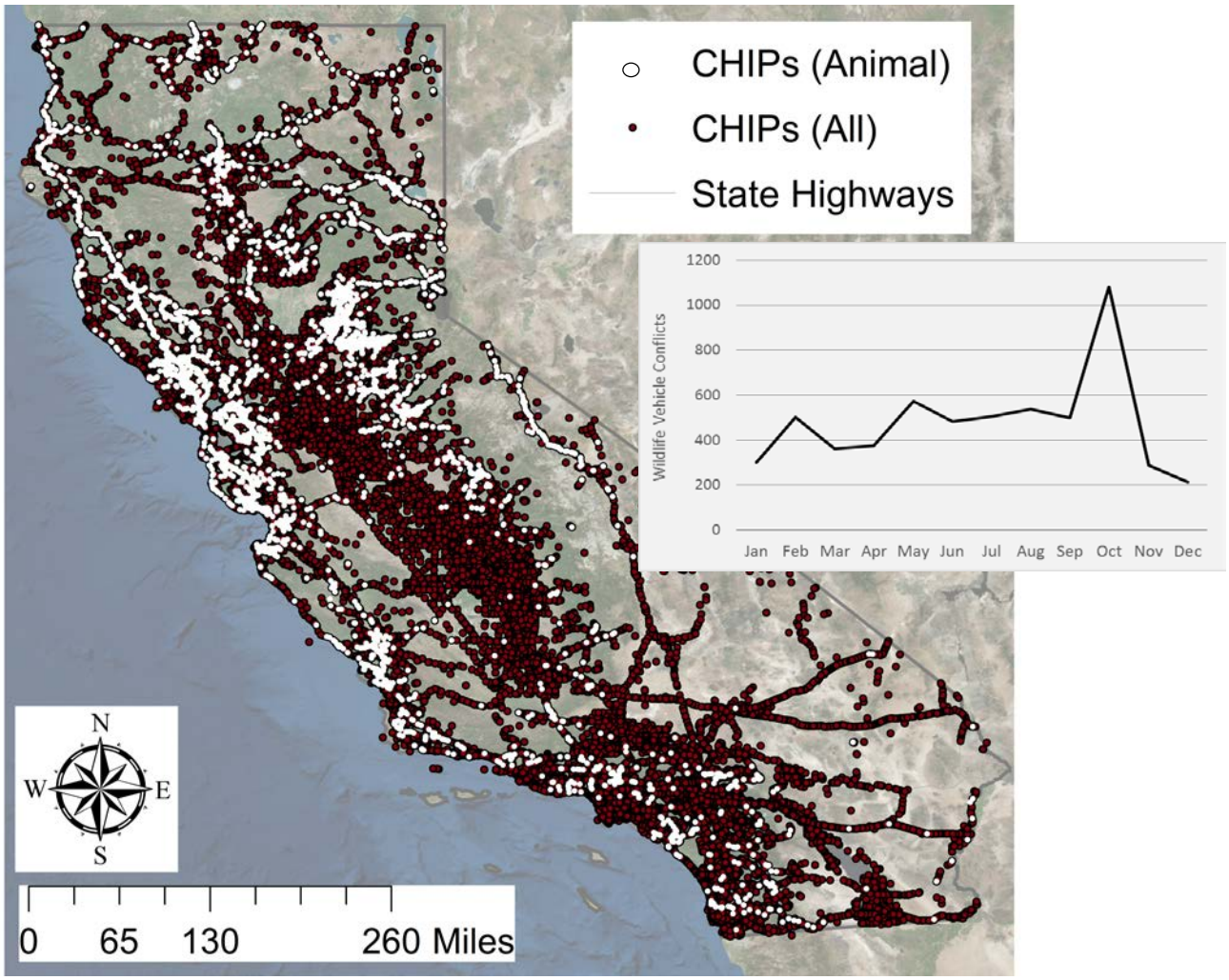
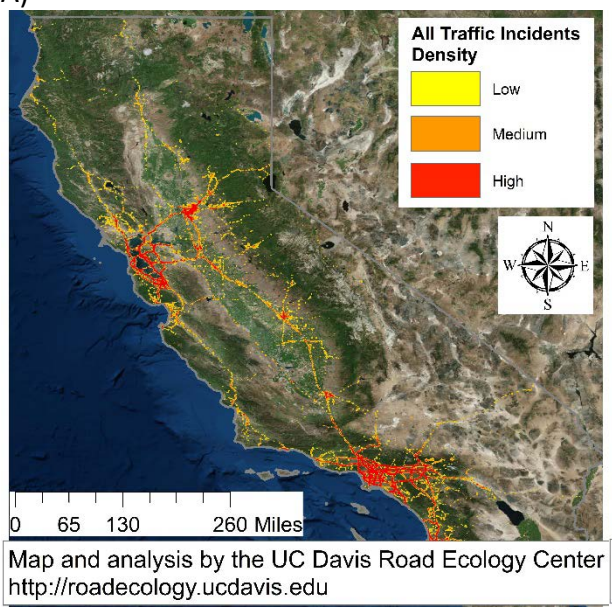


Figure 2. All traffic incidents (dark symbols) and those involving wildlife (white symbols) in the California Highways Incident Processing system (CHIPs). Inset graph: number of WVC per month for 2/2015 to 2/2016.

Statewide Highway Traffic Incident Hotspots

Because of the high density of points, it is difficult to discern patterns in the data. Therefore, we mapped both the density of points along highways/roadways and statistically-significant clusters of points. Traffic incident densities of all types are highest in urban areas and along interstates. There are also relatively high densities of incidents in rural/mountain areas, which may reflect the driving/roadway conditions in those areas. Of 563,496 traffic incidents, 51% were collisions, approximately half of these involved no injuries and the other half involved injuries and occasionally death for someone in the vehicle (<1%).

A)



B)

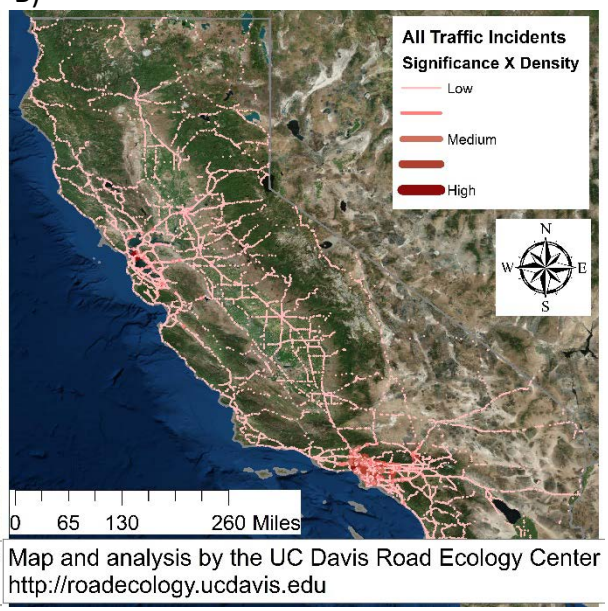


Figure 3. A) Density of all traffic incidents between 2/2015 and 2/2016; and B) The product of incident density and significance of clustering of the incidents.

During our analysis of traffic incidents involving wildlife, we noticed that none were reported as "fatality" for the driver, even though California has ~5 WVC resulting in human fatalities per year. We suspect that these events are not reported accurately because people died. We also noticed that records were modified, including being deleted, when they involved collisions with wildlife on certain highways (e.g., I-280 in the Bay Area). We have no explanation for this.

Consequences of Collisions to Drivers and Society

Individual drivers involved in a collision with an animal of any kind may be upset by the incident and if the animal is larger, also face damage to their vehicle and injury to themselves. Drivers may either collide with the animal, or swerve to avoid the animal and become involved in a

collision with another vehicle or object (Table 1). The rates of property damage, injury and death reported here are probably underestimates and may be superseded by more detailed information from state sources.

We estimated the total cost of all WVC incidents to society, using summaries of types of accident (e.g., property damage only, major injury), the loss of wildlife, and coefficients for each of these types of loss. Equivalent costs for accident types were obtained from the US Department of Transportation (2013) and a similar project in South Dakota (Cramer et al., 2016). Because the number of fatalities may not be accurately reported in data obtained from state resources, we used an average value for California (5.3/year, average 2005-2014) of the number of fatalities per year from collisions with wildlife, obtained from the Insurance Institute for Highway Safety (http://www.iihs.org/iihs/topics/t/roadway-and-environment/fatalityfacts/fixed-object-crashes, accessed 9/13/2016).

Table 1. Impact to drivers and estimated cost to society of reported collisions with animals on California highways and certain major roads.

Type of Accident	Coefficient (cost as $/event)	Number	Cost
Lost animal value (all animal types)			$36,165,000*
Collision (property damage)	$17,343	5,095	$88,362,585
Swerve off road (vehicle not drivable)	$17,343	88	$1,526,184
Injury (minor)	$105,228	247	$25,991,316
Injury (major)	$506,217	45	$22,779,765
Fatality	$9,395,247	5.3**	$49,794,809
Total			**$224,619,659**

* This value includes both reported and estimated un-reported carcasses. Others have reported under-reporting rates for carcasses from collisions of 5-10 fold (e.g., Olson et al., 2014).
** Average CA fatality rate from collisions with animals for 2005-2014

Consequences of Collisions to Species, Populations & Individual Animals

The majority of traffic incidents involving an animal (Figure 2) were with mule deer (91%, Table 2), though 5 other mammals were also involved. In addition, these are just species and number of animals that were included in a CHP incident report. Donaldson and Lafon (2008) and Olson et al. (2014) have reported under-reporting rates of collisions with ungulates of 5 to 10 fold. This suggests that as many as 25,000 to 50,000 mule deer were killed during collisions in 2015 and an unknown number of other species.

Table 2. The types and number of each type of wildlife involved in traffic incidents reported to CHP.

Wildlife type	Number	% of Total
Mule deer	5,408	91%
Coyote	361	6%
Black bear	89	2%
Mountain lion	40	<1%
Wild pig	37	<1%
Elk	15	<1%

For people who have collided with an animal, some will have observed that the animal does not always die immediately. We found that 22% (n=1,240) of animals involved in incidents were reported as injured by responding law enforcement (Table 3). There were an additional 26% (n=1,444) with an unknown fate after being involved in a traffic incident. Sixty nine percent (n=992) of these were involved in a collision, suggesting that as many as 40% of all animals (n=(1,240+992)=2,232) could have been injured during the traffic incident. Only 171 animals were reported as dispatched by responding law enforcement, meaning that the remaining up to 2,061 animals stayed injured following the collision. This may still be an under-estimate of the total as there has been shown to be chronic under-reporting of collisions with ungulates in the US (Donaldson and Lafon, 2008; Olson et al., 2014).

Table 3. Animal outcomes following collisions with vehicles.

Animal Outcome	#	%
Unknown fate	1444	25.6%
Alive / No Injury	532	9.4%
Injury	1240	22.0%
Fatality, result of collision	2259	40.0%
Fatality, result of dispatch	171	3.0%
Total	5646	

These findings raise the question of whether these incidents where animals are injured in a collision are covered by California's statutory definition of animal cruelty (California Penal Code, Sec. 597) which defines cruelty as including where animals are "mutilated, or cruelly killed" or where any animal is subject to "needless suffering". Typically, wildlife are exempted from these statutes because they may be otherwise hunted and killed. However, the cruelty exemptions (Sec. 599c) cover permitted/licensed killing of game animals (e.g., for food) and not killing in general. Drivers are not being accused of being cruel, but it will help them as much as animals to do everything possible to prevent the collision and therefore stop the resulting cruelty.

Statewide Highway Wildlife-Traffic Incident Hotspots

In 2015, there were at least 5,950 reported traffic incidents involving wildlife on state highways and roadways (2/2015-2/2016; Figure 2). These do not represent all traffic incidents involving wildlife, just the ones reported to CHP. A heat-map was developed based upon these incidents, which indicates where on the landscape rates of incidents were relatively high (Figure 4). Relative WVC density was scaled to low and high within each of 10 regions to permit prioritization within each area of the state. In a separate statistical analysis (Ripley's K function), the WVC points were found to be significantly clustered at the local and state scale.

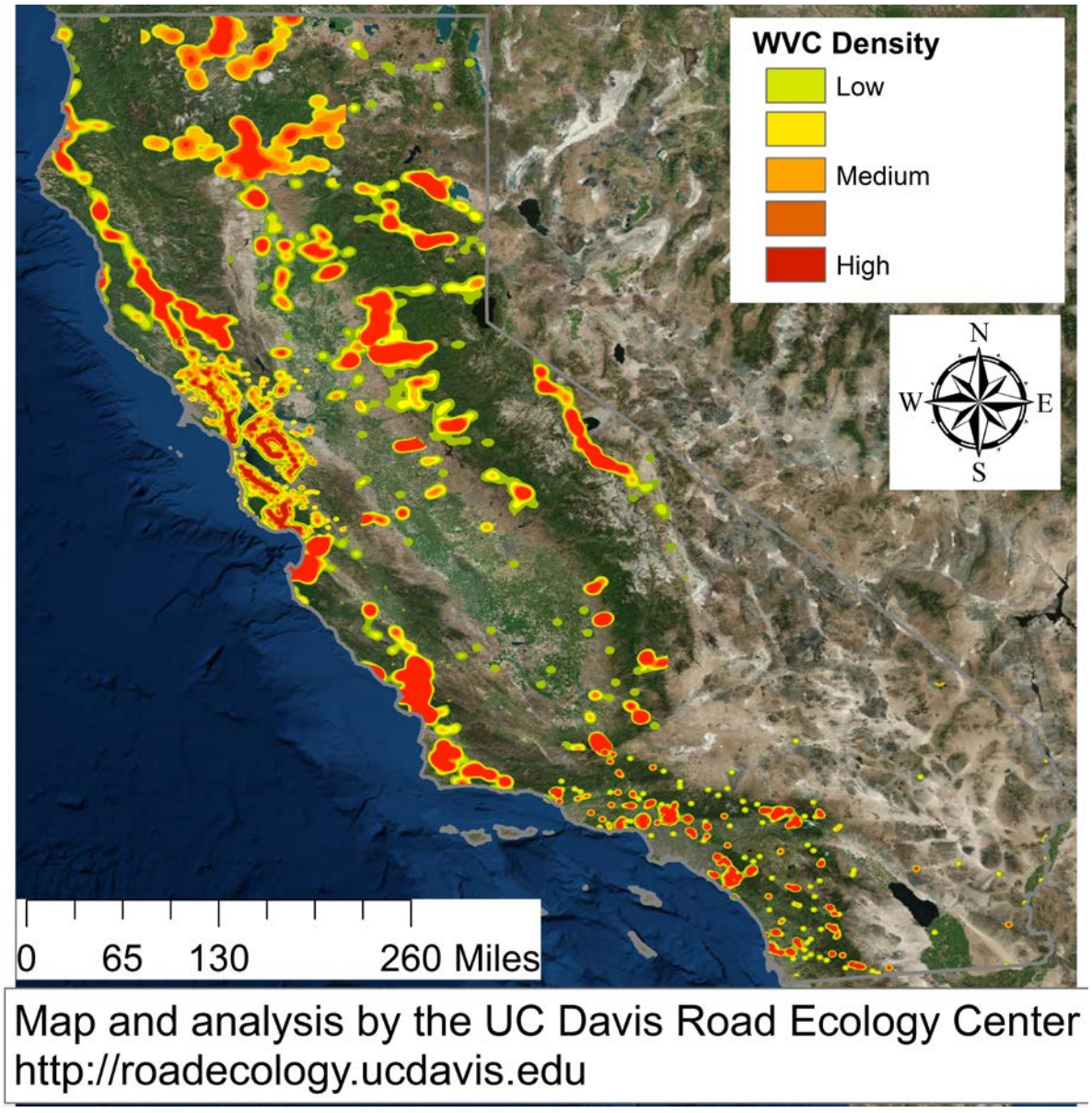


Figure 4. Relative intensity of WVC within each region, where the values corresponding to "low" and "high" were scaled within each region.

Statewide Highway Wildlife-Traffic Incident Costs

Reported traffic incidents involving collision with wildlife have associated average costs. These vary depending on whether or not a vehicle has been totaled, whether injuries have occurred and the severity of injuries (Table 1). We mapped all WVC according to estimated costs associated with the incident type (Figure 5). Where incidents involved major injuries, or where clusters of incidents occurred, the color ranges from turquoise to blue. Where property damage only incidents occurred, the color is green.

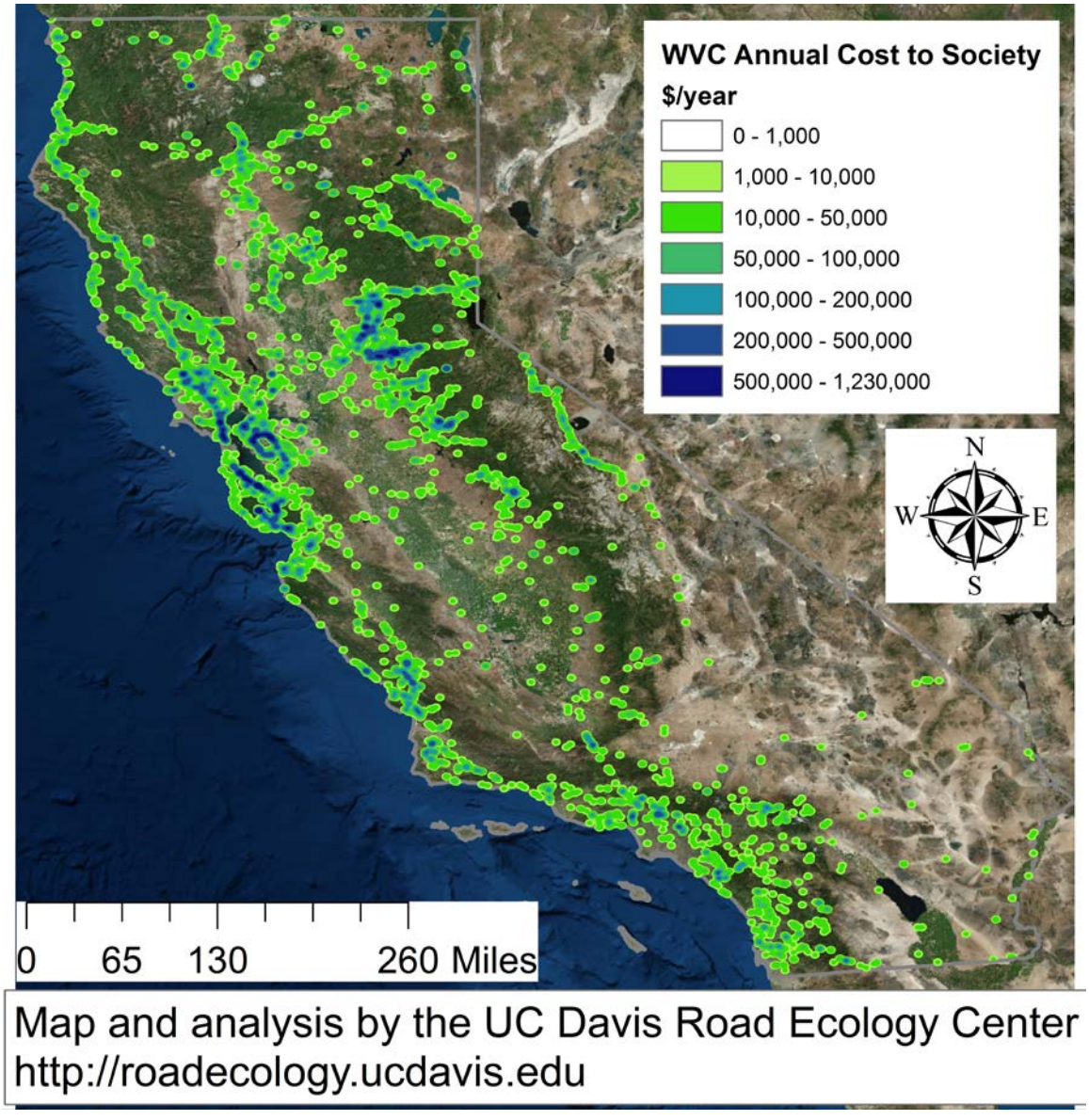
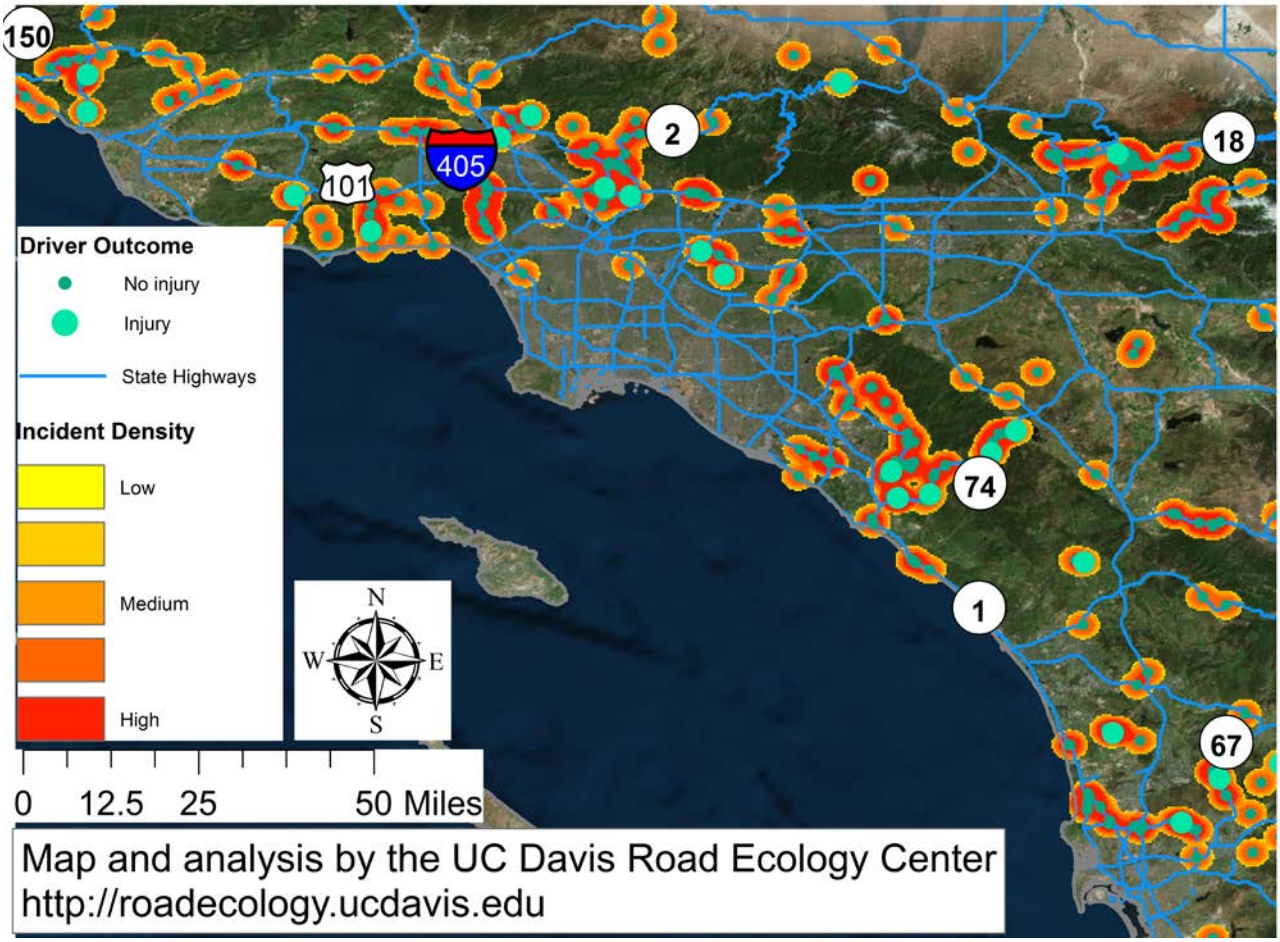


Figure 5. Estimated annual costs of traffic incidents where property damage and/or injury was reported.

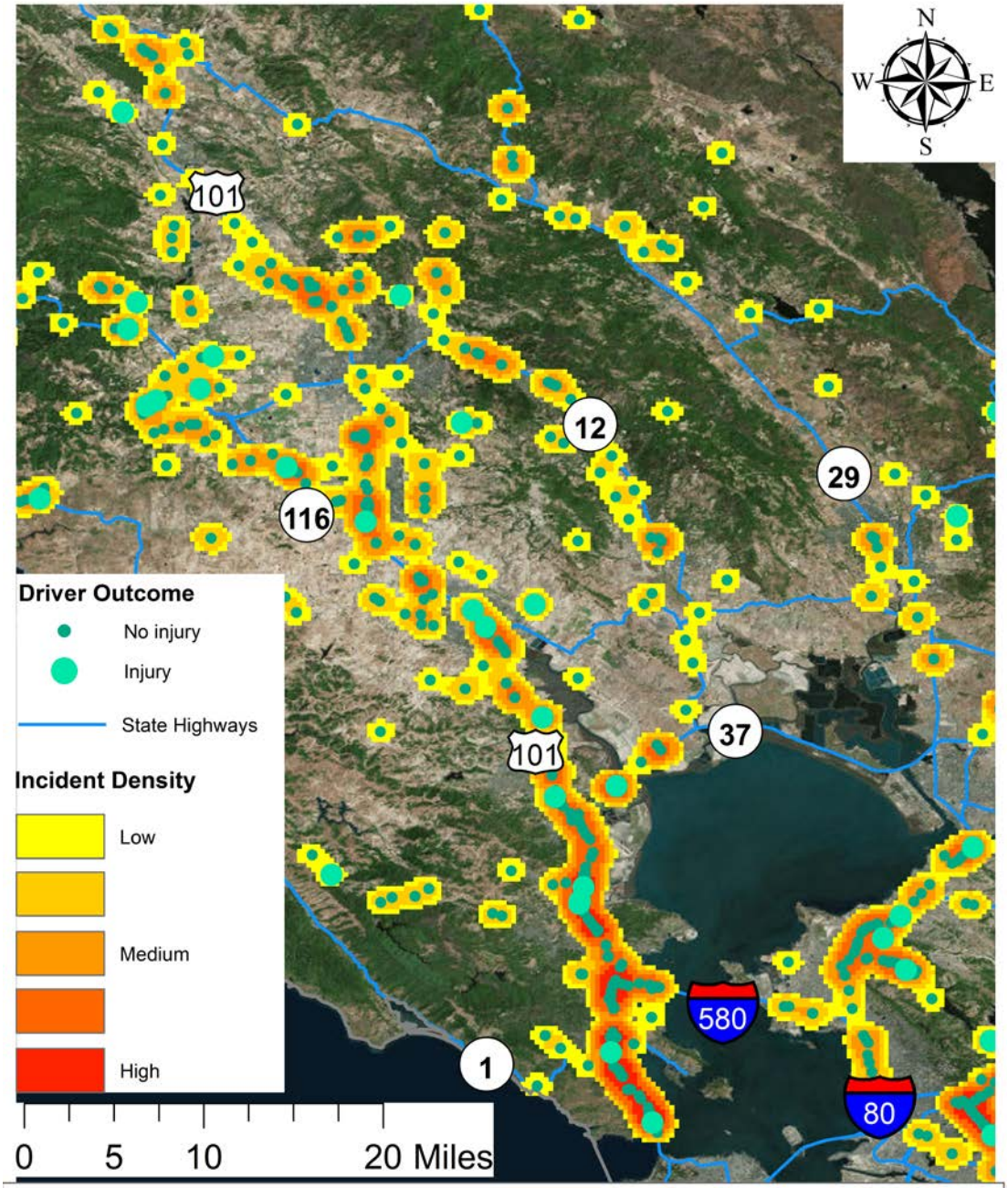
Southern California, Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). A similar map of all traffic incidents would highlight most highways in the Los Angeles Basin. The WVC hotspots are on SR33, SR60, SR134, SR2, SR18, SR74, SR52, and SR67.



North San Francisco Bay Area, Regional Highway Hotspots

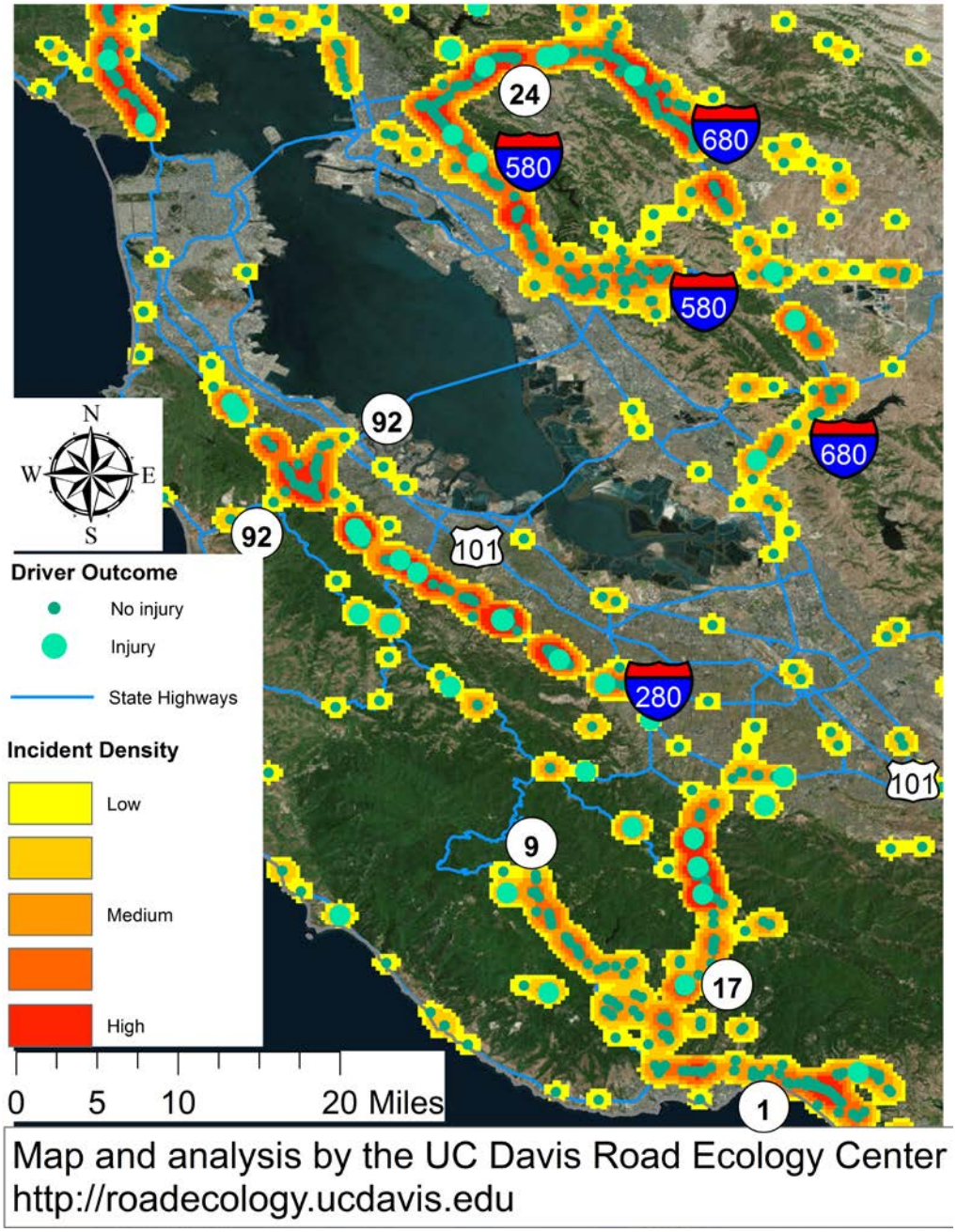
This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred on I-80, SR101, SR37, and SR116. The stretch of highway 101 with high WVC densities and injury accidents is also a hotspot for roadkill reports in the California Roadkill Observation System.



Map and analysis by the UC Davis Road Ecology Center
http://roadecology.ucdavis.edu

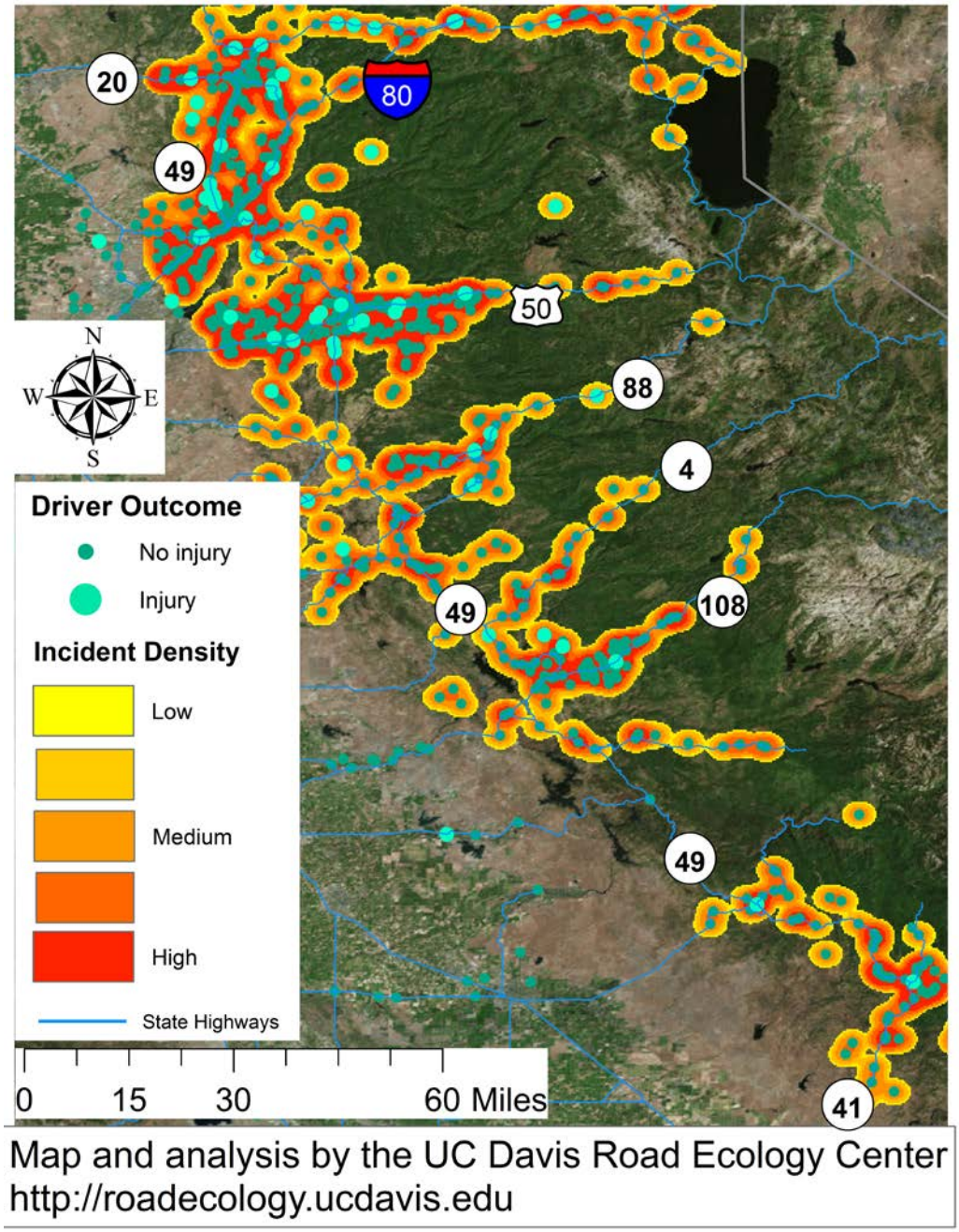
South/East San Francisco Bay Area, Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred on I-580, I-680, I-280, SR 24, SR1 and SR17. The stretches of I-280, I-580 and highway 1 with high WVC densities and injury accidents are also hotspots for roadkill reports in the California Roadkill Observation System.



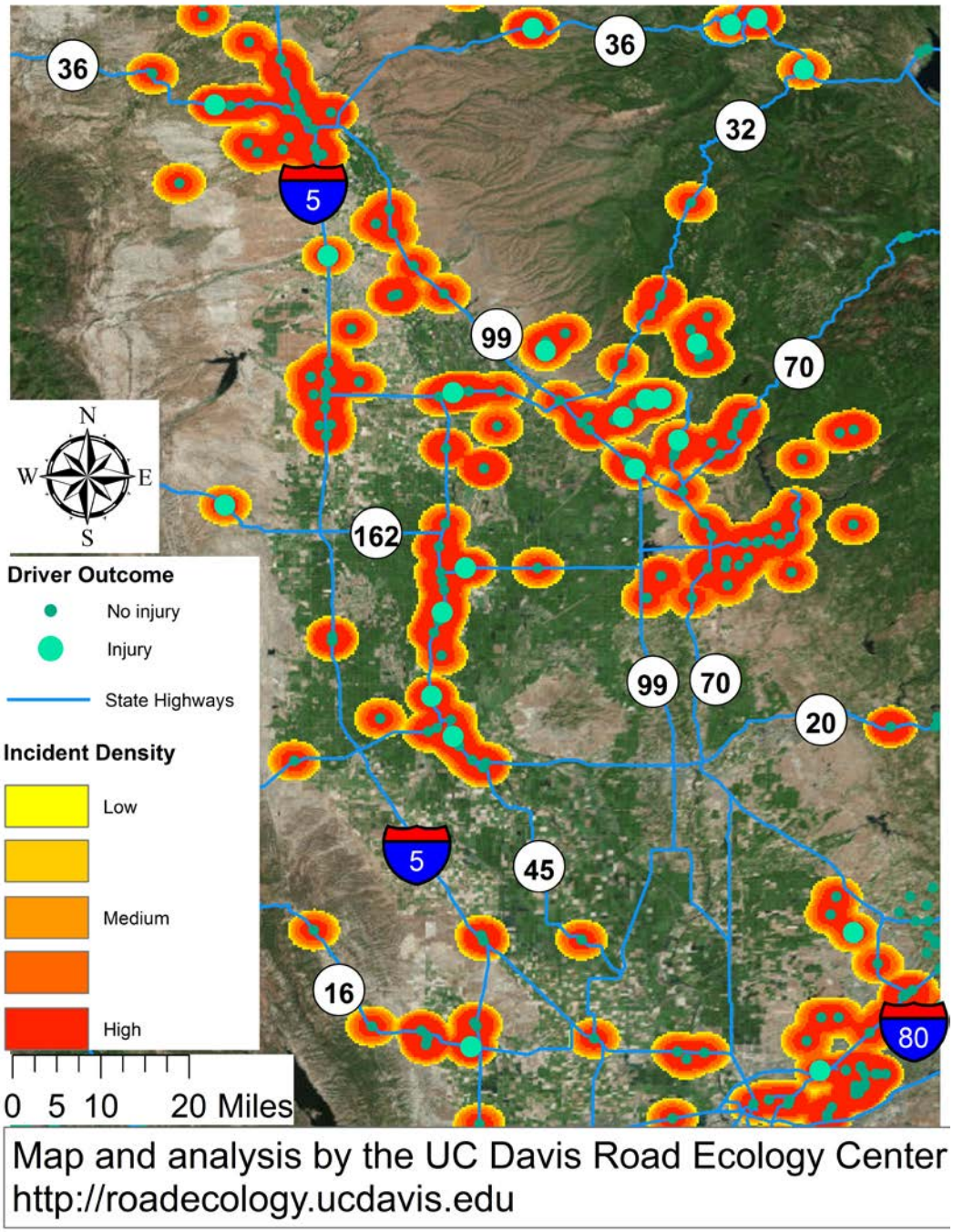
Sierra Nevada Foothills, Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred on I-80, SR20, SR49, US50, SR108, SR88, and SR41. The stretches of highways 49 and 50 with high WVC densities and injury accidents are also hotspots for roadkill reports in the California Roadkill Observation System.



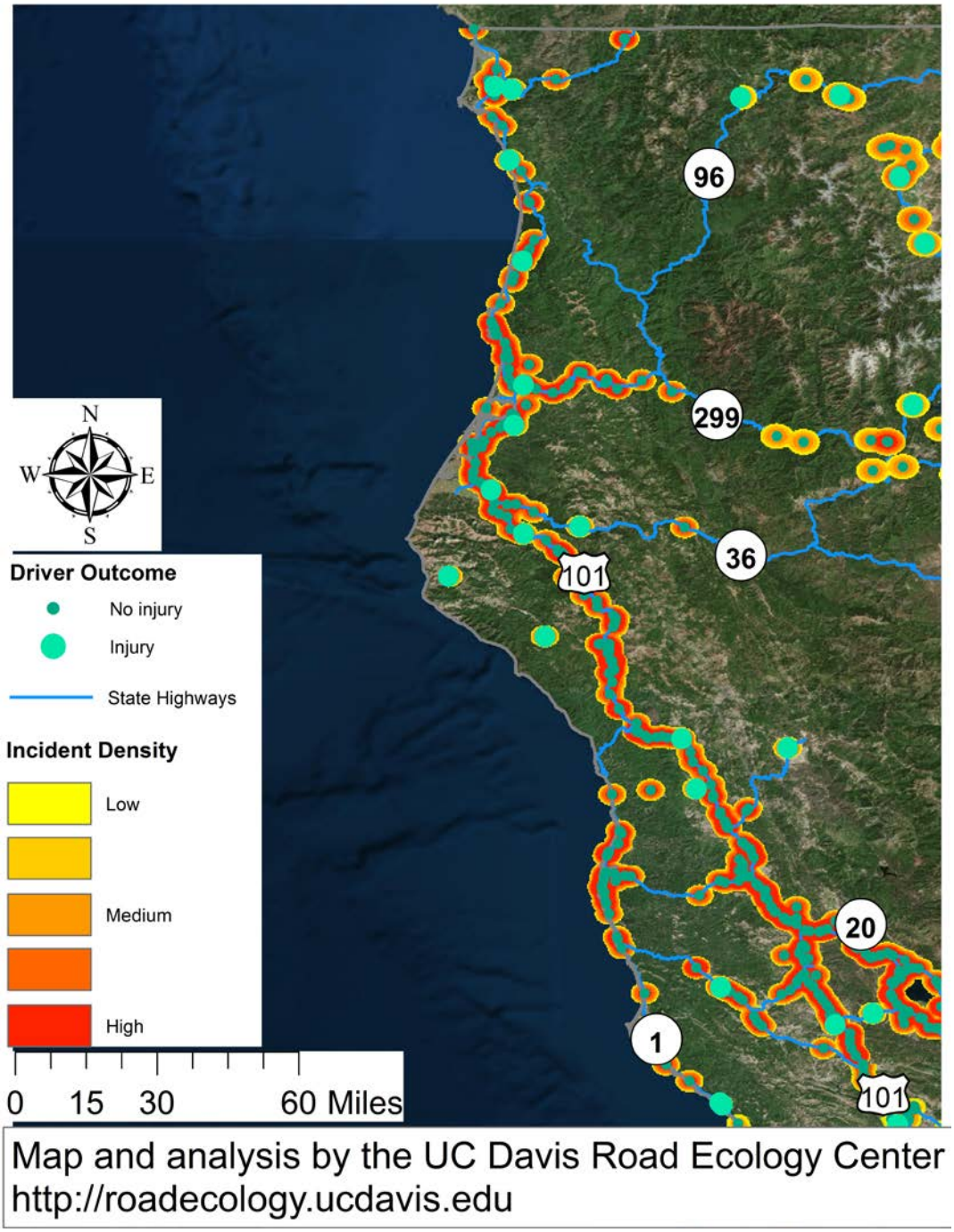
Sacramento Valley, Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred on I-80, I-5, SR36, SR99, SR45, and SR16.



North Coast and Mountains, Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred primarily on SR101/1. Certain stretches of highway 101/1 with high WVC densities and injury accidents are also hotspots for roadkill reports in the California Roadkill Observation System.



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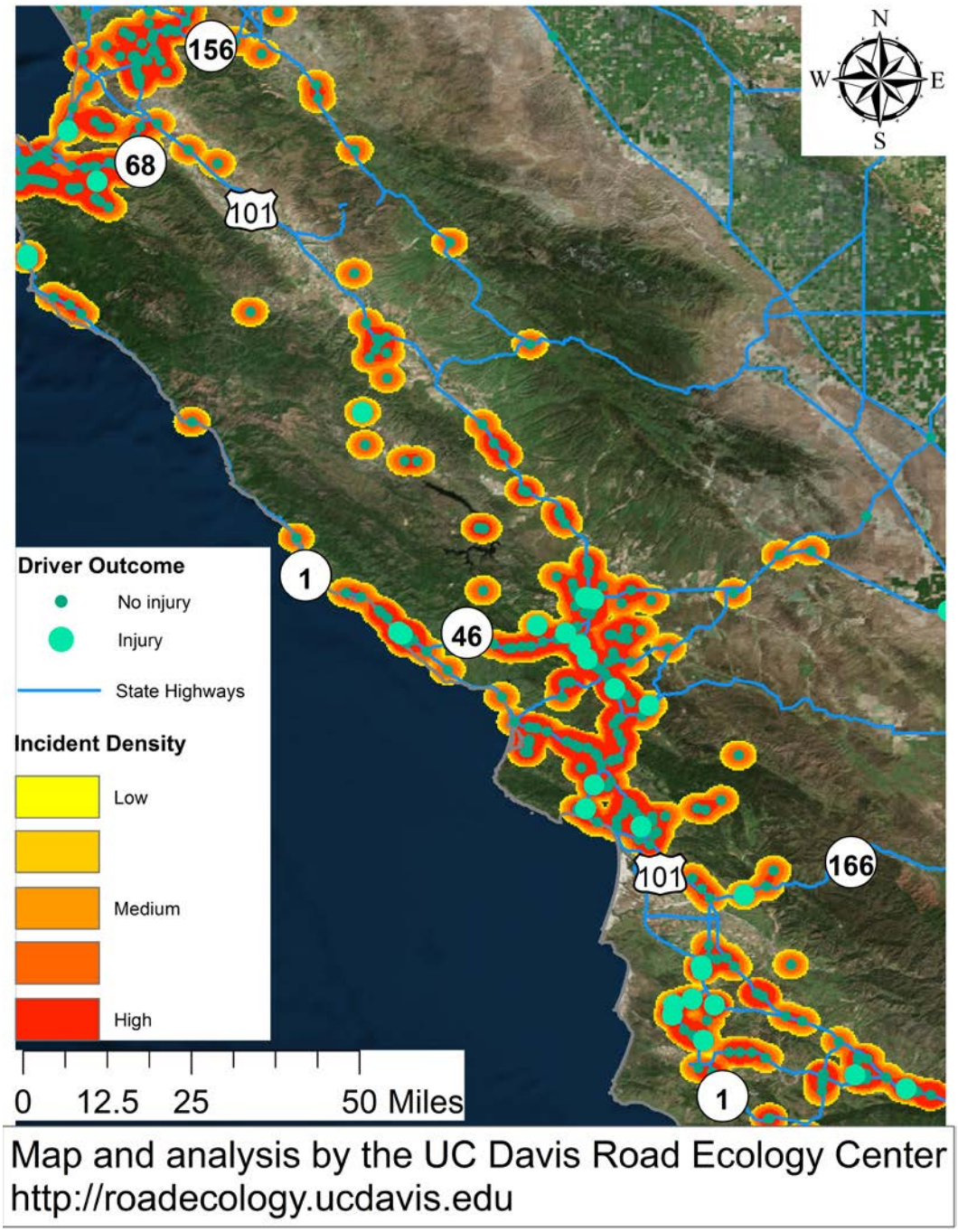
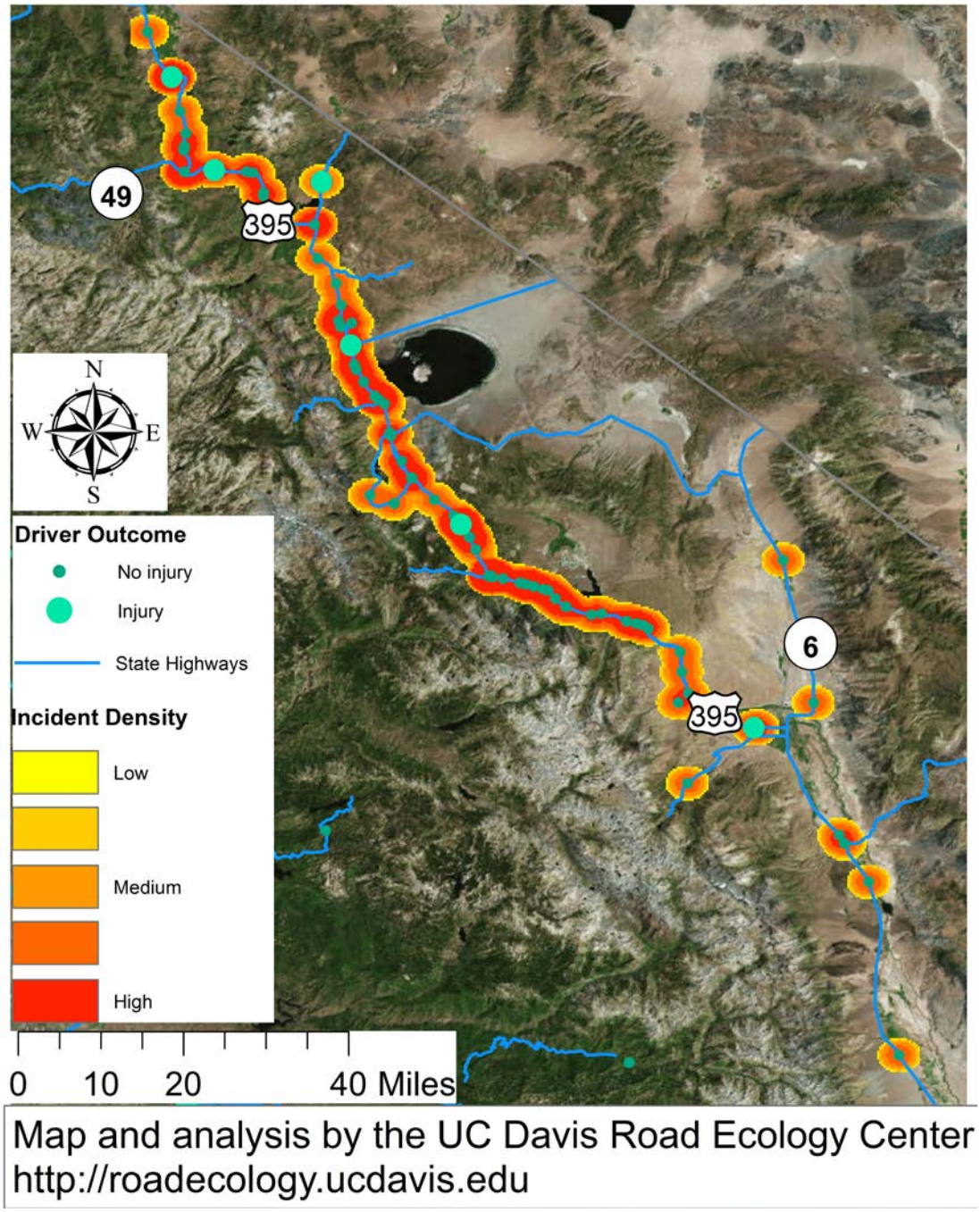
South-Central Coast Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred primarily on SR101, SR1, SR68, SR46, and SR166. The stretches of highways 101/1 with high WVC densities and injury accidents are also hotspots for roadkill reports in the California Roadkill Observation System.



High Desert Regional Highway Hotspots

This map shows the intensity and clustering of WVC traffic incidents. The density of WVC reported per segment of highway (yellow to red scale) is overlaid with the outcome for drivers (no injury or injury). Hotspots with both high densities of WVC and injury accidents occurred primarily on US395. Certain stretches of highway 395 with high WVC densities and injury accidents are also hotspots for roadkill reports in the California Roadkill Observation System.



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