From Wildlife-Vehicle Conflict to Solutions for California Wildlife & Drivers

2023

"The ultimate solution is to induce people to drive much less, more slowly, and not at night…." –Ben Goldfarb, author of **Crossings: How Road Ecology Is Shaping the Future of Our Planet**

ROAD ECOLOGY CENTER

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Executive Summary: From Wildlife-Vehicle Conflict to Solutions for California Drivers and Animals

This report provides a statewide overview of wildlife-vehicle conflict (WVC) in general, including collisions with small and large animals. We highlight WVC hotspots on California highways based on a combination of >30,000 traffic incidents involving wildlife that were recorded by the CHP (primarily mule deer) and >160,000 carcass observations reported to the California Roadkill Observation System (CROS, https://wildlifecrossing.net/california) and other roadkill reporting systems, between 2009 and 2022, inclusive. The primary message of this report is that WVC is exacting a continuing and damaging toll on the state's wildlife and drivers and that many of these impacts are preventable with adequate roadside fencing.

We used WVC data to estimate trends in wildlife populations (mule deer, elk, mountain lion, black bear, coyote) which indicate that mule deer and coyote populations are in decline, possibly due to excessive rates of traffic collisions. Using observations of reported traffic incidents and carcasses the Road Ecology Center has previously estimated the total economic cost of reported (large) wildlife-vehicle collisions in California for 2016 to 2020, inclusive to be > $250 million per year (Shilling et al., 2017-2021). These costs to society could have been reduced by >$200,000/mile over the last seven years by installing fencing on 669 1-mile highway segments. There were also 615 statistically-significant hotspots, appropriate for focused action. We show locations of hotspots of mountain lion and other species' mortality from traffic and compare those to highways identified as priority barriers for wildlife movement (CDFW, 2022). We highlight the new (as of 2022) Priority Barrier on I-15 associated with the Brightline rail alignment, which could draw public funds to mitigate for this private project. We highlight and give kudos for the dramatic increase in wildlife fencing and crossing planning that the state has engaged in since the last report. Within the next decade, at least a dozen sites in the state may see construction of wildlife over-crossings similar to the Wallis-Annenberg wildlife overpass in Agoura Hills. Fencing remains the only way to reduce WVC at the state scale.

Data Sharing/Collaboration: We frequently receive data requests from transportation and environmental planners, fish and wildlife scientists, academic faculty, students, and non-governmental organizations. We can meet data requests within California for specific highways, counties, etc., within a few days of the request. With funding from the Wildlife Conservation Network, we will be releasing a web-system that allows users to define project areas and collect our data (and other data) for project planning purposes. Our crowd-source approach depends on constant data contributions and our California Roadkill Observation System app supports "one-click" reporting (https://wildlifecrossing.net/california) with a smartphone.

Contributors:

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Cover photo credit. Coyote killed on an interstate (Fraser Shilling)

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Coyote in the Sierra Nevada (Photo credit: Amy Collins and Fraser Shilling, Road Ecology Center, UC Davis)

Top 5 Talking Points

1. **Wildlife-vehicle collisions continues to be an under-recognized and under-reported threat to wildlife populations and drivers and is preventable with fencing.** Even common species like mule deer may be experiencing unsustainable levels of mortality from traffic. In addition, WVC continues to be costly to the State (>$250 million/year) and occurs in identifiable "hotspots". This type of safety issue for the driving public is preventable with adequate fencing. We urge the State to spend its transportation funds on fencing to reduce costs associated with wildlife-vehicle collisions and both enhance public safety and reduce wildlife mortality.
2. **Wildlife populations are in local and statewide decline and traffic is (partly) to blame.** Although California does not track the size of most wildlife populations, measuring rates of roadkill provides insight into the impact of WVC on population trends of easy-to-monitor species (e.g., mule deer). The rate at which mule deer are dying from traffic is decreasing, suggesting that the population is declining, possibly because of vehicle-strikes, or due to other impacts, such as habitat loss or degradation. In addition, according to mountain lion experts, the rate at which mountain lions are killed by vehicles is the first or second leading cause of death in some Southern California populations.
3. **The increase in state and federal legislative, public, and agency support for wildlife crossing and fencing projects may help to reduce WVC.** In the past seven reports we highlighted the massive ecological debt that is accumulating because of un-mitigated traffic impacts on wildlife. In the last session, California legislators approved close to $1 billion in new funding to help us catch up to other states and build wildlife fencing and over and under-passes. Ecological champions in Caltrans, the Wildlife Conservation Board and California Department of Fish and Wildlife are already taking advantage of this opportunity.
4. **We can improve the decision-making about wildlife fencing placement and design of wildlife crossings.** Passage of AB2344 (2022) and new funding from the legislature has suddenly accelerated the rate of planning for wildlife barrier fencing and crossings. It has also highlighted the need for improved, evidence-based, decision-making about the need for roadside wildlife fencing and where to place and design crossing structures for wildlife. The Road Ecology Center is developing standard data collection and analysis approaches that can be systematically applied to improve the locating and design of fencing and crossings to maximize benefits for wildlife and drivers.
5. **We can all help the State systematically collect and share data.** Though CHP data is an important dataset for understanding and studying wildlife-vehicle collisions in California, they were not collected with the purpose of studying WVC, unlike the volunteer data submitted through the California Roadkill Observation System. California agencies should be encouraged to collect and share data about WVC to help inform decision-making about this important conservation and safety problem. Although there are "ecological champions" in certain Caltrans districts who encourage WVC data collection and use these data to plan wildlife crossings, routine wildlife-vehicle collision data collection is not officially supported by state agencies. Recent legislation (AB2344) requires greater attention to safe passage for wildlife across highways in California, but so far that statute has not been supported by requirements for data collection and use. To overcome data gaps in wildlife-vehicle collisions, we urge all Californians to collect roadkill data using this web-app: https://wildlifecrossing.net/california, which not only support research efforts but are also used to support building wildlife crossings.

Introduction to Study

Wildlife need to move, but transportation and other linear infrastructure are barriers to this movement. Vehicular traffic often deters wildlife from crossing roads, impeding their ability to find food, water, mates and respond to extreme weather events, exacerbated by climate change. But vehicle traffic can completely arrest wildlife movement when wildlife are struck by vehicles in their attempt to cross roads, contributing to reduced genetic diversity because dead wildlife don't move into new populations and reproduce, improving gene pools. Mortality can be reduced with wildlife fencing; wildlife crossings (culverts and bridges) improve connectivity, but by themselves don't reduce mortality. In other words, reducing wildlife mortality by traffic is only accomplished with fencing, with or without associated crossings. Rates of mortality can be high enough for many species to affect population size (Fahrig and Rytwinski, 2009), especially larger, more mobile species (Rytwinski and Fahrig, 2011), and for certain species make them regionally threatened or extirpated (for example, for mountain lions in Southern California). Measuring rates of wildlife-vehicle conflict (WVC) is important for identifying locations and consequences of the conflict for wildlife populations and the driving public. With climate change and destructive land-use patterns, California's wildlife are under increasing pressure. WVC adds to this pressure, contributing to the decline of many wildlife species in California.

Using data on traffic incidents and roadkill observations in California, the Road Ecology Center has mapped stretches of ~15,000 miles of California state highways that are likely to be continuing hotspots for WVC. Animals entering roadways are often killed and pose a hazard to drivers, who may collide with the animal, or swerve 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 throughout the food web. 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 measures to protect drivers and wildlife populations. Measures with proven effectiveness include 1) building fencing and over/under-passes along priority (i.e., high WVC) highways to allow the safe passage of wildlife across highways and 2) reducing speed limits in protected wildlife habitat. Caltrans staff and Districts are ramping up their construction of solutions to WVC, beyond that required for mitigation of transportation projects. To provide agencies information to aid their decisions, we collate CHP and volunteer-collected data, including >5,000 reported crashes per year on California highways involving deer and other large wildlife. Our data 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; Shilling and Waetjen, 2015).

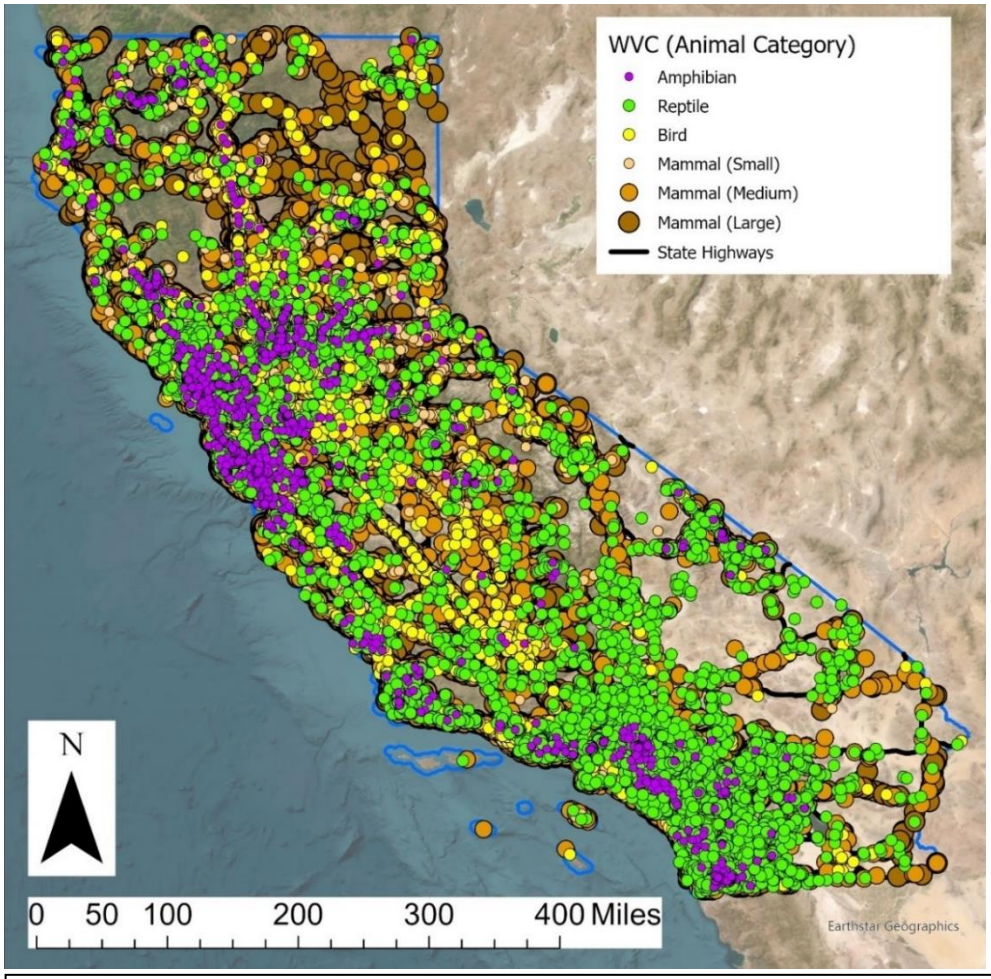
Statewide Carcass Observations

In the fourteen years of the California Roadkill Observation System (CROS, https://wildlifecrossing.net/california), members of the public, agencies, and others have made >200,000 observations of wild animal carcasses on local roads and state highways to various

roadkill reporting systems, primarily through CROS (Figure 1, Table 1). These are not the total roadkill that occurred, just the ones that expert observers saw and reported. The amphibian reports include a large dataset of observations collected by volunteers, of thousands of Pacific newts killed every year while migrating across Alma Bridge Road in Santa Clara Co. each winter.

Table 1. Summaries of wildlife categories reported as roadkill in California between 2009 and 2022. NB: These are counts of reports, not counts of all wildlife killed on roads. These counts also do not include reports from prior to 2009.

Animal Type	Number of Species	Number of Observations
Amphibian	19	34,104
Bird	234	8,893
Mammal (Large)	9	50,975
Mammal (Medium)	30	60,959
Mammal (Small)	65	11,767
Reptile	59	6,810



More than 30,000 WVC involving large mammals across California were reported to the CHP or through CROS during 2016-2022, inclusive. (Figure 2). However, these data do not reflect all large mammal WVC occurrences during this time. State Farm Insurance Inc. estimates that there are ~22,000 claims/year for collisions with deer in California. In other states, under-reporting of

Figure 1. California wildlife-vehicle collision observations reported to various roadkill reporting systems, primarily CROS (https://wildlifecrossing.net/california).

collisions can be 4 to 10-fold (Donaldson 2008), meaning that at least 22,000 and up to 220,000 deer/annually could be hit by vehicles in California on all roadways.

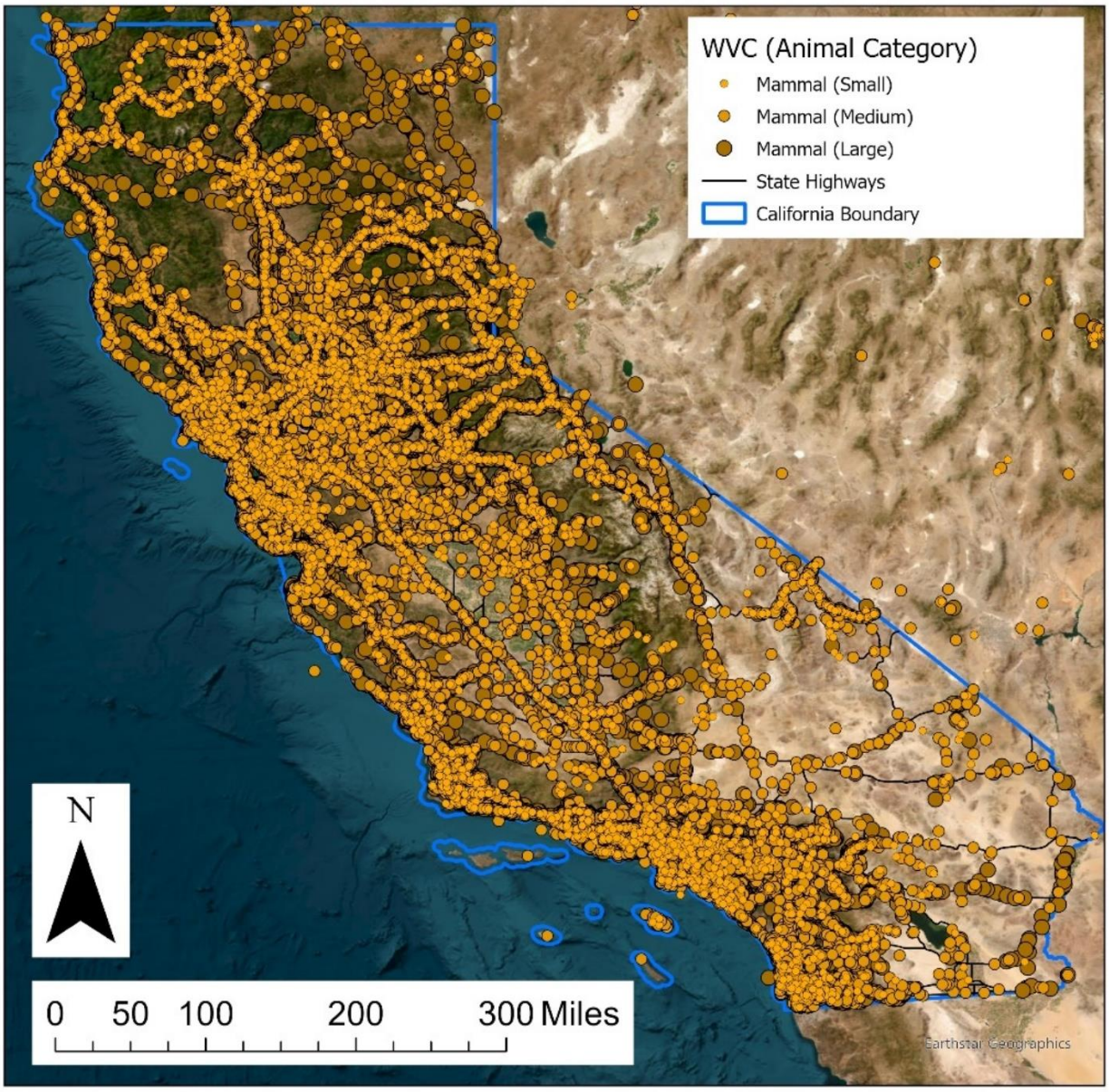


Figure 2. Mammalian roadkill reported to various roadkill reporting systems, including CROS and the Californina Highway Incident Processing System (large mammals), between 2009 and 2022. The symbols for small and medium sized mammals (lighter, smaller symbols) overlay the symbols for large mammals (darker, larger symbols), making the large mammal symbols difficult to see.

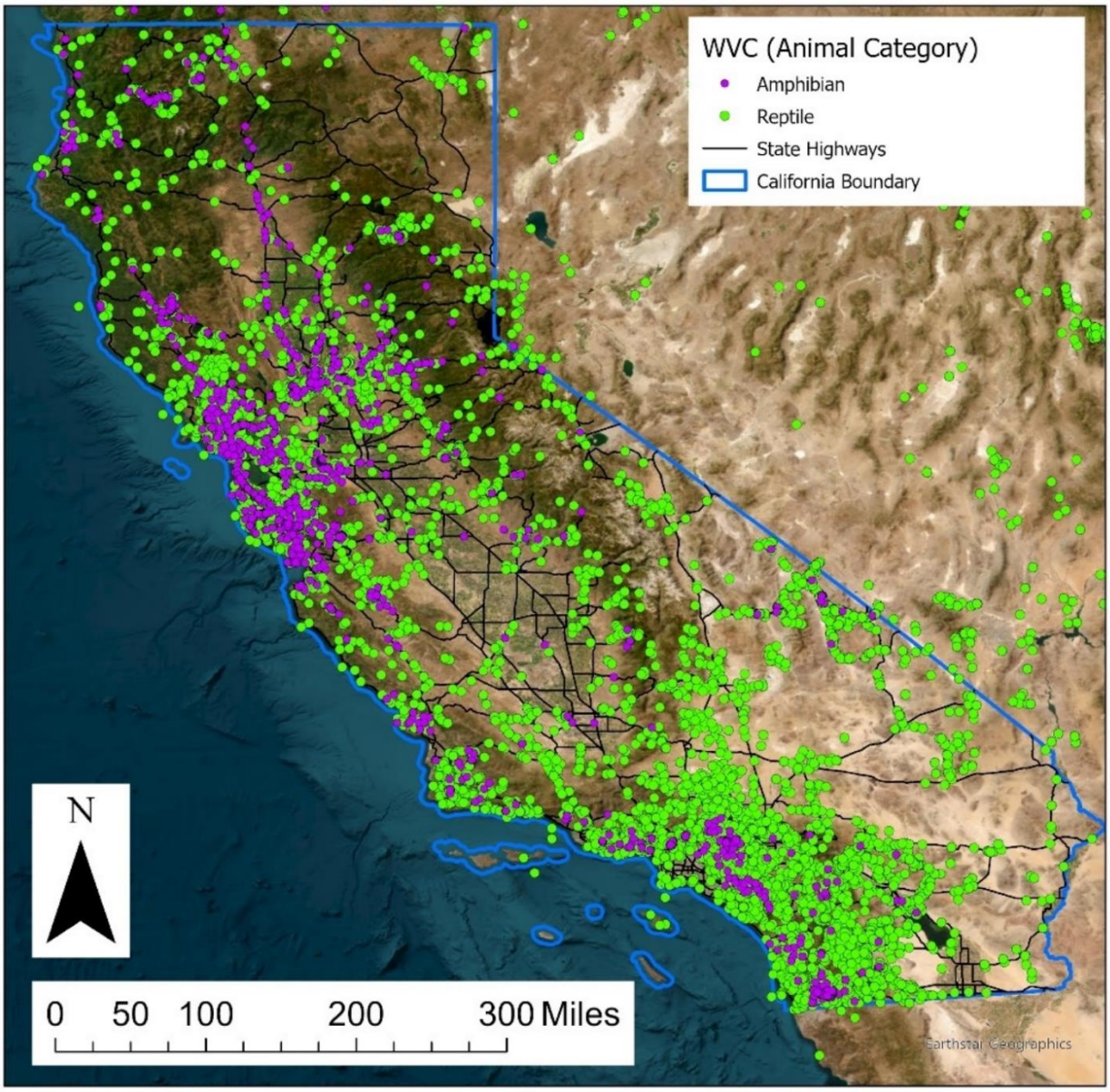


Figure 3. Amphibian (purple symbols) and reptile (green symbols) roadkill reported to various systems.

Impacts to Mountain Lions and Black Bears

Like most species at the top of the food web, mountain lions are especially vulnerable to WVC because they have large home ranges and can move several miles per day across the landscape, thus encountering numerous roads among their movements. Mountain lions are important ecologically because they are a keystone predator, the only large, widespread predator in most California ecosystems, and have been proposed for listing in southern California under the California Endangered Species Act. They are also important socially, with great interest in their well-being in Southern California and Bay Area urban regions. Black bears are similarly critical

species in most California ecosystems, ranging widely to forage and regularly crossing roads. A critical problem for mountain lions and black bears 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 or by CHP. There is no way of knowing the actual WVC impact to these important and charismatic species. Between 2016 and 2022, inclusive, 470 mountain lions and 1,024 black bears killed on roads, as reported by a combination of CROS volunteers, CHP, CDFW, and biologists in Southern California (Figure 4). Duplicates records were carefully removed prior to analysis. These were incidental reports and **do not represent all mountain lions and black bears killed** on the state's roads and highways.

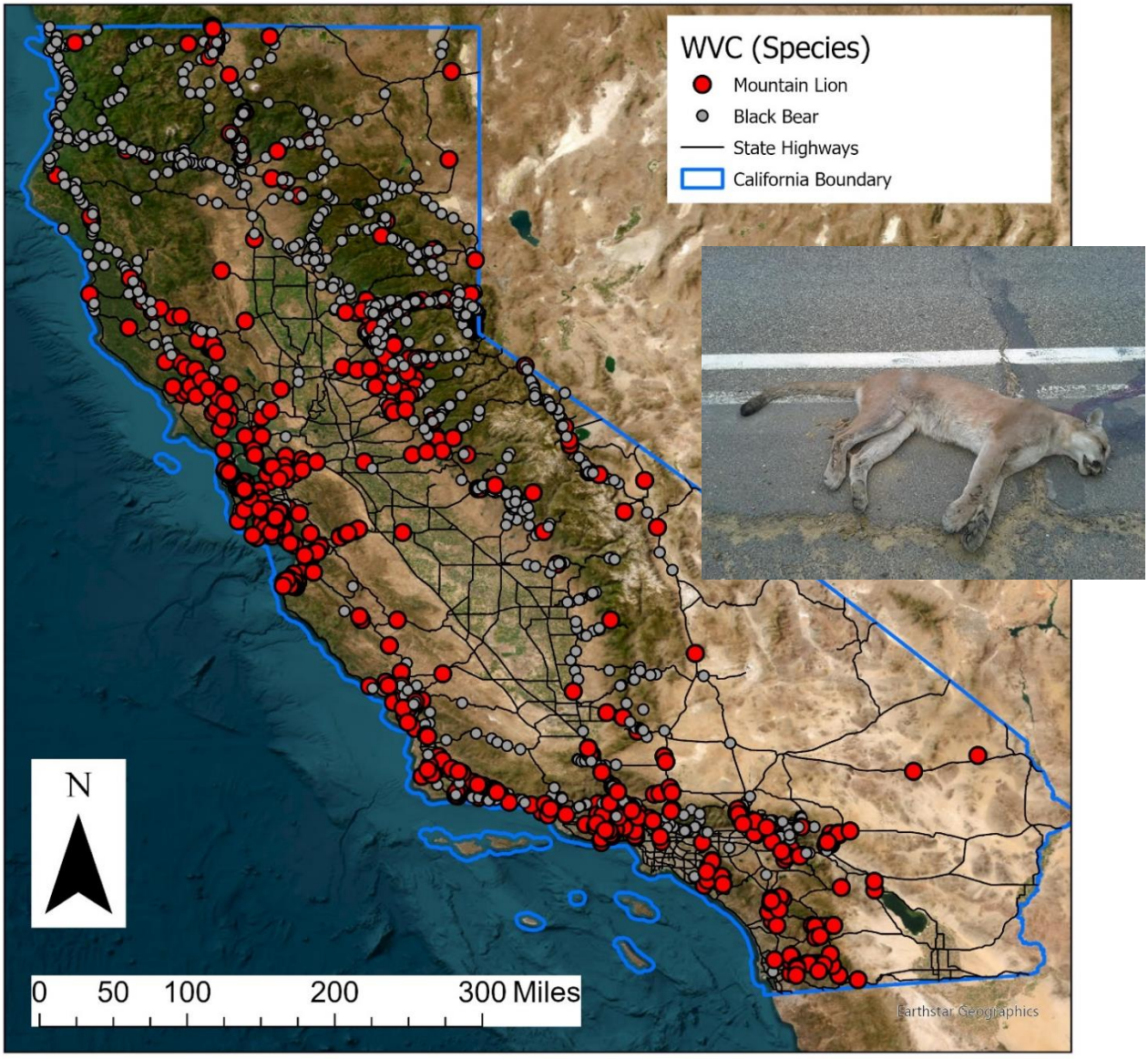
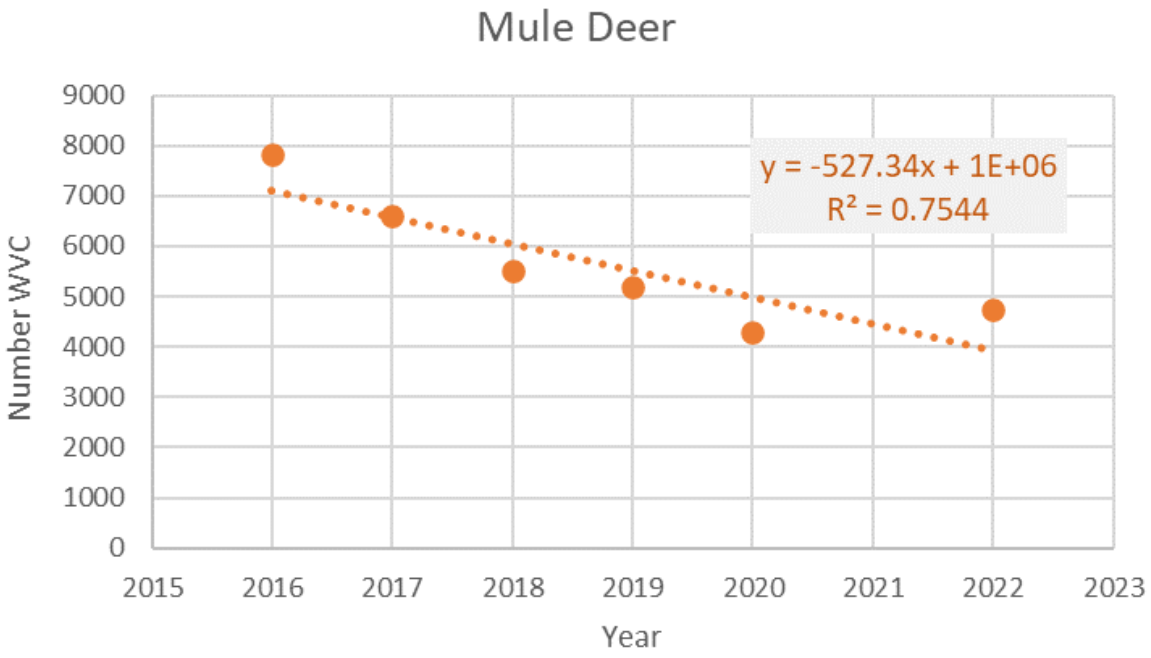


Figure 4. Locations of mountain lion and black bear mortality on roads in CA, between 2016 and 2022.

Special Case: Trends in Wildlife Populations

Wildlife populations normally fluctuate, depending on species, and can depend on several factors, including feeding and reproductive strategies, habitat availability, climate change and human impacts. The amount of roadkill in an area, like a US state, varies with traffic, size of the wildlife population and changes in the movement of species. This means that rates of roadkill can be used as indices of the size of wildlife populations (e.g., Canova and Balestrieri, 2019), assuming traffic and wildlife movement stays relatively constant. Other explanations for changes include: 1) drought, which could cause an increase in WVC as animals move around more, then a decline as drought caused populations declines; 2) habitat degradation, potentially causing animals to move more in search for food, increasing the rate of collisions with traffic; 3) changes in rate of reporting, for which there is no evidence for large mammals; and 4) increased rates of installing fencing to prevent WVC, which is not being implemented in California to the extent that would explain statewide changes in WVC occurrences.

1) Mule Deer roadkill in California are in decline (Figure 5A), suggesting that mule deer populations are also in decline. In contrast, elk roadkill is increasing.



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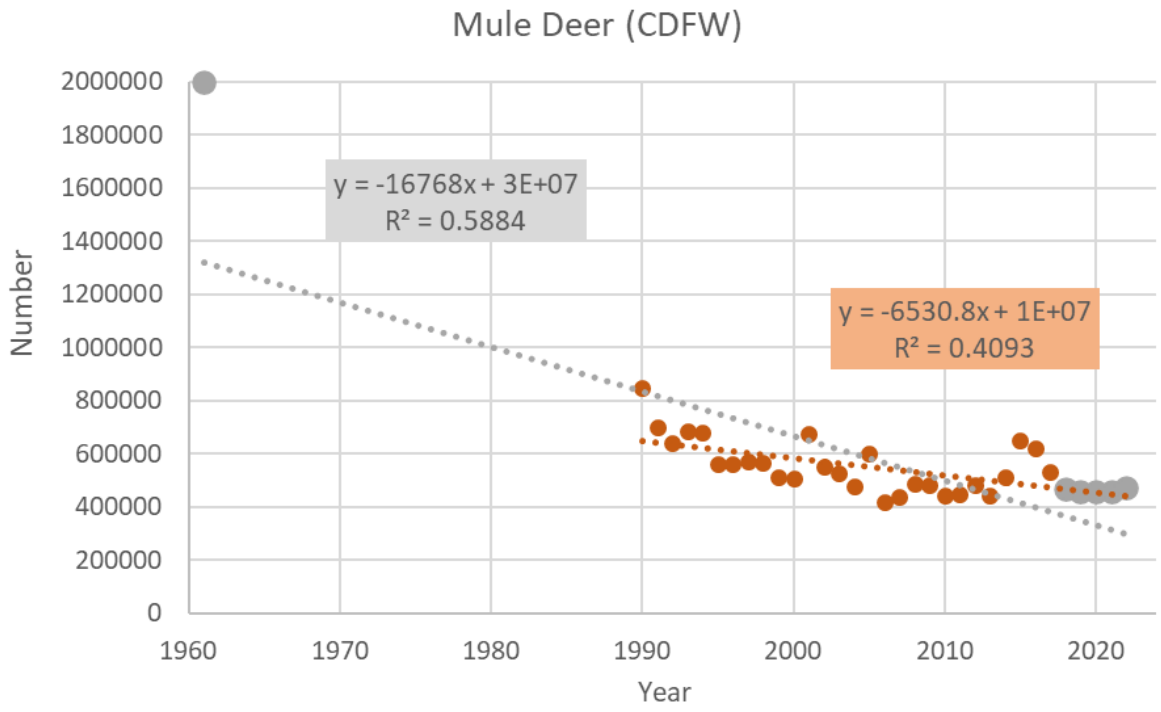


B

Figure 5. A) Mule deer WVC, from 2016 to 2022; and B) Mule deer population size in CA estimated by CDFW. Red circles and trend line are based on data from https://wildlife.ca.gov/Conservation/Mammals/Deer/Population and gray circles and trend line are based on data from https://www.deerfriendly.com/deer/california.

Most of our mule deer and elk roadkill data come from CHP reporting of crashes and carcasses on state highways and major roads, a constant and regular source of reporting. Over the period 2016 to 2022, mule deer mortality declined by ~10%/year, a remarkable rate of decrease (Figure 5A). The CDFW has also reported statewide declines of ~1%/year in mule deer populations over the 26 years preceding 2016 (CDFW, 2023), based primarily on hunting-report data (Figure 5B). The CDFW-reported declines are greatest in the southern North Coast, the Bay Area, the Central Coast, the Central Valley and the Sierra Nevada foothills between Chico and Fresno (Hunting Zones A and D3-9), areas of rapid development and traffic increases. The CDFW has historically not recognized WVC as a primary cause of deer population trends, instead attributing the decline to a loss in habitat quality

(CDFG, 1998; see https://www.deerfriendly.com/deer/california for extensive discussion). Our data reinforces the idea that this common and critically-important species is experiencing a high rate of decline. This is similar to the situation in other Western states. For example, in Colorado, mule deer populations in some areas (e.g., White River deer herd) have experienced ~10% rates of decline, which has been attributed to human development (National Wildlife Federation, 2014). Similarly, US rates of human-fatality crashes with animals has been declining by about 1%/year since 2007 (https://www.iihs.org/topics/fatality-statistics/detail/collisions-with-fixed-objects-and-animals), which could be due to declines in populations of these animals. Our and CDFW data suggest that in one to two decades, statewide mule deer may be reduced to the low hundreds of thousands, jeopardizing human enjoyment of this common keystone animal and important carnivore (wolf and mountain lion) food sources.

In contrast to the situation with mule deer, WVC rates with elk increased slightly between 2016 and 2022 (Figure 6). Over the previous 20 years, elk killed through hunting has been increasing, but in the last 7 years (according to CDFW data), hunting returns have declined by about 3% per year. It seems possible that the contrast between our increased rate of roadkill and declines in hunting success reflects a declining population that is moving around more, possibly to find food or water.

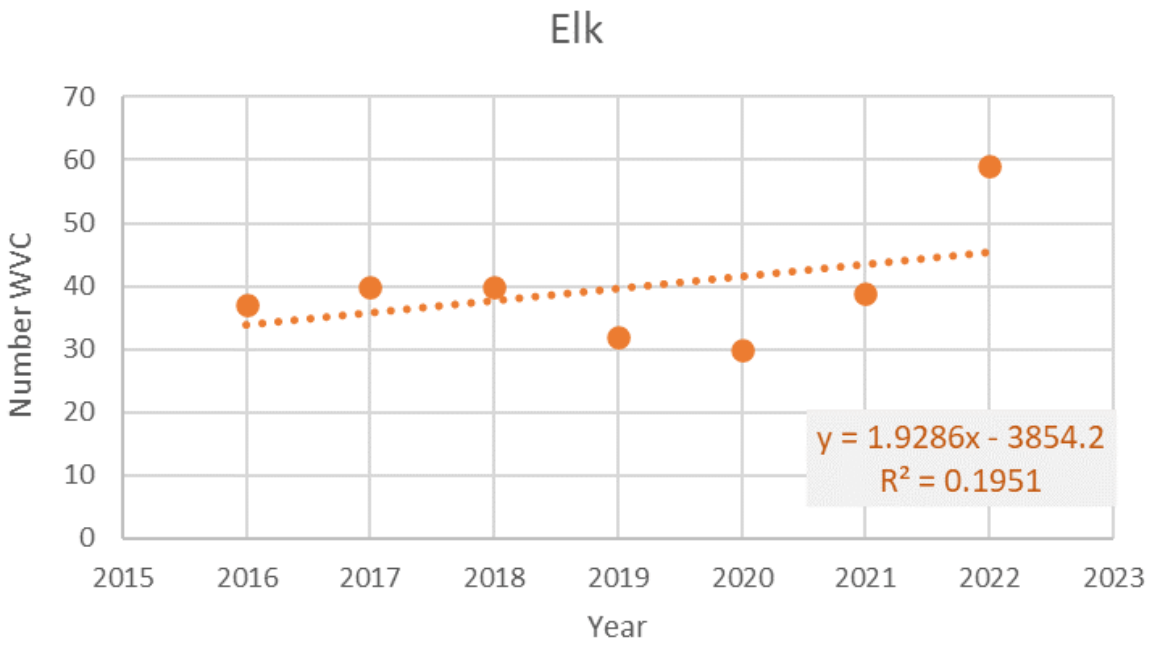
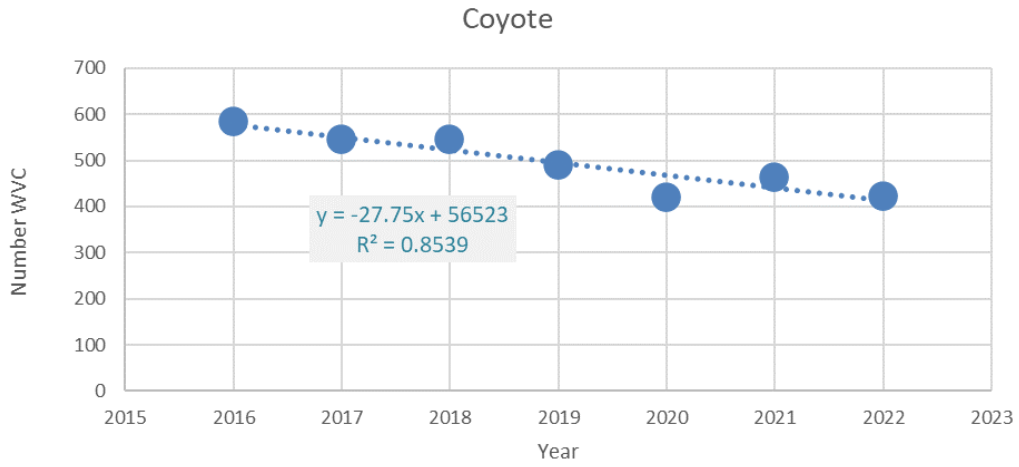


Figure 6. Elk WVC, from 2016 to 2022.

2) Coyote, Black Bear, and Mountain Lion roadkill in California have varying changes in rates (Figure 7).



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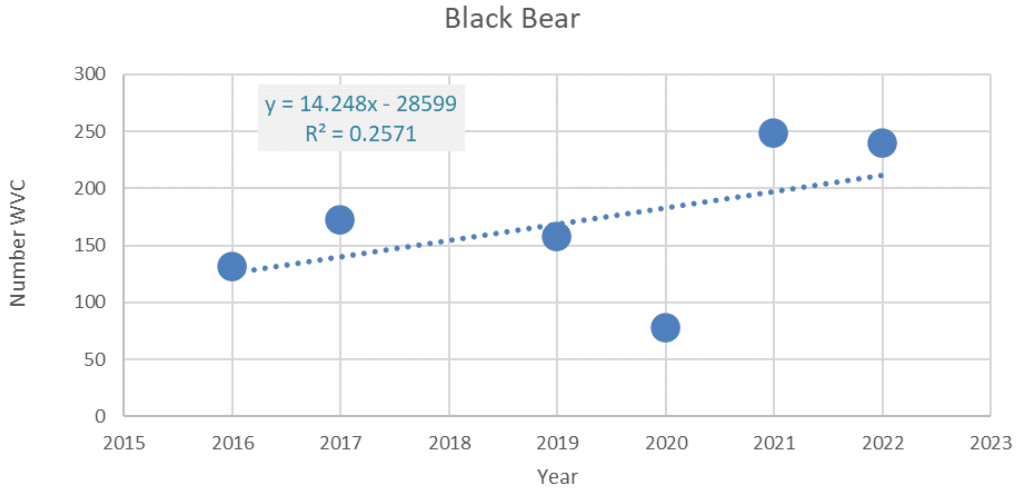

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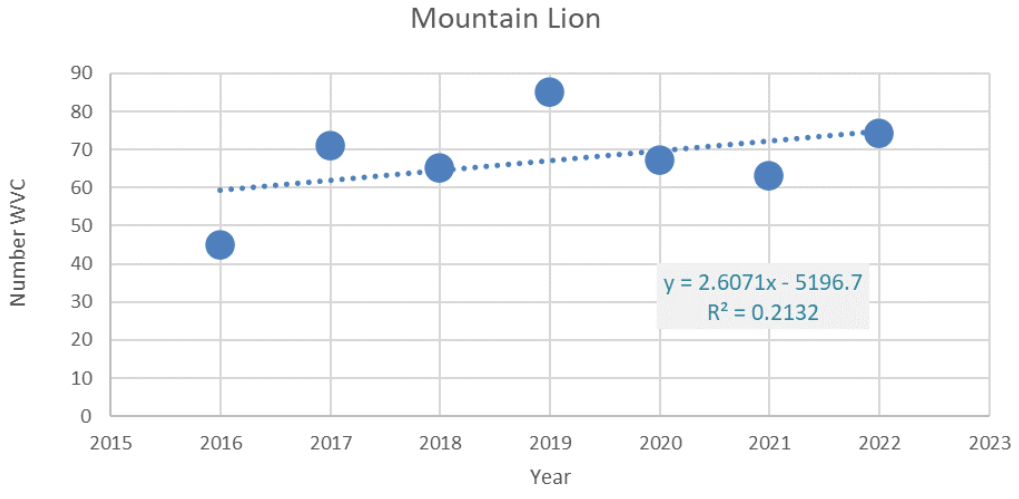

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Figure 7. Rates of WVC (2016-22) for A) coyote, B) black bear, and C) mountain lion in California

Similar to the case for mule deer and elk, most of our data for coyote, black bear, and mountain lion come from regular reporting by CHP, CDFW and others. From 2016 to 2022, coyote roadkill declined by about 5%/year (Figure 7A), similar to mule deer. This decline could indicate a declining population of coyote in California. In contrast, rates of black bear and mountain lion roadkill increased by about 10%/year (Figure 7B) and 5%/year (Figure 7C), respectively. This could indicate several things: a) an increase in the size of the population of these species, or b) an increase in movement of these species as they search for food, bringing them into greater conflict with traffic. Because CDFW does not accurately track population sizes for most wildlife, there is no corroborating scientific evidence that populations of black bear or mountain lion are increasing in California. There are indications from scientific research that human-wildlife conflict involving large predators, such as black bear and mountain lion, increases due to a combination of increased human activity in their habitats and decreased food availability for these species, leading them to range further to find food (van Bommel et al., 2020; Johnson et al., 2020).

What does this mean? Mule deer, elk, and coyote and other species are prey for mountain lion and to a lesser extent black bear. If prey species are in decline, it makes sense that predators would move around more to hunt and forage and therefore, get hit by vehicles at higher rates. In addition, there have been previous reports that wide-ranging species, such as mountain lion and black bear, may be getting hit more often on roads as they flee large wildfires. Because the state does not actively monitor the population size of the vast majority of species in CA, we will continue to provide this service of indicating relative trends in wildlife populations.

Locations of WVC Hotspots

Two ways to identify hotspots of WVC include: 1) density of WVC for all wildlife, or for classes of wildlife (e.g., large mammals) along roadways, and 2) statistically-significant clusters of WVC. Both methods have utility when trying to characterize threats and consequences of WVC, and plan mitigation of WVC. We use the number of large, wild mammals killed per mile per year as one indicator of WVC density. The reporting of this type of WVC is fairly consistent across the State, despite under-reporting. The consistency comes from CHP officers responding to crashes with wildlife and animal carcasses in roadways. This allows us to compare WVC rates across different parts of the state. Finally, if locations of high WVC density occur consistently, they may result in statistically-significant clusters on highways, suggesting these as defined areas to apply mitigation measures.

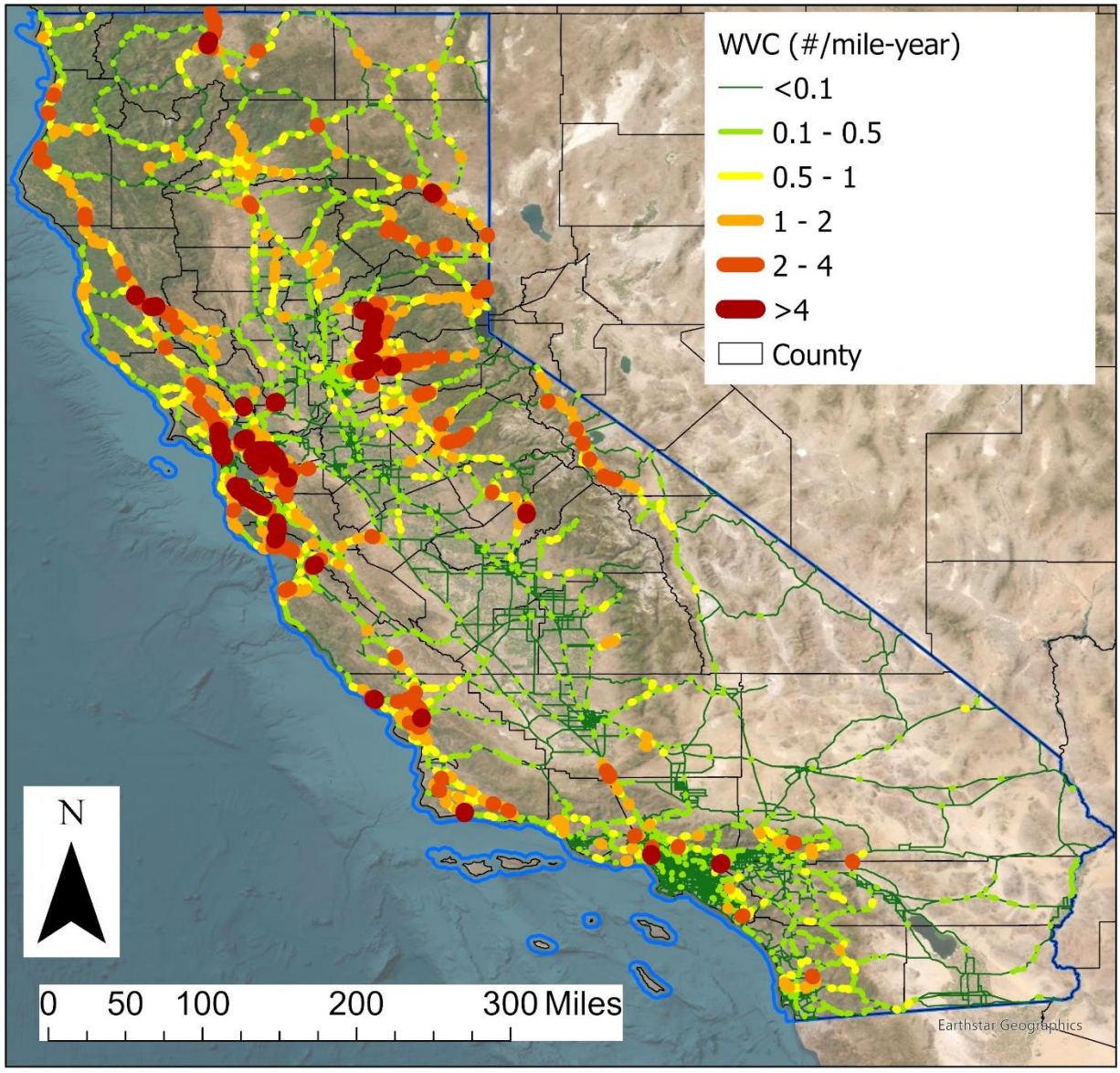


Figure 8. Annual density of large-mammal WVC per mile of state highway.

WVC can occur in clusters, which may indicate areas of particularly high rates of collision as well as being places where WVC can be prevented more efficiently. These clusters are partially indicated by higher densities (Figure 2), but are more accurately highlighted using statistical tests. We used the statistical test Getis-Ord and the index value Gi* to identify one-mile segments where WVC clusters were significantly higher than adjacent segments. We found 615 statistically-significant clusters throughout California, where clusters were usually in the same places as high densities of WVC. This suggests that mitigation actions here (fencing plus crossing structure) could cost-effectively reduce WVC. We also found 960 miles where costly crashes were occurring (>$13,000/mile-year), but they were not part of clusters, meaning they were similar to adjacent and nearby highway segments.

Cost of Statewide Highway WVC Incidents

As is the case for all states in the US, California drivers experience costs associated with crashes, including those involving wildlife. WVC are often framed (and discounted) as "environmental issues" by some, but there are real (and potentially deadly) consequences for the drivers, passengers and wildlife involved in WVC. One way to measure these impacts is from a human economic point of view, though we acknowledge that this approach should not be seen as more important than the ecological impacts caused by WVC. Figure 9 shows these costs per mile per year for California highways. There were 669 one-mile highway segments where fencing these segments over the last seven years would have saved >$200,000/mile (the cost of the fencing).

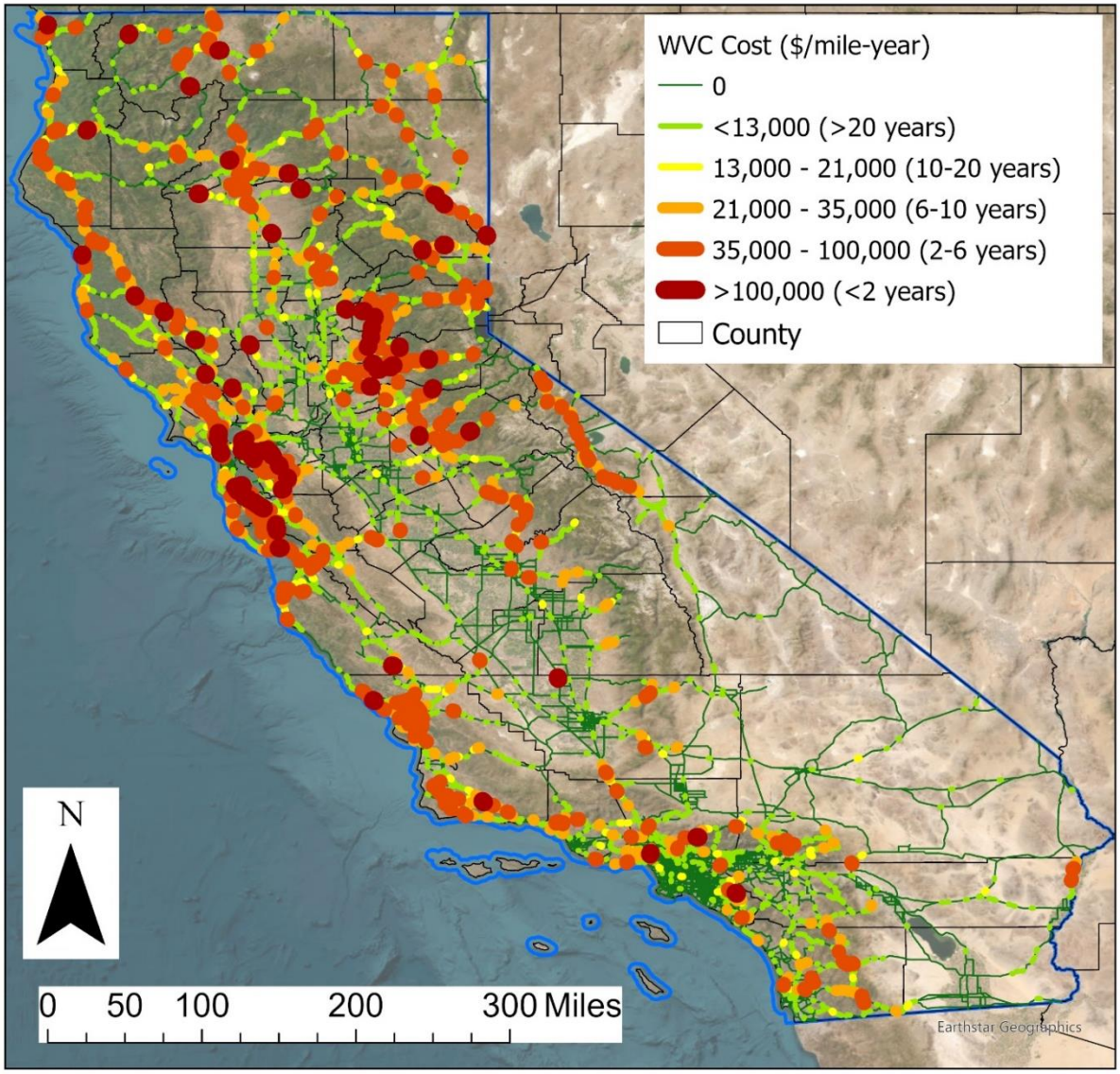


Figure 9. Annual cost of WVC per mile. The time in parentheses in the legend indicate how many years of reduced WVC on a highway segment would have the equivalent cost of fencing along that segment. For example, "<2 years" indicates that the cost of fencing that segment is the same or less than the fiscal benefit of reduced WVC for <2 years.

Special Case: Costliest and Deadliest Highways in California

One of the more common questions for studies like this is "where are the worst places in California for roadkill?" One way to answer that is using the cost of WVC to society. The highways with the consistently highest rate and cost of WVC in any given year in the last seven have included I-680 in Contra Costa and Alameda Counties and I-280 on the San Francisco Peninsula (Table 5). In the last seven years, the total economic and partial ecological costs from WVC on 27 and 22 miles of I-680 and I-280, respectively are $14.1 million (I-680) and $12.7 million (I-280), and 420 (I-680) and 412 (I-280) individuals of large wildlife species killed in collisions. In 2013, the Road Ecology Center partnered with Caltrans to study wildlife movement and roadkill associated with I-280 and reported that fencing most of I-280 to prevent wildlife access into the operating right of way and reduce WVC would be very cost-effective, in terms of reduced collisions with wildlife (https://roadecology.ucdavis.edu/resources/final-report-interstate-280-wildlife-connectivity-research-project). For example, since the report was finalized, the cost of WVC on I-280 has exceeded the cost of fencing to reduce WVC by at least 2-fold. In a significant step forward for I-680, in 2023, the WCB awarded the Alameda County Resource Conservation District (with Caltrans as a partner) $7 million to start planning for wildlife fencing and crossing planning along I-680 and I-580.

Table 2. Regional WVC hotspots and costs on state highways.

Bay Area

Highway (county, length)	Average Cost ($/year-mile)	Total Cost ($, 2016-2022)	Total Large Wild Mammals **Reported** Killed (2016-2022)
I-680 (Alameda/Contra Costa, 27 miles)	104,912	14,099,537	420
I-280 (San Mateo/Santa Clara, 22 miles)	75,574	12,736,243	412
Hwy 17 (Santa Clara/Santa Cruz, 16 miles)	64,612	7,265,258	392
Hwy 24 (Alameda/Contra Costa, 8 miles)	51,816	3,295,688	231
US 101 (Marin, 19 miles)	50,433	6,707,725	453

North State

Highway (county, length)	Average Cost ($/year-mile)	Total Cost ($, 2016-2022)	Total Large Wild Mammals **Reported** Killed (2016-2022)
Hwy 49 (Placer/Nevada, 23 miles)	52,601	8,468,759	369
I-80 (Placer, 27 miles)	39,005	7,371,967	370
US 50 (Sacramento/El Dorado, 36 miles)	37,823	9,531,306	408
US 20 (Lake/Mendocino, 18 miles)	35,516	4,475,076	248
US 101 (Mendocino S, 27 miles)	21,224	4,011,250	219
I-5 (Siskiyou, 28 miles)	20,001	3,834,066	239
Hwy 70 (Plumas)	18,441	6,196,268	380
US 101 (Humboldt, 74 miles)	16,067	8,322,622	349
US 395 (Lassen, 60 miles)	15,233	6,432,221	230

Central Sierra Nevada

Highway (county, length)	Average Cost ($/year-mile)	Total Cost ($, 2016-2022)	Total Large Wild Mammals **Reported** Killed (2016-2022)
Hwy 108 (Tuolumne, 19 miles)	25,850	3,438,027	159
Hwy 88 (Amador, 19 miles)	18,646	2,480,006	156
Hwy 4 (Calaveras, 23 miles)	15,093	2,429,960	109

Hwy 41 (Madera, 29 miles)	13,744	2,790,076	151
US 395 (Mono, 89 miles)	13,309	8,291,651	401

Central Coast and Southern California

Highway (county, length)	Average Cost ($/year-mile)	Total Cost ($, 2016-2022)	Total Large Wild Mammals **Reported** Killed (2016-2022)
I-405 (Los Angeles, 3 miles)	31,735	666,443	38
US 101 (Santa Barbara, 9 miles)	28,928	1,822,514	92
US 101 (San Luis Obispo, 35 miles)	27,636	6,770,811	328
Hwy 154 (Santa Barbara, 23 miles)	18,795	3,026,067	125
Hwy 1 (San Luis Obispo, 32 miles)	16,329	3,657,726	168
I-5 (Kern, 14 miles)	11,528	1,129,781	79
Hwy 18 (San Bernadino, 23 miles)	9,034	1,454,447	76

New State Support for Restoring Wildlife Movement

In the last legislative session (2022-23), approximately $1 billion in funding was allocated over several years to the Wildlife Conservation Board (WCB), CDFW, and Caltrans to plan and build new wildlife crossings. This is a remarkable turn-around by the state and has allowed California to jump to the top tier of states working to reduce the impact of traffic and roadways on wildlife and improve connectivity.

Through an influx of funding, first from Prop 68 and most recently the State General Fund, the WCB has supported and awarded funds to various stakeholder groups and projects statewide. Funded projects have primarily been located within CDFW wildlife movement priority barriers (CDFW 2020, 2022). These projects include the following: WCB-supported projects include I-680/I-580 (Alameda County), I-8 (Imperial County), US-395 (Lassen County), SR-152 (Santa Clara County), and SR-20 (Colusa County). Caltrans is also continuing wildlife crossing work beyond normal mitigation requirements. In the Northern Region, this include: 1) two upcoming projects on I80 (Monte Vista and Blue Canyon) that will have multiple crossings each); 2) two new crossings finishing construction this season on Nevada 20 (Omega Curves); 3) one crossing constructed last season in Lake County SR 29; 4) a crossing on US-50 at Camino that just finished construction; and 4) planned crossings on SR97 and other locations in the next 3-5 years.

AB 2344 (2022) was an important first step in increasing the requirement for and rate of projects to reduce the impact of traffic on wildlife and its co-authors and supporters should be applauded. As happens during the passage of many bills, during the last days of passing AB

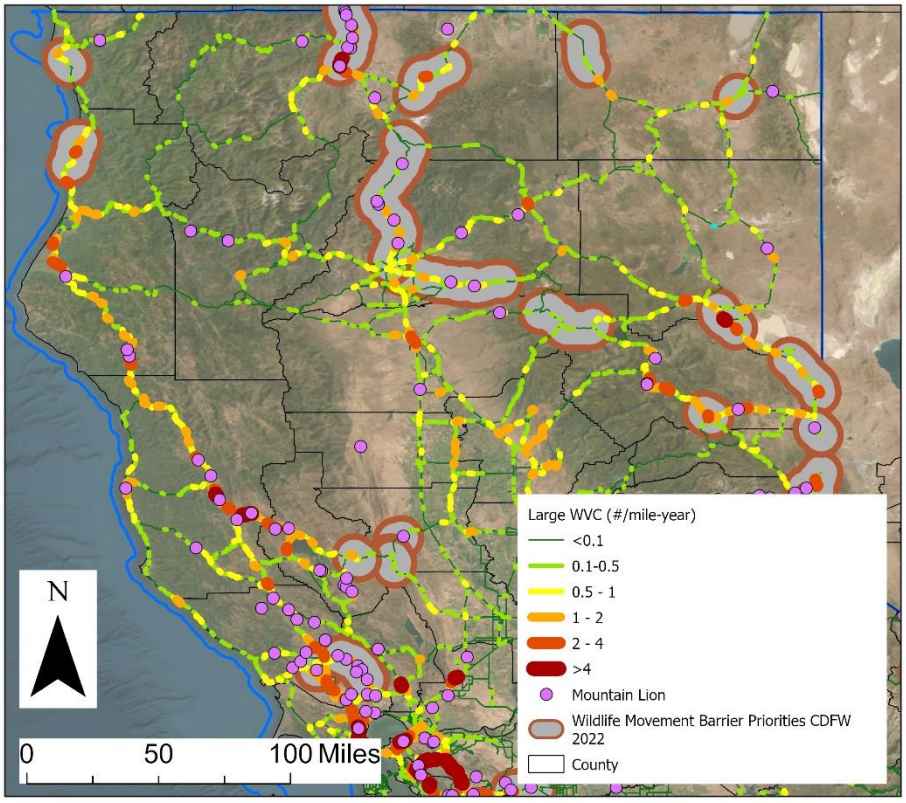
2344, the bill was weakened, reducing the requirement for a certain amount of activity by Caltrans and local transportation agencies to mitigate the legacy and continuing impacts of traffic on wildlife. Legislation is still needed that: 1) protects wildlife movement by requiring retrofit of ALL existing and proposed new or expanded infrastructure to allow wildlife passage; 2) pays for improvements to transportation infrastructure using transportation funds and not the very-limited wildlife, parks, and open space bond funds; and 3) requires these actions fast enough to prevent local extinctions and restore wildlife populations where they have been impacted by past infrastructure.

In terms of wildlife mortality on state highways and major roads, the Road Ecology Center has some knowledge about where the greatest impacts to wildlife are occurring. We also can make educated guesses about the impact this mortality is having on iconic, special-status and common species in California. Going forward, we need greater investment in data collection (the California Roadkill Observation System, Caltrans Maintenance, County Animal Services data collection), data analysis, estimation of the impact of roadkill on wildlife populations, use of this information in decision-making, and maintenance of regular funding to support construction of wildlife fencing and crossings.

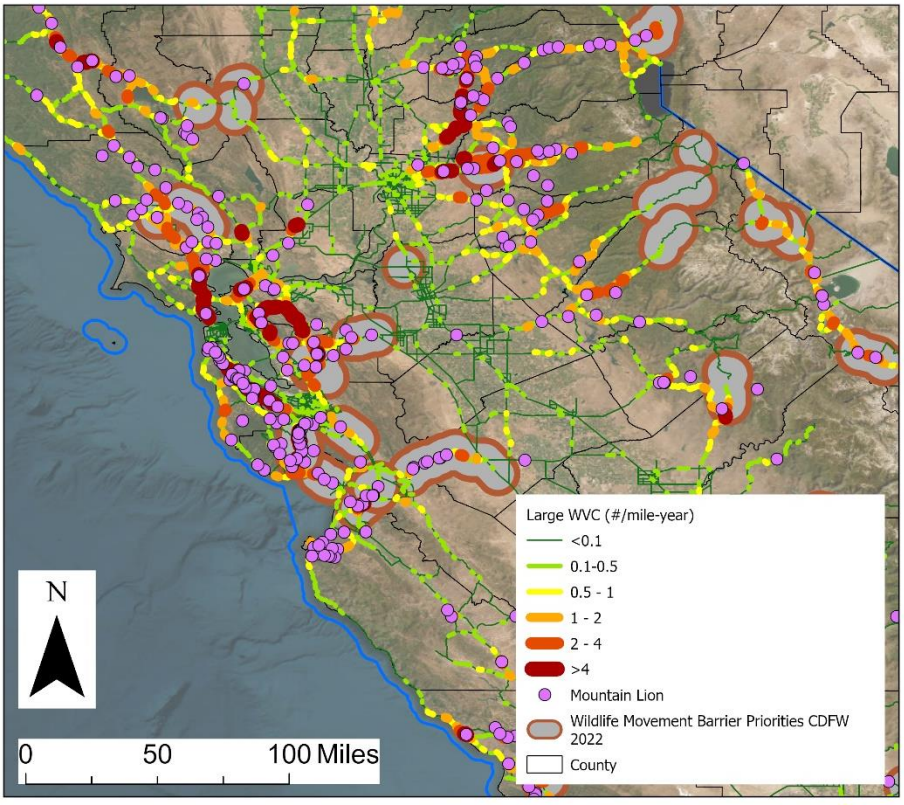
Special Case: Overlap Between WVC Hotspots and CDFW Priority Barriers

The California Department of Fish and Wildlife recently published 2 maps of "Wildlife Movement Priority Barriers" (CDFW 2020 and 2022). It is not obvious what the quantitative criteria were for selection of these putative barriers, but the narrative description included with the maps describes the basis for practitioner selection of locations as involving 10 factors, including primarily barrier and habitat effects (9 of 10 factors) and secondarily mortality effects (1 of 10 factors) on wildlife movement. Mortality effects may be at least as important for wildlife populations as barriers to movement (dead wildlife don't need to move), suggesting the approach for selecting Priority Barriers could be improved.

Mountain lions were often featured as one of the wildlife species of concern in locating these barriers. We compared the position of Priority Barriers (2022) with large wildlife WVC hotspots (Figure). There were Priority Barriers that overlapped with WVC hotspots and mountain lion mortality, but about 2/3 of Priority Barriers did not overlap or contain WVC hotspots. This can partly be because for mountain lions and some other species, high traffic levels prevent animals from even attempting to cross the highway, thus a barrier is created, but WVC's are relatively infrequent. In addition, some of the "hottest" WVC and mountain lion hotspots (Bay Area, Central Coast, and Sierra Nevada foothills) did not overlap with Priority Barriers. This emphasizes the need for expanded systematic and mandated reporting of WVC's by agencies such as Caltrans and others that deal with animals killed by traffic. Absent WVC data that is collected more uniformly, CDFW has inadequate information for creating the most accurate and well-supported barrier maps.


Large WVC (#/mile-year)
<0.1
0.1-0.5
0.5 - 1
1 - 2
2 - 4
>4
Mountain Lion
Wildlife Movement Barrier Priorities CDFW 2022
County
N
0
50
100 Miles

A


Large WVC (#/mile-year)
<0.1
0.1-0.5
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Mountain Lion
Wildlife Movement Barrier Priorities CDFW 2022
County
N
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100 Miles

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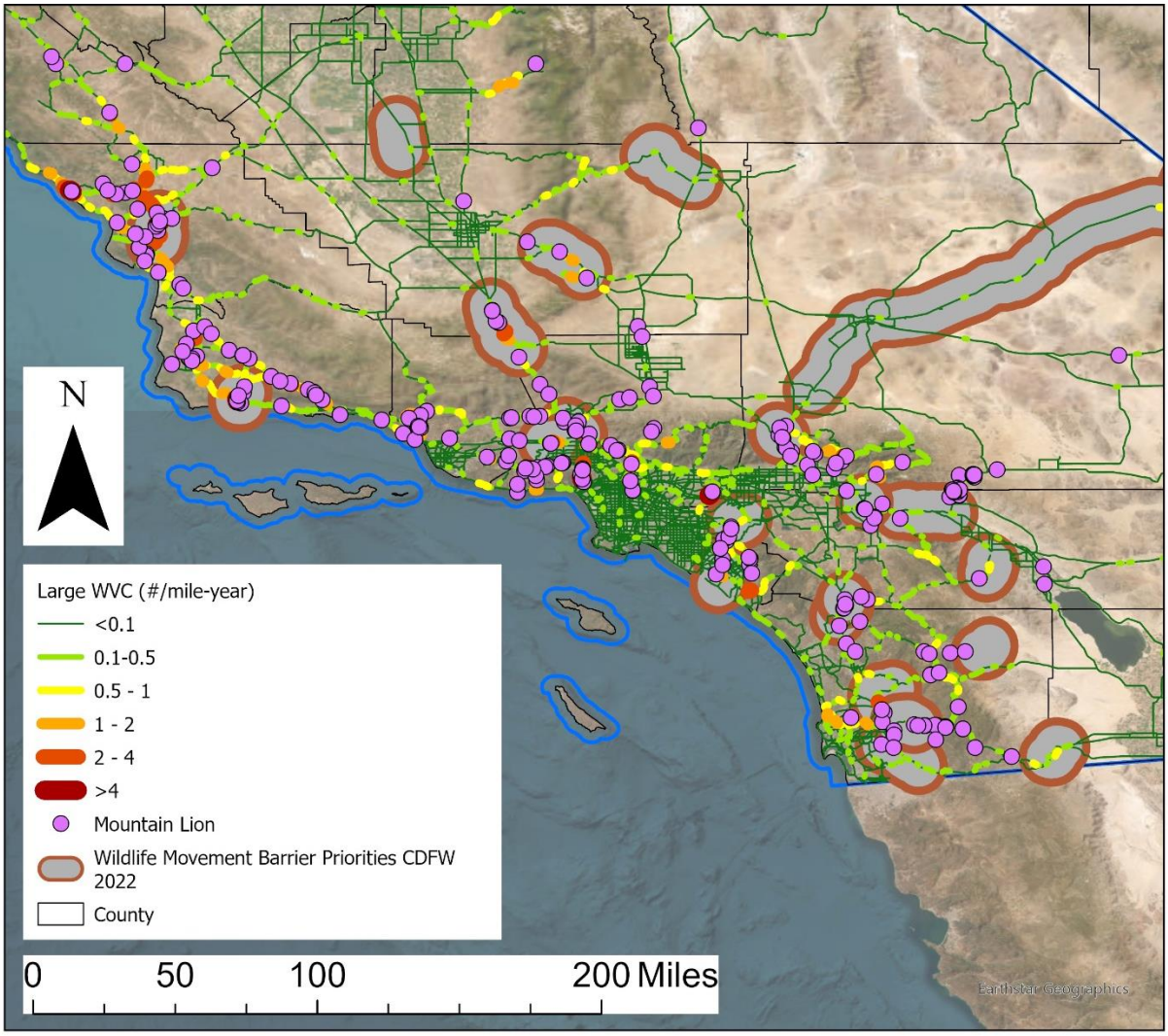

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Figure 10. Overlap between density of large wildlife WVC and mountain lion mortalities with CDFW Wildlife Movement Priority Barriers (CDFW 2022) in A) Northern California, B) Central California, and C) Southern California.

One of the most remarkable mismatches between WVC and CDFW's Priority Barriers occurred between 2020 and 2022. In CDFW's 2020 Priority Barriers report, CDFW did not highlight I-15 through the Mojave Desert as an important barrier. In the 2022 version, a new 148-mile long Priority Barrier appeared on I-15. Annotations in the dataset indicate that this barrier is associated with the proposed Brightline alignment. As the expert wildlife agencies have stated, the adverse effect of the project would be caused entirely by the rail Project, not the I-15 highway (https://protectnps.org/2022/09/09/coalition-comments-on-fra-brightline-west-nepa-re-evaluation-of-las-vegas-to-apple-valley-segment/). The inclusion of this barrier to the report is significant because the priority barriers are used to prioritize allocation of public funds to support wildlife crossing efforts. Indeed, after the I-15 barrier was included in the 2022 Priority

Barriers report, in early 2023 CDFW and Caltrans entered into an agreement with Brightline West (Caltrans, 2023), authorizing the use of public funds to build wildlife crossings and conduct mitigation for a private project. This seems to indicate that the state is prioritizing an alignment because of a private development project. The Priority Barriers are currently used to prioritize public funds allocation from WCB and CDFW, activity, including funding wildlife crossings. The inclusion of a new priority barrier—over double the length of any other barrier in the report—that coincides with the State's recent large commitment of funds to construct wildlife overpasses suggests this barrier was included to justify the use of public funds to allow the private Brightline West project to proceed. It could also be a harmless coincidence. The ecological point could also be made that it doesn't matter to the wildlife who paid for the crossings. This is relevant when funds are not limited, in contrast to the limited wildlife-associated appropriations.

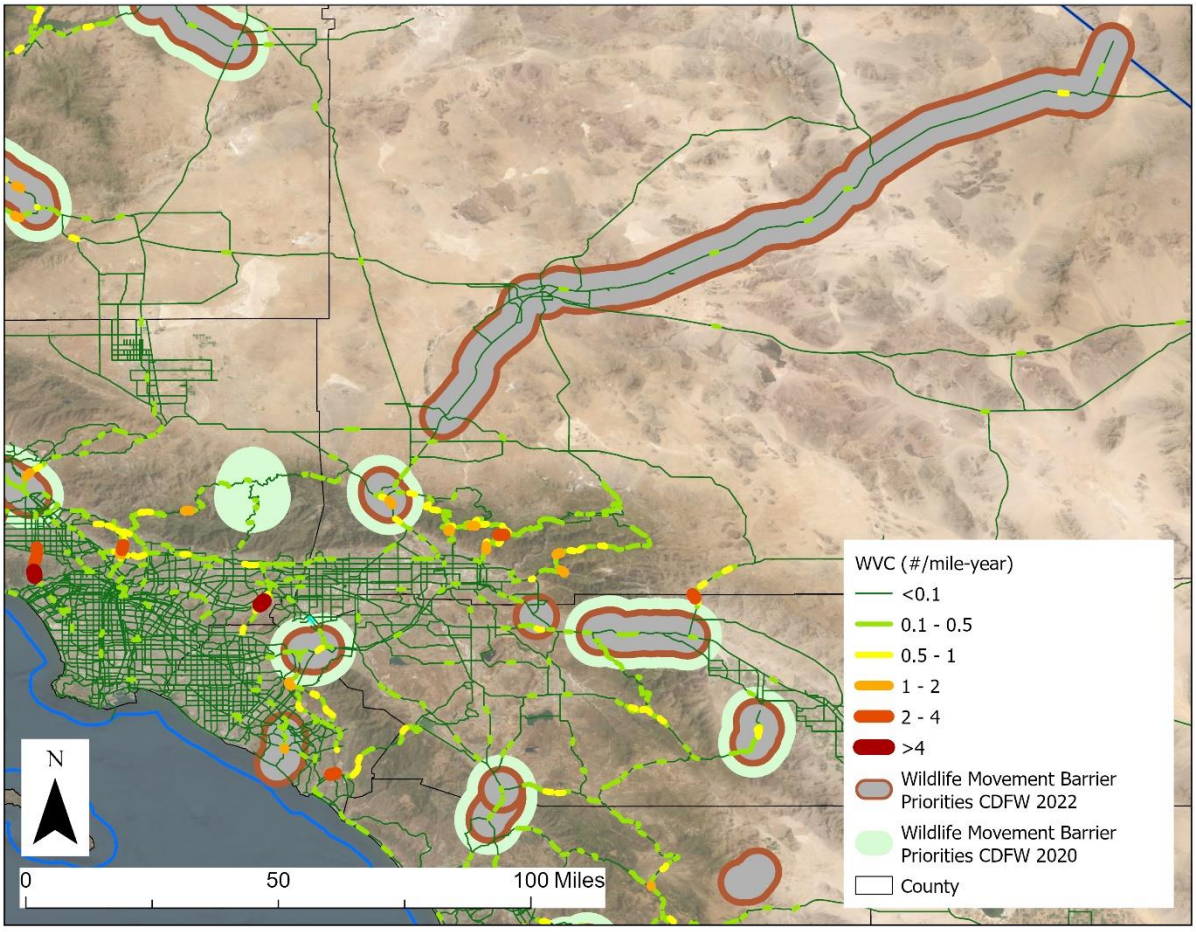

Figure 11. New Priority Barrier in 2022 along I-15 paralleling the Brightline rail alignment.

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 trends

in roadkill rates and thus health of iconic wildlife species (e.g., mule deer), successful methods for monitoring WVC in California, the areas of most frequent WVC statewide; and costs of WVC to wildlife and drivers and the general public.

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 analytical methods and one-click roadkill reporting tool: California Roadkill Observation System (CROS, https://wildlifecrossing.net/california). We also thank the Pew Charitable Trust for their support for the economic analysis component of the study (https://wildlifecrossingcalculator.org). This and previous reports and the analyses contained within would not have been possible without the concerted and coordinated efforts of thousands of volunteer roadkill observers over the last 14 years who contribute to CROS and parallel systems, as well as similar efforts by CHP, CDFW, Caltrans and other agency staff to report on WVC. Through their endeavors, they have so far (8/2023) collected >200,000 observations of >400 species, representing one of the largest and most comprehensive wildlife monitoring programs in California and the US. The accuracy rate of volunteer-observers 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). Finally, we thank several expert peer reviewers for their insightful comments and critiques.

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

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

Literature Cited

Caltrans (2023) Legislative proposal and press release (https://esd.dof.ca.gov/trailer-bill/public/trailerBill/pdf/964; https://dot.ca.gov/news-releases/news-release-2023-005)

Canova, L., Balestrieri, A. (2019) Long-term monitoring by roadkill counts of mammal populations living in intensively cultivated landscapes. Biodivers Conserv 28, 97–113. https://doi.org/10.1007/s10531-018-1638-3

CDFW (2020) Wildlife Movement Barrier Priorities - CDFW – 2020. https://data-cdfw.opendata.arcgis.com/maps/wildlife-movement-barrier-priorities-cdfw-2020-ds3023

CDFW (2022) Wildlife Movement Barrier Priorities - CDFW – 2022. https://data.cnra.ca.gov/dataset/wildlife-movement-barrier-priorities-cdfw-2022-ds3025

CDFW (2023) (https://wildlife.ca.gov/Conservation/Mammals/Deer/Population)

Donaldson, B.M., 2017. Improving animal-vehicle collision data for the strategic application of mitigation (No. FHWA/VTRC 18-R16). Virginia Transportation Research Council.

Fahrig, L., and T. Rytwinski. 2009. Effects of roads on animal abundance: an empirical review and synthesis. Ecology and Society 14(1): 21. [online] URL: http://www.ecologyandsociety.org/vol14/iss1/art21/

Ha, H. and F. Shilling (2018) Modelling potential wildlife-vehicle collisions (WVC) locations using environmental factors and human population density: A case-study from 3 state highways in Central California. Ecological Informatics 43 (2018) 212–221. https://doi.org/10.1016/j.ecoinf.2017.10.005.

Johnson, H.E., Lewis, D.L. and Breck, S.W., 2020. Individual and population fitness consequences associated with large carnivore use of residential development. *Ecosphere*, *11*(5), p.e03098.

Rytwinski, T. and Fahrig, L., 2011. Reproductive rate and body size predict road impacts on mammal abundance. Ecological Applications, 21(2), pp.589-600.

Shilling, F.M. and Waetjen, D.P. (2015) Wildlife-vehicle collision hotspots at US highway extents: scale and data source effects. Nature Conservation, 11: 41-60. doi: 10.3897/natureconservation.11.4438

Shilling et al. California Wildlife Vehicle Collision Hotspots 2017, 2018, 2019, 2021. (https://roadecology.ucdavis.edu/research/projects/ca-wvc-hotspots)

van Bommel, J.K., Badry, M., Ford, A.T., Golumbia, T. and Burton, A.C., 2020. Predicting human-carnivore conflict at the urban-wildland interface. *Global Ecology and Conservation*, *24*, p.e01322.

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