Large Mammal-Vehicle Collision Hot Spot Analyses, California, USA

by

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16. Abstract
This report documents the methods and results of hot spot analyses of large wild mammal-vehicle collisions in the state of California, with an emphasis on mule deer. This project relates to all state managed highways in California with a total length of about 15,090 miles (24,285 km). The results of the analyses will help Caltrans make informed decisions on the potential future implementation of mitigation measures aimed at reducing collisions with large wild mammals along highways, specifically mule deer. The goals are to improve human safety, reduce unnatural deaths of large wild mammals (specifically mule deer), while also maintaining or improving habitat connectivity for wildlife in general, regardless of their size or taxonomic group. A statewide hot spot analysis for significant concentrations of deer-vehicle crashes showed regions in the state of California where significantly more deer-vehicle crashes occur than expected, compared to a theoretical random spatial distribution of deer-vehicle crashes. In addition, three descriptive types of Kernel density hot spot analyses were conducted; a state-wide deer-vehicle crash hot spot analysis, per Caltrans district deer-vehicle crash analyses, and per Caltrans district mule deer carcass analyses. These analyses identified the road sections that had the "highest" concentration of deer-vehicle crashes and mule deer carcasses. The hot spots were prioritized based on parameters related to human safety, biological conservation, and economics. Finally, the researchers provided practical guidelines for the implementation of mitigation measures and suggest mitigation strategies for the highest-ranking hot spots in each Caltrans district.

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EXECUTIVE SUMMARY

This report documents the methods and results of hot spot analyses of large wild mammal-vehicle collisions in the state of California, with an emphasis on mule deer. This project relates to all state managed highways in California with a total length of about 15,090 miles (24,285 km) (ignoring multiple lanes). The results of the analyses will help Caltrans make informed decisions on the potential future implementation of mitigation measures aimed at reducing collisions with large wild mammals along highways, specifically mule deer. The goals are to improve human safety, reduce unnatural deaths of large wild mammals (specifically mule deer), while also maintaining or improving habitat connectivity for wildlife in general, regardless of their size or taxonomic group. Note that in the context of this report "mitigation" refers to measures aimed at reducing impacts of roads and traffic on wildlife. In this report "mitigation" never refers to any regulatory or legal framework. However, the "mitigation measures" suggested in this report may assist Caltrans and natural resource agencies with their permitting negotiations.

Two data sources were used to identify large wild mammal-vehicle collision hot spots: crash data collected by law enforcement personnel and carcass removal data collected by road maintenance crews. Note that in this report, the term "collisions" refers to both crash data and carcass data. Deer-vehicle crashes represented 65.6% of the animal-vehicle crashes, followed by livestock (11.0%) and unidentified other species (23.4%). Most of the reported carcasses of large wild animal species (larger than a coyote) also related to mule deer (97.8%). Therefore, all further analyses were carried out with either deer-vehicle crashes or mule deer carcasses. Deer-vehicle collisions were more numerous from May through November compared to December through April, with the highest numbers occurring in October and November. Deer crashes occur mostly at night, especially around dusk (5-10 pm) and dawn (5-7 am). Overall, the number of reported deer-vehicle crashes increased significantly during the study period (2005 through 2014). These seasonal, day-night, and trend patterns are similar to other studies.

There was no evidence of inconsistent reporting effort between years or between Caltrans districts for the deer-vehicle crash data. However, there was evidence of substantial underreporting of mule deer carcasses compared to deer-vehicle crash data in all Caltrans districts except District 10. In addition, there was evidence of inconsistent reporting effort between years, between Caltrans districts, and within certain Caltrans districts for the deer-vehicle crash data. Therefore, the researchers only conducted statewide analyses for deer-vehicle crashes, and not for mule deer carcasses. Additional hot spot analyses were carried out for all Caltrans districts for both deer-vehicle crashes and mule deer carcasses.

A statewide hot spot analysis for significant concentrations of deer-vehicle crashes showed regions in the state of California where significantly more deer-vehicle crashes occur than expected compared to a theoretical random spatial distribution of deer-vehicle crashes. Regions with a significantly high concentration of deer-vehicle crashes (hot spots) include the areas around:

- Yreka/Mt Shasta.
- The coastal areas between Eureka and Fort Bragg.
- The foothills and Sierra Nevada north and south-east of Sacramento.

- The eastern slopes of the Sierra Nevada and desert around Susanville.
- The western slopes of the Sierra Nevada near Merced.
- The eastern slopes of the Sierra Nevada near Mono Lake and Mammoth Lakes.
- The coastal areas between San Francisco until just south of Carmel-by-the-Sea.
- The coastal areas near San Simeon until Santa Barbara.

Regions with a significantly low concentration of deer-vehicle crashes (cold spots) include the areas around:

- The southern portion of the Central Valley around Modesto until south of Bakersfield.
- The deserts north and east of Los Angeles and San Diego.

In addition, three descriptive types of Kernel density hot spot analyses were conducted. These analyses identify the road sections that have the "highest" concentration of deer-vehicle crashes and mule deer carcasses given the distribution of the other crashes or carcasses. The first descriptive analysis related to all deer-vehicle crash data from all highways in the state of California. This resulted in the identification of 13 hot spots spread over northern California, the Sierra Nevada, and the coastal ranges. The second type of descriptive analysis consisted of deer-vehicle crash hot spot analyses within each Caltrans district. Similarly, the third type of descriptive analysis consisted of mule deer carcass hot spot analyses within each Caltrans District.

In some districts (Caltrans Districts 2, 4, 6, 9, 10, and 12) there was at least some spatial similarity between the hot spots based on deer-vehicle crash data and mule deer carcass data. Since these two data sources are independent, this makes it more likely that there is indeed a relatively high concentration of deer-vehicle collisions along these road sections. However, there is also evidence of missing mule deer carcass data from certain areas in Districts 1 and 2.

The project data suggest that mule deer-vehicle carcasses are not only underreported compared to deer-vehicle crash data, but that there are also spatial inconsistencies in the search and reporting effort for mule deer carcasses. Practical suggestions include verification that all maintenance crews do record and submit mule deer carcasses, especially along road sections already identified as hot spots based on deer-vehicle crash data, and that these records are entered in the central database. Regular data entry and standard data summary reports can help identify areas from which mule deer carcasses are substantially below the expected number of observations.

The hot spots that were identified based on the descriptive Kernel density hot spot analyses were prioritized based on parameters related to human safety, biological conservation, and economics. The three types of parameters were weighted equally in the prioritization process. However, it is important to remember that the human safety parameters were the departure point for these analyses. This means that all the hot spots, by definition, had a relatively high number and concentration of deer-vehicle crashes or mule deer carcasses already.

The economic parameter expressed the number of deer-vehicle crashes or mule deer carcasses in costs per mile per year related to the deer collisions. Only some of the hot spots met or exceeded the economic thresholds for the implementation of wildlife fences in combination with wildlife crossing structures or animal detection systems. However, the values of the economic parameter for the different hot spots should not be compared to the thresholds as if it was a litmus test for implementing or not implementing a mitigation project. The thresholds are primarily based on human safety parameters and exclude passive values associated with biological conservation; they are very conservative by nature. In addition, there is evidence of severe underreporting of mule deer carcasses. While the researchers strongly advise to use the cost-benefit analyses as an important decision support tool, they also urge users to recognize that these analyses are only one of the factors that should be considered in the decision-making process.

The researchers selected the highest-ranking deer-vehicle crash or mule deer hot spots within each Caltrans district and formulated mitigation recommendations. The researchers aimed to identify the five worst hot spots in each district. However, in some districts there were fewer hot spots present (less than five), and in some other districts there were more than five hot spots that met the requirements to be indicated as a hot spot.

While there are dozens of different types and combinations of mitigation measures, there are only two types of mitigation packages that can substantially reduce collisions with large wild mammals:

1. Wildlife fences in combination with wildlife crossing structures (underpasses or overpasses);
2. Animal detection systems, either as a stand-alone measure or at a gap in the fence.

Fences in combination with wildlife crossing structures address both objectives; collision reduction and providing safe crossing opportunities for wildlife. However, animal detection systems do not make it any easier for animals to cross a road. To get to the other side of the highway, animals still must cross an open area with unnatural substrate and avoid the vehicles that drive on the road. Therefore, animal detection systems should only be considered if reducing collisions with large mammals is the only objective. Animal detection systems should not be considered if increasing habitat connectivity is also an objective. The researchers provide practical guidelines for the implementation of mitigation measures and suggest mitigation strategies for the highest-ranking hot spots in each Caltrans district.

Practical guidelines for the implementation of mitigation measures, especially wildlife fences in combination with large mammal crossing structures:

1. Focus on hot spots with a relatively high number of collisions first. If there are less than 10 reported deer-vehicle crashes or less than 10 reported mule deer carcasses in a hot spot, implementation of mitigation measures is relatively risky compared to sites that have greater collision numbers. The identification of hot spots with low numbers is less robust than the identification of hot spots with higher numbers. The authors of this report suggest minimizing the risk of investing in mitigation measures by focusing on hot spots that are likely to be a substantial and consistent hot spot rather than a less important hot spot or a hot spot that may have been wrongly identified because of variations in the number of collisions.

2. Interview law enforcement personnel and road maintenance personnel in the first phase of exploring the potential implementation of mitigation measures. Get confirmation that it is indeed a “bad spot” for deer-vehicle collisions, and get confirmation about the exact road section (start and end points).

3. Some hot spots appear particularly difficult or costly to mitigate. The presence of 8-12 lanes of traffic, frontage roads, intersections, private lands, residential and commercial development, etc. all make it more challenging to effectively mitigate a hot spot. These types of challenges are “ignored” in the ranking of the hot spots. However, the challenges of each hot spot should be carefully weighed when proceeding with the planning, design, and implementation of mitigation measures.

4. Carefully evaluate what species other than mule deer may require mitigation for direct road mortality or the barrier effect along the road section that is considered for mitigation. Consult spatial and biological databases, interview representatives from natural resource management agencies, interview people with local knowledge and experience. Modify or add to the list of target species as it may well influence the design of the mitigation measures.

5. In general, the first choice or recommendation for mitigating a hot spot is a wildlife fence in combination with designated wildlife crossing structures. Implement large mammal fences (2.4 m high (8 ft)) along the full length of a hot spot and buffer zones that span an additional 1,600 m (1.0 mile) from each end of the hot spot. As a general principle, provide a crossing structure that is suitable for mule deer (at least 7-8 m (23-26 ft) wide, 4-5 m (13-16 ft) high) once every 2,400 m (1.49 mile) in the fenced road section. With reduced ambition levels (i.e. address only collisions with large mammals, do not provide safe crossing opportunities for wildlife) animal detection systems are suggested as a second choice for road sections with less than 5,000 vehicles per day.

6. If there were existing structures in a hot spot, identified through satellite images, these were noted in the tables. However, structures primarily designed for motorized vehicles were not listed. Nonetheless, very long bridges with only small or unpaved roads were included as an existing structure that may be adapted to also allow for wildlife use. In addition to connecting these structures to wildlife fences, the structures may need some modifications to make them suitable for wildlife use. These modifications will likely vary between the structures, and some structures may not need any modifications.

7. In general, structures for mule deer should be considered about every 2,400 m (1.49 mile). This means that long hot spots may need multiple crossing structures. These structures can be any combination of existing structures originally built for other purposes and designated wildlife crossing structures. Fences may extend into adjacent buffer zones, and there may be additional existing structures in those areas. Tying these existing structures into the wildlife fence and allowing potential wildlife use through these structures makes sense, as long as it is compatible with the primary use of a structure and the land use in the areas surrounding the structure.

1. INTRODUCTION

1.1. Background

Wildlife-vehicle collisions affect human safety, property (damage), and wildlife. The total number of large mammal–vehicle collisions has been estimated at one to two million in the United States annually (Conover et al., 1995; Huijser et al., 2009). These collisions have been estimated to cause 211 human fatalities, 29,000 human injuries, and over one billion US dollars in property damage annually (Conover et al., 1995). More recent estimates that include costs associated with human injuries and human fatalities estimate the yearly costs associated with wildlife-vehicle collisions between 6 and 12 billion US dollars (Huijser et al., 2009). In most cases, the animals die immediately or shortly after the collision (Allen & McCullough, 1976). In some cases, it is not just the individual animals that suffer. Road mortality may also affect some species on the population level (e.g., van der Zee et al., 1992; Huijser & Bergers, 2000), and some species may even be faced with a serious reduction in population survival probability as a result of road mortality, habitat fragmentation, and other negative effects associated with roads and traffic (Proctor, 2003; Huijser et al., 2008). In addition, some species also represent a monetary value that is lost once an individual animal dies (Romin & Bissonette, 1996; Conover, 1997).

The highways in the state of California are important for local, state and interstate travel. However, the frequency of large wild mammal-vehicle collisions, specifically with mule deer (or black-tailed deer) (*Odocoileus hemionus*), was considered high enough for Caltrans to explore procedures and tools to identify and prioritize large wild mammal-vehicle collision hot spots, with an emphasis on mule deer. The authors of this report identified large wild mammal-vehicle collision hot spots, and then prioritized these hot spots based on human safety, biological conservation, and cost-benefit analyses. The authors of this report then formulated mitigation measures aimed at reducing large wild mammal-vehicle collisions and at providing safe crossing opportunities for a wide range of wildlife species, regardless of their size or taxonomic group. Note that in the context of this report “mitigation” refers to measures aimed at reducing impacts from roads and traffic on wildlife. In this report “mitigation” never refers to any regulatory or legal framework. However, the “mitigation measures” suggested in this report may assist Caltrans and natural resource agencies with their permitting negotiations.

1.2. Goals and Objectives

This project aims to conduct a statewide hot spot analysis of large wild mammal-vehicle collisions in the state of California, with an emphasis on mule deer. This project relates to all state managed highways in California. The total length of these highways is estimated at about 15,090 miles (24,285 km) (total length of the highways, ignoring multiple lanes). The results of the analyses will help Caltrans make informed decisions on the potential future implementation of mitigation measures aimed at reducing collisions with large wild mammals along highways, specifically mule deer. The goals are to improve human safety, reduce unnatural deaths of large wild mammals (specifically mule deer), while also maintaining or improving habitat connectivity for wildlife in general, regardless of their size or taxonomic group. This project is based on the methods developed from a pilot study conducted in Caltrans District 10 titled "Procedures and Tools for Wildlife-Vehicle Collision Hotspot Analyses; Using Caltrans District 10 as an Example" (Huijser et al., 2014).

The objectives for the current project are to:

1. Provide a sound methodology to identify highway sections in the state of California that have the highest concentration of collisions with large wild mammals, namely mule deer, in specific ("hot spots").

   Conduct two types of analyses:
   a. Statewide analysis that identifies and prioritizes the "worst" hot spots in the state.
   b. Analyses per Caltrans district that identify and prioritize the "worst" hot spots within each of the 12 Caltrans districts (Figure 1).

2. Prioritize the hot spots based on:
   a. Human safety data based on large wild mammal-vehicle and mule deer crash data, and carcass removal data.
   b. Biological conservation data derived from the California Essential Habitat Connectivity analyses (Spencer et al., 2010) and critical habitat data (USFWS, 2019).
   c. Cost-benefit data on the cost of wildlife-vehicle collisions and the implementation of mitigation measures aimed at reducing large wild mammal-vehicle collisions and providing connectivity for a wide range of species, regardless of their size or taxonomic group. The measures include wildlife fences combined with wildlife crossing structures (overpasses and underpasses) and animal detection systems. These mitigation measures do (wildlife fences combined with crossing structures) or can (animal detection systems) reduce collisions with large mammals substantially (i.e. >80%). However, animal detection systems should be considered experimental and do not address the barrier effect of highways. These systems should still be considered experimental because many systems have challenges with reliably detecting the target species, and many projects fail because of technological, management, maintenance, or financial problems. Furthermore, animal detection systems do not address the barrier effect of highways as the animals are still required to cross an open area with unnatural substrate (pavement) and confront the disturbance and danger posed by traffic.

   The outcome of the prioritization process can be used to assist Caltrans with funding decisions and prioritizing transportation investments in the State Highway Operations and Protection Plan within each district.

The procedures, tools, and outcomes of this project should be aligned with the Caltrans 2015-2020 Strategic Plan and goals related to Safety and Sustainability.

Figure 1: The location of the 12 Caltrans districts.

2. DEFINE PROBLEM AND DECIDE ON APPROACH

2.1. Define the Problem

Implementation of measures aimed at reducing wildlife-vehicle collisions requires knowledge about the locations of these collisions. Along most roads in North America there are two types of wildlife-vehicle collision data that can help identify the "worst" road sections:

- **Crash data:** These data are typically collected by law enforcement personnel. For a crash to be entered into the database there is often a threshold (e.g. the minimum estimated vehicle repair cost is at least US $1,000 and/or there are human injuries and human fatalities) (Huijser et al., 2007).
- **Carcass data:** These data are typically collected by road maintenance crews when they remove carcasses of large mammals that are on the road or that are very visible from the road in the right-of-way and that are an immediate safety hazard or a distraction to drivers (Huijser et al., 2007). Note that carcass data are sometimes also collected or recorded by others, e.g. by personnel from natural resource management agencies, researchers, or the general public.

Both types of collision data tend to relate to large mammals only; medium-sized and small-sized mammals and other species groups such as amphibians, reptiles and birds are usually inconsistently recorded or not recorded at all (Huijser et al., 2007). Furthermore, crash data typically represent only a fraction (14-50%) of the carcass data, even if both data sets relate to large mammals only (Tardif and Associates Inc., 2003; Riley & Marcoux, 2006; Donaldson & Lafon, 2008). Finally, the carcass data are far from complete as well; animals that are not very visible from the road in the right-of-way may not be removed and do not get recorded. Wounded animals that make it beyond the right-of-way fence before they die are also usually not recorded at all.

If only wildlife-vehicle collision data are used to identify and prioritize locations along highways that that may require wildlife mitigation measures, then the concern is typically primarily with human safety and reducing collisions with common large wild mammals. Depending on the region in North America, the most common large wild mammals and the most frequently hit large wild mammal species include ungulates such as white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*) and moose (*Alces americanus*).

If the concern is with direct road mortality for species or species groups other than common large wild mammals, then data sources other than crash data and carcass removal data may be required. A specific road-kill monitoring program may have to be developed as roadkill data on small and rare species are typically not available. Depending on the exact goals of the project and the associated requirements such data may be collected by personnel from natural resource management agencies, researchers or the public. Small species may require monitoring with slow speed, perhaps even traveling on foot (e.g. Teixeira et al., 2013). Rare species are not only rarely encountered, but the carcasses may be removed (legally or illegally) by others before agency personnel, researchers, or citizen scientists come by. If the interest is to reduce road mortality of rare species, it becomes increasingly likely that reducing roadkill is not only or not primarily about human safety; it becomes more about biological conservation. In this context, it may be a good strategy to not only focus on current road mortality hot spots, but to also address historic roadkill hot spots that may have acted as a population sink in the past and where the population is now so depleted that it no longer shows up as a hot spot for collisions (Teixeira et al., 2017). Therefore, sites that require mitigation for rare species may need to be primarily based on suitable habitat or corridors instead of carcass and crash data, which are inherently rare.

While there is much emphasis on mitigating for large mammal-vehicle collisions in North America, crashes, dead animals, and associated costs and risks to humans are not the only reason mitigation for wildlife along highways may be considered (Van der Ree et al., 2015). The authors of this report distinguish five different categories of effects of roads and traffic on wildlife (Figure 2):

- Habitat loss: e.g., the paved road surface, heavily altered environment through the road bed with non-native substrate, and seeded species and mowing in the clear zone.
- Direct wildlife road mortality as a result of collisions with vehicles.
- Barrier to wildlife movements: e.g., animals do not cross the road as often as they would have crossed natural terrain and only a portion of the crossing attempts is successful.
- Decrease in habitat quality in a zone adjacent to the road: e.g., noise and light disturbance, air and water pollution, increased access to the areas adjacent to the highways for humans.
- Right-of-way habitat and corridor: Depending on the surrounding landscape the right-of-way can promote the spread of non-native or invasive species (surrounding landscape largely natural or semi-natural) or it can be a refugium for native species (surrounding landscape heavily impacted by humans).

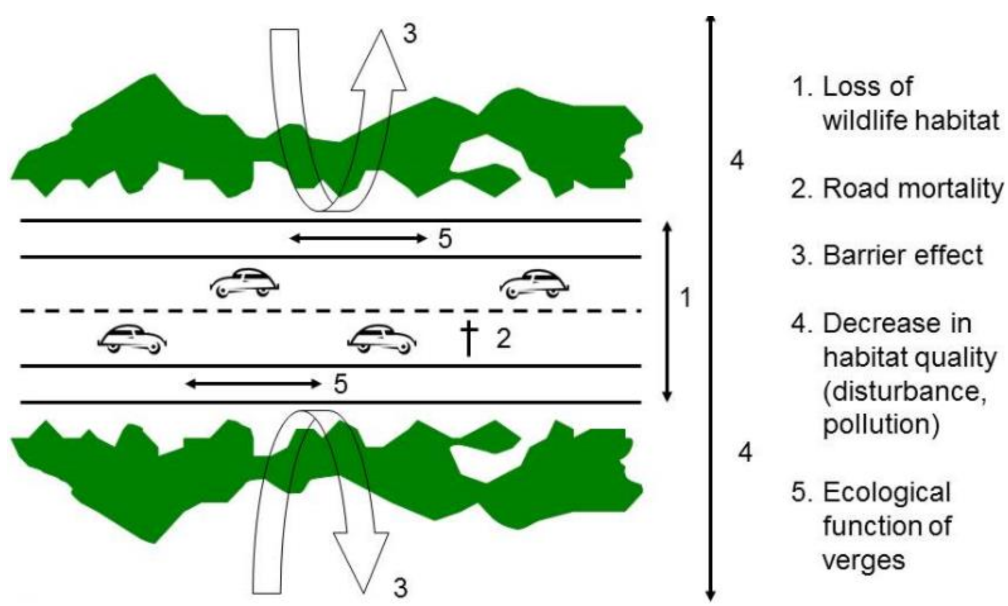

Figure 2: The effects of roads and traffic on wildlife.

If mitigation is required for habitat loss, barrier effects, a decrease in habitat quality in a zone adjacent to the road, or the ecological functioning of rights-of-way, other types of data are needed than wildlife-vehicle collision data. Examples of such data are data on the quantity and quality of the habitat impacted, animal movement data, data on noise or chemical pollutants, and the presence of non-native invasive species.

2.2. Decide on the Approach: Avoidance, Mitigation, or Compensation

While mitigation (reducing the severity of an impact) is common, avoidance is better and should generally be considered first (Cuperus et al., 1999). For example, the negative effects of roads and traffic may be avoided if a road is not constructed, or the most severe negative effects may be avoided by re-routing away from the most sensitive areas (Figure 3). If the effects cannot be avoided, mitigation is a logical second step. Mitigation is typically done in the road-effect zone (Figure 3) and may include measures aimed at reducing wildlife-vehicle collisions and reducing the barrier effect (e.g., through providing for safe wildlife crossing opportunities) (Huijser et al., 2008; Clevenger & Huijser, 2011). However, mitigation may not always be possible, or the mitigation may not be sufficient. In such situations, a third approach may be considered: compensation or mitigation off-site. Compensation may include increasing the size existing habitat patches, creating new habitat patches, or improving the connectivity between the habitat patches that would allow for larger, more connected, and more viable network populations. Finally, in some situations, a combination of avoidance, mitigation, and compensation may be implemented.

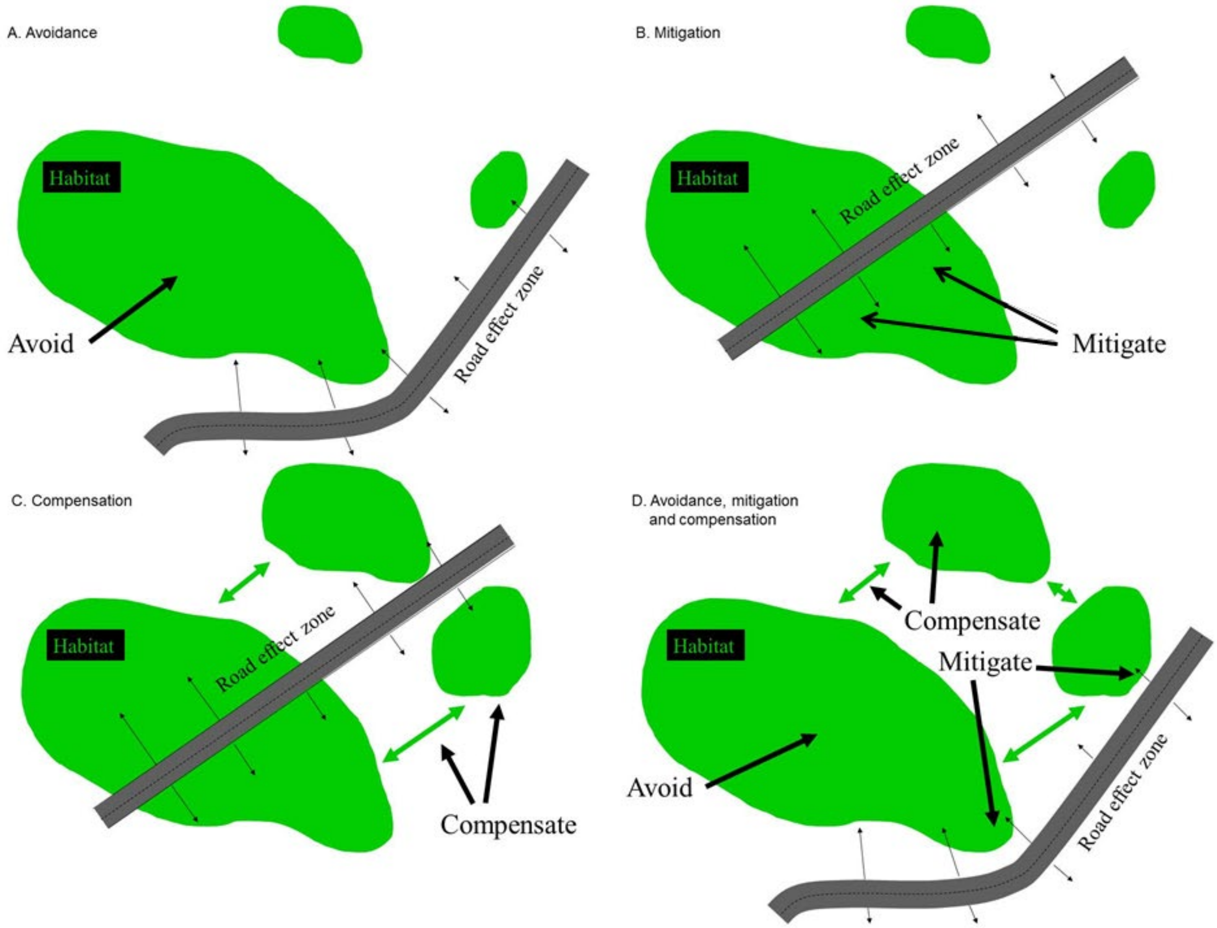

Figure 3: A three step approach: A. Avoidance, B. Mitigation, C. Compensation, D. Combination of avoidance, mitigation and compensation.

3. LARGE MAMMAL-VEHICLE COLLISION DATA

3.1. Project-specific Approach

This chapter describes the large mammal-vehicle crash data and carcass removal data used to identify and prioritize wildlife-vehicle collision hot spots. The authors evaluated large mammal-vehicle collision data along 15,090 miles (24,285 km), spread over all 12 Caltrans districts (Table 1).

Table 1: The road length within each Caltrans district that was evaluated for this project.

District	Road length (miles)
1	942.65
2	1,724.85
3	1,497.20
4	1,410.70
5	1,154.65
6	1,794.75
7	1,128.35
8	1,827.05
9	958.95
10	1,323.55
11	1,050.70
12	276.80
Total	15,090.20

The researchers used two datasets to identify large mammals-vehicle collision hot spots:

- Large mammal-vehicle crash data recorded by California Highway Patrol (Traffic Accident Surveillance and Analysis System data (“TASAS”)).
- Carcass removal data recorded by Caltrans maintenance personnel (Animal Vehicle Collision data (“AVC”) later replaced by Integrated Maintenance Management System data (“IMMS”)).

These two data sets are described and summarized in further detail in the following sections. Note that in this report the term “collisions” refer to both crashes and carcasses.

3.2. Search and Reporting Effort

For the data analyses described in this report (trend over time, hot spot analyses) the researchers assumed that the search and reporting effort between the different years, districts and road sections within a district were consistent. If the search and reporting effort varies between years, it may not be appropriate to use the data to investigate if there are changes (increase or decrease) in the number of wildlife-vehicle collisions over the years. If the search and reporting effort varies between districts or road sections within a district, it may not be appropriate to use the data to investigate if there are concentrations of wildlife-vehicle collisions along certain road sections either on a statewide level or on a district level.

While a consistent search and reporting effort is essential for analyzing temporal and spatial trends, it is not assumed that every wildlife-vehicle collision (e.g. deer-vehicle crash or mule deer carcass) ends up in the crash database or the carcass removal database. Consistent search and reporting effort can relate to only a fraction of the actual number of collisions. What matters is that a crash or carcass has similar likelihood of being recorded in different years (for temporal analyses to investigate if the deer-vehicle collisions may have increased or decreased over the years) and similar likelihood of being recorded in different districts or on different road sections within a district (for spatial analyses to investigate if there are concentrations of deer-vehicle collisions on certain road sections (“hot spots”)).

The search and reporting effort for crash data is typically lower than for carcass removal data (Tardif and Associates Inc., 2003; Riley & Marcoux, 2006; Donaldson & Lafon, 2008). For a crash to be included in the crash database in the state of California, there must be human injuries or human fatalities associated with the crash or the estimated damage to property has to be at least US $500 (Caltrans, 2013). However, depending on the severity of a reported crash, other tasks, and the distance to the crash site, there is not always sufficient law enforcement personnel available to respond and record the crash. For a carcass to be included in the carcass removal database, Caltrans personnel must have gone out and removed a carcass. The presence of a carcass is reported to Caltrans maintenance crews in the following manners (Personal communication Caltrans maintenance personnel in Pinegrove and Jamestown, Caltrans District 10):

- Telephone call by the public.
- Reports from Caltrans personnel commuting to and from work.
- Requests from law enforcement personnel/dispatch.
- Observations by Caltrans maintenance personnel on route to or from an assigned task.
- Observations by Caltrans maintenance personnel conducting regular road inspections.

3.3. Large Mammal Crash Data

The large mammal crash data related to the period 1 January 2005 through 31 December 2014 (the most recent 10 years data were available for). There were 10,552 reported crashes with either livestock, deer, or other animals (Table 2). There were 25 crashes with 28 human fatalities, mostly with deer (Table 2). There were 1,351 crashes with 1,617 human injuries, also mostly with deer (Table 3). The probability that a deer-vehicle crash results in at least one human injury was 12.22% (847 out of 6,922). For human fatalities this was 0.19% (13 out of 6,922).

Table 2: Human fatalities because of a crash with livestock, deer, or other animal species or species group.

	Crashes (n)			
Human fatalities in an individual crash (n)	**Livestock**	**Deer**	**Other species**	**Total**
0	1,156	6,909	2,462	10,527
1	6	12	4	22
2	0	1	2	3
Total crashes (n)	1,162	6,922	2,468	10,552
Total crashes (% of total)	11.01	65.60	23.39	100.00
Total crashes with human fatalities (n)	6	13	6	25
Total crashes with human fatalities (% of total)	24.00	52.00	24.00	100.00

Table 3: Human injuries because of a crash with livestock, deer, or other animal species or species group.

	Crashes			
Human injuries in an individual crash (n)	**Livestock**	**Deer**	**Other species**	**Total**
0	954	6,075	2,172	9,201
1	149	736	240	1125
2	49	102	48	199
3	3	7	7	17
4	6	1	0	7
5	1	1	1	3
Total crashes (n)	1,162	6,922	2,468	10,552
Total crashes (% of total)	11.01	65.60	23.39	100.00
Total crashes with human injuries (n)	208	847	296	1,351
Total crashes with human injuries (% of total)	15.40	62.69	21.91	100.00

Most of the crashes were with passenger cars (7,764 out of 10,552 crashes) (Table 4). However, the percentage of crashes that resulted in at least one human injury or human fatality was 5.72% for pickup trucks (vehicle type D), 9.66% for passenger cars (vehicle type A), and 91.13% for motorcycles (vehicle type C) (Table 4). For passenger cars, the percentage of human injuries or human fatalities was higher with livestock crashes (22.36%) compared to crashes with "deer" or other species (Table 5). The same applied to pickup trucks (9.88%), but for motorcyclists the percentage of human injuries or human fatalities was at least 90% regardless of the species group involved (Table 5).

Table 4: Human injuries or fatalities because of a crash with livestock, deer, or other species by vehicle type.

	Crashes with human injuries or fatalities (n)			**Crashes with at least one human injury or fatality**
Vehicle type	None	≥1	Total	**(%)**
A-Passenger car / station wagon	7,014	750	7,764	9.66
B-Passenger car with trailer	12	1	13	7.69
C-Motorcycle	47	483	530	91.13
D-Pickup / panel truck	1,253	76	1,329	5.72
E-Pickup / panel truck with trailer	53	5	58	8.62
F-Truck / truck tractor	48	4	52	7.69
G-Truck / tractor and 1 trailer	204	8	212	3.77
H-School bus	20	1	21	4.76
I-Other bus	22	1	23	4.35
J-Emergency vehicle	404	28	432	6.48
L-Bicycle	0	3	3	100.00
M-Other-motor vehicle	43	1	44	2.27
N-Other non-motor vehicle	1	0	1	0.00
2-Truck / tractor & 2 trailers	32	2	34	5.88
U-Pedestrian	1	6	7	85.71
Unknown	27	1	28	3.57
V-Dismount pedestrian	1	0	1	0.00

Table 5: Human injuries or fatalities because of a crash with livestock, deer, or other species by vehicle type.

Species group	Human injuries or fatalities (n)	A-Passenger car / station wagon	C-Motorcycle	D-Pickup / panel truck
Livestock	None	552	0	228
	≥1	159	14	25
	≥1 (%)	22.36	100.00	9.88
Deer	None	4,703	37	820
	≥1	410	378	38
	≥1 (%)	8.02	91.08	4.43
Other species	None	1,759	10	205
	≥1	181	91	13
	≥1 (%)	9.33	90.10	5.96

For the following sections and chapters of this report that are based on crash data, we selected deer-vehicle crashes (i.e. we excluded "livestock" and "other species"). Deer-vehicle crashes were more numerous from May through November compared to December through April, with the highest numbers occurring in October and November (Figure 4).

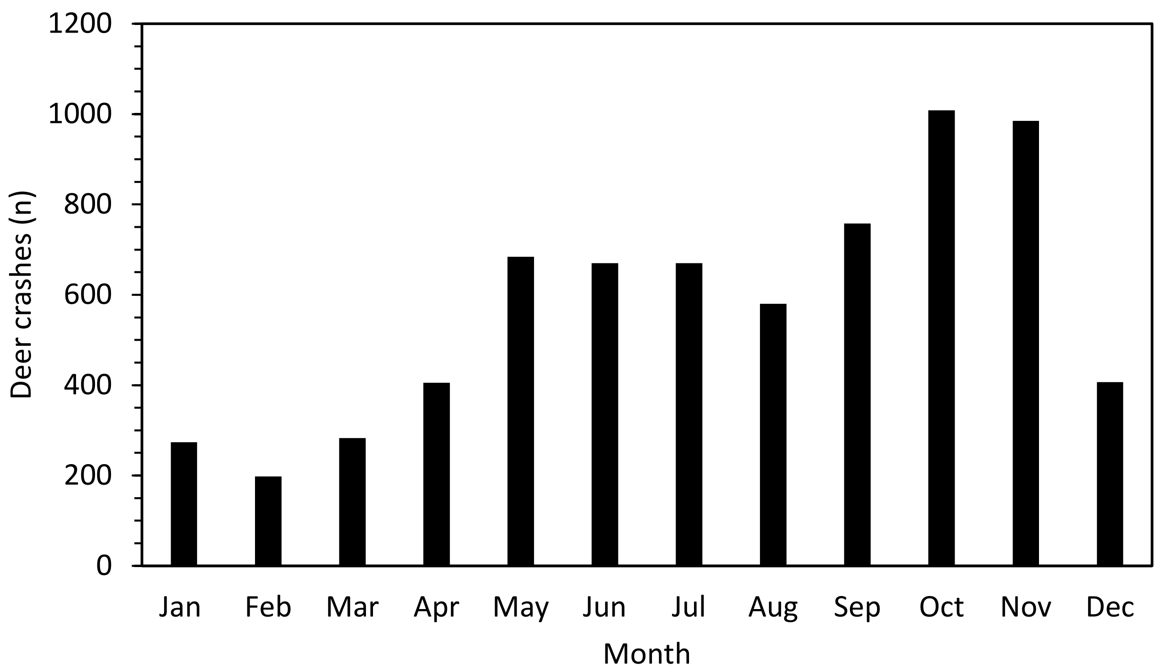

Figure 4: Distribution of reported deer crashes per month (n=6,922 in total).

Deer-vehicle crashes occur mostly at night, especially around dusk (5-10 pm) and dawn (5-7 am) (Figure 5). There is a noticeable effect of shorter days in the winter, and dusk occurring earlier at the end of the afternoon and early evening. Deer-vehicle crashes peak around 5-7 pm in November and December, compared to around 8-10 pm in June and July. The seasonal effect on the hour of day is less pronounced for the peak in the morning hours.

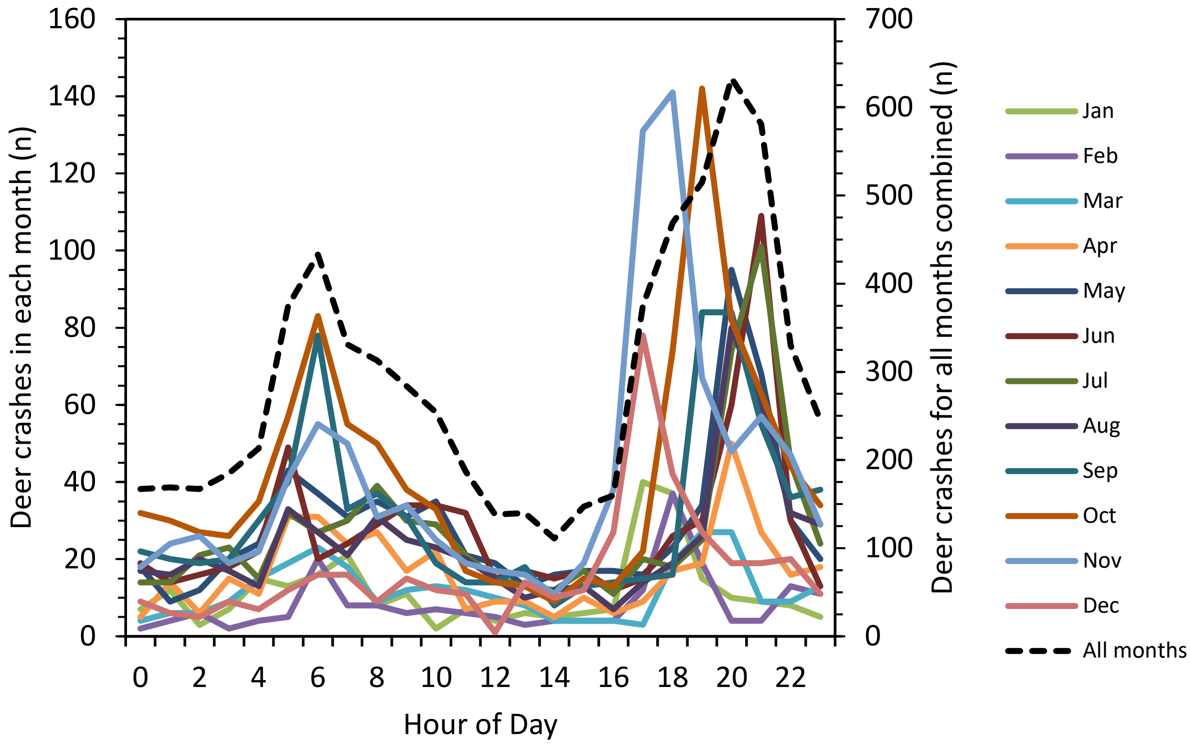

Figure 5: Distribution of reported deer-vehicle crashes by hour of day (per month and for all months combined).

The number of deer-vehicle crashes within each district per year was relatively consistent (Table 6). This suggests that, within each district, the search and reporting effort for deer-vehicle crashes was relatively constant throughout the data collection period (2005 through 2014), and that hot spot analyses within each district are justified. The lowest number of records in a district (total for 10 years) was 103 (District 12), which the authors of this report considered high enough for a meaningful hot spot analysis within that district. The relatively constant search and reporting effort within each of the districts also means that the individual districts had a relatively consistent share of the total number of deer-vehicle crashes in the entire state of California, and that the total number of deer-vehicle collisions in the entire state is also relatively constant (Table 6). This suggests that statewide hot spot analyses are also justified. Nonetheless, it is still possible that the search and reporting effort varied between the 12 districts. However, investigating such potential differences in search and reporting effort between the individual districts is complicated and confounded by likely differences between the districts in deer population size and movements, and traffic volume, even when the number of deer-vehicle crashes would be corrected for the total road length within each district.

Table 6: The number of reported deer crashes per Caltrans district per year.

District	Total (n)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	790	77	64	70	78	75	66	72	94	103	91
2	1,366	110	115	155	140	139	121	150	141	146	149
3	913	74	69	74	93	100	92	94	90	114	113
4	789	93	82	91	92	80	75	75	63	75	63
5	1,104	90	70	105	108	108	114	139	128	148	94
6	272	38	33	35	28	25	22	23	24	27	17
7	205	18	18	10	21	13	12	25	33	31	24
8	129	4	10	9	19	7	13	10	21	15	21
9	540	35	32	33	38	38	54	74	70	83	83
10	568	60	66	59	76	65	44	42	59	60	37
11	143	7	8	10	14	16	11	16	25	14	22
12	103	9	17	10	12	6	12	7	12	14	4
Total (n)	**6,922**	**615**	**584**	**661**	**719**	**672**	**636**	**727**	**760**	**830**	**718**

Because there was no evidence of inconsistent reporting effort between years or between Caltrans districts, a regression analysis was conducted to investigate potential increases or decreases in the total number of reported deer-vehicle crashes in the state of California in the period 2005 through 2014 (Figure 6). The regression analysis showed that the slope significantly deviated from zero ($p=0.007$); the number of reported deer-vehicle crashes increased significantly in this period (Figure 6). On average, the increase in the number of reported deer-vehicle crashes was 18.98 per year.

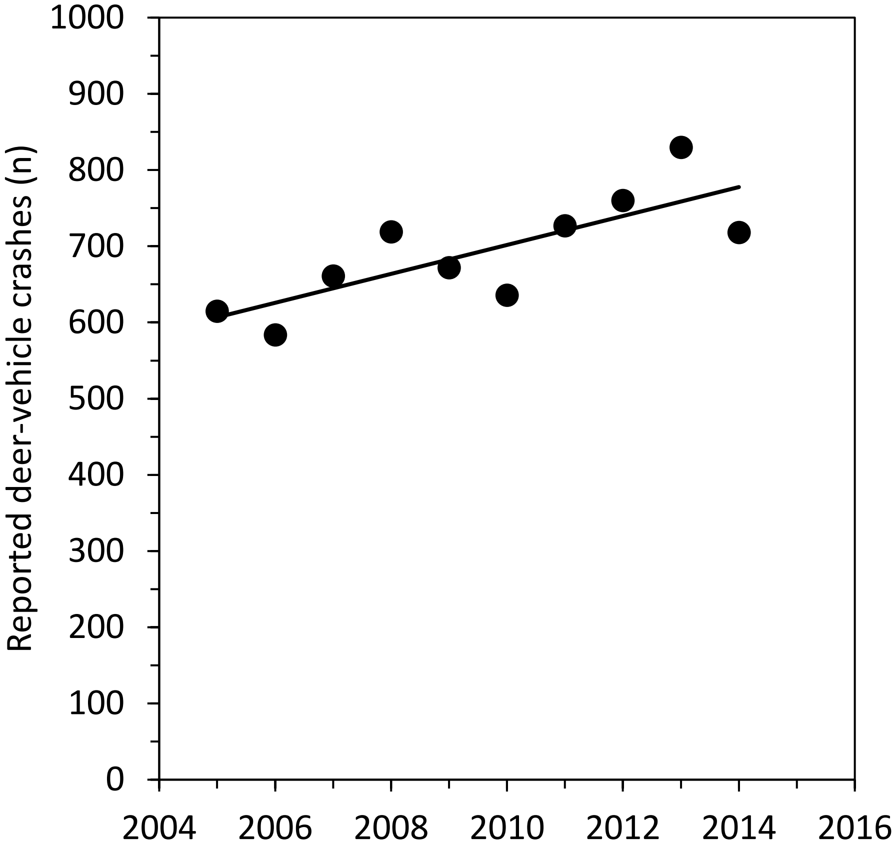

Figure 6: Number of reported deer-vehicle crashes per year in the state of California.
Formula for the trend line: Crash = -37451.76 + (18.98 × Year); R2=0.614, p=0.007, slope 18.98).

3.4. Large Mammal Carcass Removal Data

The carcass removal data related to the period 1 January 2000 through 31 December 2009 (the most recent 10 years data were available for). The carcass removal data used for this project were based on the following data sources and periods:

- "AVC" data:1 January 2000 through 31 December 2005.
- "IMMS" data: 1 January 2006 through 31 December 2009.

The researchers edited the database so that each individual carcass corresponds to a record in the database (rather than one record relating to multiple carcasses). In addition, the researchers made the species descriptions as consistent and precise as possible. Most of the reported carcasses (66.8%) related to mule deer (Table 7). However, mule deer represented 97.8% of all large mammal carcasses of species larger in size than a coyote (Table 7). Other large mammals included black bear, elk, mountain lion, wild boar, bighorn sheep, and pronghorn (all <1%) (Table 7).

Large mammal species of possible conservation concern to Caltrans include elk, mountain lion, and bighorn sheep (Pers. comm. Jim Henke, Caltrans). However, given the low numbers in the carcass removal database for these species, hot spot analyses for these individual species are unlikely to accurately identify road sections where these species are hit most frequently. Based on the species descriptions by road maintenance personnel that recorded the carcasses, it is not certain that there were any federal or state threatened or endangered species reported. However, some of the species descriptions did not identify carcasses to the species level (e.g. “Fox”), or subspecies level (e.g. “Bighorn sheep” or “Kit fox”) and it is still possible that threatened or endangered species or subspecies were encountered and removed by road maintenance personnel (e.g. Peninsular bighorn sheep (*Ovis canadensis nelsoni*), Sierra Nevada bighorn sheep (*Ovis canadensis sierra*), Sierra Nevada red fox (*Vulpes vulpes necator*), or San Joaquin kit fox (*Vulpes macrotis mutica*). However, most of the threatened and endangered mammal species in California are too small to have been detected by road maintenance personnel from a moving vehicle (Teixeira et al., 2013).

Table 7: Species and number of reported carcasses in California (2000-2009).

Species description	Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Mule deer (*Odocoileus hemionus*)	3,424	357	123	833	487	462	142	155	287	321	257
Unknown	743	0	0	7	0	0	0	201	207	176	152
Raccoon (*Procyon lotor*)	315	24	5	13	17	18	9	14	37	104	74
Coyote (*Canis latrans*)	211	28	2	25	29	29	12	6	11	18	51
Virginia opossum (*Didelphis virginiana*)	99	14	2	17	16	8	14	3	6	13	6
Skunk sp.	88	10	0	4	5	3	8	6	16	21	15
Bird	65	8	1	7	3	8	34	0	3	1	
Black bear (*Ursus americanus*)	50	0	0	20	0	7	0	2	13	5	3
Fox sp.	22	6	0	0	2	1	0	1	6	4	2
Rabbit sp.	21	0	0	0	0	0	0	2	9	8	2
Bobcat (*Lynx rufus*)	20	5	0	2	5	2	1	0	1	1	3
Rabbit or hare sp.	18	6	0	3	2	2	5	0	0	0	0
Elk (*Cervus canadensis*)	17	0	0	2	1	5	0	0	3	4	2
Squirrel sp.	5	1	0	1	0	0	2	0	0	1	0
Gray fox (*Urocyon cinereoargenteus*)	4	2	1	0	0	0	0	0	1	0	0
Mammal sp.	4	0	0	0	1	2	1	0	0	0	0
Mountain lion (*Puma concolor*)	4	0	1	2	0	0	0	0	0	1	0
American badger (*Taxidea taxus*)	3	0	0	0	0	0	0	0	0	0	3
Red fox (*Vulpes vulpes*)	3	0	0	0	0	0	0	0	0	2	1
Wild boar (*Sus scrofa*)	3	0	0	0	0	0	0	0	0	0	3
Jack rabbit (*Lepus* sp.)	2	0	0	0	0	0	0	0	1	1	0
Bighorn sheep (*Ovis canadensis*)	1	0	0	0	0	0	0	0	1	0	0
Kit fox (*Vulpes macrotis*)	1	1	0	0	0	0	0	0	0	0	0
River otter (*Lontra canadensis*)	1	0	0	0	0	0	0	0	0	1	0
Pronghorn (*Antilocapra americana*)	1	0	0	1	0	0	0	0	0	0	0
Total (n)	5,125	462	135	937	568	547	228	390	602	682	574

For the following sections and chapters of this report that are based on carcass removal data, we selected mule deer carcass removal data only. Mule deer carcasses were more numerous from May through November compared to December through April, with the highest numbers occurring in September through November, and in May (Figure 7).

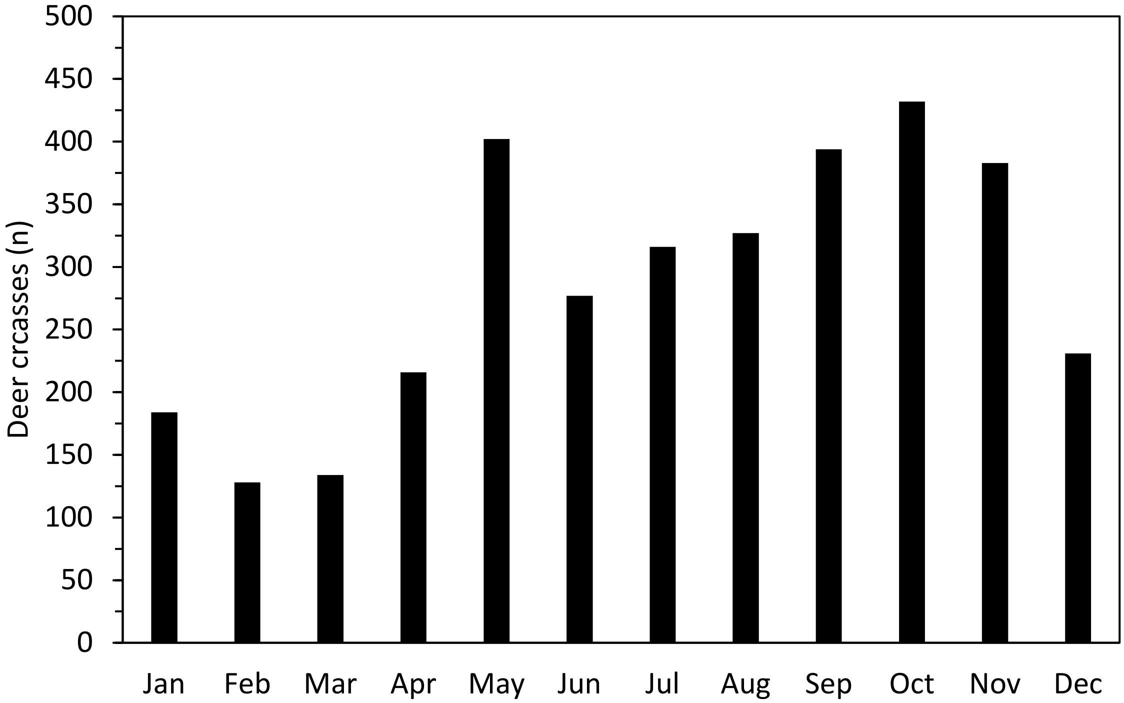

Figure 7: Distribution of reported mule deer carcasses per month in California over a ten-year period (2000 through 2009).

Mule deer carcasses were not reported in some years in some of the Caltrans districts (Table 8). For Districts 1 through 8, reporting was mostly restricted to 2006-2009. For Districts 9 and 12, the reporting was mostly restricted to 2000-2005. District 10 reported consistently throughout the data collection period, and District 11 reported very few observations with no reports in most of the years (Table 8). The data illustrate that the search and reporting effort for mule deer carcasses was inconsistent between years in all but one of the districts. Some districts even had no reported mule deer carcasses at all in some years.

Because of the temporal and spatial inconsistencies in the carcass data, trend analyses for the number of carcasses reported per year and statewide hot spot analyses are not meaningful for the 10-year dataset, nor for a selection out of these 10 years. The hot spot analyses within each district are still meaningful though, assuming that the search and reporting effort only varied between years, but not spatially within each district. However, it is prudent to set a minimum sample size for each district. For the purposes of this report, the minimum sample size (total number of mule deer carcasses over 10 years) was set at 50 records. This means that mule deer carcass hot spot analyses were conducted for Districts 1, 2, 4, 6, 9, 10, and 12, and not for Districts 3, 5, 7, 8, and 11 (Table 8). The authors of this report suggest improving efforts by Caltrans personnel to more consistently report mule deer carcasses with similar search and reporting effort between years as well as between districts.

Table 8: The number of reported mule deer carcasses per Caltrans district per year.

District	Total (n)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	230	15	10	18	0	0	0	41	71	37	38
2	202	0	0	175	0	0	0	0	3	14	10
3	9	0	0	0	0	0	0	1	3	1	4
4	367	0	0	0	0	0	0	40	83	135	109
5	32	0	0	0	0	0	0	11	12	6	3
6	58	0	0	2	1	0	0	4	14	22	15
7	14	0	0	0	0	0	0	6	1	3	4
8	5	0	0	0	0	0	0	2	2	0	1
9	670	95	35	140	127	157	115	0	1	0	0
10	1,746	222	73	487	347	290	13	48	95	99	72
11	3	1	0	0	0	0	0	0	1	1	0
12	88	24	5	11	12	15	14	2	1	3	1
Total (n)	3,424	357	123	833	487	462	142	155	287	321	257

Wildlife-vehicle crash data typically represent only a fraction (14-50%) of the wildlife carcass data, even if both data sets relate to large mammals only (Tardif and Associates Inc., 2003; Riley & Marcoux, 2006; Donaldson & Lafon, 2008). Because of the suspected underreporting of mule deer carcasses in many of the Caltrans districts (see Table 8), the researchers compared the deer-vehicle crash number and the mule deer carcass number for each of the 12 Caltrans districts (Table 9). Note that both the crash (2005-2014) and carcass data (2000-2009) related to 10 years, but that only a portion of the years overlapped (2005-2009). Only one of the districts was within the expected range (14-50%); all other districts had more deer-vehicle crash records than mule deer carcasses, the opposite of what is considered normal, and far outside the expected range. This is further evidence of severe underreporting of mule deer carcasses in general, and in 11 out of the 12 Caltrans districts.

Table 9: The percentage of deer-vehicle crashes compared to mule deer carcasses per Caltrans district.

District	Deer-vehicle crashes (n) 2005-2014	Mule deer carcasses (n) 2000-2009	% of crash data compared to carcass data	In or out of expected range
1	790	230	343.48	Out
2	1,366	202	676.24	Out
3	913	9	10,144.44	Out
4	789	367	214.99	Out
5	1,104	32	3,450.00	Out
6	272	58	468.97	Out
7	205	14	1,464.29	Out
8	129	5	2,580.00	Out
9	540	670	80.60	Out
10	568	1,746	32.53	In
11	143	3	4,766.67	Out
12	103	88	117.05	Out
Total	6,922	3,424	202.16	Out

3.5. Discussion

The probability of human injuries as a result of a crash with a deer was 12.22% (847 out of 6,922 crashes). This was somewhat higher than the range reported in a review by Huijser et al. (2009): range 2.8-9.7%. The probability of human fatalities as a result of a crash with a deer was 0.19% (13 out of 6,922 crashes). This was within the range reported in a review by Huijser et al. (2009): range 0.009-0.05%. Motorcyclists were particularly vulnerable to human injuries or human fatalities as a result of a collision with a deer; 91.13% compared to under 10% for other types of motor vehicles. This is also consistent with other studies (e.g. Abra et al., 2019)

Deer-vehicle collisions (both deer crash and mule deer carcass data) were more numerous from May through November compared to December through April, with the highest numbers occurring in October and November. These deer crashes occur mostly at night, especially around dusk (5-10 pm) and dawn (5-7 am). Finally, the number of reported deer-vehicle crashes increased significantly in the study period. Note that the estimated deer population in California decreased rather than increased over this time period (CDFW, 2018). These seasonal, day-night, and trend patterns are similar to other studies (e.g. Huijser et al., 2008).

There was no evidence of inconsistent reporting effort between years or between Caltrans districts for the deer-vehicle crash data collected by the California Highway Patrol (CHP). However, there was evidence of substantial underreporting of mule deer carcasses compared to deer-vehicle crash data in all Caltrans districts except District 10.

4. IDENTIFY CRASH AND CARCASS HOT SPOTS

4.1. Introduction

This chapter contains the procedures used to identify large mammal-vehicle collision hot spots. The hot spot identification process results in hot spots that are primarily based on human safety data. This is important to recognize, as an alternative process that would identify hot spots based on – for example – biological conservation parameters, may result in the identification of very different road segments with different road lengths because it would probably be based on different species and habitat. This is not necessarily a problem, but it is important to recognize that the "departure point" for the identification process for the hot spots is based on human safety concerns and collisions with large wild mammals rather than anything else.

Based on the data exploration in Chapter 3, the authors of this report conducted the following types of hot spot analyses:

- Statewide hot spot analysis for regions with significant concentrations of deer-vehicle crashes. This analysis identifies regions in the state of California where deer-vehicle crashes occur significantly more than expected compared to a theoretical random spatial distribution of deer-vehicle crashes. Note that a statewide analysis for mule deer carcass data could not be conducted because of inconsistent search and reporting effort (see Chapter 3).
- Descriptive statewide hot spot analysis based on deer-vehicle crash data. This analysis identifies the road sections that have the highest concentration of deer-vehicle crashes in the state of California.
- Descriptive hot spot analyses within each Caltrans district based on deer-vehicle crash data. These analyses identify the road sections that have the highest concentration of deer-vehicle crashes within each Caltrans district.
- Descriptive hot spot analyses within each Caltrans district based on mule deer carcass removal data (i.e. for the Districts 1, 2, 4, 6, 9, 10, and 12, but not for Districts 3, 5, 7, 8, and 11 as these districts had insufficient data; See Chapter 3). These analyses identify the road sections that have the highest concentration of mule deer carcasses within each Caltrans district.
- Maps (no formal hot spot analyses) showing the locations of the reported collisions with black bear, elk, mountain lion, wild boar, bighorn sheep, and pronghorn.

4.2. Methods

Integrating Data into a Spatial Database

The deer crash and large wild mammal carcass locations were integrated into a spatial database (ArcGIS 10.6.1). In the state of California, different counties may have the same 0.1 postmile numbers for the different highway segments in their respective counties. The authors of this report generated unique 0.1-postmile descriptions based on the Caltrans district, the county, the highway number, and the 0.1 postmile. For example, "10_MPA_49_123" means Caltrans District 10, Mariposa County, Hwy 49, postmile 12.3.

Statewide Analysis for Significant Concentrations of Deer-Vehicle Crashes

The authors of this report conducted a statewide optimal hot spot analysis (Getis-Ord Gi*) for deer-vehicle crashes in ArcGIS 10.6.1 (ESRI, 2018a). This analysis identifies statistically significant spatial clusters (hot spots) of deer crash locations. This analysis also identifies statistically significant areas with a no or low occurrence of deer crashes (cold spots). We selected all deer crash records along the highways that were part of this project. We then created a bounding polygon around the highways. This is the "analysis field" where observations are possible. This bounding polygon was a 500 m (1,640 ft) buffer from approximately the center of the highways resulting in a 1 km wide zone with the highways in the center. This allowed for some spatial imprecision in the original data.

We conducted analyses with 6,827 valid observations, and there were 106 locational outliers that were more than three times the standard deviation distance away from their closest non-coincident neighbor. The optimal grid size was 10,361 m (6.4 mile) (cells of 10,361 m x 10,361 m (6.4 x 6.4 mile)), and the optimal fixed distance band was 62,167 m (38.6 mile). Areas without highways that were part of this project did not have a grid cell and were not evaluated for significant concentrations of deer-vehicle crashes (hot spots), or for significant low concentration of deer-vehicle collisions (cold spots). The authors distinguished three categories of hot spots and cold spots based on a confidence interval of 90%, 95%, and 99%.

Descriptive Hot Spot Analyses

These analyses identify the road sections that have the "highest" concentration of deer-vehicle crashes and mule deer carcasses. The authors conducted three different Kernel density analyses for point features using ArcGIS 10.6.1 (ESRI, 2018b): one statewide analysis for deer-vehicle crashes and two analyses for each Caltrans district (one for deer-vehicle crash data and one for mule deer carcasses).

The statewide analysis included all deer-vehicle crash data from all highways in the state of California considered part of this project (15,090 miles (24,285 km); see Table 1). This statewide analysis can, at least in theory, result in hot spots that are all located in one district, and along one road section, with no hot spots at all in other districts or along other roads. The statewide analysis identifies the road sections with the "highest concentration" of deer-vehicle crashes in the state of California, regardless of the boundaries of the Caltrans districts.

The analyses per district only included either the deer-vehicle crash data or the mule deer carcass data for the district concerned. The analyses per district identify the road sections with the "highest concentration" of deer-vehicle crashes or mule deer carcasses within each district, regardless of the data for other Caltrans districts. Note that because of minimum sample size requirements, the analyses for mule deer carcasses were only conducted in Caltrans Districts 1, 2, 4, 6, 9, 10, and 12 (see Chapter 3). The analyses per district can result in a situation where the

number of deer-vehicle crashes or mule deer carcasses in the "worst" hot spots in one district would not necessarily be sufficient to be identified as hot spots in other districts.
For the Kernel density analyses, the researchers divided the study area (either the whole state or an individual Caltrans district) into a grid with a cell size of 25 x 25 m (82 x 82 ft). A 25 m (82 ft) cell size is relatively fine scale and accommodates for some spatial inaccuracies in GPS coordinates of the crash data. The Kernel density analysis calculates the density of deer-vehicle crashes or mule deer carcasses in a neighborhood around each cell based on the quartic kernel function described by Silverman (1986). The locations of the deer-vehicle crashes and mule deer carcasses are considered points and the Kernel density analysis calculates the density of crashes or carcasses in a neighborhood around each cell. Points that are close are weighted more than points that are farther away. Consistent with Gomes et al. (2009) we set the search radius at 500 m (1,640 ft). On a straight road this basically means that crashes or carcasses that are up to 500 m (1,640 ft) away are included in the density analyses for each cell. For the Kernel density, the researchers calculated the area covered within five Kernel isopleths, each with their own color code for displaying on the heatmaps (Table 10).

The researchers considered road sections with no crashes or carcasses, and road sections that fell into the two lowest density categories (50-100%; Table 10) to be "background". For the statewide analysis for deer-vehicle crash data, the road sections that had the highest densities ("top 50%") were considered a "hot spot" (i.e. yellow, orange or red; Table 10). If two hot spots were less than two miles apart, they were treated as one hot spot. For the analyses per Caltrans district (both for deer-vehicle crash data and mule deer carcasses), a similar threshold was applied. However, if the number of "red" or "orange" hot spots reached five or more within a district, no further "yellow" hot spots were identified in that district. Similarly, if the road length covered by the hot spots within a district reached 10 miles or more, no further "yellow" hot spots were identified.

The researchers described the individual hot spots based on the Kernel density category, the length of the hot spots, the number of lanes (based on satellite images), whether potential existing structures are present that may also serve as a wildlife crossing after potential modifications (based on satellite images), and the traffic volume (Annual Average Daily Traffic (AADT; Caltrans, 2019).

Maps of the Reported Carcasses for Selected Other Species

The authors of this report plotted the locations showing the locations of the reported carcasses of black bear, elk, mountain lion, wild boar, bighorn sheep, and pronghorn. Because of the small sample sizes for these species, no formal hot spot analyses were conducted. The low number of carcass removal data for these species illustrate that when it comes to specific species that are relatively rare (even if they are large), that their carcasses may be removed by others, legally or illegally, before the road maintenance crews come by. This suggests that for these relatively rare species other data sources may need to be consulted (e.g. data from natural resource management agencies, community science (or citizen science) data etc.). These other data may include observations of road-killed animals, observations of live animals seen on or near the road, or existing or potential habitat near transportation corridors.

Table 10: The categories used for maps with the hot spots based on the crash and carcass data.

Percentile categories	Color on maps	Description
75-100%	Green	The 25% of the cells with the lowest density (provided that the density is greater than 0)
50-74.9%	Light green	The next 25% of the cells with the lowest density (provided that the density is greater than 0)
25-49.9%	Yellow	The next 25% of the cells with the lowest density (provided that the density is greater than 0)
5-24.9%	Orange	The next 20% of the cells with the lowest density (provided that the density is greater than 0)
<5%	Red	The 5% of cells with the highest density (provided that the density is greater than 0)

4.3. Results

Statewide Analysis for Significant Concentrations of Deer-Vehicle Crashes

Regions with a statistically significant high concentration of deer-vehicle crashes (hot spots) include the areas around (Figure 8):

- Yreka/Mt Shasta.
- The coastal areas between Eureka and Fort Bragg.
- The foothills and Sierra Nevada north and south-east of Sacramento.
- The eastern slopes of the Sierra Nevada and desert around Susanville.
- The western slopes of the Sierra Nevada near Merced.
- The eastern slopes of the Sierra Nevada near Mono Lake and Mammoth Lakes.
- The coastal areas between San Francisco until just south of Carmel-by-the-Sea.
- The coastal areas near San Simeon until Santa Barbara.

Regions with a statistically significant low concentration of deer-vehicle crashes (cold spots) include the areas around (Figure 8):

- The southern portion of the Central Valley around Modesto until south of Bakersfield.
- The deserts north and east of Los Angeles and San Diego.

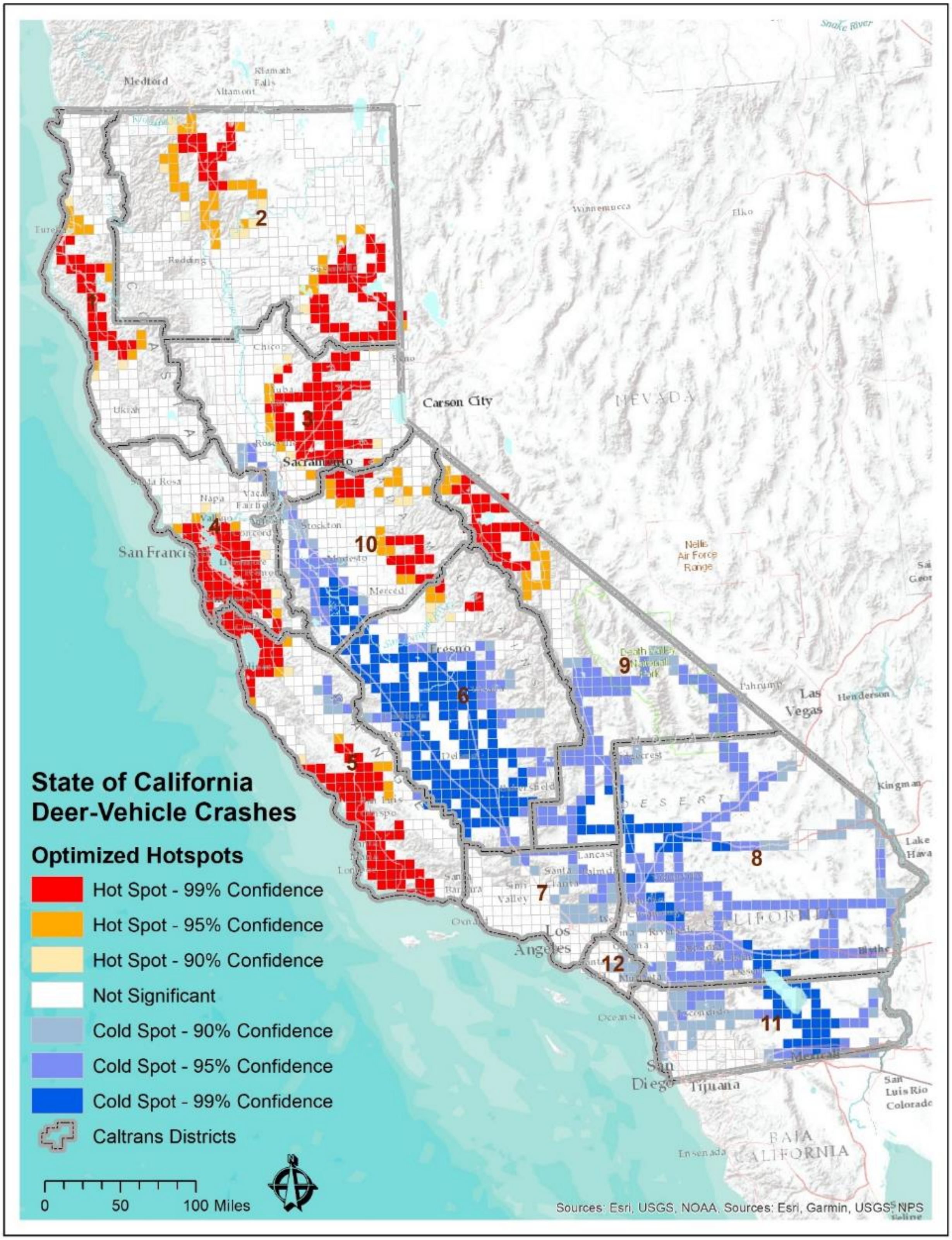

Figure 8: Significant hot spots (red) and cold spots (blue) based on a statewide analysis of deer-vehicle crashes.

Descriptive Hot Spot Analyses

For the statewide descriptive hot spot analysis, there were 13 hot spots that were at least "yellow" (i.e. the top 50% of densest cells representing the highest concentration of deer-vehicle crashes in the state of California, regardless of the boundaries of the Caltrans districts (Figure 9, Table 11, Appendix A).

The hot spots based on per district analyses for deer-vehicle crashes and mule deer carcasses analyses are shown in Figures 10-11. The hot spots based on per district analyses for deer-vehicle crashes are further characterized in Table 12 and detailed maps (per district and for each individual hot spot) are included in Appendix B. The hot spots based on per district analyses for mule deer carcasses are further characterized in Table 13 and detailed maps (per district and for each individual hot spot) are included in Appendix C.

A comparison of the deer-vehicle crash data and mule deer carcass data for each district showed the following:

District 1: While "deer'-vehicle crash data are reported throughout the district, mule deer carcass data are missing from the area north of Eureka. There is no overlap between the hot spots identified through the two data sets. Based on the apparent underreporting of mule deer carcasses, especially north of Eureka, hot spots based on deer-vehicle crash data seem more reliable than those identified based on mule deer carcass data.

District 2: While "deer'-vehicle crash data are reported throughout the district, mule deer carcass data are missing from the areas in the east and south-east portions of the district (e.g. around Susanville) and in the southern areas of the district (e.g. around Red Bluff). However, there is some overlap between the hot spots identified through the two data sets; most notably on I-5, just south of Yreka.

District 3: Only "deer'-vehicle crash data were considered for a hot spot analysis for this district. The mule deer carcass removal data were deemed insufficient. Most of the deer-vehicle crashes were reported from the foothills of the Sierra Nevada, especially around Grass Valley and Placerville.

District 4: Both "deer'-vehicle crash data and mule deer carcass data are reported throughout the district. Both data sources identify sections of I-280 and Hwy 92 around and between Highlands-Baywood Park and Cupertino as hot spots. Mule deer carcasses are also reported in relatively high numbers between Berkeley and Fremont along sections of I-680, Hwy 13, Hwy 24, and I-580.

District 5: Only "deer'-vehicle crash data were considered for a hot spot analysis for this district. The mule deer carcass removal data were deemed insufficient. There was one hot spot identified: US Hwy 101 south of Templeton.

District 6: Both "deer'-vehicle crash data and mule deer carcass data are reported from the western foothills of the Sierra Nevada. Both data sources identify road sections along Hwy 41 near Oakhurst as a hot spot. The carcass data also show a hot spot along Hwy 198 near Three Rivers.

District 7: Only “deer’-vehicle crash data were considered for a hot spot analysis for this district. The mule deer carcass removal data were deemed insufficient. The most severe hot spots were along Hwy 134 and Hwy 2 near Glendale, with additional hot spots near Sherman Oaks (I-405), Casitas Springs (Hwy 33), and Moorpark (Hwy 23).

District 8: Only “deer’-vehicle crash data were considered for a hot spot analysis for this district. The mule deer carcass removal data were deemed insufficient. The most severe hot spots were along Hwy 18, Hwy 138, Hwy 330 on the forested slopes just north of San Bernardino.

District 9: Both “deer’-vehicle crash data and mule deer carcass data are reported from the area near the border with Nevada and not or barely from the areas around Mojave. Both data sets identify sections of US Hwy 395 just west of Bridgeport and another section just east of Mammoth Lakes as hot spots. Other sections of US Hwy 395 were also identified as hot spots, but only by one of the two data sources at a time.

District 10: Both “deer’-vehicle crash data and mule deer carcass data are reported in relatively high numbers from the western foothills of the Sierra Nevada. Both data sets identify sections of Hwy 49 near Bootjack and between Mariposa and Bootjack as a hot spot. However, other hot spots in the foothills were identified by only one of the data sources. The carcass data showed long road sections near Pinegrove (Hwy 88), near Jackson (Hwy 49), east of Sonora and Jamestown (Hwy 108), west of Moccasin (Hwy 49), and east and west of Groveland (Hwy 120).

District 11: Only “deer’-vehicle crash data were considered for a hot spot analysis for this district. The mule deer carcass removal data were deemed insufficient. Most hot spots were along Hwy 79, especially near Warner Springs, Santa Ysabel, and south of Julian.

District 12: Both “deer’-vehicle crash data and mule deer carcass data are reported in relatively high numbers around San Joaquin Hills (Hwy 73), and the foothills of the Santa Ana Mountains (Hwy 241, Hwy 261, Hwy 74).

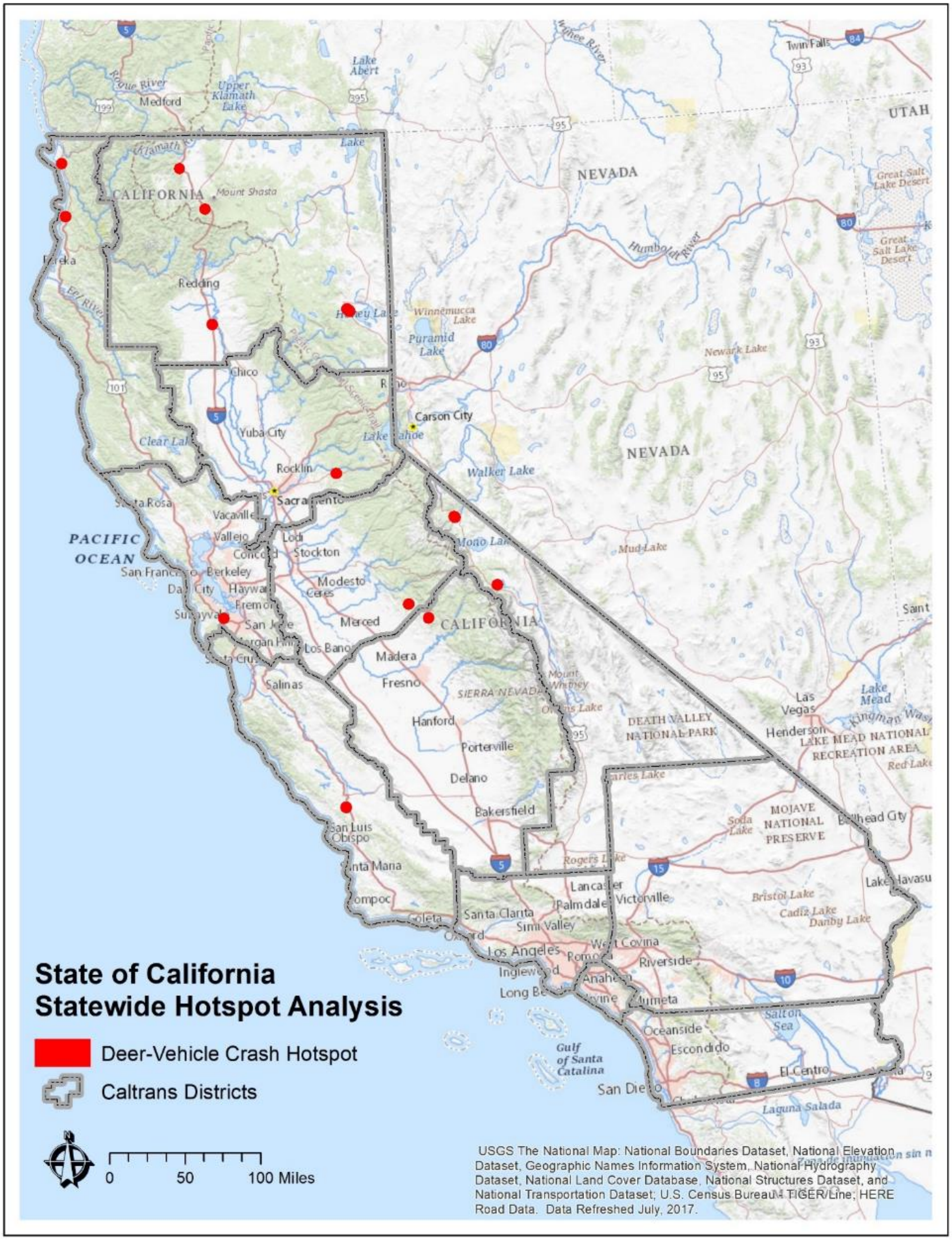

Figure 9: The "worst" hot spots based on a statewide analysis for deer-vehicle crashes in the entire state of California.

Table 11: The "worst" hot spots based on a statewide analysis for deer-vehicle crashes in the entire state of California. Note: AADT = Annual Average Daily Traffic.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
1	1	Del Norte	Crescent City	US Hwy 101	1_DN_101_237	1_DN_101_235	yellow	0.2	0.2	0.0	0.0	2	No	4,450
2	1	Humboldt	Orick	US Hwy 101	1_HUM_101_1148	1_HUM_101_1145	yellow	0.3	0.3	0.0	0.0	2	Yes	4,050
3	2	Siskiyou	Yreka	I-5	2_SIS_5_447	2_SIS_5_446	yellow	0.1	0.1	0.0	0.0	4	No	19,000
4	2	Siskiyou	Mt. Shasta	I-5	2_SIS_5_99	2_SIS_5_96	yellow	0.3	0.3	0.0	0.0	4	No	22,350
5	2	Tehama	Red Bluff	I-5	2_TEH_5_275	2_TEH_5_272	yellow	0.3	0.3	0.0	0.0	4	No	38,500
6	2	Lassen	Susanville	US Hwy 395	2_LAS_395_555	2_LAS_395_529	yellow	2.6	1.0	0.0	0.0	3	Yes	6,950
7	3	El Dorado	Placerville	US Hwy 50	3_ED_50_221	3_ED_50_224	yellow	0.3	0.3	0.0	0.0	4	No	27,450
8	4	Santa Clara	Los Altos Hills	I-280	4_SCL_280_153	4_SCL_280_151	yellow	0.2	0.2	0.0	0.0	8	No	131,500
9	5	San Luis Obispo	Templeton	US Hwy 101	5_SLO_101_497	5_SLO_101_492	red	0.5	0.2	0.3	0.1	4	Yes	58,850
10	6	Madera	Oakhurst	Hwy 41	6_MAD_41_352	6_MAD_41_348	yellow	0.4	0.4	0.0	0.0	3	No	16,500
11	9	Mono	Bridgeport	US Hwy 395	9_MNO_395_819	9_MNO_395_809	orange	1.0	0.6	0.3	0.0	2	No	3,050
12	9	Mono	Mammoth Lakes	US Hwy 395	9_MNO_395_201	9_MNO_395_195	orange	0.6	0.2	0.4	0.0	4	No	9,650
13	10	Mariposa	Mariposa	Hwy 49	10_MPA_49_126	10_MPA_49_123	yellow	0.3	0.3	0.0	0.0	2	Yes	5,200

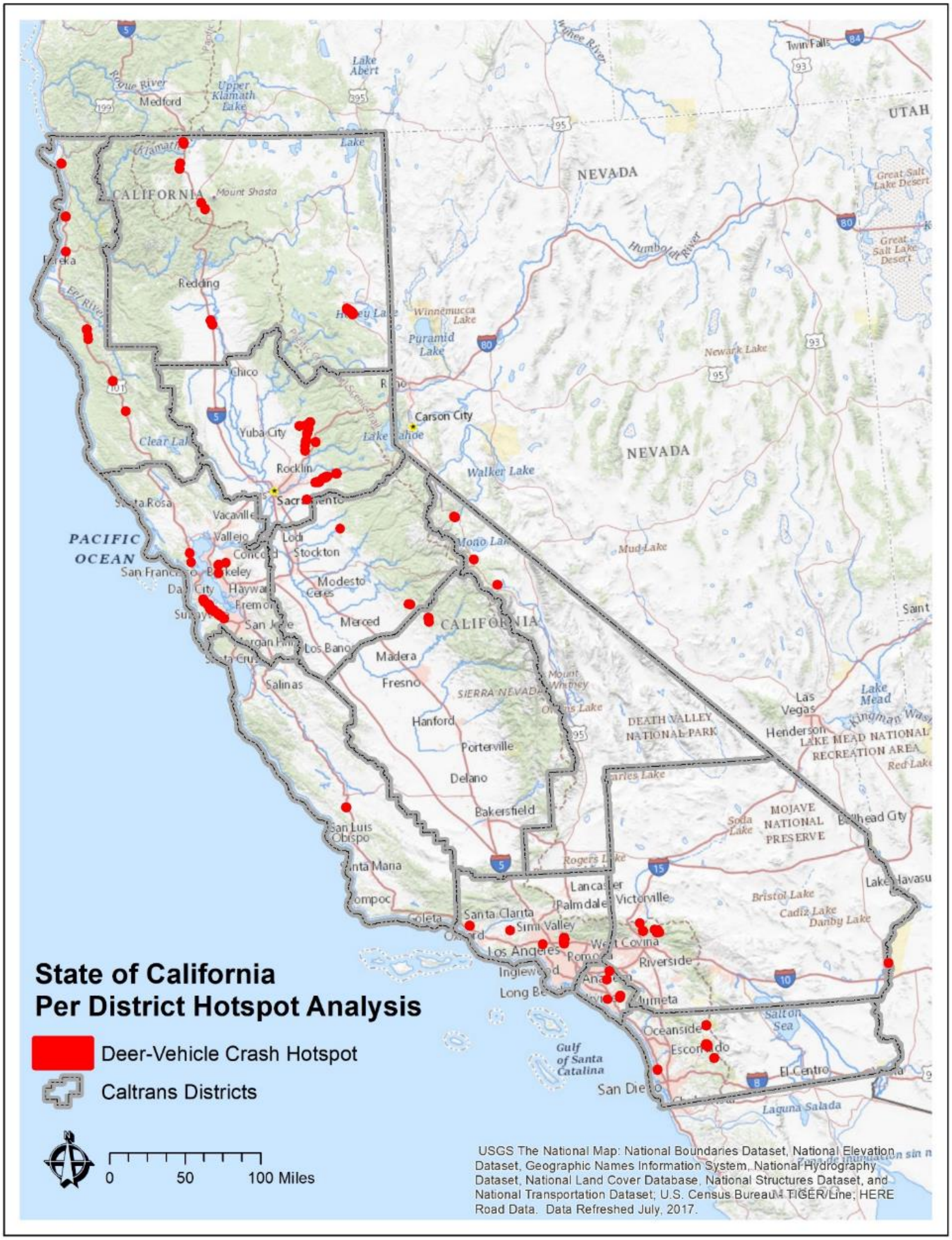

Figure 10: The "worst" hot spots based on deer-vehicle crashes within each Caltrans district.

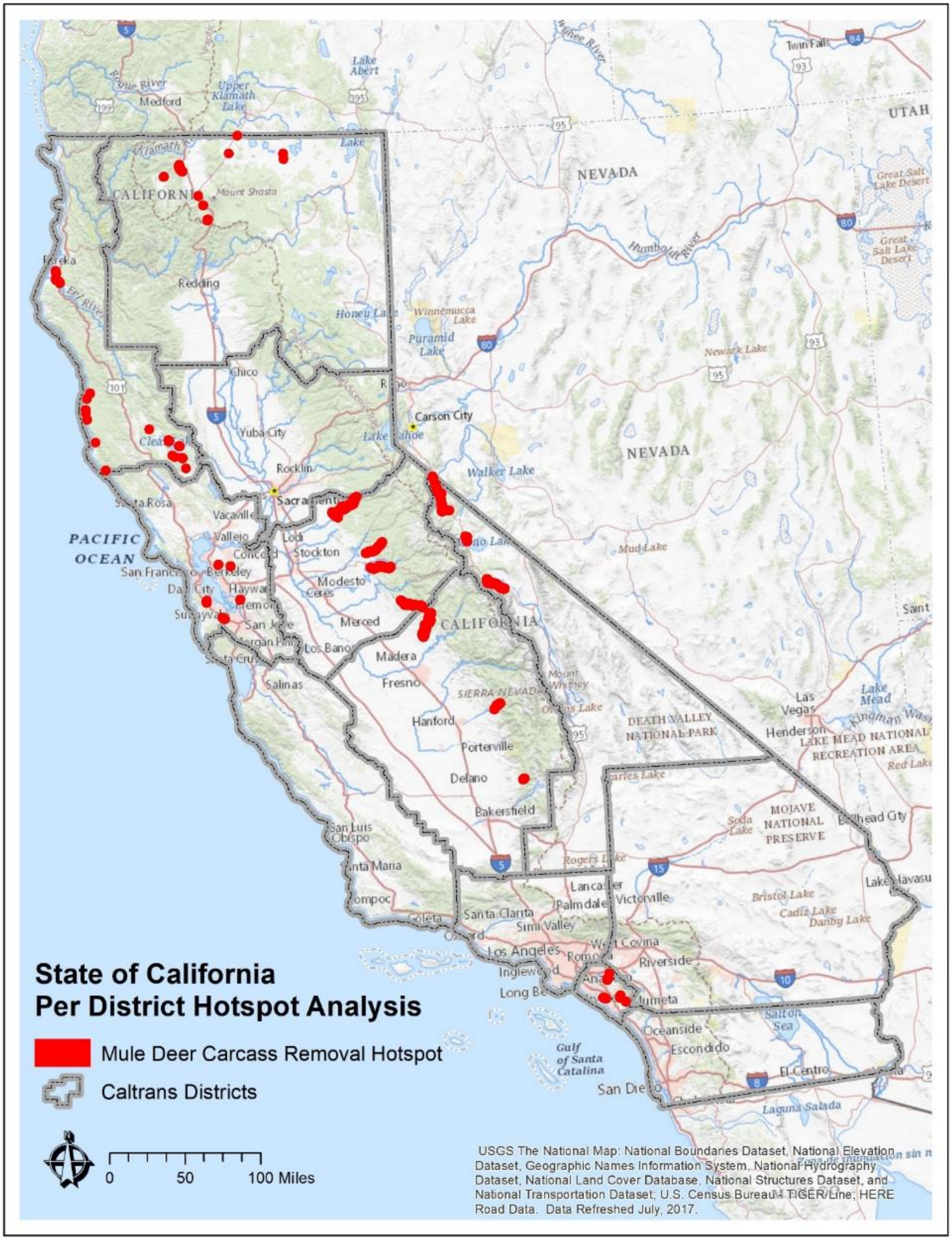

Figure 11: The "worst" hot spots based on mule deer carcasses within each Caltrans district.

Table 12: The "worst" hot spots based on analyses for deer-vehicle crashes per Caltrans district. Note: AADT = Annual Average Daily Traffic.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
1a	1	Del Norte	Crescent City	US Hwy 101	1_DN_101_239	1_DN_101_233	orange	0.6	0.3	0.3	0.0	2	No	4,450
1b	1	Humboldt	Orick	US Hwy 101	1_HUM_101_1150	1_HUM_101_1142	red	0.8	0.4	0.2	0.2	2	Yes	4,050
1c	1	Humboldt	Arcata	US Hwy 101	1_HUM_101_878	1_HUM_101_875	yellow	0.3	0.3	0.0	0.0	4	No	38,200
1d	1	Humboldt	Redway	US Hwy 101	1_HUM_101_147	1_HUM_101_143	yellow	0.4	0.4	0.0	0.0	4	No	8,100
1e	1	Humboldt	Redway	US Hwy 101	1_HUM_101_102	1_HUM_101_100	yellow	0.2	0.2	0.0	0.0	5	No	7,650
1f	1	Humboldt	Redway	US Hwy 101	1_HUM_101_70	1_HUM_101_69	yellow	0.1	0.1	0.0	0.0	4	No	6,850
1g	1	Mendocino	Laytonville	US Hwy 101	1_MEN_101_668	1_MEN_101_665	yellow	0.3	0.3	0.0	0.0	2	No	7,800
1h	1	Mendocino	Willits	US Hwy 101	1_MEN_101_426	1_MEN_101_424	yellow	0.2	0.2	0.0	0.0	4	No	21,000
2a	2	Siskiyou	Hornbrook	I-5	2_SIS_5_651	2_SIS_5_636	yellow	2.5	0.8	0.0	0.0	4	Yes	16,200
2b	2	Siskiyou	Yreka	I-5	2_SIS_5_486	2_SIS_5_483	yellow	0.3	0.3	0.0	0.0	4	Yes	16,550
2c	2	Siskiyou	Yreka	I-5	2_SIS_5_450	2_SIS_5_444	orange	0.6	0.3	0.3	0.0	4	No	18,850
2d	2	Siskiyou	Mt. Shasta	I-5	2_SIS_5_100	2_SIS_5_95	orange	0.5	0.2	0.3	0.0	4	No	22,350
2e	2	Tehama	Red Bluff	I-5	2_TEH_5_319	2_TEH_5_314	yellow	0.5	0.5	0.0	0.0	5	Yes	42,750
2f	2	Tehama	Red Bluff	I-5	2_TEH_5_276	2_TEH_5_271	yellow	0.5	0.2	0.3	0.0	4	No	38,500
2g	2	Lassen	Susanville	US Hwy 395	2_LAS_395_557	2_LAS_395_501	red	5.6	2.3	0.8	0.2	3	Yes	6,950
2h	2	Siskiyou	Black Butte	I-5	2_SIS_5_149	2_SIS_5_145	yellow	0.4	0.4	0.0	0.0	4	No	24,800
3a	3	El Dorado	Placerville	US Hwy 50	3_ED_50_229	3_ED_50_220	red	0.9	0.2	0.5	0.2	4	No	27,450
3b	3	El Dorado	Perks Corner	US Hwy 50	3_ED_50_152	3_ED_50_115	orange	3.7	1.4	0.2	0.0	4	Yes	10,600
3c	3	El Dorado	Shingle Springs	US Hwy 50	3_ED_50_88	3_ED_50_54	yellow	3.4	1.1	0.0	0.0	6	No	66,200
3d	3	Sacramento	Rancho Murieta	Hwy 16	3_SAC_16_197	3_SAC_16_194	yellow	0.3	0.3	0.0	0.0	2	No	11,250
3e	3	Nevada	Grass Valley	Hwy 49/20	3_NEV_20_150	3_NEV_20_135	yellow	0.5	0.5	0.0	0.0	6	No	21,800
3f	3	Nevada	Grass Valley	Hwy 20	3_NEV_20_115	3_NEV_20_111	yellow	0.4	0.4	0.0	0.0	3	No	21,300
3g	3	Nevada	Penn Valley	Hwy 20	3_NEV_20_70	3_NEV_20_66	orange	0.4	0.2	0.2	0.0	3	No	15,800
3h	3	Nevada	La Barr Meadows	Hwy 49	3_NEV_49_121	3_NEV_49_117	orange	0.4	0.2	0.2	0.0	3	No	24,500
3i	3	Nevada	Alta Sierra	Hwy 49	3_NEV_49_90	3_NEV_49_79	orange	1.1	0.5	0.2	0.0	3	No	23,550
3j	3	Nevada	Higgins Corner	Hwy 49	3_NEV_49_40	3_NEV_49_26	orange	1.4	0.7	0.3	0.0	2	Yes	23,200
3k	3	Placer	Overhill Dr	Hwy 49	3_PLA_49_113	3_PLA_49_110	yellow	0.3	0.3	0.0	0.0	4	No	30,700
3l	3	Placer	Elders Corner	Hwy 49	3_PLA_49_81	3_PLA_49_78	orange	0.3	0.3	0.0	0.0	4	No	32,500
3m	3	Placer	Weimar	I-80	3_PLA_80_295	3_PLA_80_291	yellow	0.4	0.4	0.0	0.0	5	Yes	39,450

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
4a	4	Marin	San Rafael	US Hwy 101	4_MRN_101_128	4_MRN_101_125	yellow	0.3	0.3	0.0	0.0	10	No	202,700
4b	4	Marin	Strawberry	US Hwy 101	4_MRN_101_59	4_MRN_101_56	yellow	0.3	0.3	0.0	0.0	10	No	152,800
4c	4	San Mateo	Highlands-Baywood Park	I-280	4_SM_280_144	4_SM_280_122	yellow	2.2	1.0	0.0	0.0	10	Yes	129,000
4d	4	San Mateo	Woodside	I-280	4_SM_280_95	4_SM_280_31	orange	6.4	1.7	0.3	0.0	8	Yes	114,000
4e	4	Santa Clara	Stanford	I-280	4_SM_280_2	4_SCL_280_182	yellow	2.6	0.6	0.0	0.0	8	No	121,000
4f	4	Santa Clara	Los Altos Hills	I-280	4_SCL_280_154	4_SCL_280_150	red	0.4	1.0	2.0	1.0	6	No	131,500
4g	4	Contra Costa	Condit	Hwy 24	4_CC_24_78	4_CC_24_76	yellow	0.2	0.2	0.0	0.0	8	No	209,500
4h	4	Contra Costa	Orinda	Hwy 24	4_CC_24_25	4_CC_24_21	yellow	0.4	0.4	0.0	0.0	8	No	188,000
4i	4	Alameda	Redwood Heights	Hwy 13	4_ALA_13_54	4_ALA_13_51	yellow	0.3	0.3	0.0	0.0	4	No	54,600
5a	5	San Luis Obispo	Templeton	US Hwy 101	5_SLO_101_497	5_SLO_101_492	red	0.5	0.2	0.3	0.1	4	Yes	58,850
6a	6	Madera	Oakhurst	Hwy 41	6_MAD_41_352	6_MAD_41_347	red	0.5	0.2	0.2	0.1	3	No	19,000
6b	6	Madera	Oakhurst	Hwy 41	6_MAD_41_317	6_MAD_41_314	yellow	0.3	0.3	0.0	0.0	2	No	19,000
7a	7	Los Angeles	Glendale	Hwy 134	7_LA_134_94	7_LA_134_90	red	0.4	0.1	0.2	0.1	8	No	209,500
7b	7	Los Angeles	Glendale	Hwy 2	7_LA_2_228	7_LA_2_200	orange	2.8	0.7	0.1	0.0	9	No	124,500
7c	7	Los Angeles	Sherman Oaks	I-405	7_LA_405_387	7_LA_405_383	orange	0.4	0.3	0.1	0.0	12	No	253,500
7d	7	Ventura	Casitas Springs	Hwy 33	7_VEN_33_59	7_VEN_33_55	orange	0.4	0.3	0.1	0.0	3	No	26,500
7e	7	Ventura	Moorpark	Hwy 118	7_VEN_118_202	7_VEN_118_200	yellow	0.2	0.2	0.0	0.0	5	No	79,500
8a	8	San Bernardino	Crestline	Hwy 18	8_SBD_18_162	8_SBD_18_151	red	1.1	0.3	0.6	0.2	4	No	16,550
8b	8	San Bernardino	Silverwood Lake	Hwy 138	8_SBD_138_249	8_SBD_138_247	yellow	0.2	0.2	0.0	0.0	2	No	2,925
8c	8	San Bernardino	Running Springs	Hwy 330	8_SBD_330_433	8_SBD_330_407	orange	2.6	0.6	0.3	0.0	2	No	11,500
8d	8	San Bernardino	Running Springs	Hwy 18	8_SBD_18_294	8_SBD_18_290	yellow	0.4	0.4	0.0	0.0	2	No	5,750
8e	8	San Bernardino	Skyforest	Hwy 18	8_SBD_18_263	8_SBD_18_261	yellow	0.2	0.2	0.0	0.0	2	No	5,750
8f	8	Riverside	Palo Verde Intake	US Hwy 95	8_RIV_95_125	8_RIV_95_123	yellow	0.2	0.2	0.0	0.0	2	No	1,300

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
9a	9	Mono	Bridgeport	US Hwy 395	9_MNO_395_819	9_MNO_395_809	red	1.0	0.5	0.3	0.2	2	No	3,050
9b	9	Mono	Whitmore Hot Spr.	US Hwy 395	9_MNO_395_202	9_MNO_395_195	red	0.7	0.3	0.3	0.1	4	No	7,250
9c	9	Mono	Grant Lake	US Hwy 395	9_MNO_395_448	9_MNO_395_445	yellow	0.3	0.3	0.0	0.0	4	No	4,625
10a	10	Mariposa	Bootjack	Hwy 49	10_MPA_49_127	10_MPA_49_111	red	1.6	0.4	0.2	0.2	2	Yes	5,200
10b	10	Calaveras	San Andreas	Hwy 49	10_CAL_49_208	10_CAL_49_205	yellow	0.3	0.3	0.0	0.0	2	Yes	7,250
11a	11	San Diego	Warner Springs	Hwy 79	11_SD_79_363	11_SD_79_357	red	0.6	0.2	0.2	0.2	2	No	1,400
11b	11	San Diego	Santa Ysabel	Hwy 78	11_SD_78_548	11_SD_78_520	red	2.8	0.5	0.3	0.1	2	No	4,425
11c	11	San Diego	Lake Cuyamaca	Hwy 79	11_SD_79_103	11_SD_79_99	yellow	0.4	0.4	0.0	0.0	2	No	1,650
11d	11	San Diego	La Jolla	I-5	11_SD_5_298	11_SD_5_295	yellow	0.3	0.3	0.0	0.0	12	No	174,500
12a	12	Orange	Las Flores	Hwy 241	12_ORA_241_168	12_ORA_241_152	red	1.6	0.3	0.2	0.1	4	Yes	6,900
12b	12	Orange	Peters Cany. Res.	Hwy 261	12_ORA_261_59	12_ORA_261_56	yellow	0.3	0.3	0.0	0.0	5	Yes	32,200
12c	12	Orange	Villa Park	Hwy 241	12_ORA_241_388	12_ORA_241_385	yellow	0.3	0.3	0.0	0.0	9	No	47,800
12d	12	Orange	Laguna Woods	Hwy 73	12_ORA_73_167	12_ORA_73_165	yellow	0.2	0.2	0.0	0.0	7	No	62,700

Table 13: The "worst" hot spots based on analyses for mule deer carcasses per Caltrans district.
Note: AADT = Annual Average Daily Traffic.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
1A	1	Humboldt	Eureka	US Hwy 101	1_HUM_101_704	1_HUM_101_681	red	2.3	0.9	0.7	0.1	4	yes	24150
1B	1	Humboldt	Fortuna	US Hwy 101	1_HUM_101_641	1_HUM_101_601	yellow	4.0	1.5	0.0	0.0	4	yes	24000
1C	1	Mendocino	Inglenook	Hwy 1	1_MEN_1_685	1_MEN_1_681	yellow	0.4	0.4	0.0	0.0	2	No	4925
1D	1	Mendocino	Fort Bragg	Hwy 1	1_MEN_1_640	1_MEN_1_636	yellow	0.4	0.4	0.0	0.0	2	No	4925
1E	1	Mendocino	Caspar	Hwy 1	1_MEN_1_554	1_MEN_1_534	yellow	2.0	0.5	0.0	0.0	2	Yes	10200
1F	1	Mendocino	Little River	Hwy 1	1_MEN_1_483	1_MEN_1_479	yellow	0.4	0.4	0.0	0.0	2	Yes	3750
1G	1	Mendocino	Elk	Hwy 1	1_MEN_1_275	1_MEN_1_272	yellow	0.3	0.3	0.0	0.0	2	No	1300
1H	1	Mendocino	Anchor Bay	Hwy 1	1_MEN_1_30	1_MEN_1_28	yellow	0.2	0.2	0.0	0.0	2	No	3500
1I	1	Lake	Blue Lakes	Hwy 20	1_LAK_20_10	1_LAK_20_12	yellow	0.2	0.2	0.0	0.0	2	No	9650
1J	1	Lake	Pepperwood Grove	Hwy 20	1_LAK_20_180	1_LAK_20_192	yellow	1.2	0.6	0.0	0.0	2	No	8100
1K	1	Lake	Clearlake Oaks	Hwy 20	1_LAK_20_289	1_LAK_20_297	yellow	0.8	0.6	0.0	0.0	2	No	8150
1L	1	Lake	Riviera Estates	Hwy 281	1_LAK_281_167	1_LAK_281_169	yellow	0.1	0.1	0.0	0.0	2	No	6400
1M	1	Lake	Jct Hwy 281	Hwy 29	1_LAK_29_262	1_LAK_29_259	yellow	0.3	0.3	0.0	0.0	2	No	9350
1N	1	Lake	Lower lake	Hwy 29	1_LAK_29_207	1_LAK_29_198	yellow	0.9	0.6	0.0	0.0	2	No	10900
1O	1	Lake	Hidden Valley L.	Hwy 29	1_LAK_29_112	1_LAK_29_110	yellow	0.2	0.2	0.0	0.0	2	No	9900
2A	2	Siskiyou	Yreka	I-5	2_SIS_5_471	2_SIS_5_418	red	6.3	1.3	0.3	0.2	4	Yes	19000
2B	2	Siskiyou	Weed	I-5	2_SIS_5_202	2_SIS_5_199	yellow	0.3	0.3	0.0	0.0	4	No	17050
2C	2	Siskiyou	Mt. Shasta	I-5	2_SIS_5_126	2_SIS_5_122	yellow	0.4	0.4	0.0	0.0	4	No	23900
2D	2	Siskiyou	Dunsmuir	I-5	2_SIS_5_15	2_SIS_5_4	yellow	1.1	0.5	0.0	0.0	4	No	20350
2E	2	Siskiyou	Ft. Jones	Hwy 3	2_SIS_3_332	2_SIS_3_329	yellow	0.3	0.3	0.0	0.0	2	No	3625
2F	2	Siskiyou	Indian Tom Lake	US Hwy 97	2_SIS_97_540	2_SIS_97_524	yellow	0.3	0.3	0.0	0.0	2		665
2G	2	Siskiyou	Macdoel	US Hwy 97	2_SIS_97_405	2_SIS_97_403	yellow	0.2	0.2	0.0	0.0	2	No	1190
2H	2	Modoc	Hannchen	Hwy 139	2_MOD_139_391	2_MOD_139_385	yellow	0.6	0.6	0.0	0.0	2	No	1625
2I	2	Modoc	Hannchen	Hwy 139	2_MOD_139_356	2_MOD_139_353	yellow	0.3	0.3	0.0	0.0	2	No	1625
	3	Insufficient data												
4A	4	San Mateo	Highlands-Baywood P.	Hwy 92	4_SM_92_96	4_SM_92_79	orange	1.7	0.9	0.1	0.0	4	No	77200
4B	4	Santa Clara	Los Altos Hills	I-280	4_SCL_280_165	4_SCL_280_144	orange	2.1	0.6	0.2	0.0	8	No	131500

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
4C	4	Alameda	Mission San Jose	I-680	4_ALA_680_67	4_ALA_680_64	red	0.5	0.2	0.2	0.1	6	No	155400
4D	4	Contra Costa	Orinda	Hwy 24	4_CC_24_27	4_CC_24_19	orange	0.8	0.2	0.6	0.0	8	No	188000
4E	4	Contra Costa	Alamo	I-680	4_CC_680_116	4_CC_680_110	orange	0.6	0.3	0.3	0.0	6	No	153850
	5	Insufficient data												
6A	6	Madera	Oakhurst	Hwy 41	6_MAD_41_393	6_MAD_41_196	red	19.7	2.6	0.6	0.3	2	No	19000
6B	6	Tuolumne	Three Rivers	Hwy 198	6_TUL_198_374	6_TUL_198_369	red	0.5	0.2	0.2	0.1	2	Yes	4525
6C	6	Tuolumne	Three Rivers	Hwy 198	6_TUL_198_440	6_TUL_198_400	yellow	4.4	0.6	0.0	0.0	2	Yes	3175
6D	6	Kern	Alta Sierra	Hwy 155	6_KER_155_491	6_KER_155_469	yellow	2.2	0.2	0.0	0.0	2	No	355
	7	Insufficient data												
	8	Insufficient data												
9A	9	Mono	Topaz Lake	US Hwy 395	9_MNO_395_1201	9_MNO_395_1178	orange	2.3	0.6	0.3	0.0	2	No	3900
9B	9	Mono	Walker	US Hwy 395	9_MNO_395_1143	9_MNO_395_1058	red	8.5	1.7	1.2	0.8	2	Yes	3550
9C	9	Mono	Walker	US Hwy 395	9_MNO_395_1032	9_MNO_395_1008	orange	2.4	0.5	0.1	0.0	2	No	3425
9D	9	Mono	Sonora Junction	US Hwy 395	9_MNO_395_989	9_MNO_395_878	orange	11.1	3.6	0.7	0.0	2	Yes	3425
9E	9	Mono	Mono City	US Hwy 395	9_MNO_395_641	9_MNO_395_579	orange	6.2	0.8	0.1	0.0	4	Yes	3350
9F	9	Mono	Whitmore Hot Sprs.	US Hwy 395	9_MNO_395_282	9_MNO_395_134	red	15.6	2.4	0.6	0.1	4	Yes	7200
10A	10	Amador	Pine Grove	Hwy 88	10_AMA_88_377	10_AMA_88_149	red	22.6	10.8	10.2	0.5	2	No	8250
10B	10	Amador	Jackson	Hwy 49	10_AMA_49_58	10_AMA_49_0	orange	5.8	0.2	1.6	0.0	2	No	8100
10C	10	Tuolumne	Mono Vista	Hwy 108	10_TUO_108_154	10_TUO_108_0	orange	15.4	5.3	0.2	0.0	2	Yes	3975
10D	10	Tuolumne	Moccasin	Hwy 120	10_TUO_120_244	10_TUO_120_219	orange	3.0	2.0	0.2	0.0	2	Yes	4425
10E	10	Tuolumne	Groveland	Hwy 120	10_TUO_120_410	10_TUO_120_303	orange	10.7	2.1	0.1	0.0	2	No	6225
10F	10	Mariposa	Bootjack	Hwy 49	10_MPA_49_196	10_MPA_49_78	orange	11.8	3.0	0.3	0.0	2	Yes	5200
10G	10	Mariposa	Bootjack	Hwy 49	10_MPA_49_38	10_MPA_49_9	orange	2.9	1.1	0.1	0.0	2	No	3500
	11	Insufficient data												
12A	12	Orange	Peters Canyon Reservoir	Hwy 241	12_ORA_241_339	12_ORA_241_321	red	1.8	0.8	0.2	0.1	6	Yes	40150
12B	12	Orange	Las Flores	Hwy 241	12_ORA_241_170	12_ORA_241_150	orange	2.0	0.5	0.1	0.0	4	Yes	6900
12C	12	Orange	San Joaquin Hills	Hwy 73	12_ORA_73_198	12_ORA_73_173	orange	2.5	1.0	0.2	0.0	8	Yes	67650

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
12D	12	Orange	Peters Canyon Reservoir	Hwy 241	12_ORA_241_373	12_ORA_241_369	yellow	0.4	0.4	0.0	0.0	7	Yes	47800
12E	12	Orange	Rancho Mission Viejo	Hwy 74	12_ORA_74_97	12_ORA_74_93	yellow	0.4	0.4	0.0	0.0	2	No	11100

Maps of the Reported Carcasses for Selected Other Species

The locations of the reported carcasses of black bear, elk, mountain lion, bighorn sheep, pronghorn, and wild boar carcasses are shown in Figures 12-17. Black bear carcasses were reported from north-west California, along east and west slopes of the Sierra Nevada, and areas north, west, and east of Los Angeles (Figure 12). Elk carcasses were reported from northern California, north-western California, and along the eastern slope of the Sierra Nevada (Figure 13). Mountain lion carcasses were rarely reported, but have been found from north to south in the state (Figure 14). Bighorn sheep carcasses were reported in the Mojave Desert (Figure 15). The one pronghorn carcass was reported from near the Oregon border (Figure 16). Wild boar carcasses were reported from the western foothills of the Sierra Nevada between Fresno and Bakersfield (Figure 17).

Figure 12: The locations of the reported black bear carcasses.

Figure 13: The locations of the reported elk carcasses.

Figure 14: The locations of the reported mountain lion carcasses.

Figure 15: The locations of the reported bighorn sheep carcasses.

Figure 16: The locations of the reported pronghorn carcasses.

Figure 17: The locations of the reported wild boar carcasses.

4.4. Discussion

In some districts (Caltrans Districts 2, 4, 6, 9, 10, and 12) there is at least some spatial similarity between the hot spots based on deer-vehicle crash data and mule deer carcass data. Since these two data sources are independent, this makes it more likely that there is indeed a relatively high concentration of deer-vehicle collisions along these road sections. However, there is also evidence of missing mule deer carcass data from certain areas, especially in Districts 1 and 2.

In addition to the general underreporting of mule deer carcasses compared to crash data in all districts except District 10 (see Chapter 3), the hot spot analyses in this chapter illustrate that in at least some of the districts (i.e. Districts 1 and 2) some areas within a district did not report any mule deer carcasses whereas these same areas did report deer-vehicle crashes, sometimes in high enough numbers to result in the identification of hot spots. This suggests that the quality of the mule deer carcass data can benefit from more consistent search and reporting effort in the different areas of some districts. Practical suggestions include verification that all maintenance crews do record and submit mule deer carcasses, especially along road sections already identified as hot spots based on deer-vehicle crash data, and that these records are entered in the central database. Regular data entry and standard data summary reports can help identify areas from which mule deer carcasses are substantially below the expected number of observations.

5. PRIORITIZATION DEER-VEHICLE CRASH AND MULE DEER CARCASS HOT SPOTS

5.1. Introduction

Chapter 4 identified the worst deer-vehicle crash and mule deer carcass hot spots based on a statewide analysis (crash data only) and analyses per Caltrans district (crash and carcass data). In this chapter, these hot spots are prioritized based on parameters related to human safety, biological conservation, and economics.

5.2. Methods

The deer-vehicle crash and mule deer carcass hot spots were prioritized based on three types of parameters:

- **Human safety:** the absolute number of deer-vehicle crashes or mule deer carcasses recorded in each hot spot over 10 years (crash data 2005 through 2014; carcass data 2000 through 2009).
- **Biological conservation:** whether the hot spot was (partially) located in or adjacent to one or both of the following types of areas:
    - A "Natural Landscape Block" or an "Essential Connectivity Area" (Figure 18). The researchers used existing maps generated through the California Essential Habitat Connectivity Project (Spencer et al., 2010) to identify areas that are considered most important to a spatial network of areas important to nature conservation. The maps distinguish between "Natural Landscape Blocks" and "Essential Connectivity Areas". Natural Landscape Blocks are relatively large areas (blocks ≥10,000 acres (≥4,047 ha)) with relatively high nature conservation values. Essential Connectivity Areas are paths of least resistance between these Natural Landscape Blocks (Spencer et al., 2010). Of the 15,090 highway miles (24,285 km) that are part of this project, 4,048 miles (6,515 km) (26.8%) overlapped with a "Natural Landscape Block" or an "Essential Connectivity Area".
    - Critical habitat for threatened or endangered species (USFWS, 2019) (Figure 19). Of the 15,090 highway miles (24,285 km) that are part of this project, 1,353 miles (2,177 km) (9.0%) overlapped with critical habitat.

  Note that of the 15,090 highway miles (24,285 km) that are part of this project, 4,741 miles (4,741 km) (31.4%) overlapped with either a "Natural Landscape Block", an "Essential Connectivity Area" or critical habitat.
- **Economics:** The total estimated costs associated with deer-vehicle crashes or mule deer carcasses in a hot spot, standardized per mile per year. Each deer-vehicle collision (crash or carcass) was set at $6,617 (Huijser et al., 2009). Note that this value is primarily based on human safety parameters and not on passive use values for wildlife.

Figure 18: "Natural Landscape Block" or an "Essential Connectivity Area" from the California Essential Habitat Connectivity Project (Spencer et al., 2010).

Figure 19: Critical habitat for threatened or endangered species (USFWS, 2019).

Each of the three types of parameters contributed equally to the prioritization process. The human safety, biological conservation and economic parameters each had 100 "points" that were distributed over the hot spots included in that analysis. For example, for the statewide deer-vehicle crash hot spot analysis, there were 13 hot spots, and depending on the number of deer-vehicle crashes in a hot spot, each hot spot received a portion of the 100 human safety points. However, for the "per-district analyses", the 100 points were distributed over the hot spots within each district.

For biological conservation there were two sub-parameters; one for a hot spot being in a Natural Landscape Block or an Essential Connectivity Area and one for a hot spot being in critical habitat for threatened or endangered species. For each hot spot, the researchers tallied whether the hot spot met one, both, or neither of the two sub-parameters. This resulted in a maximum tally of "2" for each hot spot. The researchers then tallied how many points (2 maximum per hot spot) were allotted to all of the hot spots that were part of that particular analysis. Based on this total number, and the tally for the individual hot spots, the 100 points for biological conservation were proportionally distributed over the hot spots.

Finally, the economics parameter was also allotted 100 points that were distributed over the hot spots that were part of the analysis. Note that the economic parameter was expressed in dollars per mile per year. These dollar values can be compared to the economic thresholds for different types and combinations of mitigation measures by Huijser et al. (2009) (Table 14).

The total score for human safety, biological conservation, and for economics was summed and divided by 3. This meant that the sum of the total score for each analysis was 100 points, distributed over the individual hot spots that were part of that analysis. The hot spots were ranked based on this final score.

If a hot spot was in or adjacent to critical habitat, the authors of this report listed the threatened or endangered animal species concerned. Knowing which threatened or endangered animal species are present in or near a hot spot can help guide the design of mitigation measures aimed at reducing deer-vehicle collisions and providing habitat connectivity for a wide range of animal species. It can help guide the design so that threatened or endangered species may also benefit from the mitigation measures, or it can help guide the design so that the threatened or endangered species are not negatively impacted by the mitigation measures.

While it may seem strange to include non-terrestrial animal species (e.g. fish and birds) in this analysis, it is advisable to include all species. For example, if an underpass for large mammals is combined with a stream crossing, knowing about threatened or endangered fish species is important for the decision, design, construction and maintenance phase. Similarly, knowing about threatened or endangered birds in the area can be important for potential vegetation management in the rights-of-way (either as a stand-alone measure, or at the approaches of crossing structures for large wild mammals). We also included all listed animal species in the weighting process for how important a road section is to biological conservation. All animal species can suffer from habitat fragmentation associated with highways; terrestrial species are confronted with open habitat, unnatural substrate (pavement) and traffic, aquatic species may be confronted with changes in hydrology, light, and aquatic vegetation in culverts or other structures under the highway, and flying species may be reluctant to cross the open linear areas resulting from highways and adjacent rights-of-way.

Table 14: Economic thresholds (primarily based on human safety parameters) for the implementation of different types and combinations of mitigation measures (based on Huijser et al., 2009).

Measure	Threshold	
	per km per year	per mile per year
Fence, underpass (one per 2 km (1.24 mile)), jump-outs	$18,123	$29,166.07
Fence, underpass (one per 2 km) and overpass (one per 24 km (14.91 mile)), jump-outs	$24,230	$38,994.31
Animal detection system (ADS)	$37,014	$59,568.11
Fence, gap with ADS (one per 2 km (1.24 mile)), jump-outs	$28,150	$45,302.92

5.3. Results

The scoring results and the final ranking processes for the statewide deer-vehicle crash analyses and the deer-vehicle crash and mule deer carcass analyses per district are summarized in Tables 15 through 17.

Table 15: The ranking of the hot spots based on a statewide analysis for deer-vehicle crashes in the entire State of California.

					Human safety		Biological conservation			Economics		Total	
Hot spot ID#	Dis-trict	County	Nearby town	Highway	Deer crashes (n)	Score	Essential Habitat Connectivity	Critical Habitat USFWS	Score	Deer crashes ($/mi/yr)	Score	Score	Rank
1	1	Del Norte	Crescent City	US Hwy 101	10	5.08	Yes	No	16.67	$33,085.00	10.95	10.90	4
2	1	Humboldt	Orick	US Hwy 101	10	5.08	Yes	Yes	33.33	$22,056.67	7.30	15.24	1
3	2	Siskiyou	Yreka	I-5	5	2.54	No	No	0.00	$33,085.00	10.95	4.50	10
4	2	Siskiyou	Mt. Shasta	I-5	10	5.08	No	No	0.00	$22,056.67	7.30	4.13	11
5	2	Tehama	Red Bluff	I-5	10	5.08	Yes	No	16.67	$22,056.67	7.30	9.68	5
6	2	Lassen	Susanville	US Hwy 395	44	22.34	No	No	0.00	$11,198.00	3.71	8.68	6
7	3	El Dorado	Placerville	US Hwy 50	8	4.06	No	No	0.00	$17,645.33	5.84	3.30	13
8	4	Santa Clara	Los Altos Hills	I-280	10	5.08	No	No	0.00	$33,085.00	10.95	5.34	8
9	5	San Luis Obispo	Templeton	US Hwy 101	19	9.64	No	No	0.00	$25,144.60	8.33	5.99	7
10	6	Madera	Oakhurst	Hwy 41	13	6.60	No	No	0.00	$21,505.25	7.12	4.57	9
11	9	Mono	Bridgeport	US Hwy 395	29	14.72	Yes	No	16.67	$19,189.30	6.35	12.58	2
12	9	Mono	Mammoth Lakes	US Hwy 395	20	10.15	Yes	No	16.67	$22,056.67	7.30	11.37	3
13	10	Mariposa	Mariposa	Hwy 49	9	4.57	No	No	0.00	$19,851.00	6.57	3.71	12

Table 16: The ranking of the hot spots based on analyses for deer-vehicle crashes per Caltrans district.

					Human safety		Biological conservation			Economics		Total	
Hot spot ID#	District	County	Nearby town	Highway	Deer crashes (n)	Score	Essential Habitat Connectivity	Critical Habitat USFWS	Score	Deer crashes ($/mi/yr)	Score	Score	Rank
1a	1	Del Norte	Crescent City	US Hwy 101	11	19.64	Yes	No	25.00	$12,131.17	10.65	18.43	2
1b	1	Humboldt	Orick	US Hwy 101	13	23.21	Yes	Yes	50.00	$10,752.63	9.44	27.55	1
1c	1	Humboldt	Arcata	US Hwy 101	6	10.71	No	No	0.00	$13,234.00	11.62	7.45	6
1d	1	Humboldt	Redway	US Hwy 101	7	12.50	No	Yes	25.00	$11,579.75	10.17	15.89	3
1e	1	Humboldt	Redway	US Hwy 101	5	8.93	No	No	0.00	$16,542.50	14.53	7.82	4
1f	1	Humboldt	Redway	US Hwy 101	3	5.36	No	No	0.00	$19,851.00	17.43	7.60	5
1g	1	Mendocino	Laytonville	US Hwy 101	6	10.71	No	No	0.00	$13,234.00	11.62	7.45	6
1h	1	Mendocino	Willits	US Hwy 101	5	8.93	No	No	0.00	$16,542.50	14.53	7.82	4
2a	2	Siskiyou	Hornbrook	I-5	19	11.45	Yes	No	25.00	$5,028.92	4.95	13.80	4
2b	2	Siskiyou	Yreka	I-5	8	4.82	No	No	0.00	$17,645.33	17.38	7.40	5
2c	2	Siskiyou	Yreka	I-5	13	7.83	No	No	0.00	$14,336.83	14.12	7.32	6
2d	2	Siskiyou	Mt. Shasta	I-5	11	6.63	No	No	0.00	$14,557.40	14.34	6.99	7
2e	2	Tehama	Red Bluff	I-5	10	6.02	Yes	No	25.00	$13,234.00	13.03	14.69	2
2f	2	Tehama	Red Bluff	I-5	10	6.02	Yes	No	25.00	$13,234.00	13.03	14.69	2
2g	2	Lassen	Susanville	US Hwy 395	87	52.41	No	No	0.00	$10,279.98	10.12	20.84	1
2h	2	Siskiyou	Black Butte	I-5	8	4.82	Yes	No	25.00	$13,234.00	13.03	14.28	3
3a	3	El Dorado	Placerville	US Hwy 50	19	10.80	No	No	0.00	$13,969.22	9.63	6.81	3
3b	3	El Dorado	Perks Corner	US Hwy 50	35	19.89	No	No	0.00	$6,259.32	4.32	8.07	2
3c	3	El Dorado	Shingle Springs	US Hwy 50	28	15.91	No	No	0.00	$5,449.29	3.76	6.56	4
3d	3	Sacramento	Rancho Murieta	Hwy 16	5	2.84	Yes	No	100.00	$11,028.33	7.60	36.82	1
3e	3	Nevada	Grass Valley	Hwy 49/20	13	7.39	No	No	0.00	$17,204.20	11.86	6.42	5
3f	3	Nevada	Grass Valley	Hwy 20	6	3.41	No	No	0.00	$9,925.50	6.84	3.42	10
3g	3	Nevada	Penn Valley	Hwy 20	7	3.98	No	No	0.00	$11,579.75	7.99	3.99	9
3h	3	Nevada	La Barr Meadows	Hwy 49	7	3.98	No	No	0.00	$11,579.75	7.99	3.99	9
3i	3	Nevada	Alta Sierra	Hwy 49	15	8.52	No	No	0.00	$9,023.18	6.22	4.91	6
3j	3	Nevada	Higgins Corner	Hwy 49	22	12.50	No	No	0.00	$10,398.14	7.17	6.56	4
3k	3	Placer	Overhill Dr	Hwy 49	6	3.41	No	No	0.00	$13,234.00	9.13	4.18	8
3l	3	Placer	Elders Corner	Hwy 49	7	3.98	No	No	0.00	$15,439.67	10.65	4.87	7
3m	3	Placer	Weimar	I-80	6	3.41	No	No	0.00	$9,925.50	6.84	3.42	10

					Human safety		Biological conservation			Economics		Total	
Hot spot ID#	**Dis-trict**	**County**	**Nearby town**	**Highway**	**Deer crashes (n)**	**Score**	**Essential Habitat Connectivity**	**Critical Habitat USFWS**	**Score**	**Deer crashes ($/mi/yr)**	**Score**	**Score**	**Rank**
4a	4	Marin	San Rafael	US Hwy 101	6	4.38	Yes	No	10.00	$13,234.00	9.13	7.84	6
4b	4	Marin	Strawberry	US Hwy 101	6	4.38	No	No	0.00	$13,234.00	9.13	4.50	9
4c	4	San Mateo	Highlands-Baywood Park	I-280	19	13.87	Yes	Yes	20.00	$5,714.68	3.94	12.60	2
4d	4	San Mateo	Woodside	I-280	62	45.26	Yes	Yes	20.00	$6,410.22	4.42	23.23	1
4e	4	Santa Clara	Stanford	I-280	14	10.22	Yes	No	10.00	$3,563.00	2.46	7.56	7
4f	4	Santa Clara	Los Altos Hills	I-280	10	7.30	Yes	No	10.00	$16,542.50	11.41	9.57	4
4g	4	Contra Costa	Condit	Hwy 24	5	3.65	Yes	No	10.00	$16,542.50	11.41	8.35	5
4h	4	Contra Costa	Orinda	Hwy 24	7	5.11	Yes	Yes	20.00	$11,579.75	7.99	11.03	3
4i	4	Alameda	Redwood Heights	Hwy 13	8	5.84	No	No	0.00	$17,645.33	12.17	6.00	8
5a	5	San Luis Obispo	Templeton	US Hwy 101	19	100.00	No	No	100	$25,144.60	100	100	1
6a	6	Madera	Oakhurst	Hwy 41	15	71.43	No	No	0	$19,851.00	58.41	43.28	1
6b	6	Madera	Oakhurst	Hwy 41	6	28.57	No	No	0	$13,234.00	38.94	22.50	2
7a	7	Los Angeles	Glendale	Hwy 134	8	19.05	No	No	0.00	$13,234.00	26.17	15.07	4
7b	7	Los Angeles	Glendale	Hwy 2	18	42.86	No	No	0.00	$4,253.79	8.41	17.09	3
7c	7	Los Angeles	Sherman Oaks	I-405	6	14.29	No	No	0.00	$9,925.50	19.63	11.30	5
7d	7	Ventura	Casitas Springs	Hwy 33	6	14.29	Yes	Yes	50.00	$9,925.50	19.63	27.97	2
7e	7	Ventura	Moorpark	Hwy 118	4	9.52	Yes	Yes	50.00	$13,234.00	26.17	28.56	1
8a	8	San Bernardino	Crestline	Hwy 18	6	23.08	Yes	No	16.67	$3,609.27	11.06	16.94	4
8b	8	San Bernardino	Silverwood Lake	Hwy 138	2	7.69	Yes	Yes	33.33	$6,617.00	20.28	20.44	2
8c	8	San Bernardino	Running Springs	Hwy 330	10	38.46	Yes	No	16.67	$2,545.00	7.80	20.98	1
8d	8	San Bernardino	Running Springs	Hwy 18	4	15.38	Yes	No	16.67	$6,617.00	20.28	17.44	3
8e	8	San Bernardino	Skyforest	Hwy 18	2	7.69	Yes	No	16.67	$6,617.00	20.28	14.88	5
8f	8	Riverside	Palo Verde Intake	US Hwy 95	2	7.69	No	No	0.00	$6,617.00	20.28	9.33	6

					Human safety		Biological conservation			Economics		Total	
Hot spot ID#	**Dis-trict**	**County**	**Nearby town**	**Highway**	**Deer crashes (n)**	**Score**	**Essential Habitat Connectivity**	**Critical Habitat USFWS**	**Score**	**Deer crashes ($/mi/yr)**	**Score**	**Score**	**Rank**
9a	9	Mono	Bridgeport	US Hwy 395	30	50.85	Yes	No	33.33	$19,851.00	34.62	39.60	1
9b	9	Mono	Whitmore Hot Springs	US Hwy 395	21	35.59	Yes	No	33.33	$19,851.00	34.62	34.51	2
9c	9	Mono	Grant Lake	US Hwy 395	8	13.56	Yes	No	33.33	$17,645.33	30.77	25.89	3
10a	10	Mariposa	Bootjack	Hwy 49	22	84.62	No	No	0.00	$9,098.38	50.77	45.13	2
10b	10	Calaveras	San Andreas	Hwy 49	4	15.38	Yes	No	100.00	$8,822.67	49.23	54.87	1
11a	11	San Diego	Warner Springs	Hwy 79	6	27.27	Yes	Yes	50.00	$6,617.00	32.19	36.49	1
11b	11	San Diego	Santa Ysabel	Hwy 78	10	45.45	Yes	No	25.00	$2,363.21	11.49	27.32	2
11c	11	San Diego	Lake Cuyamaca	Hwy 79	3	13.64	Yes	No	25.00	$4,962.75	24.14	20.93	3
11d	11	San Diego	La Jolla	I-5	3	13.64	No	No	0.00	$6,617.00	32.19	15.27	4
12a	12	Orange	Las Flores	Hwy 241	12	52.17	No	No	0.00	$4,962.75	15.25	22.48	2
12b	12	Orange	Peters Canyon Reservoir	Hwy 261	4	17.39	No	No	0.00	$8,822.67	27.12	14.84	3
12c	12	Orange	Villa Park	Hwy 241	4	17.39	No	No	0.00	$8,822.67	27.12	14.84	3
12d	12	Orange	Laguna Woods	Hwy 73	3	13.04	Yes	No	100.00	$9,925.50	30.51	47.85	1

Table 17: The ranking of the hot spots based on analyses for mule deer carcasses per Caltrans district.

					Human safety		Biological conservation			Economics		Total	
Hot spot ID#	Dis-trict	County	Nearby town	Highway	Mule deer car-casses (n)	Score	Essential Habitat Connectivity	Critical Habitat USFWS	Score	Mule deer carcasses ($/mi/yr)	Score	Score	Rank
1A	1	Humboldt	Eureka	US Hwy 101	20	25.32	No	Yes	25.00	$5,753.91	8.16	19.49	1
1B	1	Humboldt	Fortuna	US Hwy 101	19	24.05	No	Yes	25.00	$3,143.08	4.46	17.84	2
1C	1	Mendocino	Inglenook	Hwy 1	3	3.80	No	No	0.00	$4,962.75	7.04	3.61	9
1D	1	Mendocino	Fort Bragg	Hwy 1	3	3.80	No	No	0.00	$4,962.75	7.04	3.61	9
1E	1	Mendocino	Caspar	Hwy 1	5	6.33	No	No	0.00	$1,654.25	2.35	2.89	12
1F	1	Mendocino	Little River	Hwy 1	2	2.53	Yes	No	25.00	$3,308.50	4.69	10.74	4
1G	1	Mendocino	Elk	Hwy 1	2	2.53	No	No	0.00	$4,411.33	6.26	2.93	11
1H	1	Mendocino	Anchor Bay	Hwy 1	2	2.53	No	No	0.00	$6,617.00	9.39	3.97	6
1I	1	Lake	Blue Lakes	Hwy 20	2	2.53	Yes	No	25.00	$6,617.00	9.39	12.31	3
1J	1	Lake	Pepperwood Grove	Hwy 20	5	6.33	No	No	0.00	$2,757.08	3.91	3.41	11
1K	1	Lake	Clearlake Oaks	Hwy 20	6	7.59	No	No	0.00	$4,962.75	7.04	4.88	5
1L	1	Lake	Riviera Estates	Hwy 281	1	1.27	No	No	0.00	$6,617.00	9.39	3.55	10
1M	1	Lake	Jct Hwy 281	Hwy 29	2	2.53	No	No	0.00	$4,411.33	6.26	2.93	11
1N	1	Lake	Lower lake	Hwy 29	5	6.33	No	No	0.00	$3,676.11	5.22	3.85	8
1O	1	Lake	Hidden Valley lake	Hwy 29	2	2.53	No	No	0.00	$6,617.00	9.39	3.97	6
2A	2	Siskiyou	Yreka	I-5	35	58.33	No	No	0.00	$3,676.11	8.39	22.24	1
2B	2	Siskiyou	Weed	I-5	3	5.00	No	No	0.00	$6,617.00	15.11	6.70	7
2C	2	Siskiyou	Mt. Shasta	I-5	2	3.33	Yes	No	20.00	$3,308.50	7.55	10.30	6
2D	2	Siskiyou	Dunsmuir	I-5	8	13.33	Yes	No	20.00	$4,812.36	10.99	14.77	2
2E	2	Siskiyou	Ft. Jones	Hwy 3	3	5.00	No	No	0.00	$6,617.00	15.11	6.70	7
2F	2	Siskiyou	Indian Tom Lake	US Hwy 97	2	3.33	No	No	0.00	$4,411.33	10.07	4.47	8
2G	2	Siskiyou	Macdoel	US Hwy 97	2	3.33	Yes	No	20.00	$6,617.00	15.11	12.81	3
2H	2	Modoc	Hannchen	Hwy 139	3	5.00	Yes	No	20.00	$3,308.50	7.55	10.85	5
2I	2	Modoc	Hannchen	Hwy 139	2	3.33	Yes	No	20.00	$4,411.33	10.07	11.14	4

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Human safety		Biological conservation			Economics		Total	
					Mule deer car-casses (n)	Score	Essential Habitat Connectivity	Critical Habitat USFWS	Score	Mule deer carcasses ($/mi/yr)	Score	Score	Rank
	3	Insufficient data											
4A	4	San Mateo	Highlands-Baywood Park	Hwy 92	16	37.21	Yes	No	20.00	$6,227.76	22.57	26.59	2
4B	4	Santa Clara	Los Altos Hills	I-280	9	20.93	Yes	No	20.00	$2,835.86	10.28	17.07	3
4C	4	Alameda	Mission San Jose	I-680	4	9.30	Yes	No	20.00	$5,293.60	19.19	16.16	4
4D	4	Contra Costa	Orinda	Hwy 24	8	18.60	Yes	Yes	40.00	$6,617.00	23.98	27.53	1
4E	4	Contra Costa	Alamo	I-680	6	13.95	No	No	0.00	$6,617.00	23.98	12.65	5
	5	Insufficient data											
6A	6	Madera	Oakhurst	Hwy 41	28	71.79	No	No	0.00	$940.49	16.97	29.59	2
6B	6	Tuolumne	Three Rivers	Hwy 198	2	5.13	No	No	0.00	$2,646.80	47.76	17.63	3
6C	6	Tuolumne	Three Rivers	Hwy 198	5	12.82	Yes	No	100.00	$751.93	13.57	42.13	1
6D	6	Kern	Alta Sierra	Hwy 155	4	10.26	No	No	0.00	$1,203.09	21.71	10.65	4
	7	Insufficient data											
	8	Insufficient data											
9A	9	Mono	Topaz Lake	US Hwy 395	19	5.16	No	No	0.00	$5,466.22	18.67	7.94	6
9B	9	Mono	Walker	US Hwy 395	81	22.01	Yes	No	20.00	$6,305.61	21.53	21.18	3
9C	9	Mono	Walker	US Hwy 395	8	2.17	Yes	No	20.00	$2,205.67	7.53	9.90	5
9D	9	Mono	Sonora Junction	US Hwy 395	103	27.99	Yes	No	20.00	$6,140.10	20.97	22.99	2
9E	9	Mono	Mono City	US Hwy 395	39	10.60	Yes	No	20.00	$4,162.31	14.21	14.94	4
9F	9	Mono	Whitmore Hot Springs	US Hwy 395	118	32.07	Yes	No	20.00	$5,005.17	17.09	23.05	1

					Human safety		Biological conservation			Economics		Total	
Hot spot ID#	**Dis-trict**	**County**	**Nearby town**	**Highway**	**Mule deer car-casses (n)**	**Score**	**Essential Habitat Connectivity**	**Critical Habitat USFWS**	**Score**	**Mule deer carcasses ($/mi/yr)**	**Score**	**Score**	**Rank**
10A	10	Amador	Pine Grove	Hwy 88	587	52.60	Yes	No	50.00	$17,186.63	28.85	43.82	1
10B	10	Amador	Jackson	Hwy 49	80	7.17	Yes	No	50.00	$9,126.90	15.32	24.16	2
10C	10	Tuolumne	Mono Vista	Hwy 108	222	19.89	No	No	0.00	$9,538.79	16.01	11.97	3
10D	10	Tuolumne	Moccasin	Hwy 120	43	3.85	No	No	0.00	$9,484.37	15.92	6.59	4
10E	10	Tuolumne	Groveland	Hwy 120	81	7.26	No	No	0.00	$5,009.13	8.41	5.22	5
10F	10	Mariposa	Bootjack	Hwy 49	83	7.44	No	No	0.00	$4,654.33	7.81	5.08	6
10G	10	Mariposa	Bootjack	Hwy 49	20	1.79	No	No	0.00	$4,563.45	7.66	3.15	7
	11	Insufficient data											
12A	12	Orange	Peters Canyon Reservoir	Hwy 241	10	27.78	No	No	0.00	$3,676.11	19.12	15.63	4
12B	12	Orange	Las Flores	Hwy 241	5	13.89	No	No	0.00	$1,654.25	8.60	7.50	5
12C	12	Orange	San Joaquin Hills	Hwy 73	15	41.67	Yes	No	25.00	$3,970.20	20.65	29.11	1
12D	12	Orange	Peters Canyon Reservoir	Hwy 241	3	8.33	Yes	No	25.00	$4,962.75	25.81	19.72	3
12E	12	Orange	Rancho Mission Viejo	Hwy 74	3	8.33	Yes	Yes	50.00	$4,962.75	25.81	28.05	2

The threatened or endangered species that had critical habitat in or adjacent to the hot spots are listed in Table 18. The species include a fish species, amphibians (frog and toad species), reptiles (a snake species), a butterfly species, and several bird species.

Table 18: The ranking of the hot spots based on analyses for mule deer carcasses per Caltrans district.

Hot spot ID#	District	County	Nearby town	Highway	Species 1	Species 2
Statewide deer-vehicle crashes						
2	1	Humboldt	Orick	US Hwy 101	Marbled murrelet	Tidewater goby
Per district deer-vehicle crashes						
1b	1	Humboldt	Orick	US Hwy 101	Marbled murrelet	Tidewater goby
1d	1	Humboldt	Redway	US Hwy 101	Marbled murrelet	
4c	4	San Mateo	Highlands-Baywood Park	I-280	Bay checkerspot butterfly	California red-legged frog
4d	4	San Mateo	Woodside	I-280	Bay checkerspot butterfly	California red-legged frog
4h	4	Contra Costa	Orinda	Hwy 24	Alameda whipsnake (=striped racer)	
7d	7	Ventura	Casitas Springs	Hwy 33	Southwestern willow flycatcher	
7e	7	Ventura	Moorpark	Hwy 118	Coastal California gnatcatcher	
8a	8	San Bernardino	Crestline	Hwy 18		
8b	8	San Bernardino	Silverwood Lake	Hwy 138	Arroyo (=arroyo southwestern) toad	
11a	11	San Diego	Warner Springs	Hwy 79	Arroyo (=arroyo southwestern) toad	
Per district mule deer carcasses						
1A	1	Humboldt	Eureka	US Hwy 101	Tidewater goby	
1B	1	Humboldt	Fortuna	US Hwy 101	Western snowy plover	Yellow-billed Cuckoo
4D	4	Contra Costa	Orinda	Hwy 24	Alameda whipsnake (=striped racer)	
12E	12	Orange	Rancho Mission Viejo	Hwy 74	Arroyo (=arroyo southwestern) toad	

5.4. Discussion

While the deer-vehicle crash and mule deer carcass hot spots were ranked based on human safety, biological conservation, and economic parameters, it is important to remember that the human safety parameters were the departure point for these analyses. This means that the hot spots, by definition, had a relatively high number and concentration of deer-vehicle crashes or mule deer carcasses. In other words, it was not possible for a road section that bisects an area of very high biodiversity or very high importance to biological conservation in general, but that had no or only few collisions with deer or mule deer to be identified as a hot spot, let alone receive a high ranking. It was only in the ranking process of these deer-vehicle crash and mule deer carcass hot spots that human safety, biological conservation, and economic parameters had equal weight. In this chapter the tables contain the data for each parameter and parameter group. This allows Caltrans and others to change parameter selections and add potential weight to certain parameters later, should they choose to do so.

Only some of the hot spots met or exceed the economic thresholds from Table 14. However, the values of the economic parameter for the different hot spots should not be compared to the thresholds as if it was a litmus test for implementing or not implementing mitigation measures. The thresholds are primarily based on human safety parameters and exclude passive values associated with biological conservation; they are very conservative by nature. In addition, the economic costs of wildlife-vehicle collisions and the economic benefits of mitigation measures change in time and vary by location.

Note that the economic thresholds in Table 14 are based on a four-lane divided highway (Huijser et al., 2009). However, many of the hot spots are along two-lane highways. If mitigation measures are put in place without widening the road then the thresholds are likely lower than projected in this chapter; there are likely more and longer road sections where the costs associated with wildlife-vehicle collisions meet or exceed the thresholds. If the road is completely reconstructed and widened to four-lanes at the same the mitigation measures are installed there can be overall cost savings, but the costs for the crossing structures will increase compared to those for a two-lane road. Furthermore, there may be cost savings if existing structures originally built for other purposes can be modified so that they are also suitable for wildlife use.

With the consideration of mitigation measures, it is also important to note that the crash and carcass counts are minimum numbers rather than the actual number of deer-vehicle crashes or mule deer carcass counts, and we know based on Chapter 3 that the mule deer carcass counts are severely underreported in all Caltrans districts, except for District 10. While the researchers strongly advise to use the cost-benefit analyses as an important decision support tool, they also urge users to recognize that these analyses are only one of the factors that may or should be considered in the decision-making process. For example, if there are also threatened or endangered species present that would benefit from the mitigation measures (in addition to only mule deer), costs associated with species recovery may be reduced (Personal comment John Cleckler, Caltrans District 4 Liaison, U.S. Fish and Wildlife Service).

6. MITIGATION RECOMMENDATIONS

6.1. Introduction to Effective Mitigation Measures

This chapter contains descriptions of potential mitigation measures at the crash and carcass hot spots, should Caltrans or other stakeholders choose to implement mitigation measures. The approach presented in this chapter is limited to mitigation, rather than also including options for avoidance and compensation (see Chapter 2). For this project, the approach is also restricted to mitigation measures aimed at:

- Improving human safety and reducing direct wildlife mortality through reducing deer-vehicle collisions or collisions with other large mammals or large ungulates.
- Keeping the highways permeable or making them more permeable to wildlife in general despite the presence of the highway, traffic and potential mitigation measures aimed at keeping deer off the road (e.g. wildlife fencing).

There are many publications that include an overview of mitigation measures aimed at reducing collisions with large mammals and at providing safe crossing opportunities for wildlife (see e.g. Huijser et al., 2008; Clevenger & Huijser, 2011). We refer to these publications for a general overview of the effectiveness or lack of effectiveness of dozens of different types and combinations of mitigation measures. However, there are only two types of mitigation packages that can substantially reduce collisions with large wild mammals (Table 19):

1. Wildlife fences in combination with wildlife crossing structures (underpasses or overpasses)
2. Animal detection systems, either as a stand-alone measure or at a gap in the fence.

However, while wildlife crossing structures allow for safe crossing opportunities to the other side of the highway, animal detection systems do not make it any easier for animals to cross a road (Huijser et al., 2015b; Table 19). To get to the other side of the highway, animals still must cross an open area with unnatural substrate and avoid the vehicles that drive on the road. Therefore, animal detection systems should only be considered if reducing collisions with large mammals is the only objective, and they should not be considered if providing safe crossing opportunities and increasing habitat connectivity is also an objective. Alternatively, animal detection systems are a temporary measure to reduce collisions with large mammals until a highway needs reconstruction because the road is at the end of its life span or because the highway has become so busy that road reconstruction and road widening is required.

Table 19: Comparison of fences, fences in combination with wildlife crossing structures, and animal detection systems.

Parameter	Fences	Fences and wildlife crossing structures	Animal detection systems (stand-alone or at gap in fence)
Substantial collision reduction (>80%) with large mammals.	Yes (80-100%) if the measures are designed for the target species, correctly installed, and maintained (Huijser et al., 2016a).	Yes (80-100%) if the measures are designed for the target species, correctly installed, and maintained (Huijser et al., 2016a).	Possibly (33-97%) but many animal detection systems are not reliable in detecting the target species, or do not result in substantial (>80%) collision reduction (Huijser et al., 2015b).
Maintain or improve habitat connectivity for a wide range of species (large mammals, small and medium sized mammals, reptiles, amphibians).	No, fences alone result in a (near) absolute barrier, at least for the target species, and no safe crossing opportunities are provided for any species.	Yes, if the structures are in the correct locations for the target species, if the type and dimensions match the requirements of the target species, wildlife use can be high, and if the structures are sufficiently close, connectivity can be improved compared to an unmitigated highway (Clevenger et al., 2009; Huijser et al., 2016b)	No, animal detection systems warn drivers about the presence of large mammals on or near the highway, but these systems do not make it any easier for animals to cross a road (Huijser et al., 2015b).
Indicative costs	$155,000 per mile road length with fences on both sides (Huijser et al., 2009)	$155,000 per mile road length with fences on both sides; $500,000 for a large mammal underpass; $5,000,000 for an overpass (Huijser et al., 2009).	Highly variable (e.g. $65,000-$333,000 per mile road length), depending on the technology topography, curvature, and access roads (Huijser et al., 2009; Pers. comm. Deb Wambach, Montana Department of Transportation). However, because the life span of technological equipment is much shorter (e.g. 10 yrs) than for fences (20-25 yrs) and concrete structures (75-80 yrs), the life cycle costs of detection systems may be higher than for fences in combination with crossing structures.
Application	All roads, but access roads, driveways and other access points require attention.	All roads, but access roads, driveways and other access points require attention. In addition, easements may be required to ensure the habitat quality at both sides of wildlife crossing structures.	Lower volume roads only because of the potential for sudden stops and rear-end collisions (do not use on roads with >15,000 vehicles per day, perhaps <5,000 vehicles per day is most acceptable).
Risk assessment	Fence designs for large mammals as well as many small animal species groups are well established. Fence system projects should be regarded as low risk.	Fence designs for large mammals as well designs for many small animal species groups are well established. Guidelines exist for crossing structure locations, structure type, dimensions, and spacing. Fence and crossing structure projects should be regarded as low to moderate risk.	While some animal detection systems are reliable in detecting large mammals and effective in reducing collisions, many systems are removed after a few years, because of technical problems, management or financial problems, or insufficient resources for maintenance (Huijser et al., 2015b). Animal detection system projects should be regarded as high risk.

6.2. Practical Guidelines for Wildlife Fences

Wildlife fences reduce collisions with large mammals by 80-100% as long as (Huijser et al., 2015a; 2016):

- The fences are designed for the target species' ability to jump, climb, and dig, as well as their strength.
- There is expert oversight during the construction of the fences, especially when the terrain is uneven, if the fences cross streams or other water bodies, and where the fences connect to wildlife underpasses or overpasses.
- There is a fence inspection and fence maintenance program in place.
- Fences are constructed over relatively long distances so that potential fence end effects are diluted, and the fences reach their full potential in reducing collisions. The fences need to cover the length of the hot spot, as well as buffer zones adjacent to the hot spot, but the habitat and topography of a specific mitigation site is also important to consider. In general, for large mammals such as deer, fences along road sections that are at least 3 miles (5 km) long almost always reduce collisions with large wild mammals by at least 80%.

For large ungulates in North America, 8 ft (2.4 m) high mesh wire fencing with wooden posts is the most frequently used fence type to keep animal species such as white-tailed deer, mule deer, elk, and moose off the road (Huijser et al., 2015a). For species that can climb a fence with large meshes or wooden posts (e.g. black bears, mountain lions), smaller mesh sizes, metal posts, and overhangs at the top of the fence are sometimes used. To discourage animals from digging under the fence (e.g. coyotes) sometimes dig barriers are installed (Huijser et al., 2008; Clevenger & Huijser, 2011; Huijser et al., 2015a). Should other species groups such as amphibians and reptiles be a concern as well, there are specialized amphibian and reptile fences (including plastic sheets) available that can be attached to a standard ungulate fence.

Wildlife fencing is most effective if implemented over relatively long distances (e.g. at least 5 km (3.1 miles)) (Huijser et al., 2016). If no or relatively short fencing is provided, animals that approach the road section at or near the safe crossing opportunity may simply walk to the fence end and cross at grade. This means that relatively short sections of wildlife fencing (e.g. less than 5 km (3.1 miles) are, on average, less effective and more variable in reducing wildlife-vehicle collisions than long sections of wildlife fencing (e.g. at least 5 km (3.1 miles long)) (e.g. Huijser et al., 2016). Short sections of wildlife fencing may partially relocate wildlife-vehicle collisions rather than substantially (>80% reduction) reduce them.

The wildlife fencing should at a minimum cover the full length of a hot spot on both sides of the road. However, if the fence ends at the end of a road section that has been identified as a hot spot, a substantial portion of the animals that would have crossed at the hot spot barely have to go out of their way to cross at-grade at one of the two fence ends rather than through a safe crossing opportunity in the mitigated hot spot. This may then result in a slight shift in the location of a hot spot rather than a real and substantial reduction in wildlife-vehicle collisions. Therefore, a buffer zone is recommended with additional fences extending from the two ends of a hot spot. The wildlife fences continue in this buffer zone and make it more energetically expensive ("costly") for the animals to walk to a fence end and cross at grade.

The length of the buffer zone can be based on the home range size of the target species. The average diameter of the home range of a mule deer may be about 2,400 m (1.49 mi) (see section 6.4). Therefore, if a mule deer would have the center of its home range at the edge of a hot spot, it may still easily travel 1,200 m (0.75 mile), suggesting that the buffer zone for mule deer should extend at least 1,200 m (0.75 mile) from the end of a hot spot. The authors of this report suggest a buffer zone of about 1,600 m (1.0 mile) extending from both ends of a hot spot.

In multifunctional landscapes, there are typically side roads, driveways and other access points from the highway. Depending on the type of access, the frequency of use by humans, and the target species, gates, wildlife guards (similar to cattle guards), electric mats or conductive concrete can help keep the target species out of the fenced road corridor at access points and at fence ends (Huijser et al., 2015a). Nonetheless, it is always possible that animals end up inside the fenced road corridor. Therefore, escape opportunities should be provided. Wildlife jump-outs or escape ramps allow wildlife that is trapped in the fenced road corridor to walk up to the height of the fence and then jump down to the safe side of the fence. The optimal jump-out height for mule deer is probably around 1.5-1.6 m (5-6 ft). Adding a horizontal bar at the top of the jump-out may help make it more difficult for animals to use the jump-out to enter the fenced road corridor.

While fences can be very effective in reducing collisions with large wild mammals, it is considered bad practice to increase the barrier effect of roads and traffic for wildlife without also providing for effective safe crossing opportunities. Safe crossing opportunities should be located in the actual hot spot, but if there is additional information of relatively large numbers of animals that cross the road successfully in the buffer zone, additional safe crossing opportunities may need to be considered in the buffer zone as well.

6.3. Practical Guidelines for Animal Detection Systems

At relatively low traffic volumes (e.g. < 3,000 vehicles/day) one may consider animal detection systems or gaps in a wildlife fence, with or without an animal detection system as a measure to reduce collisions with large wild mammals. However, at-grade crossing opportunities are not necessarily “safe” as it still puts wildlife on the same surface as the vehicles. In addition, the barrier effect of the transportation corridor is not reduced by providing at-grade crossing opportunities (review in Huijser et al., 2015b). Nonetheless, should these at-grade crossing opportunities be implemented, advisory or mandatory speed limit reduction and traffic calming measures (e.g. speed bumps or bulb outs), and measures that encourage the animals to cross the road straight (e.g. wildlife guards or electric mats or conductive concrete embedded in the road on either end of the gap) may be important to achieving a substantial reduction in large mammal-vehicle collisions. Animal detection systems may also be used at gaps in fences, but these systems are still mostly experimental rather than a robust mitigation measure that can be expected to function as intended immediately after installation. Animal detection systems can also be implemented as a stand-alone mitigation measure and can also substantially reduce collisions with large mammals (range 33-97%) (Huijser et al., 2015b). Note that while animal detection systems can substantially reduce collisions with large mammals, they do not make it any easier for animals to cross a road (Huijser et al., 2015b). To get to the other side of the highway, animals still must cross an open area with unnatural substrate and avoid the vehicles that drive on the road. Therefore, animal detection systems should only be considered if reducing collisions with large mammals is the only objective, and they should not be considered for small species such as amphibians and reptiles, or if providing safe crossing opportunities and increasing habitat connectivity is also an objective.

6.4. Practical Guidelines for Wildlife Crossing Structures

For relatively high traffic volume (>15,000 vehicles/day) a physical separation of vehicles and wildlife is almost always desirable. As it is, high-volume highways are a near absolute barrier to many species even without fences. The permeability of a highway decreases exponentially with increasing traffic volume; animals become more and more reluctant to cross the highway (Dodd et al., 2007). With high traffic volumes, even if there would be at-grade crossing opportunities at gaps in the fences, they would likely not or barely be used.

Safe crossing opportunities require a physical separation of vehicles and wildlife. This can be achieved by providing wildlife crossing structures (i.e. underpasses and overpasses) (Clevenger & Huijser, 2011). The combination of wildlife fences and wildlife crossing structures is the most effective and robust mitigation measure package available that can achieve the two objectives of improving human safety and reducing direct wildlife mortality, and keeping highways permeable or making them more permeable to wildlife. Besides keeping animals off the highway, fences can also funnel wildlife movements to wildlife crossing structures (Dodd et al., 2007; Gagnon et al., 2010).

These wildlife crossing structures should be carefully planned, designed, and placed. In general, wildlife crossing structures should be:

- Designed with the target species in mind (type, dimensions).
- Located where the target species are willing to come close to the highway.
- Spaced "sufficiently" close together (not exceed a certain distance between crossing structures).

The authors of this report distinguished seven different types of safe crossing opportunities for potential implementation on and along the roads in the study area (Table 20). Note that there are other types of crossing structures (e.g. for amphibians), but these are not included in this report because this report primarily focuses on large mammals and most amphibians and reptiles (e.g., snakes) are also able to pass through a standard ungulate fence. Nonetheless, should amphibian or reptile crossings be installed, specific precast products are available that allow for soil and air temperature and humidity inside the tunnels that is similar to outside the tunnels. Furthermore, structures that are suitable for large terrestrial mammals can also be made suitable for amphibians and reptiles by providing suitable habitat, including cover and water or wet areas.

Similarly, aquatic or semi-aquatic species are likely to use a crossing opportunity if a wildlife underpass is located at a stream or river crossing. Stream characteristics and stream dynamics must be carefully evaluated to ensure that the conditions inside the crossing structure are and remain similar to that of the stream up- and downstream of the structure. Such parameters include water velocity, variability in water velocity, erosion of substrate inside the crossing structure, or up- and downstream of the structure, and the implications of high and low water events, including debris and potential maintenance issues.

If terrestrial animals are to use underpasses associated with streams and rivers, a minimum path width of 0.5 m (1.6 ft) is recommended for small and medium mammals, and 2-3 m (6.6-9.8 ft) for large mammals (for both two lane and four lane highways) (Clevenger & Huijser, 2011). Furthermore, small mammals, amphibians and reptiles increase their use of wildlife underpasses and overpasses if cover (e.g. tree stumps, branches and rocks) is provided for continuous travel to the other side of the highway. One may choose to provide additional wildlife crossing structures specifically designed for the target species, as the location of stream crossings and the spacing of the structures is not necessarily consistent with the requirements of the target species.

While Table 20 classifies crossing structures based on their dimensions, there is no generally agreed upon definition of different types of crossing structures. One may also choose to modify the dimensions of an underpass based on the species of interest and the physical environment at the location of the underpass. The width (=road length) and the height of the underpasses in Table 20 (i.e. open span bridges, large mammal underpasses, medium mammal underpasses, small-medium mammal pipes) is for 2-lanes roads or two separate structures with a median in between along 4-lane roads. For one single structure along 4-lane roads, consider increasing the width and height of the underpasses.

Table 20. Suggested classification system of wildlife crossing structures.

Safe Crossing Opportunity	**Dimensions (as seen by the animals)**		**Safe Crossing Opportunity**	**Dimensions (as seen by the animals as they approach the crossing structure)**
Wildlife overpass	50-70 m (164-230 ft) wide		Medium mammal underpasses	0.8-3 m (2.6-9.8 ft) wide, 0.5-2.5 m (1.6-8.2 ft) high
Open span bridge	12-30 m (39-98 ft) wide, ≥5 m (16 ft) high		Small-medium mammal pipes	0.3-0.6 m (1.0-2.0 ft) in diameter
Arboreal bridge	Rope bridge connecting canopy on both sides of road		Animal Detection system	n/a
Large mammal underpass	7-8 m (23-26 ft) wide, 4-5 m (13-16 ft) high			

Table 21 provides an overview of the suitability of the seven different types of safe crossing opportunities for the medium and large mammal species that are known to occur in California.

When evaluating the suitability, the authors assumed no human co-use of the crossing opportunities. The suitability of the different types of safe crossing opportunities is not only influenced by the size of the species, but also by species-specific behavior. For some species there is little or no information on what type and dimension of crossing structure is considered suitable. However, for some species the researchers can make an educated guess. For example, ringtails are known to climb trees, nest in tree cavities, suggesting that arboreal bridges are a suitable type of crossing structure for this species.

Table 21. Suitability of different types of mitigation measures for selected species (for 2-3 lane highways [25-35 m (82-115 ft)] wide road without median).
● Recommended/Optimum solution; ○ Possible if adapted to species' specific needs; ⊗ Not recommended; ? Unknown, more data required; — Not applicable (Clevenger & Huijser, 2011; O'Brien et al., 2013; Huijser et al., preliminary data; Clevenger, unpublished data).

	Wildlife overpass	Arboreal crossing	Open span bridge	Large mammal underpass	Medium mammal underpass	Small-medium mammal underpass	Animal detection system
Mammals							
Squirrels	●	●	●	●	⊗	⊗	⊗
Porcupine	●	?	●	●	?	⊗	⊗
Beaver	○	⊗	●	●	?	?	⊗
Opossum	●	●	●	●	●	●	⊗
Raccoon	●	⊗	●	●	●	?	⊗
Ringtail	●	●	●	●	○	○	⊗
Skunks	●	⊗	●	●	●	?	⊗
Fisher	●	●	●	○	○	○	⊗
Wolverine	●	⊗	●	?	?	⊗	⊗
Badger	●	⊗	●	●	●	●	⊗
Bobcat	●	⊗	●	●	●	●	⊗
Mountain lion	●	⊗	●	●	⊗	⊗	○
Kit fox	●	⊗	●	●	○	○	⊗
Grey fox	●	⊗	●	●	●	●	⊗
Red fox	●	⊗	●	●	●	●	⊗
Coyote	●	⊗	●	●	●	●	⊗
Deer spp.	●	⊗	●	●	⊗	⊗	●
Elk	●	⊗	●	○	⊗	⊗	●
Pronghorn	●	⊗	?	⊗	⊗	⊗	●
Bighorn sheep	●	⊗	●	○	⊗	⊗	●
Black bear	●	⊗	●	●	⊗	⊗	●
Amphibians	○	⊗	○	○	○	○	⊗
Reptiles	○	⊗	○	○	○	○	⊗

When wildlife fencing is installed alongside a road, the barrier effect of the road corridor is increased. Depending on the species concerned, a wildlife fence may be an absolute or a near complete barrier. Such barriers in the landscape are to be avoided as they isolate animal populations, and smaller and more isolated populations have reduced population survival probability. Therefore, when a wildlife fence is installed, safe crossing opportunities for wildlife should be provided for as well. This section discusses suggestions for the appropriate distance between safe crossing opportunities.

The spacing of safe crossing opportunities for wildlife can be calculated in more than one way and is dependent on the goals one may have. Examples of possible goals are:

- Provide permeability under or over the road for ecosystem processes, including but not restricted to animal movements. Ecosystem processes include not only biological processes, but also physical processes (e.g. soil processes, hydrology).
- Allowing a wide variety of species to change their spatial distribution drastically, for example in response to climate change.
- Maintaining or improving the population viability of selected species based on their current spatial distribution. This includes striving for larger populations with a certain degree of connectivity between populations (including allowing for successful dispersal movements).
- Providing the opportunity for individuals (and populations) to continue seasonal migration movements (e.g. mule deer in certain regions).
- Allowing individuals, regardless of the species, that have their home ranges on both sides of the highway to continue to use these areas. This may result in a road corridor that is permeable for wildlife, at least to a certain degree, at least for the individuals that live close to the road.

A further complication is that individuals that disperse, that display seasonal migration, or that live in the immediate vicinity of a road may display differences in behavior with regard to where and how they move through the landscape; how they respond to roads, traffic, and associated barriers (e.g. wildlife fencing); and their willingness to use safe crossing opportunities. For example, dispersing individuals may originate far away from the areas where one is used to seeing them; they may not move through habitat that we may expect them to be in; they typically travel long distances, much further and quicker compared to resident individuals; but successful dispersers may also stay away from roads and traffic and other types of human disturbance that they are unfamiliar with.

Safe crossing opportunities may not be encountered by dispersing individuals as they are new to the area and are not familiar with their location, and when confronted with a road or associated wildlife fence, they may return or change the direction of their movement before they encounter and use a safe crossing opportunity. Furthermore, if dispersing individuals do encounter a safe crossing opportunity, they may be more hesitant to use them compared to resident individuals that not only know about their location, but that also have had time to learn that it is safe to use them. Since dispersal can be a relatively rare phenomenon, one may not be able to afford a dispersing individual to give up and turn back. Knowledge on the requirements (e.g. structure type, structure dimensions, interval between structures) for dispersing individuals versus requirements for residential individuals is currently not available.

Full-scale population viability analyses can be very helpful in comparing the effectiveness of different configurations of safe crossing opportunities. For this report the authors chose a simpler approach. Mule deer may have an average home range of about 450 hectares (ha) (1,112 acres) (diameter circular home range = 2,394 m (1.49 mile); 443 ha (1,095 acres) in summer, 500 ha (1,236 acres) in winter; Kie et al., 2002). The distance between safe crossing opportunities for mule deer was set to be equal to the diameter of the home range, about 2,400 m (1.49 mile) (Figure 20). This allows individuals that have the center of their home range on the road to have access to at least one safe crossing opportunity.

However, individuals that may have had their home range on both sides of the road do not necessarily have access to a safe crossing opportunity (Figure 21). Finally, this approach assumed homogenous habitat and distribution of the individuals and circular home ranges, while in reality habitat and habitat quality may vary greatly, causing variations in density of individuals and irregularly shaped home ranges. The authors of this report would like to emphasize that this approach does not necessarily result in viable populations for mule deer, and that not every individual that approaches the road and associated wildlife fence will encounter and use a safe crossing opportunity. Nonetheless, a suitable crossing structure for mule deer once every 2,400 m (1.49 mile) should result in “substantial connectivity” for this species.

Crossing structures that are suitable for mule deer can also be suitable or made to be suitable for many other species. For example, when a mule deer crossing structure is combined with a stream crossing, it may not only be suitable for many terrestrial animal species, but also for species that depend on aquatic or riparian habitat. Cover inside or on top of crossing structures is especially Important for small animal species (e.g. amphibians, reptiles, small mammals). Smaller species may also still be able to cross at grade as the meshes of a standard fence for large ungulates are typically wide enough for small mammals, amphibians, and snakes to pass through. If road mortality is to be reduced for smaller species too, smaller mesh fencing or smooth plastic sheets should be attached to the lower portion of a large mammal fence (see section 6.2).

Because the home range for smaller-bodied species (e.g., amphibians and reptiles) may be much smaller than for mule deer (see e.g. Huijser & Begley, 2012), additional crossing opportunities (in addition to the safe crossing opportunities for mule deer) may have to be provided (Figure 20). These crossing opportunities can typically be much smaller when designed for species smaller than deer. The approach described above is not necessarily the only approach or the approach that addresses the barrier effect of the road corridor and associated fencing sufficiently for all species concerned. However, the authors do think that this approach would at least be consistent, practical, based on available ecological data, and likely to result in considerable permeability of the road corridor and associated wildlife fencing for mule deer.

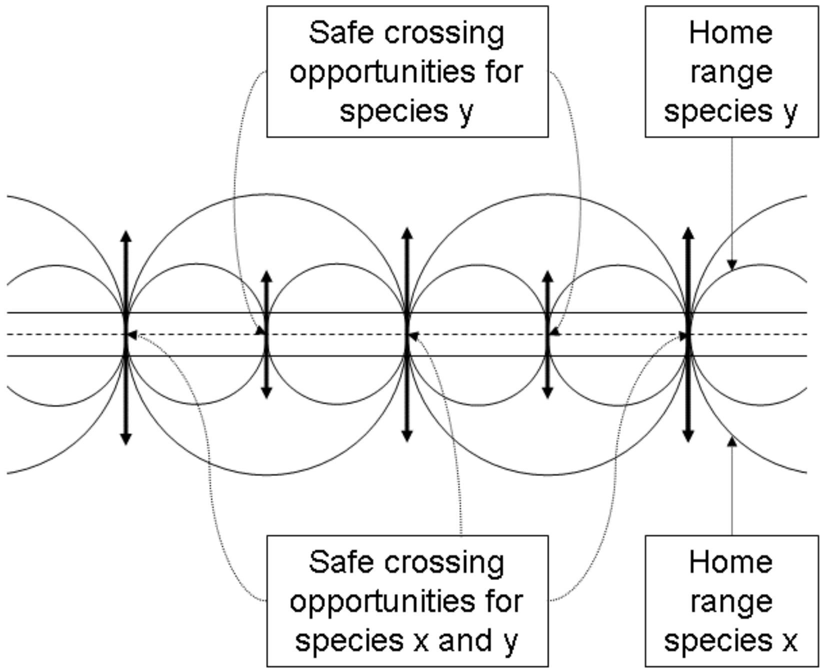

Figure 20: Schematic representation of home ranges for two theoretical species projected on a road and the distance between safe crossing opportunities (distance is equal to the diameter of their home range).

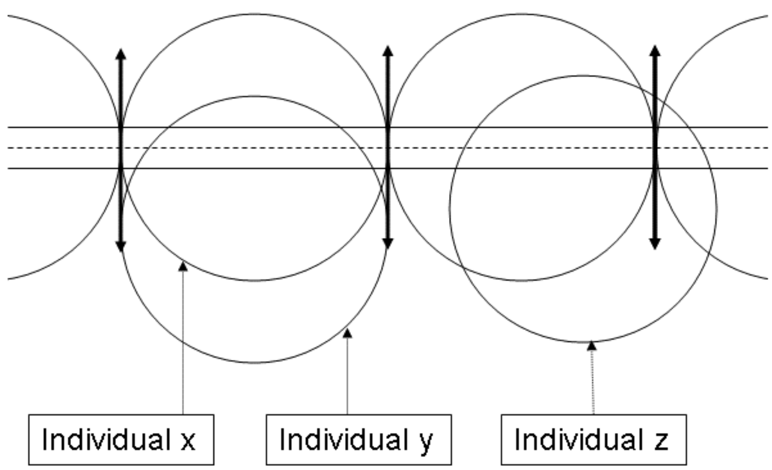

Figure 21: Schematic representation of home ranges and interval between safe crossing opportunities. Schematic representation of home range for an individual (x) that has the center of its home range on the center of the road (access to two safe crossing opportunities), an individual (y) that has the center of its home range slightly off the center of the road exactly in between two safe crossing opportunities (no access to safe crossing opportunities), and an individual (z) that has the center of its home range slightly off the center of the road but not exactly in between two safe crossing opportunities (access to one safe crossing opportunity).

Another way to decide on "appropriate distance" between safe crossing opportunities is to evaluate what the spacing is for wildlife crossing structures on other wildlife highway mitigation projects. The average spacing for large mammal crossing structures in Montana (US Hwy 93 North and South), I-75 in Florida, SR 260 in Arizona, Banff National Park in Canada, and ongoing reconstruction on I-90 in Washington State is about 1.9 km (1.2 mile) (range for the average spacing of structures in these individual areas is 0.8-2.9 km (0.50-1.80 mile)). However, the 1.9 km (1.2 mile) spacing is simply what people have done elsewhere, and it is not necessarily based on what may be needed ecologically, the requirements for the target species in one area may be different from what is needed in another area.

6.5. Mitigation Recommendations for the Top Crash and Carcass Hot Spots Per District

In Chapter 4 the researchers identified deer-vehicle crash hot spots and mule deer carcass hot spots while Chapter 5 documented the prioritization process. In this section the researchers list the recommendations for the top deer-vehicle crash and mule deer carcass hot spots in each Caltrans district. We strived for ranking the top five hot spots within each district. However, some districts had fewer hot spots (see Chapter 5). In addition, some other districts had more than five hot spots that met the criteria for hot spot identification (see Chapter 4), and the authors of this report included all hot spots in the ranking process as the authors had no way to identify which were the "worst" five without initiating the ranking process. Note that the researchers described the individual hot spots based on the Kernel density category, the length of the hot spots, the number of lanes (based on satellite images), whether potential existing structures are present that may also serve as a wildlife crossing after potential modifications (based on satellite images), and the traffic volume (Annual Average Daily Traffic (AADT; Caltrans, 2019). Small underpasses (e.g. drainage culverts or small box culverts) were not reliably visible on the satellite images. However, structures that are considered suitable for mule deer (at least 7-8 m [23-26 ft] wide, 4-5 m [13-16 ft] high) were visible on the satellite images, and that was most relevant for this project.

Should Caltrans consider implementing mitigation measures at one or more of these hot spots, the researchers advise the following:

1. Focus on hot spots with a relatively high number of collisions first. If there are less than 10 reported deer-vehicle crashes or less than 10 reported mule deer carcasses in a hot spot, implementation of mitigation measures is relatively risky compared to sites that have greater collision numbers. The identification of hot spots with low numbers is less robust than the identification of hot spots with higher numbers. The authors of this report suggest minimizing the risk of investing in mitigation measures by focusing on hot spots that are likely to be a substantial and consistent hot spot rather than a less important hot spot or a hot spot that may have been wrongly identified because of variations in the number of collisions.

2. Interview law enforcement personnel and road maintenance personnel in the first phase of exploring the potential implementation of mitigation measures. Get confirmation that

it is indeed a “bad spot” for deer-vehicle collisions, and get confirmation about the exact road section (start and end points).

3. Some hot spots appear particularly difficult or costly to mitigate. The presence of 8-12 lanes of traffic, frontage roads, intersections, private lands, residential and commercial development, etc. all make it more challenging to effectively mitigate a hot spot. These types of challenges are “ignored” in the ranking of the hot spots (Tables 22 and 23). However, the challenges of each hot spot should be carefully weighed when proceeding with the planning, design and implementation of mitigation measures.

4. Carefully evaluate what species other than mule deer may require mitigation for direct road mortality or the barrier effect along the road section that is considered for mitigation. Consult spatial and biological databases, interview representatives from natural resource management agencies, interview people with local knowledge and experience. Modify or add to the list of target species as it may well influence the design of the mitigation measures.

5. In general, the first choice or recommendation for mitigating a hot spot is a wildlife fence in combination with designated wildlife crossing structures. Implement large mammal fences (2.4 m high (8 ft)) along the full length of a hot spot and buffer zones that span an additional 1,600 m (1.0 mile) from each end of the hot spot. As a general principle, provide a crossing structure that is suitable for mule deer (at least 7-8 m (23-26 ft) wide, 4-5 m (13-16 ft) high) once every 2,400 m (1.49 mile) in the fenced road section. With reduced ambition levels (i.e., address only collisions with large mammals, do not provide safe crossing opportunities for wildlife) animal detection systems are suggested as a second choice for road sections with less than 5,000 vehicles per day (Table 22 and 23).

6. If there were existing structures in a hot spot, identified through satellite images, these were noted in the tables. However, structures primarily designed for motorized vehicles were not listed. Nonetheless, very long bridges with only small or unpaved roads were included as an existing structure that may be adapted to also allow for wildlife use. In addition to connecting these structures to wildlife fences, the structures may need some modifications to make them suitable for wildlife use. These modifications will likely vary between the structures, and some structures may not need any modifications.

7. In general, structures for mule deer should be considered about every 2,400 m (1.49 mile) (see section 6.4). This means that long hot spots may need multiple crossing structures. These structures can be any combination of existing structures originally built for other purposes and designated wildlife crossing structures. The structures listed in Table 22 and 23 are restricted to the hot spots. Fences may extend into adjacent buffer zones, and there may be additional existing structures in those areas. Tying these existing structures into the wildlife fence and allowing potential wildlife use through these structures makes sense, as long as it is compatible with the primary use of a structure and the land use in the areas surrounding the structure.

Table 22: The mitigation recommendations for the top hot spots based on analyses for deer-vehicle crashes per Caltrans district.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Total length (mi)	Lanes (n)	Existing structure	AADT	Rank	Mitigation suggestions: 1st choice	Mitigation suggestions: 2nd choice
1a	1	Del Norte	Crescent City	US Hwy 101	0.6	2	No	4,450	2	Fence, designated structures	ADS
1b	1	Humboldt	Orick	US Hwy 101	0.8	2	Yes	4,050	1	Fence, designated structures	ADS
1d	1	Humboldt	Redway	US Hwy 101	0.4	4	No	8,100	3	Fence, designated structures	
1e	1	Humboldt	Redway	US Hwy 101	0.2	5	No	7,650	4	Fence, designated structures	
1f	1	Humboldt	Redway	US Hwy 101	0.1	4	No	6,850	5	Fence, designated structures	
2a	2	Siskiyou	Hornbrook	I-5	2.5	4	Yes	16,200	4	Fence, modify existing 70-80 m bridge	
2e	2	Tehama	Red Bluff	I-5	0.5	5	Yes	42,750	2	Fence, modify existing 42 m bridge	
2f	2	Tehama	Red Bluff	I-5	0.5	4	Yes	38,500	2	Fence, modify existing 222 m bridge	
2g	2	Lassen	Susanville	US Hwy 395	5.6	3	Yes	6,950	1	Fence, upsize existing culverts and livestock underpass, designated structures	
2h	2	Siskiyou	Black Butte	I-5	0.4	4	No	24,800	3	Fence, designated structures	
3a	3	El Dorado	Placerville	US Hwy 50	0.9	4	No	27,450	3	Fence, designated structures	
3b	3	El Dorado	Perks Corner	US Hwy 50	3.7	4	Yes	10,600	2	Fence, upsize existing livestock underpass, designated structures	
3c	3	El Dorado	Shingle Springs	US Hwy 50	3.4	6	No	66,200	4	Fence, designated structures	
3d	3	Sacramento	Rancho Murieta	Hwy 16	0.3	2	No	11,250	1	Fence, designated structures	
3j	3	Nevada	Higgins Corner	Hwy 49	1.4	2	Yes	23,200	4	Fence, modify existing 47 m bridge	
4c	4	San Mateo	Highlands-Baywood Park	I-280	2.2	10	Yes	129,000	2	Fence, modify existing 501 m bridge	
4d	4	San Mateo	Woodside	I-280	6.4	8	Yes	114,000	1	Fence, modify existing 30 and 34 m bridges	
4f	4	Santa Clara	Los Altos Hills	I-280	0.4	6	No	131,500	4	Fence, designated structures	
4g	4	Contra Costa	Condit	Hwy 24	0.2	8	No	209,500	5	Fence, designated structures	
4h	4	Contra Costa	Orinda	Hwy 24	0.4	8	No	188,000	3	Fence, designated structures	
5a	5	San Luis Obispo	Templeton	US Hwy 101	0.5	4	Yes	58,850	1	Fence, modify existing 51 and 31 m bridges	
6a	6	Madera	Oakhurst	Hwy 41	0.5	3	No	19,000	1	Fence, designated structures	
6b	6	Madera	Oakhurst	Hwy 41	0.3	2	No	19,000	2	Fence, designated structures	
7a	7	Los Angeles	Glendale	Hwy 134	0.4	8	No	209,500	4	Fence, designated structures	
7b	7	Los Angeles	Glendale	Hwy 2	2.8	9	No	124,500	3	Fence, designated structures	
7c	7	Los Angeles	Sherman Oaks	I-405	0.4	12	No	253,500	5	Fence, designated structures	
7d	7	Ventura	Casitas Springs	Hwy 33	0.4	3	No	26,500	2	Fence, designated structures	

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Total length (mi)	Lanes (n)	Existing structure	AADT	Rank	Mitigation suggestions	
										1st choice	2nd choice
7e	7	Ventura	Moorpark	Hwy 118	0.2	5	No	79,500	1	Fence, designated structures	
8a	8	San Bernardino	Crestline	Hwy 18	1.1	4	No	16,550	4	Fence, designated structures	
8b	8	San Bernardino	Silverwood Lake	Hwy 138	0.2	2	No	2,925	2	Fence, designated structures	ADS
8c	8	San Bernardino	Running Springs	Hwy 330	2.6	2	No	11,500	1	Fence, designated structures	
8d	8	San Bernardino	Running Springs	Hwy 18	0.4	2	No	5,750	3	Fence, designated structures	
8e	8	San Bernardino	Skyforest	Hwy 18	0.2	2	No	5,750	5	Fence, designated structures	
9a	9	Mono	Bridgeport	US Hwy 395	1	2	No	3,050	1	Fence, designated structures	
9b	9	Mono	Whitmore Hot Spr.	US Hwy 395	0.7	4	No	7,250	2	Fence, upsize existing culvert	
9c	9	Mono	Grant Lake	US Hwy 395	0.3	4	No	4,625	3	Fence, designated structures	ADS
10a	10	Mariposa	Bootjack	Hwy 49	1.6	2	Yes	5,200	2	Fence, modify existing 65 m bridge	
10b	10	Calaveras	San Andreas	Hwy 49	0.3	2	Yes	7,250	1	Fence, modify existing 32 m bridge	
11a	11	San Diego	Warner Springs	Hwy 79	0.6	2	No	1,400	1	Fence, designated structures	ADS
11b	11	San Diego	Santa Ysabel	Hwy 78	2.8	2	No	4,425	2	Fence, designated structures	ADS
11c	11	San Diego	Lake Cuyamaca	Hwy 79	0.4	2	No	1,650	3	Fence, designated structures	ADS
11d	11	San Diego	La Jolla	I-5	0.3	12	No	174,500	4	Fence, designated structures	
12a	12	Orange	Las Flores	Hwy 241	1.6	4	Yes	6,900	2	Fence, modify existing 46 m bridge	
12b	12	Orange	Peters Cany. Res.	Hwy 261	0.3	5	Yes	32,200	3	Fence, modify existing 68 m bridge	
12c	12	Orange	Villa Park	Hwy 241	0.3	9	No	47,800	3	Fence, designated structures	
12d	12	Orange	Laguna Woods	Hwy 73	0.2	7	No	62,700	1	Fence, designated structures	

Table 23: The mitigation recommendations for the top hot spots based on analyses for mule deer carcasses per Caltrans district.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Total length (mi)	Lanes (n)	Existing structure	AADT	Rank	Mitigation 1st choice	Mitigation 2nd choice
1A	1	Humboldt	Eureka	US Hwy 101	2.3	4	yes	24150	1	Fence, upgrade culvert, designated structures	
1B	1	Humboldt	Fortuna	US Hwy 101	4.0	4	yes	24000	2	Fence, modify existing 139 m bridge	
1F	1	Mendocino	Little River	Hwy 1	0.4	2	Yes	3750	4	Fence, modify existing 21 m bridge	ADS
1I	1	Lake	Blue Lakes	Hwy 20	0.2	2	No	9650	3	Fence, designated structures	
1K	1	Lake	Clearlake Oaks	Hwy 20	0.8	2	No	8150	5	Fence, designated structures	
2A	2	Siskiyou	Yreka	I-5	6.3	4	Yes	19000	1	Fence, upsize existing culverts and livestock underpass, designated structures	
2D	2	Siskiyou	Dunsmuir	I-5	1.1	4	No	20350	2	Fence, designated structures	
2G	2	Siskiyou	Macdoel	US Hwy 97	0.2	2	No	1190	3	Fence, designated structures	ADS
2H	2	Modoc	Hannchen	Hwy 139	0.6	2	No	1625	5	Fence, designated structures	ADS
2I	2	Modoc	Hannchen	Hwy 139	0.3	2	No	1625	4	Fence, designated structures	ADS
	3	Insufficient data									
4A	4	San Mateo	Highlands-Baywood Park	Hwy 92	1.7	4	No	77200	2	Fence, designated structures	
4B	4	Santa Clara	Los Altos Hills	I-280	2.1	8	No	131500	3	Fence, designated structures	
4C	4	Alameda	Mission San Jose	I-680	0.5	6	No	155400	4	Fence, designated structures	
4D	4	Contra Costa	Orinda	Hwy 24	0.8	8	No	188000	1	Fence, designated structures	
4E	4	Contra Costa	Alamo	I-680	0.6	6	No	153850	5	Fence, designated structures	
	5	Insufficient data									
6A	6	Madera	Oakhurst	Hwy 41	19.7	2	No	19000	2	Fence, designated structures	
6B	6	Tuolumne	Three Rivers	Hwy 198	0.5	2	Yes	4525	3	Fence, modify existing 60 m bridge	ADS
6C	6	Tuolumne	Three Rivers	Hwy 198	4.4	2	Yes	3175	1	Fence, modify existing 61 m bridge, designated structures	ADS
6D	6	Kern	Alta Sierra	Hwy 155	2.2	2	No	355	4	Fence, designated structures	ADS
	7	Insufficient data									
	8	Insufficient data									
9B	9	Mono	Walker	US Hwy 395	8.5	2	Yes	3550	3	Fence, upsize existing culverts, designated structures	ADS
9C	9	Mono	Walker	US Hwy 395	2.4	2	No	3425	5	Fence, designated structures	ADS

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Total length (mi)	Lanes (n)	Existing structure	AADT	Rank	Mitigation 1st choice	2nd choice
9D	9	Mono	Sonora Junction	US Hwy 395	11.1	2	Yes	3425	2	Fence, modify existing bridge 41 m, upsize existing culverts, designated structures	ADS
9E	9	Mono	Mono City	US Hwy 395	6.2	4	Yes	3350	4	Fence, upsize existing culverts, designated structures	ADS
9F	9	Mono	Whitmore Hot Springs	US Hwy 395	15.6	4	Yes	7200	1	Fence, modify existing bridge 23 m, upsize existing culverts, designated structures	
10A	10	Amador	Pine Grove	Hwy 88	22.6	2	No	8250	1	Fence, designated structures	
10B	10	Amador	Jackson	Hwy 49	5.8	2	No	8100	2	Fence, designated structures	
10C	10	Tuolumne	Mono Vista	Hwy 108	15.4	2	Yes	3975	3	Fence, modify existing bridge 310 m, upsize existing culverts, designated structures	ADS
10D	10	Tuolumne	Moccasin	Hwy 120	3.0	2	Yes	4425	4	Fence, modify existing bridge 105 m, upsize existing culverts, designated structures	ADS
10E	10	Tuolumne	Groveland	Hwy 120	10.7	2	No	6225	5	Fence, designated structures	
	11	Insufficient data									
12A	12	Orange	Peters Canyon Reservoir	Hwy 241	1.8	6	Yes	40150	4	Fence, modify existing bridge 403 m, upsize existing culverts, designated structures	
12B	12	Orange	Las Flores	Hwy 241	2.0	4	Yes	6900	5	Fence, modify existing bridge 45 m, upsize existing culverts, designated structures	
12C	12	Orange	San Joaquin Hills	Hwy 73	2.5	8	Yes	67650	1	Fence, modify existing bridges 96 m, 49 m, upsize existing culverts	
12D	12	Orange	Peters Canyon Reservoir	Hwy 241	0.4	7	Yes	47800	3	Fence, upsize existing culverts	
12E	12	Orange	Rancho Mission Viejo	Hwy 74	0.4	2	No	11100	2	Fence, designated structures	

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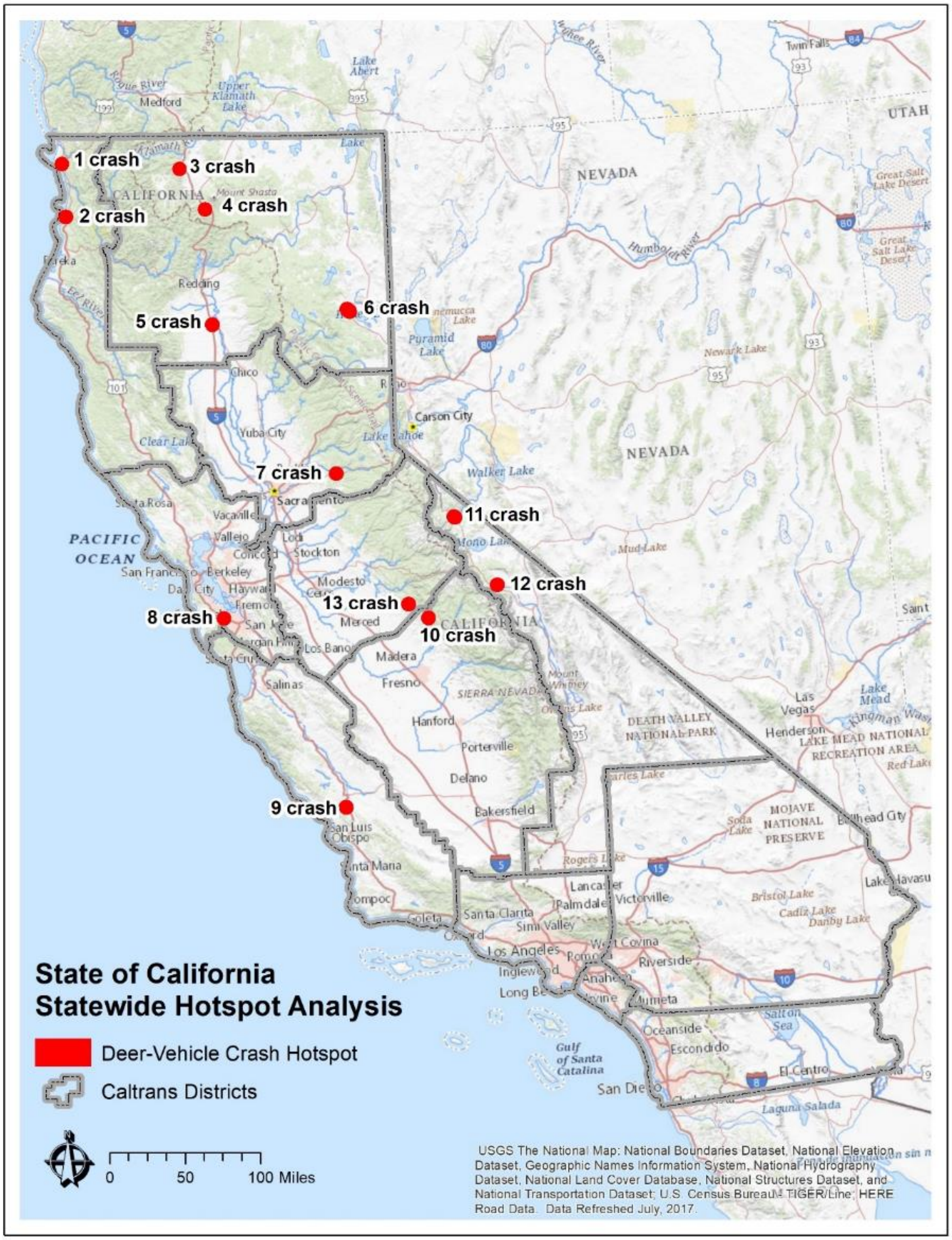
8. APPENDIX A: STATEWIDE ANALYSIS DEER-VEHICLE CRASH HOT SPOTS

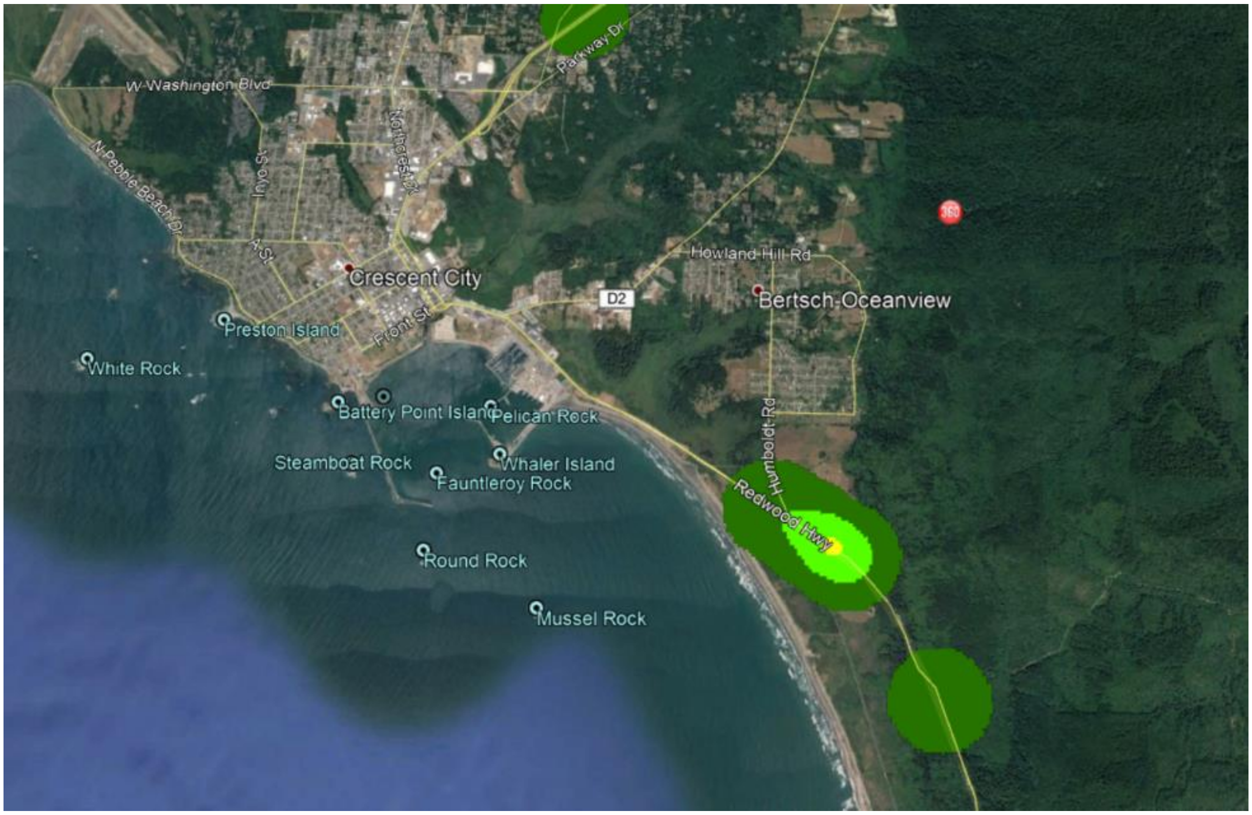


Hot spots based on statewide deer-vehicle crash data with Caltrans District boundaries (see Figure 1, page 13 for the Caltrans District numbers). The numbers correspond with the table and detailed maps of the individual hot spots on the following pages.

The “worst” hot spots based on a statewide analysis for deer-vehicle crashes in the entire state of California.
Note: AADT = Annual Average Daily Traffic.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
1	1	Del Norte	Crescent City	US Hwy 101	1_DN_101_237	1_DN_101_235	yellow	0.2	0.2	0.0	0.0	2	No	4,450
2	1	Humboldt	Orick	US Hwy 101	1_HUM_101_1148	1_HUM_101_1145	yellow	0.3	0.3	0.0	0.0	2	Yes	4,050
3	2	Siskiyou	Yreka	I-5	2_SIS_5_447	2_SIS_5_446	yellow	0.1	0.1	0.0	0.0	4	No	19,000
4	2	Siskiyou	Mt. Shasta	I-5	2_SIS_5_99	2_SIS_5_96	yellow	0.3	0.3	0.0	0.0	4	No	22,350
5	2	Tehama	Red Bluff	I-5	2_TEH_5_275	2_TEH_5_272	yellow	0.3	0.3	0.0	0.0	4	No	38,500
6	2	Lassen	Susanville	US Hwy 395	2_LAS_395_555	2_LAS_395_529	yellow	2.6	1.0	0.0	0.0	3	Yes	6,950
7	3	El Dorado	Placerville	US Hwy 50	3_ED_50_221	3_ED_50_224	yellow	0.3	0.3	0.0	0.0	4	No	27,450
8	4	Santa Clara	Los Altos Hills	I-280	4_SCL_280_153	4_SCL_280_151	yellow	0.2	0.2	0.0	0.0	8	No	131,500
9	5	San Luis Obispo	Templeton	US Hwy 101	5_SLO_101_497	5_SLO_101_492	red	0.5	0.2	0.3	0.1	4	Yes	58,850
10	6	Madera	Oakhurst	Hwy 41	6_MAD_41_352	6_MAD_41_348	yellow	0.4	0.4	0.0	0.0	3	No	16,500
11	9	Mono	Bridgeport	US Hwy 395	9_MNO_395_819	9_MNO_395_809	orange	1.0	0.6	0.3	0.0	2	No	3,050
12	9	Mono	Mammoth Lakes	US Hwy 395	9_MNO_395_201	9_MNO_395_195	orange	0.6	0.2	0.4	0.0	4	No	9,650
13	10	Mariposa	Mariposa	Hwy 49	10_MPA_49_126	10_MPA_49_123	yellow	0.3	0.3	0.0	0.0	2	Yes	5,200

1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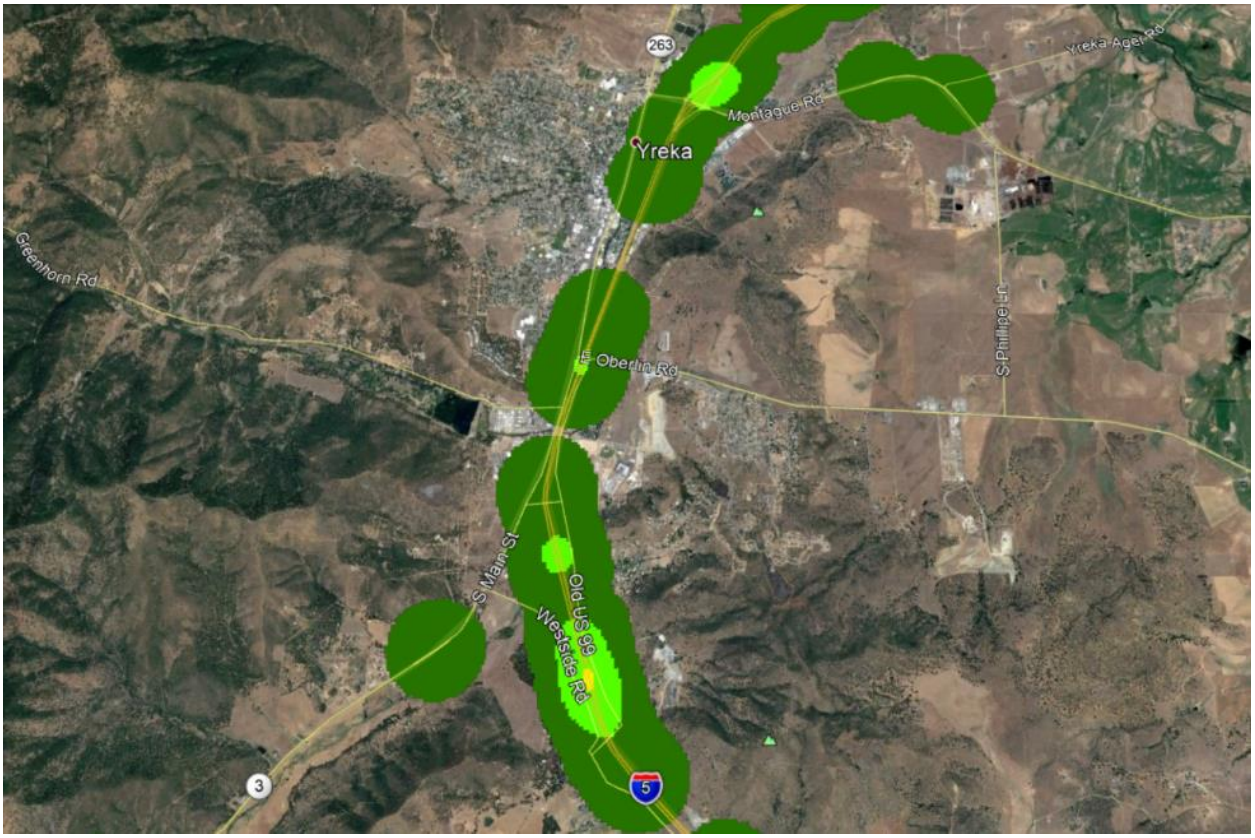
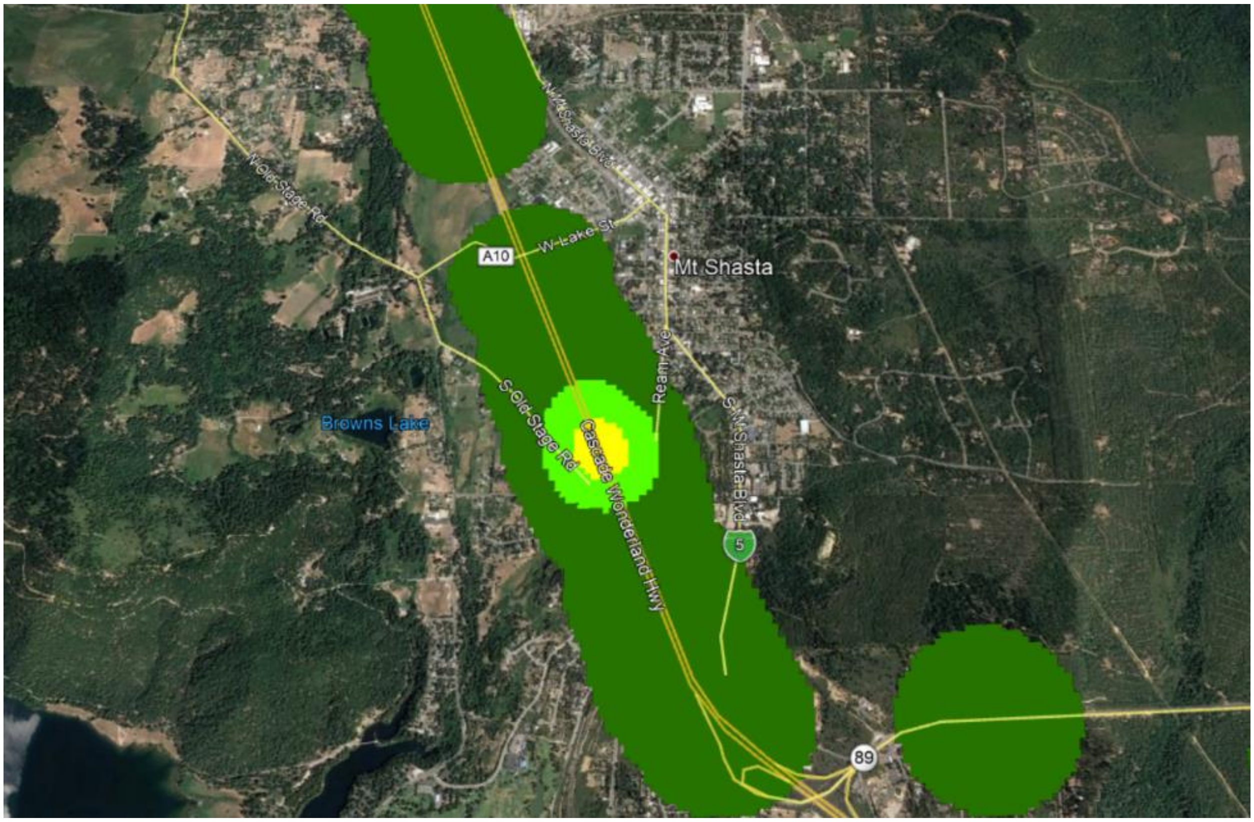
N Pebble Beach Dr
Inyo St
Northcrest Dr
Parkway Dr
A St
Crescent City
Front St
Preston Island
White Rock
Battery Point Island
Pelican Rock
Steamboat Rock
Whaler Island
Fauntleroy Rock
Round Rock
Mussel Rock
Howland Hill Rd
D2
Bertsch-Oceanview
Humboldt Rd
Redwood Hwy

2

3


263
Yreka
Montague Rd
Yreka Ager Rd
Greenhorn Rd
E Oberlin Rd
S Phillipe Ln
S Main St
Old US 99
Westside Rd
3
5

4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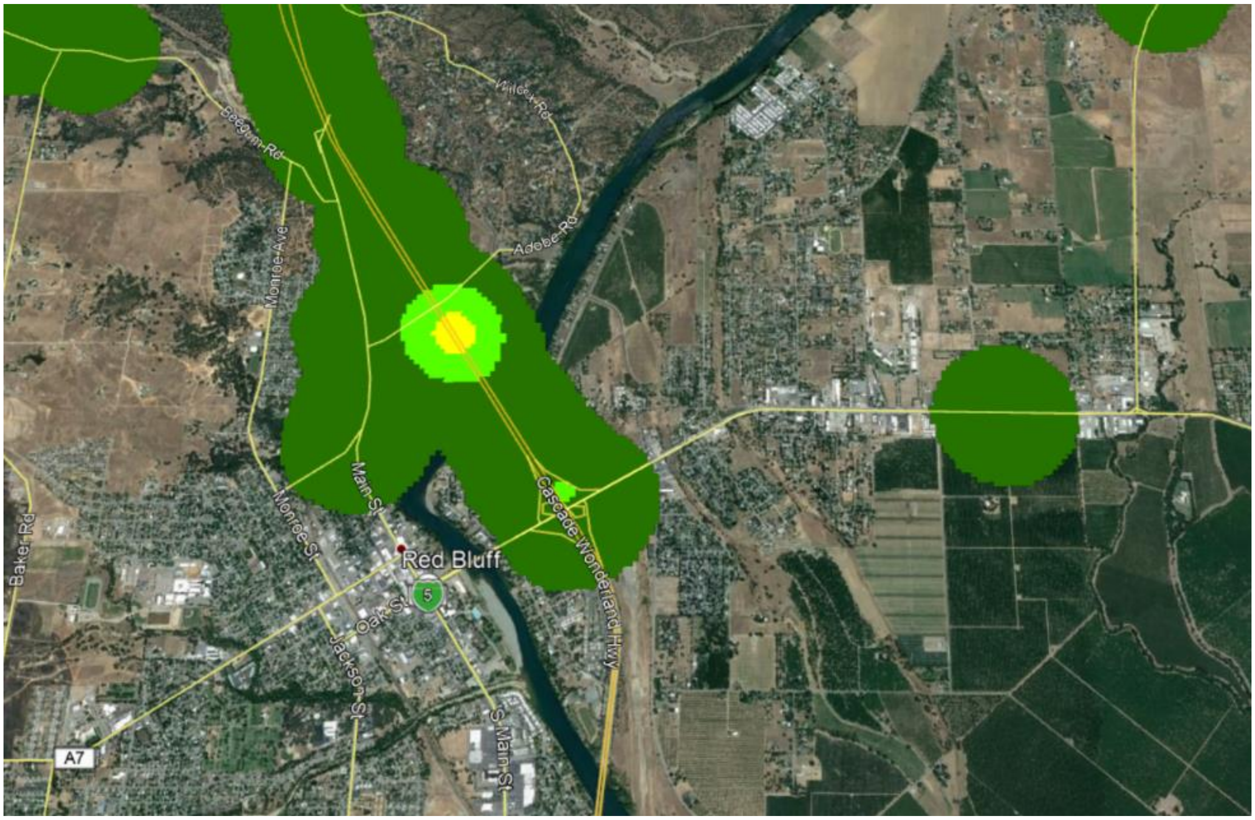
W Lake St
A10
Mt Shasta
Ream Ave
S Old Stage Rd
Browns Lake
Cascade Wonderland Hwy
S Mt Shasta Blvd
5
89

5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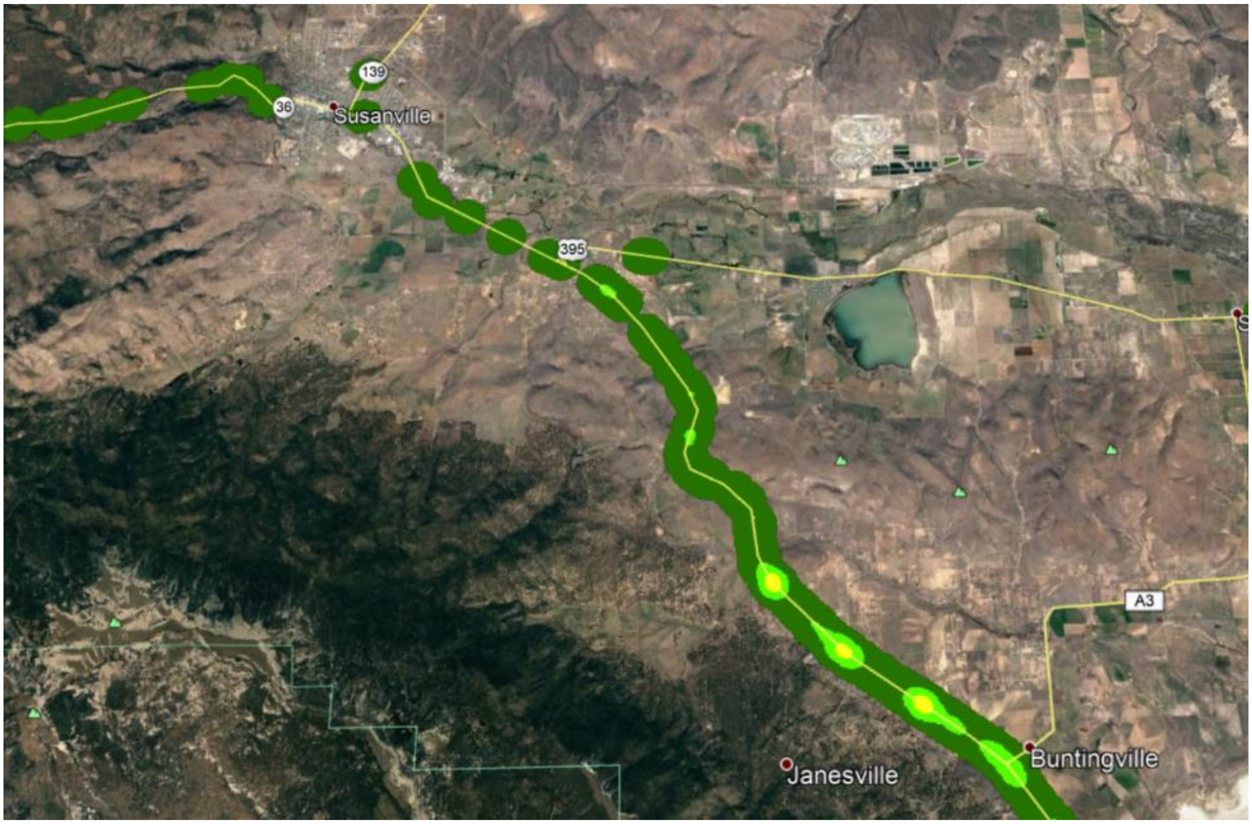
Adobe Rd
Monroe Ave
Red Bluff
Main St
Monroe St
Cascade Wonderland Hwy
Oak St
Jackson St
S Main St
Baker Rd
A7
5

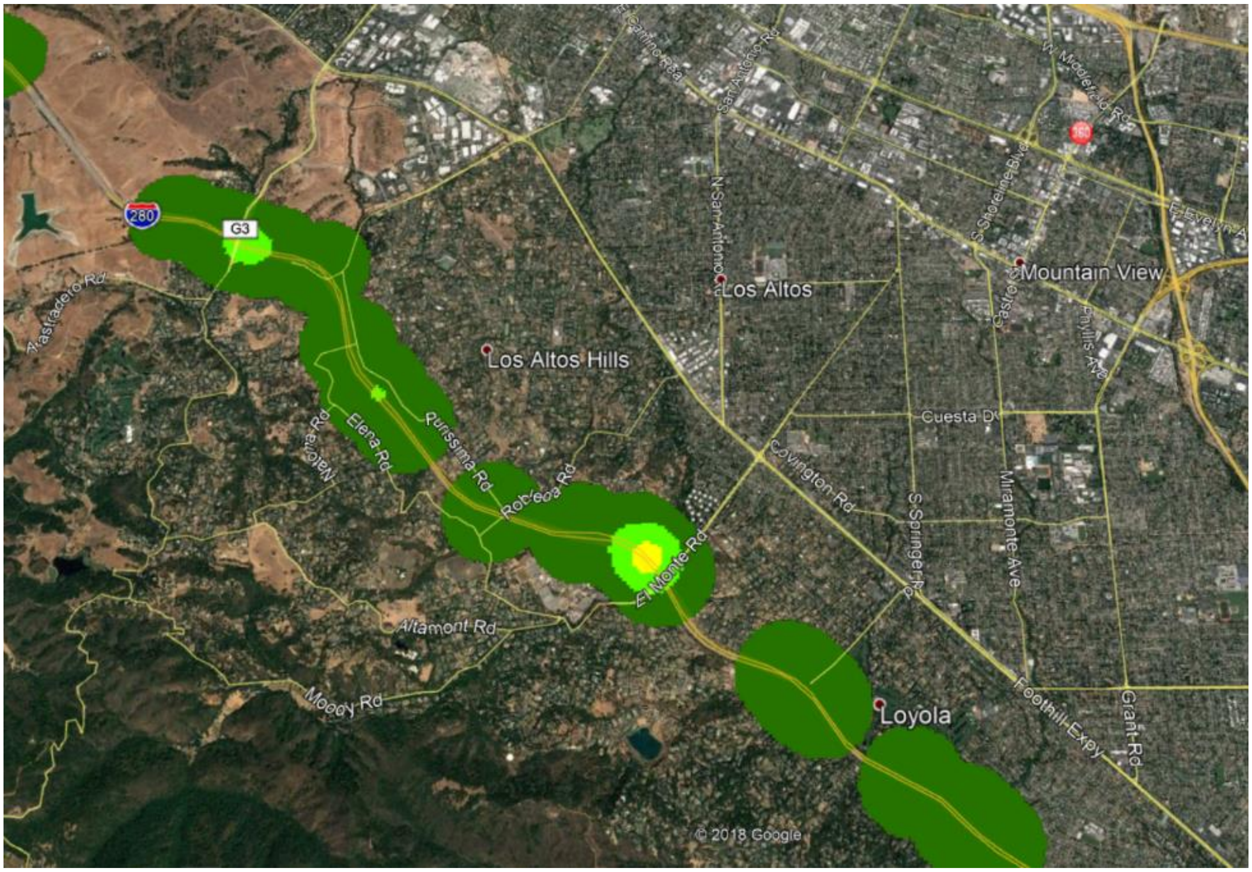
6



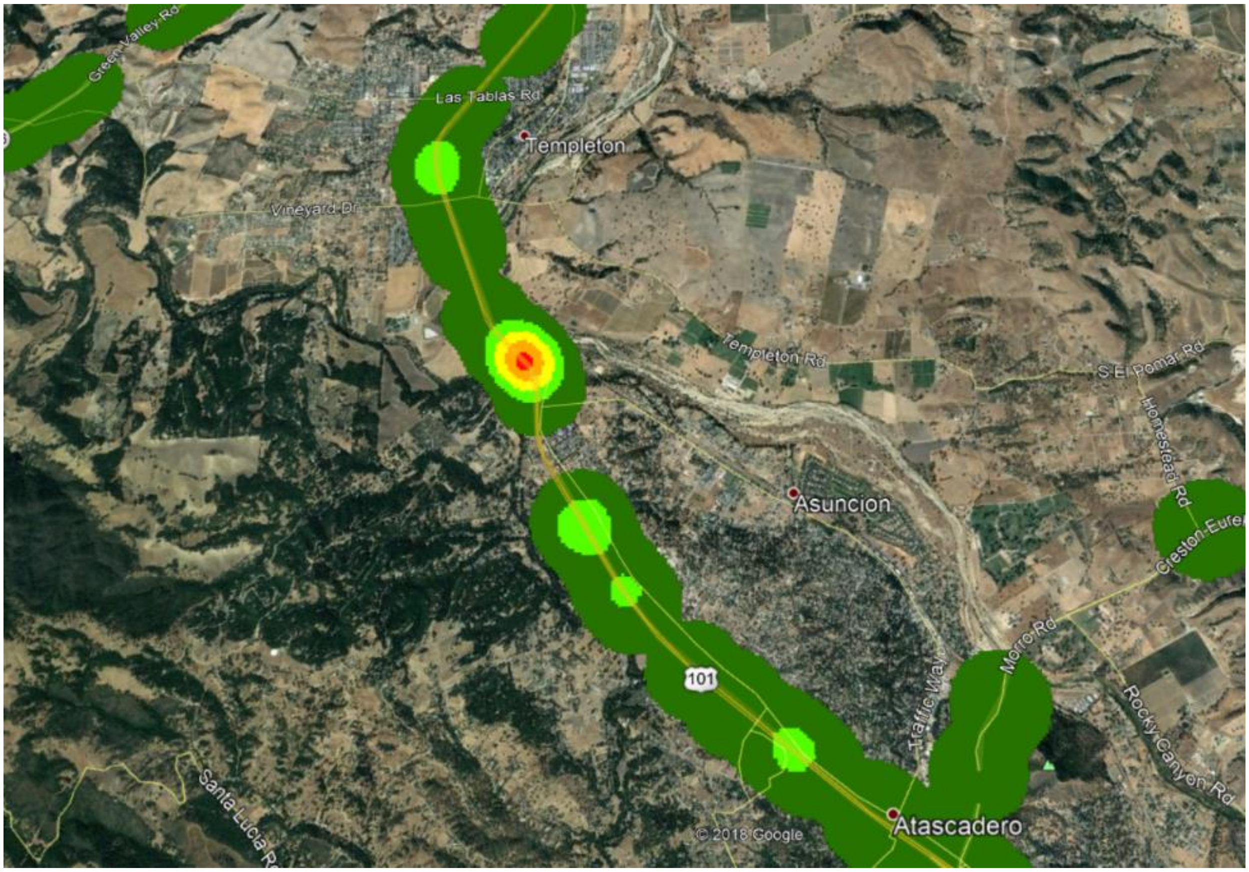
7


Union Ridge Rd
193
Carson Rd
Colona Rd
Mosquito Rd
49
50
Placerville
Cedar Ravine Rd
Smithflat
145
Motor City
Five Mile Terrace

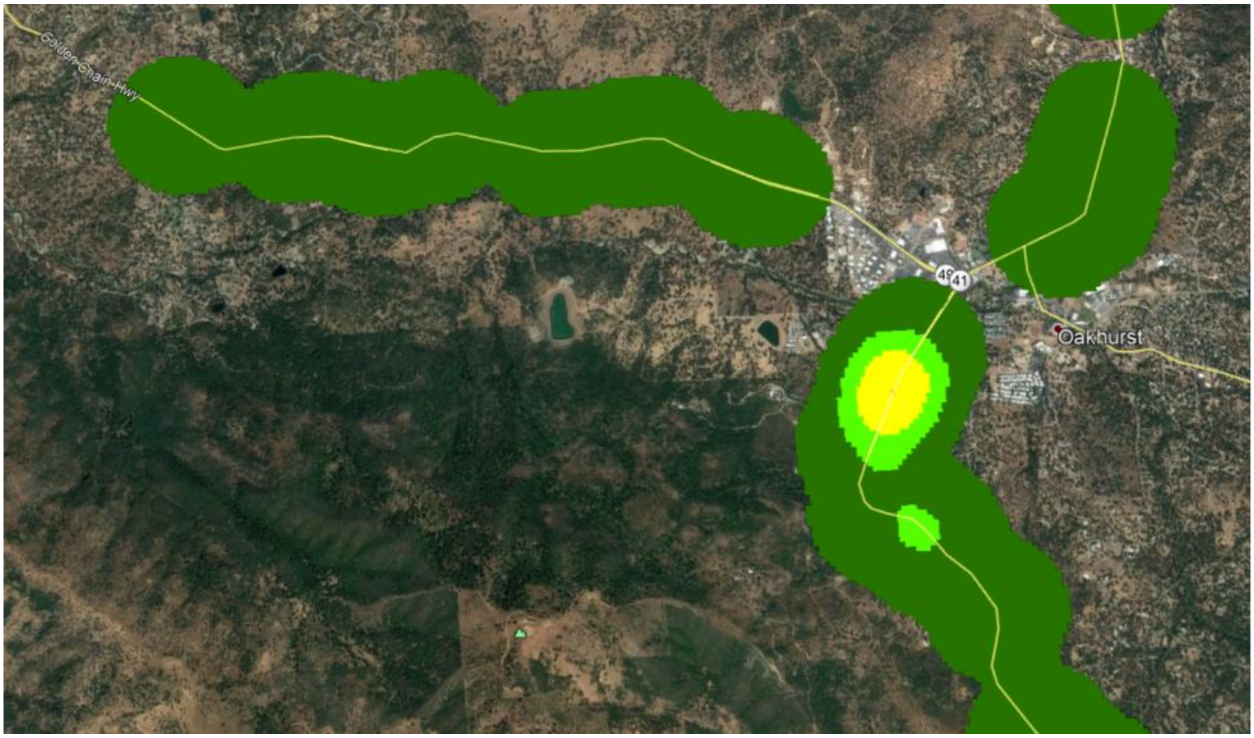
8


280
G3
Los Altos Hills
Los Altos
Mountain View
Loyola
Elena Rd
Purissima Rd
Robleda Rd
El Monte Rd
Altamont Rd
Moody Rd
Covington Rd
Cuesta Dr
S Springer Rd
Miramonte Ave
Foothill Expy
Grant Rd
N San Antonio Rd
Phyllis Ave
© 2018 Google

9


Green Valley Rd
Las Tablas Rd
Templeton
Vineyard Dr
Templeton Rd
S El Pomar Rd
Homestead Rd
Asuncion
Creston-Eure
101
Traffic Way
Morro Rd
Rocky Canyon Rd
Santa Lucia R
© 2018 Google
Atascadero

10



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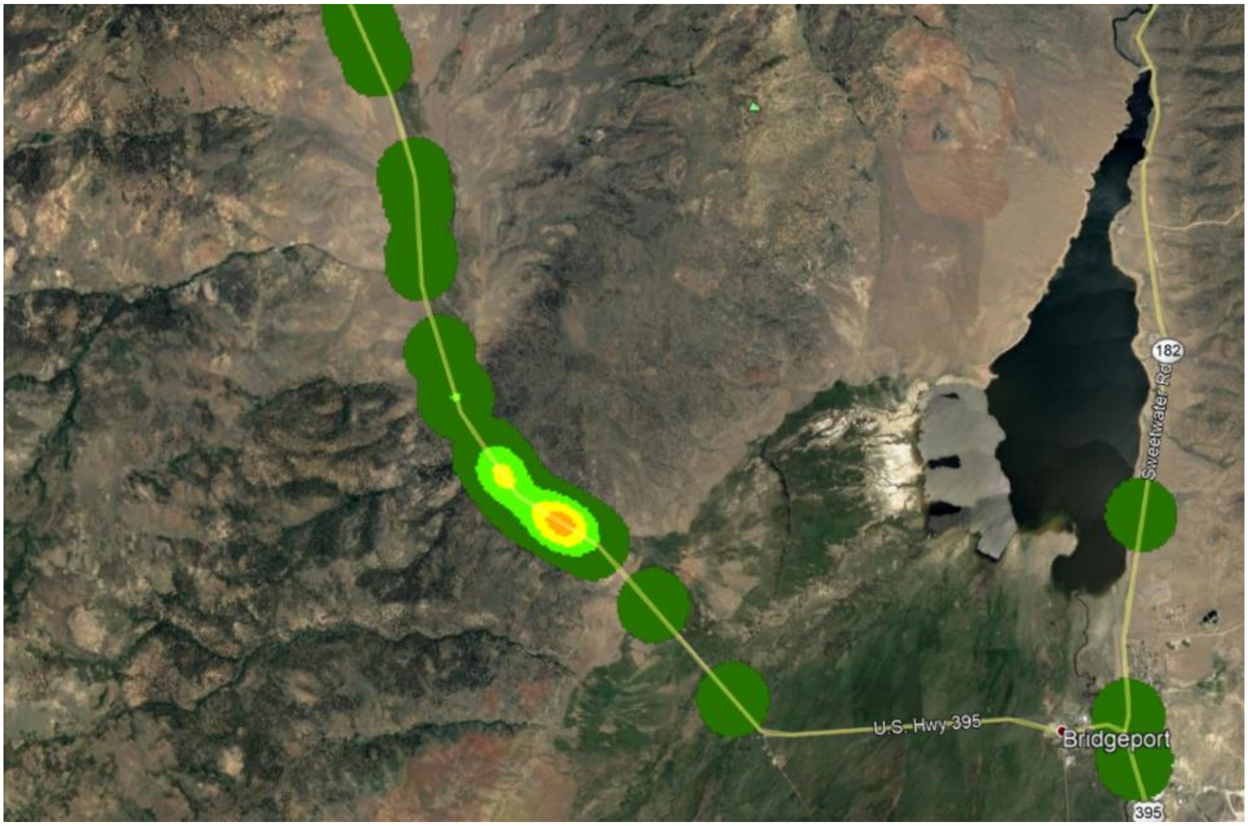
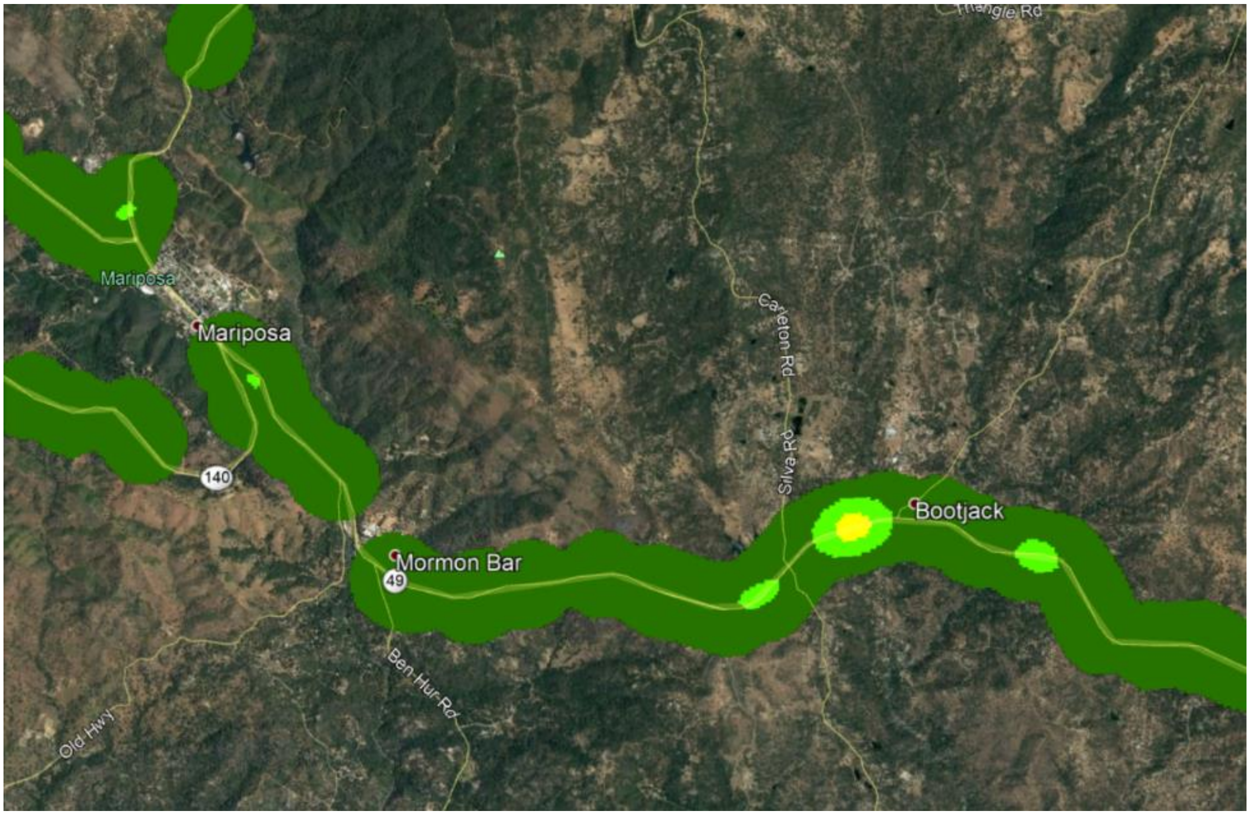


12

13


Triangle Rd
Mariposa
Mariposa
140
Mormon Bar
49
Carleton Rd
Silva Rd
Bootjack
Ben Hur Rd
Old Hwy

9. APPENDIX B: ANALYSES PER DISTRICT DEER-VEHICLE CRASH HOT SPOTS

CRASH DATA PER DISTRICT

The numbers in the table on the following page correspond with the detailed maps per district and maps of the individual hot spots within a district on the following pages.

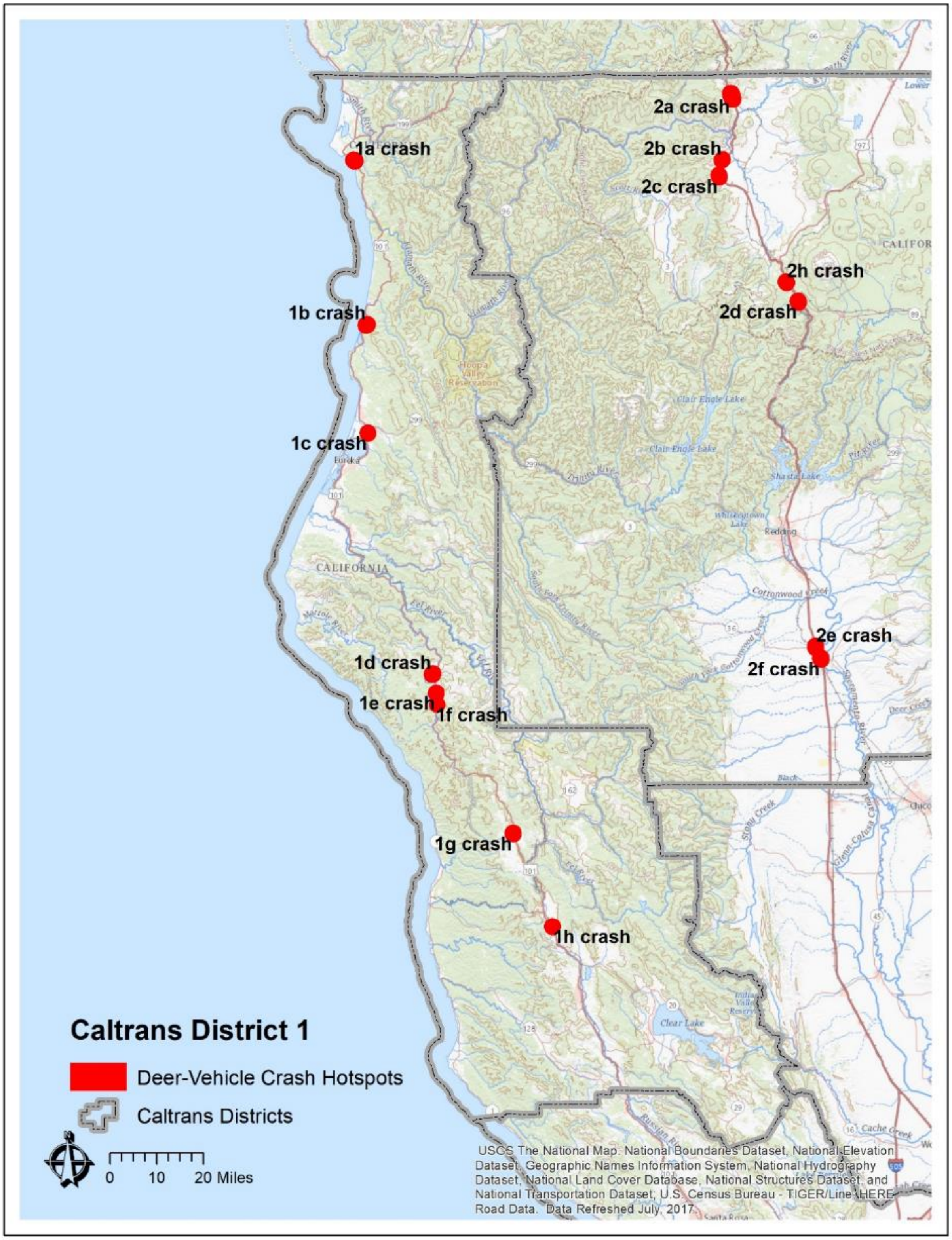
The "worst" hot spots based on analyses for deer-vehicle crashes per Caltrans district. Note: AADT = Annual Average Daily Traffic.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
1a	1	Del Norte	Crescent City	US Hwy 101	1_DN_101_239	1_DN_101_233	orange	0.6	0.3	0.3	0.0	2	No	4,450
1b	1	Humboldt	Orick	US Hwy 101	1_HUM_101_1150	1_HUM_101_1142	red	0.8	0.4	0.2	0.2	2	Yes	4,050
1c	1	Humboldt	Arcata	US Hwy 101	1_HUM_101_878	1_HUM_101_875	yellow	0.3	0.3	0.0	0.0	4	No	38,200
1d	1	Humboldt	Redway	US Hwy 101	1_HUM_101_147	1_HUM_101_143	yellow	0.4	0.4	0.0	0.0	4	No	8,100
1e	1	Humboldt	Redway	US Hwy 101	1_HUM_101_102	1_HUM_101_100	yellow	0.2	0.2	0.0	0.0	5	No	7,650
1f	1	Humboldt	Redway	US Hwy 101	1_HUM_101_70	1_HUM_101_69	yellow	0.1	0.1	0.0	0.0	4	No	6,850
1g	1	Mendocino	Laytonville	US Hwy 101	1_MEN_101_668	1_MEN_101_665	yellow	0.3	0.3	0.0	0.0	2	No	7,800
1h	1	Mendocino	Willits	US Hwy 101	1_MEN_101_426	1_MEN_101_424	yellow	0.2	0.2	0.0	0.0	4	No	21,000
2a	2	Siskiyou	Hornbrook	I-5	2_SIS_5_651	2_SIS_5_636	yellow	2.5	0.8	0.0	0.0	4	Yes	16,200
2b	2	Siskiyou	Yreka	I-5	2_SIS_5_486	2_SIS_5_483	yellow	0.3	0.3	0.0	0.0	4	Yes	16,550
2c	2	Siskiyou	Yreka	I-5	2_SIS_5_450	2_SIS_5_444	orange	0.6	0.3	0.3	0.0	4	No	18,850
2d	2	Siskiyou	Mt. Shasta	I-5	2_SIS_5_100	2_SIS_5_95	orange	0.5	0.2	0.3	0.0	4	No	22,350
2e	2	Tehama	Red Bluff	I-5	2_TEH_5_319	2_TEH_5_314	yellow	0.5	0.5	0.0	0.0	5	Yes	42,750
2f	2	Tehama	Red Bluff	I-5	2_TEH_5_276	2_TEH_5_271	yellow	0.5	0.2	0.3	0.0	4	No	38,500
2g	2	Lassen	Susanville	US Hwy 395	2_LAS_395_557	2_LAS_395_501	red	5.6	2.3	0.8	0.2	3	Yes	6,950
2h	2	Siskiyou	Black Butte	I-5	2_SIS_5_149	2_SIS_5_145	yellow	0.4	0.4	0.0	0.0	4	No	24,800
3a	3	El Dorado	Placerville	US Hwy 50	3_ED_50_229	3_ED_50_220	red	0.9	0.2	0.5	0.2	4	No	27,450
3b	3	El Dorado	Perks Corner	US Hwy 50	3_ED_50_152	3_ED_50_115	orange	3.7	1.4	0.2	0.0	4	Yes	10,600
3c	3	El Dorado	Shingle Springs	US Hwy 50	3_ED_50_88	3_ED_50_54	yellow	3.4	1.1	0.0	0.0	6	No	66,200
3d	3	Sacramento	Rancho Murieta	Hwy 16	3_SAC_16_197	3_SAC_16_194	yellow	0.3	0.3	0.0	0.0	2	No	11,250
3e	3	Nevada	Grass Valley	Hwy 49/20	3_NEV_20_150	3_NEV_20_135	yellow	0.5	0.5	0.0	0.0	6	No	21,800
3f	3	Nevada	Grass Valley	Hwy 20	3_NEV_20_115	3_NEV_20_111	yellow	0.4	0.4	0.0	0.0	3	No	21,300
3g	3	Nevada	Penn Valley	Hwy 20	3_NEV_20_70	3_NEV_20_66	orange	0.4	0.2	0.2	0.0	3	No	15,800
3h	3	Nevada	La Barr Meadows	Hwy 49	3_NEV_49_121	3_NEV_49_117	orange	0.4	0.2	0.2	0.0	3	No	24,500
3i	3	Nevada	Alta Sierra	Hwy 49	3_NEV_49_90	3_NEV_49_79	orange	1.1	0.5	0.2	0.0	3	No	23,550
3j	3	Nevada	Higgins Corner	Hwy 49	3_NEV_49_40	3_NEV_49_26	orange	1.4	0.7	0.3	0.0	2	Yes	23,200
3k	3	Placer	Overhill Dr	Hwy 49	3_PLA_49_113	3_PLA_49_110	yellow	0.3	0.3	0.0	0.0	4	No	30,700
3l	3	Placer	Elders Corner	Hwy 49	3_PLA_49_81	3_PLA_49_78	orange	0.3	0.3	0.0	0.0	4	No	32,500
3m	3	Placer	Weimar	I-80	3_PLA_80_295	3_PLA_80_291	yellow	0.4	0.4	0.0	0.0	5	Yes	39,450
4a	4	Marin	San Rafael	US Hwy 101	4_MRN_101_128	4_MRN_101_125	yellow	0.3	0.3	0.0	0.0	10	No	202,700

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
4b	4	Marin	Strawberry	US Hwy 101	4_MRN_101_59	4_MRN_101_56	yellow	0.3	0.3	0.0	0.0	10	No	152,800
4c	4	San Mateo	Highlands-Baywood Park	I-280	4_SM_280_144	4_SM_280_122	yellow	2.2	1.0	0.0	0.0	10	Yes	129,000
4d	4	San Mateo	Woodside	I-280	4_SM_280_95	4_SM_280_31	orange	6.4	1.7	0.3	0.0	8	Yes	114,000
4e	4	Santa Clara	Stanford	I-280	4_SM_280_2	4_SCL_280_182	yellow	2.6	0.6	0.0	0.0	8	No	121,000
4f	4	Santa Clara	Los Altos Hills	I-280	4_SCL_280_154	4_SCL_280_150	red	0.4	1.0	2.0	1.0	6	No	131,500
4g	4	Contra Costa	Condit	Hwy 24	4_CC_24_78	4_CC_24_76	yellow	0.2	0.2	0.0	0.0	8	No	209,500
4h	4	Contra Costa	Orinda	Hwy 24	4_CC_24_25	4_CC_24_21	yellow	0.4	0.4	0.0	0.0	8	No	188,000
4i	4	Alameda	Redwood Heights	Hwy 13	4_ALA_13_54	4_ALA_13_51	yellow	0.3	0.3	0.0	0.0	4	No	54,600
5a	5	San Luis Obispo	Templeton	US Hwy 101	5_SLO_101_497	5_SLO_101_492	red	0.5	0.2	0.3	0.1	4	Yes	58,850
6a	6	Madera	Oakhurst	Hwy 41	6_MAD_41_352	6_MAD_41_347	red	0.5	0.2	0.2	0.1	3	No	19,000
6b	6	Madera	Oakhurst	Hwy 41	6_MAD_41_317	6_MAD_41_314	yellow	0.3	0.3	0.0	0.0	2	No	19,000
7a	7	Los Angeles	Glendale	Hwy 134	7_LA_134_94	7_LA_134_90	red	0.4	0.1	0.2	0.1	8	No	209,500
7b	7	Los Angeles	Glendale	Hwy 2	7_LA_2_228	7_LA_2_200	orange	2.8	0.7	0.1	0.0	9	No	124,500
7c	7	Los Angeles	Sherman Oaks	I-405	7_LA_405_387	7_LA_405_383	orange	0.4	0.3	0.1	0.0	12	No	253,500
7d	7	Ventura	Casitas Springs	Hwy 33	7_VEN_33_59	7_VEN_33_55	orange	0.4	0.3	0.1	0.0	3	No	26,500
7e	7	Ventura	Moorpark	Hwy 118	7_VEN_118_202	7_VEN_118_200	yellow	0.2	0.2	0.0	0.0	5	No	79,500
8a	8	San Bernardino	Crestline	Hwy 18	8_SBD_18_162	8_SBD_18_151	red	1.1	0.3	0.6	0.2	4	No	16,550
8b	8	San Bernardino	Silverwood Lake	Hwy 138	8_SBD_138_249	8_SBD_138_247	yellow	0.2	0.2	0.0	0.0	2	No	2,925
8c	8	San Bernardino	Running Springs	Hwy 330	8_SBD_330_433	8_SBD_330_407	orange	2.6	0.6	0.3	0.0	2	No	11,500
8d	8	San Bernardino	Running Springs	Hwy 18	8_SBD_18_294	8_SBD_18_290	yellow	0.4	0.4	0.0	0.0	2	No	5,750
8e	8	San Bernardino	Skyforest	Hwy 18	8_SBD_18_263	8_SBD_18_261	yellow	0.2	0.2	0.0	0.0	2	No	5,750
8f	8	Riverside	Palo Verde Intake	US Hwy 95	8_RIV_95_125	8_RIV_95_123	yellow	0.2	0.2	0.0	0.0	2	No	1,300

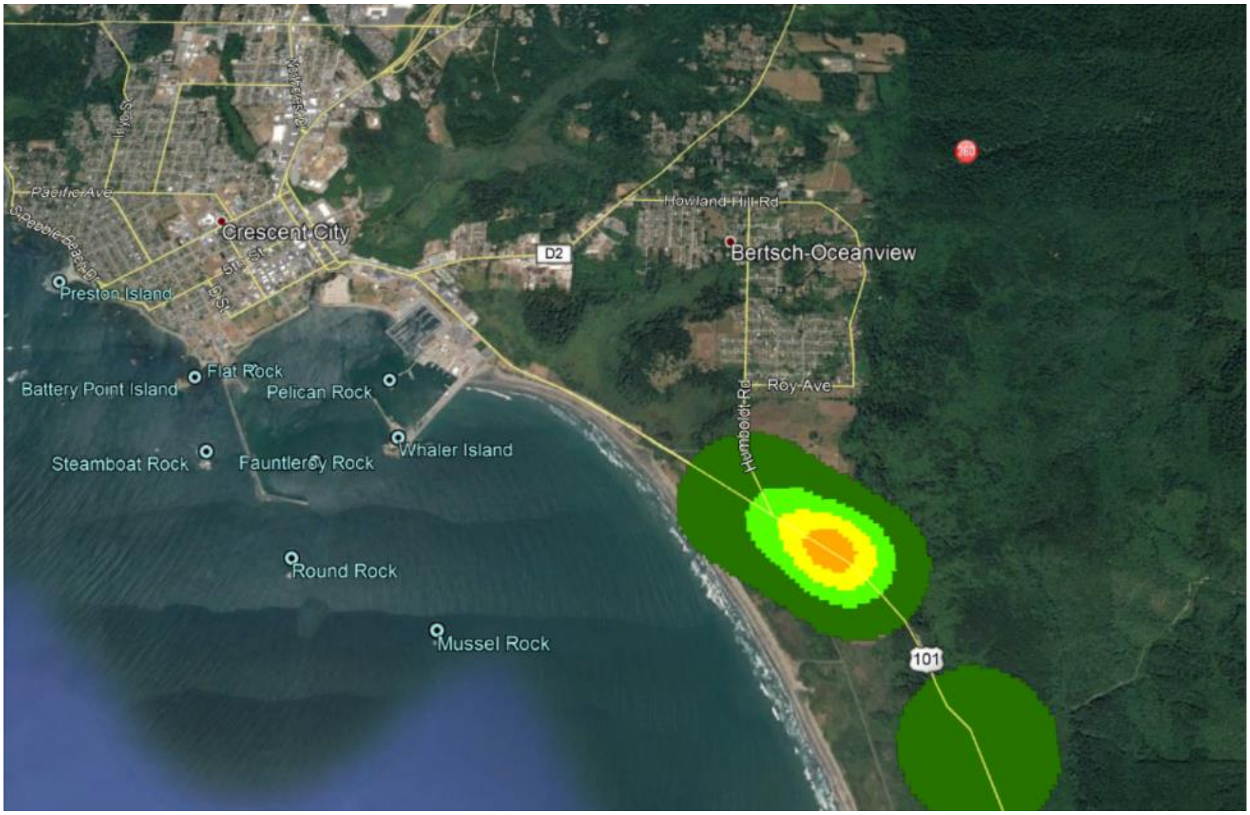
Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
9a	9	Mono	Bridgeport	US Hwy 395	9_MNO_395_819	9_MNO_395_809	red	1.0	0.5	0.3	0.2	2	No	3,050
9b	9	Mono	Whitmore Hot Spr.	US Hwy 395	9_MNO_395_202	9_MNO_395_195	red	0.7	0.3	0.3	0.1	4	No	7,250
9c	9	Mono	Grant Lake	US Hwy 395	9_MNO_395_448	9_MNO_395_445	yellow	0.3	0.3	0.0	0.0	4	No	4,625
10a	10	Mariposa	Bootjack	Hwy 49	10_MPA_49_127	10_MPA_49_111	red	1.6	0.4	0.2	0.2	2	Yes	5,200
10b	10	Calaveras	San Andreas	Hwy 49	10_CAL_49_208	10_CAL_49_205	yellow	0.3	0.3	0.0	0.0	2	Yes	7,250
11a	11	San Diego	Warner Springs	Hwy 79	11_SD_79_363	11_SD_79_357	red	0.6	0.2	0.2	0.2	2	No	1,400
11b	11	San Diego	Santa Ysabel	Hwy 78	11_SD_78_548	11_SD_78_520	red	2.8	0.5	0.3	0.1	2	No	4,425
11c	11	San Diego	Lake Cuyamaca	Hwy 79	11_SD_79_103	11_SD_79_99	yellow	0.4	0.4	0.0	0.0	2	No	1,650
11d	11	San Diego	La Jolla	I-5	11_SD_5_298	11_SD_5_295	yellow	0.3	0.3	0.0	0.0	12	No	174,500
12a	12	Orange	Las Flores	Hwy 241	12_ORA_241_168	12_ORA_241_152	red	1.6	0.3	0.2	0.1	4	Yes	6,900
12b	12	Orange	Peters Cany. Res.	Hwy 261	12_ORA_261_59	12_ORA_261_56	yellow	0.3	0.3	0.0	0.0	5	Yes	32,200
12c	12	Orange	Villa Park	Hwy 241	12_ORA_241_388	12_ORA_241_385	yellow	0.3	0.3	0.0	0.0	9	No	47,800
12d	12	Orange	Laguna Woods	Hwy 73	12_ORA_73_167	12_ORA_73_165	yellow	0.2	0.2	0.0	0.0	7	No	62,700

CRASH DATA DISTRICT 1

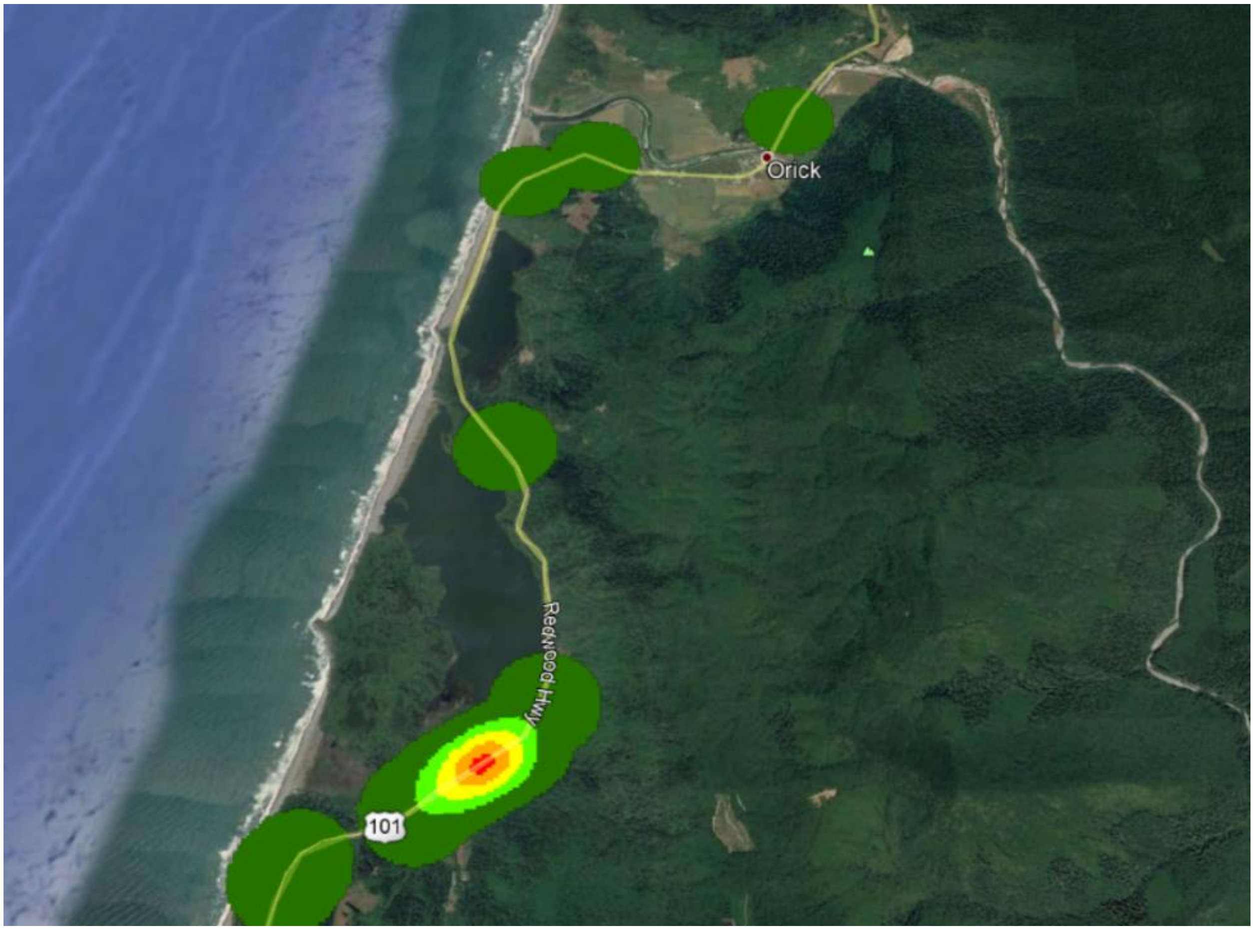


Hot spots in District 1 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

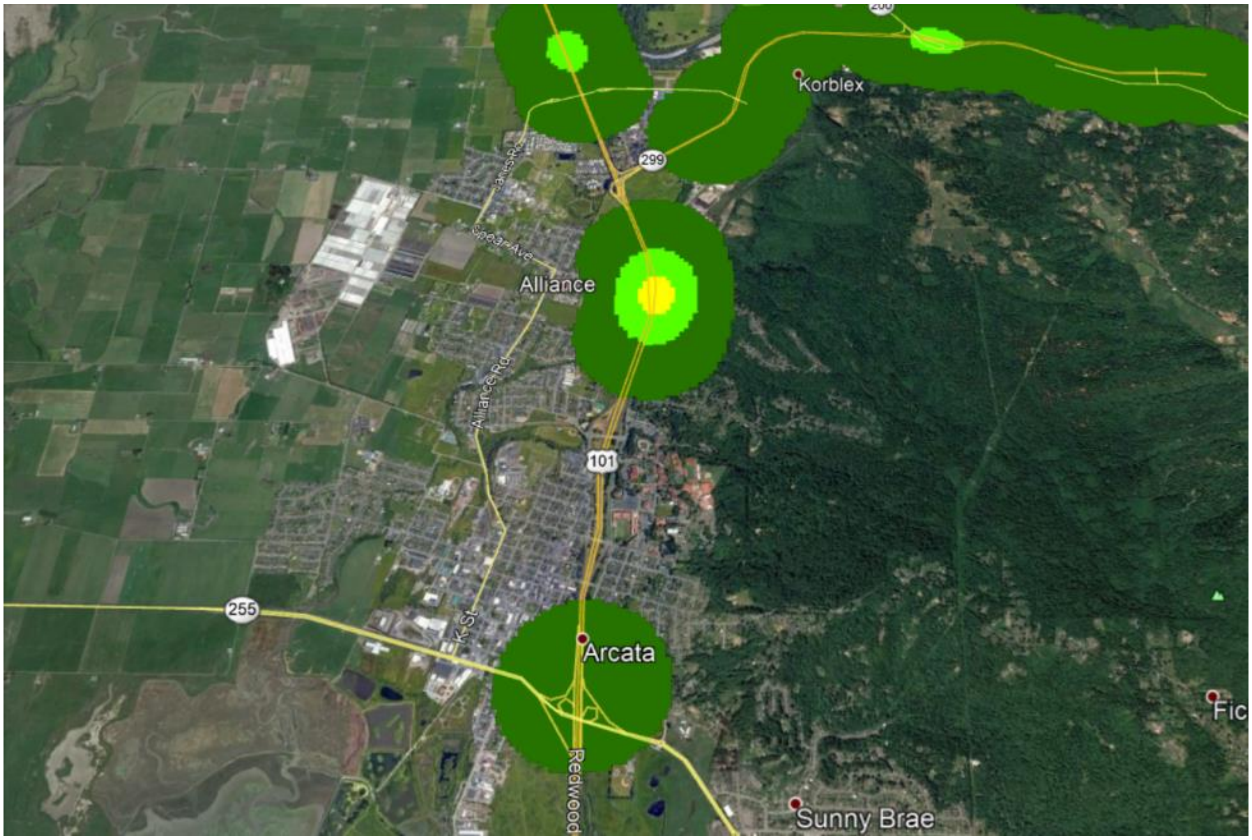
1a


Pacific Ave
Crescent City
Preston Island
Flat Rock
Battery Point Island
Pelican Rock
Steamboat Rock
Fauntleroy Rock
Whaler Island
Round Rock
Mussel Rock
Howland Hill Rd
D2
Bertsch-Oceanview
Roy Ave
Humboldt Rd
101

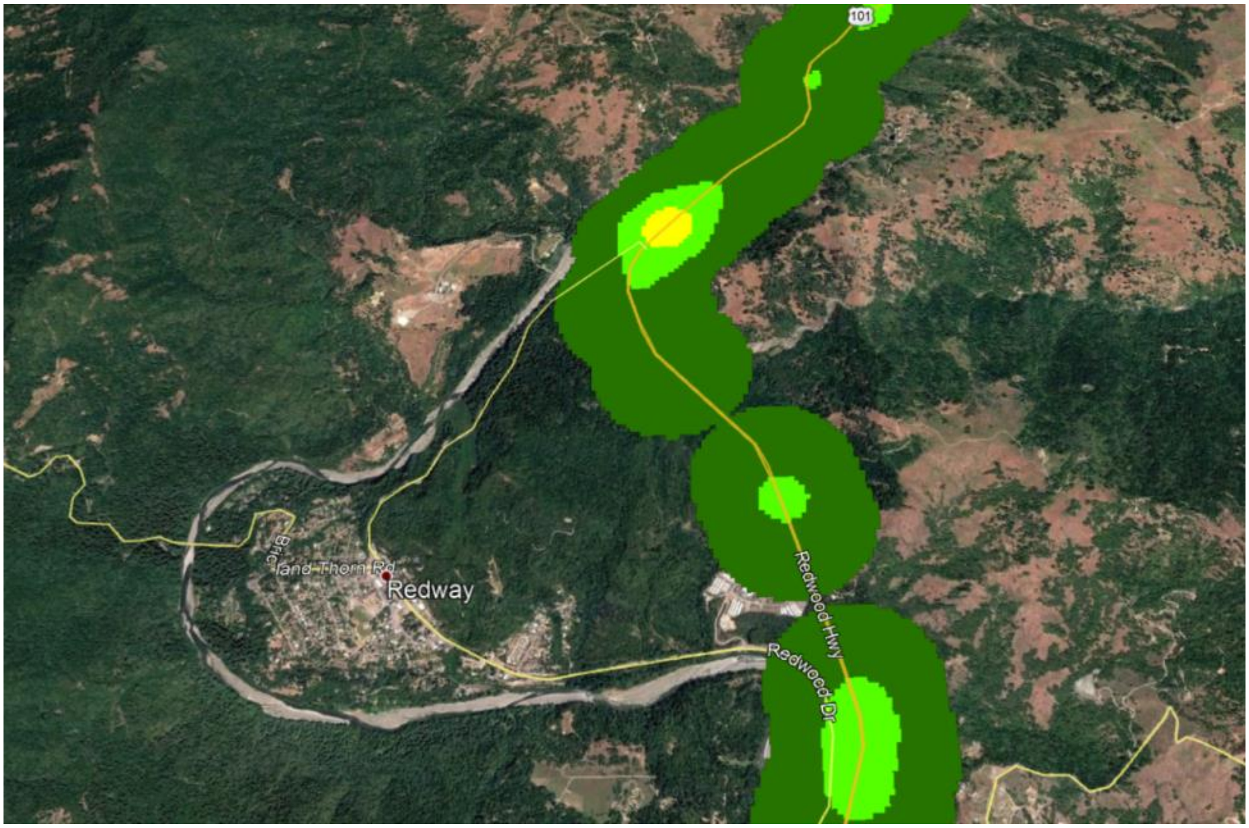
1b



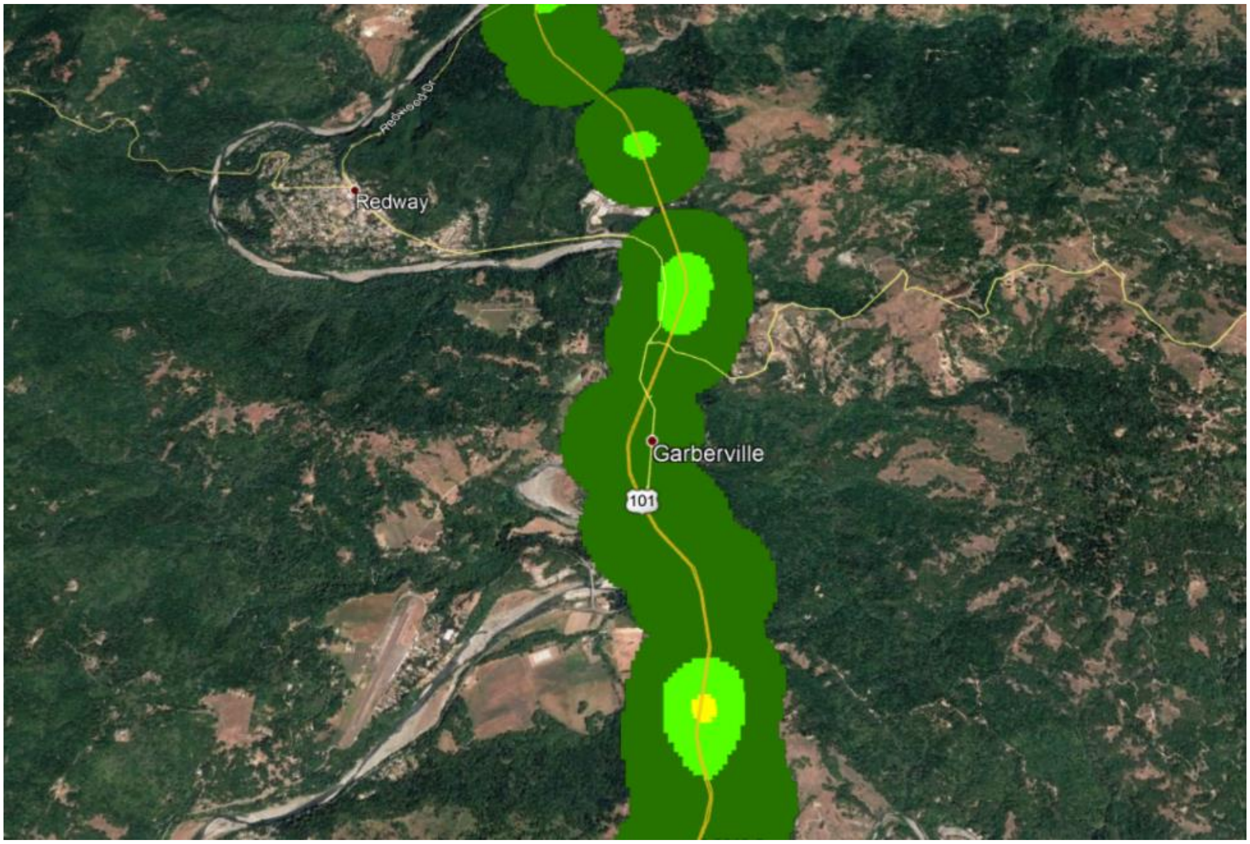
1c


Korblex
299
Alliance
Alliance Rd
101
255
K St
Arcata
Redwood
Sunny Brae
Fic

1d

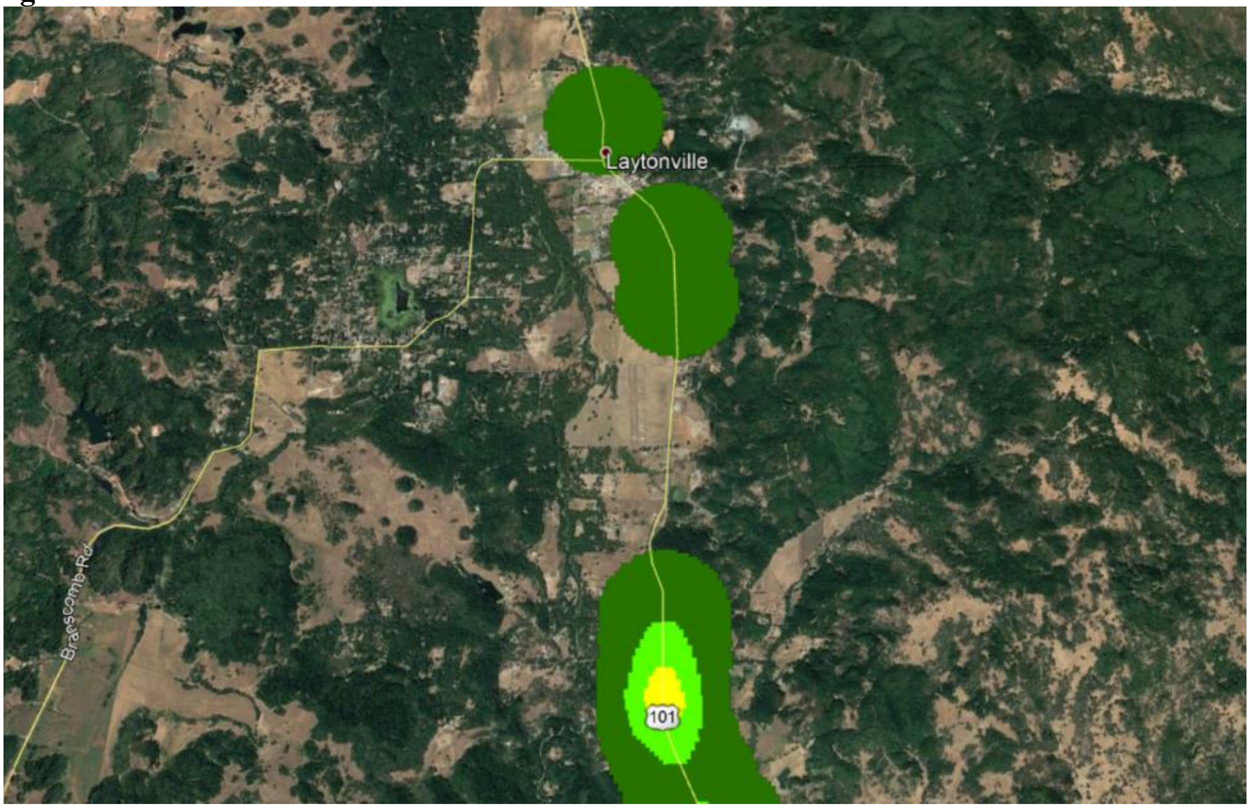


1e

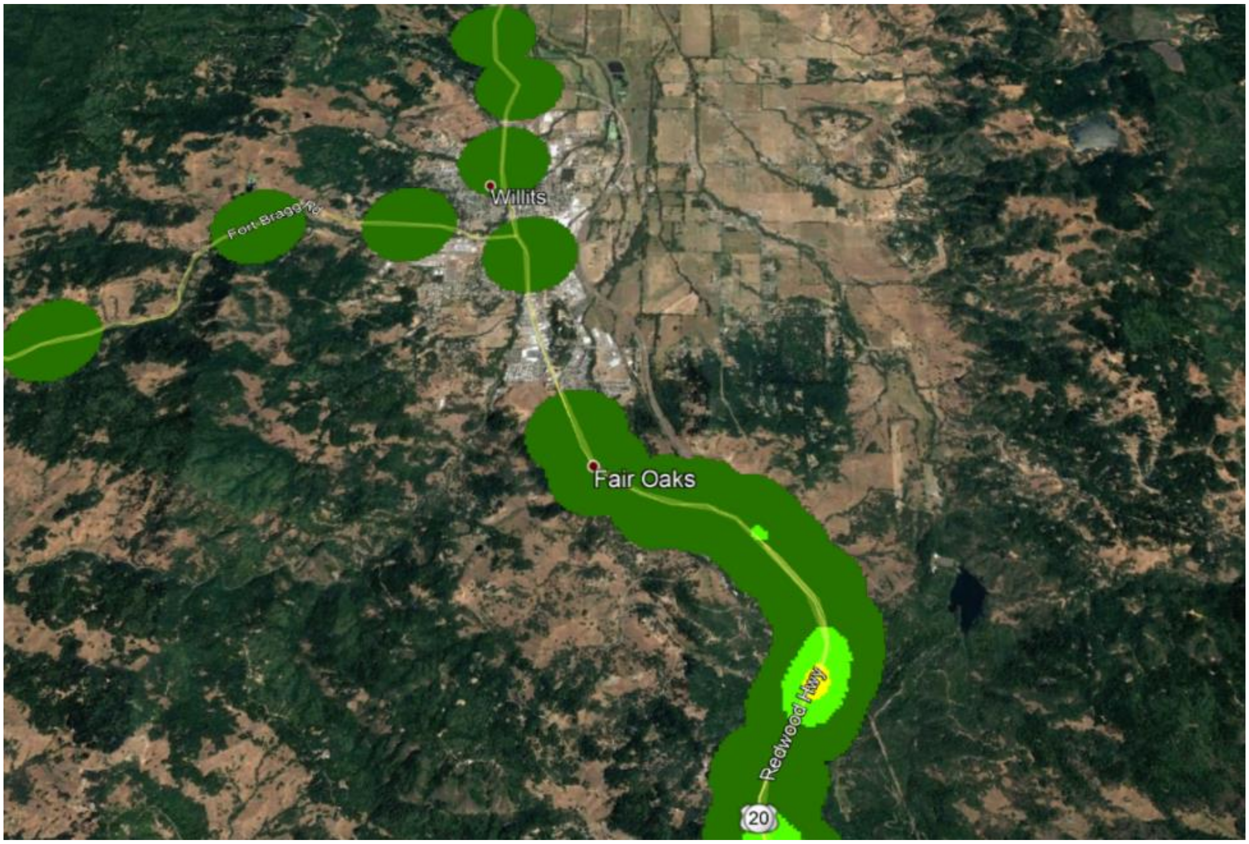


1f

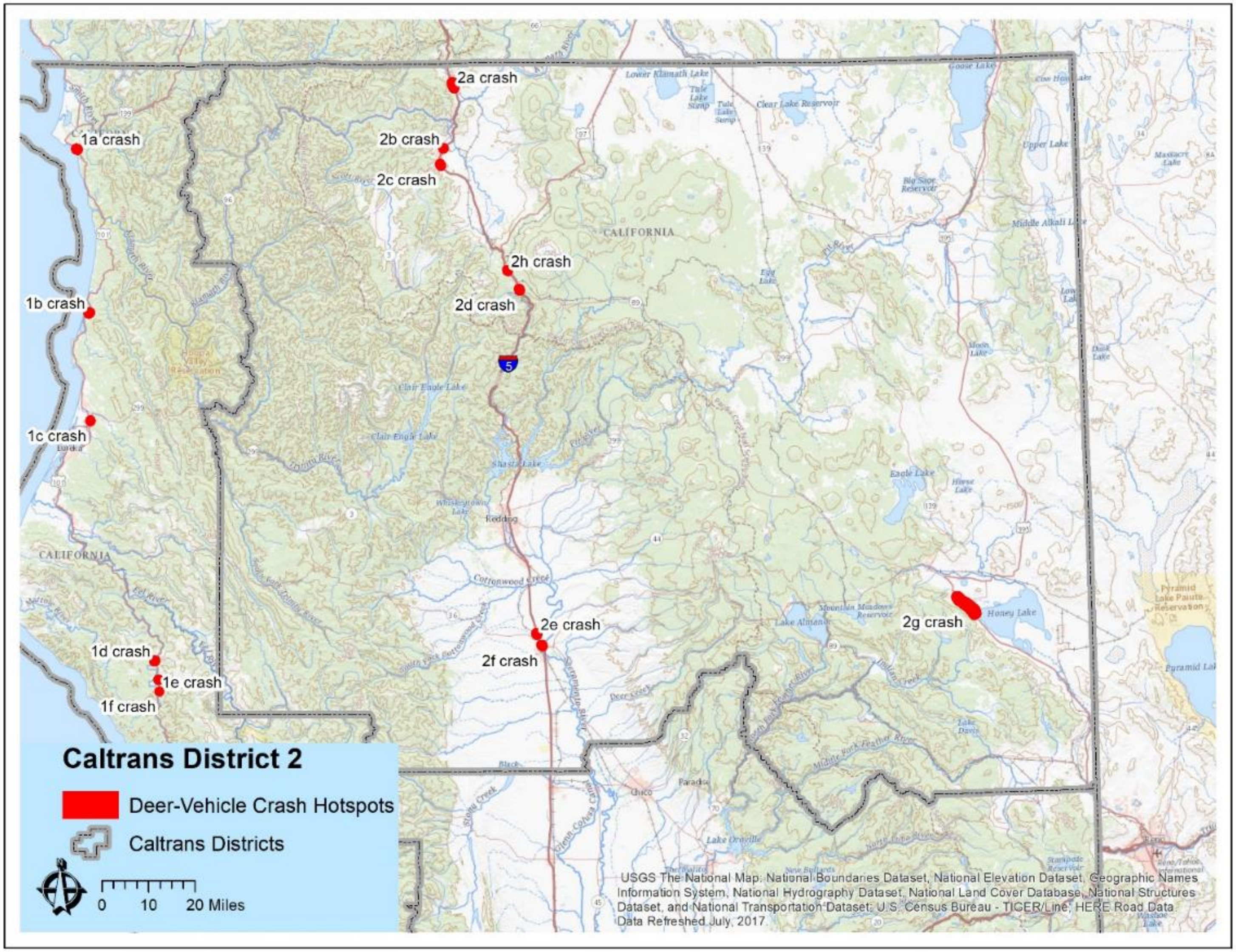
1g



1h

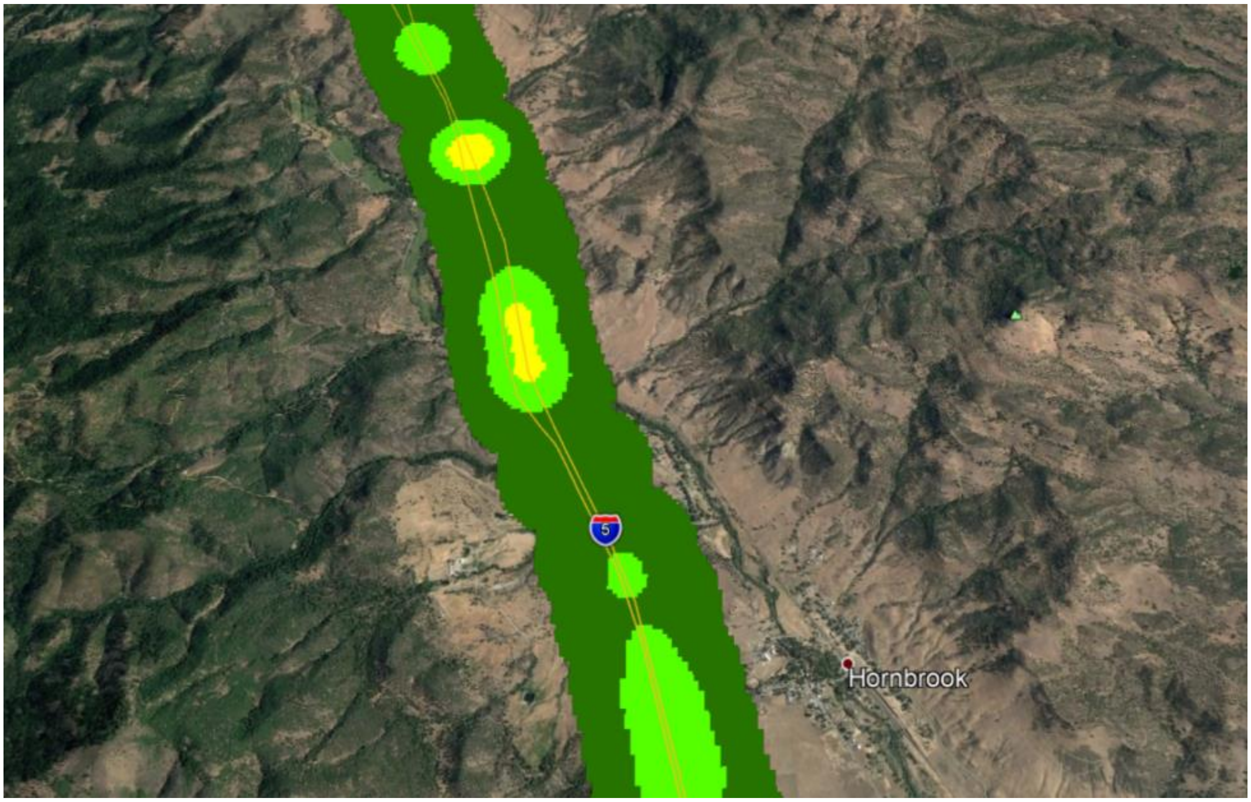


CRASH DATA DISTRICT 2



Hot spots in District 2 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

2a

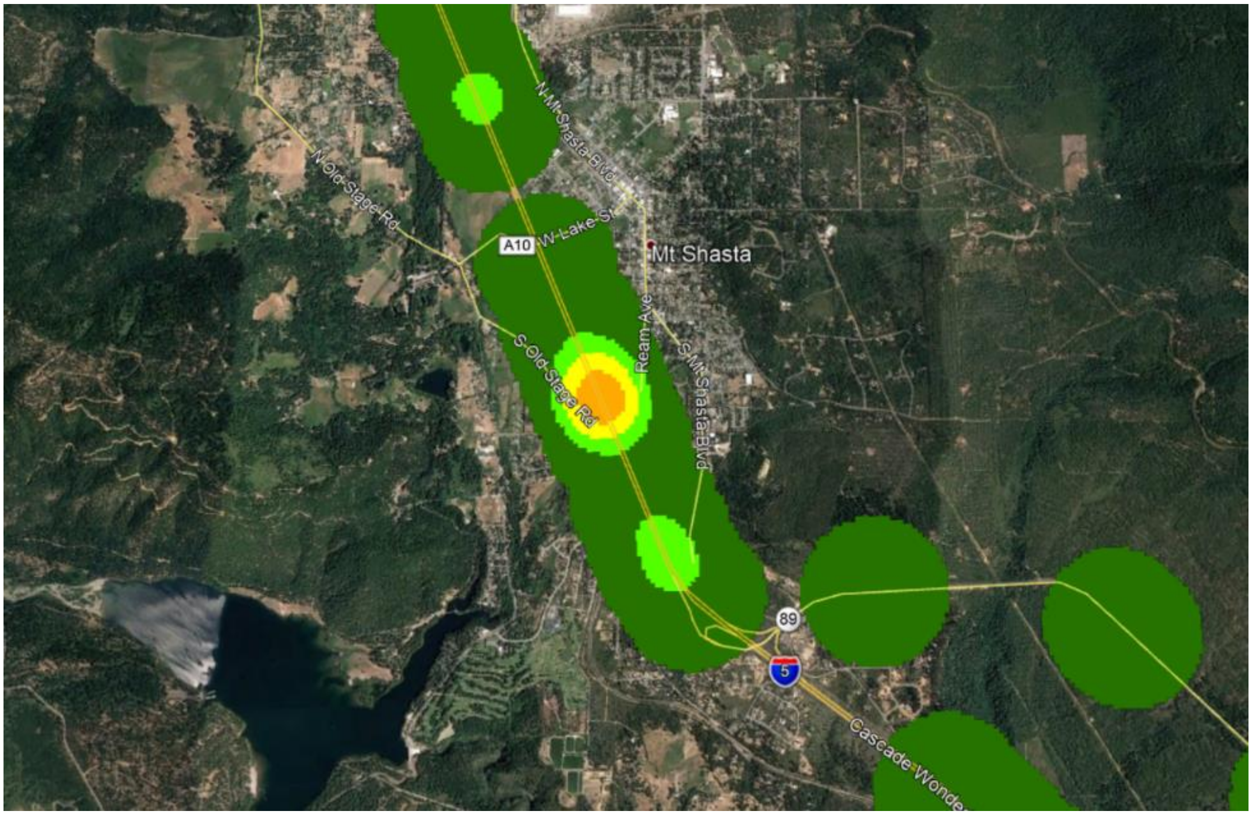


2b

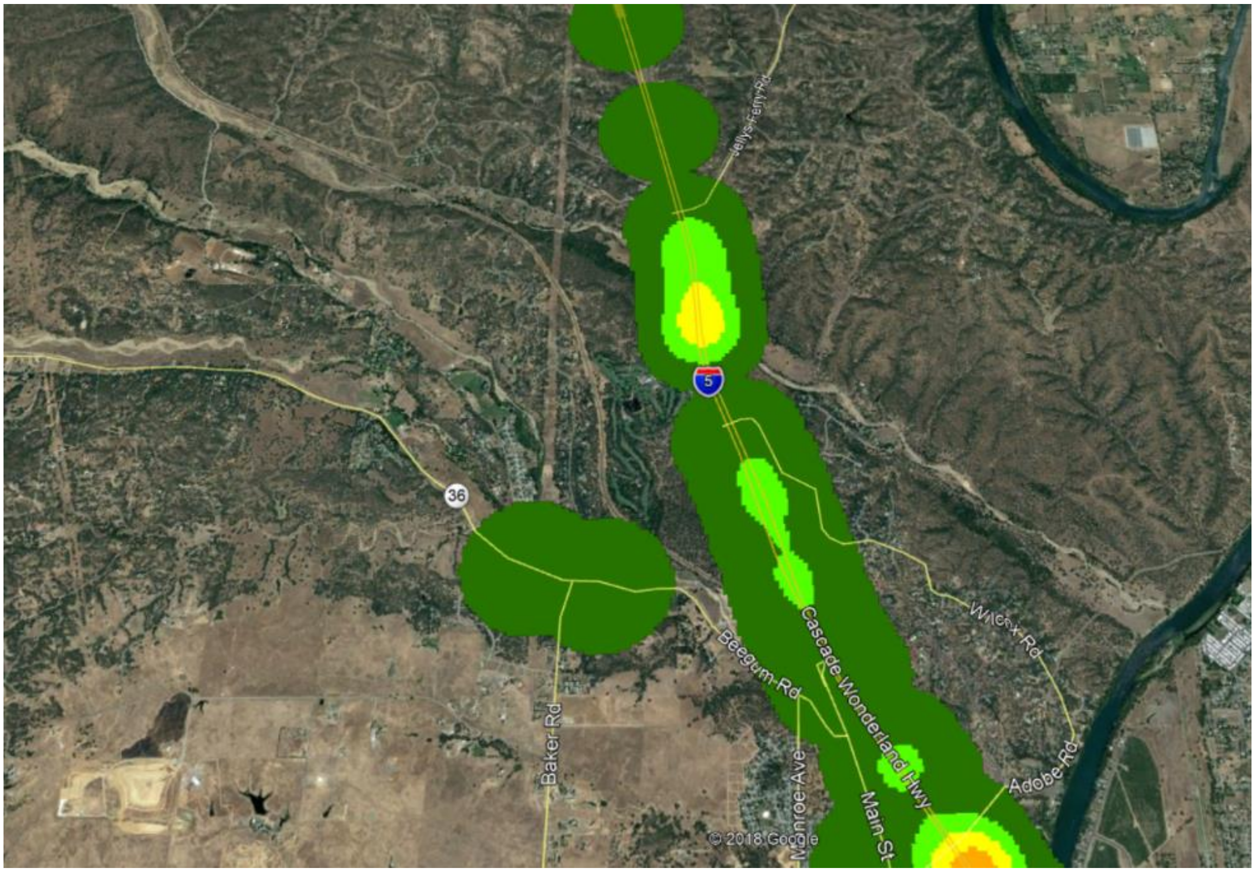
2c


Yreka
Greenhorn Rd
E Oberlin Rd
Oberlin Rd
S Main St
Fort Jones Rd
3
5
Easy St

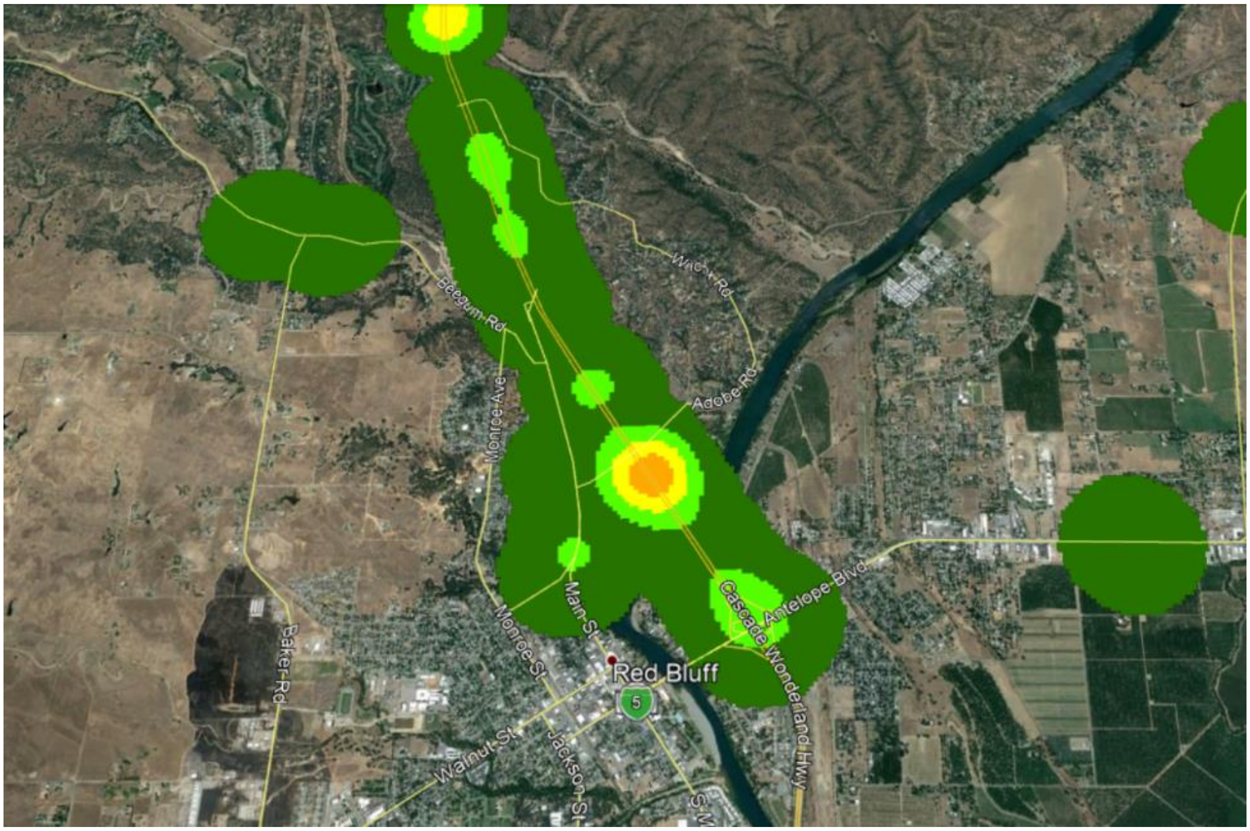
2d


N Mt Shasta Blvd
N Old Stage Rd
A10
W Lake St
Mt Shasta
Ream Ave
S Mt Shasta Blvd
S Old Stage Rd
89
5
Cascade Wonder

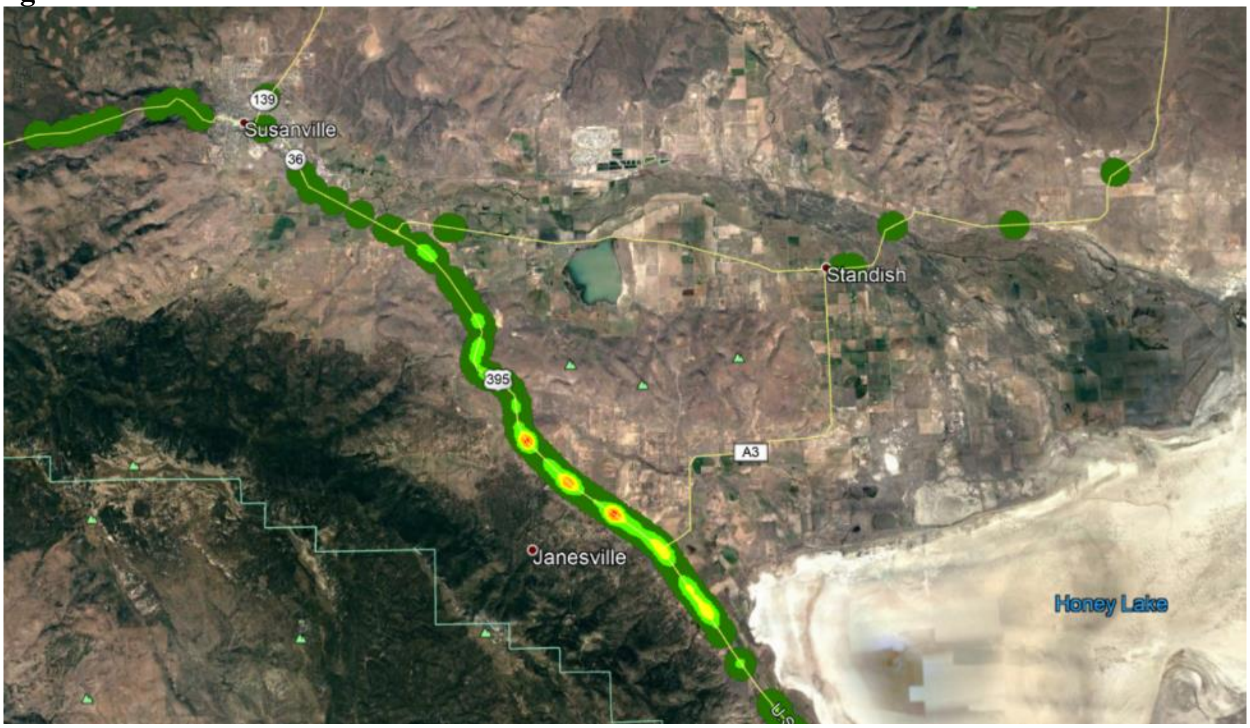
2e


Jellys Ferry Rd
5
36
Beegum Rd
Cascade Wonderland Hwy
Wilcox Rd
Baker Rd
Monroe Ave
Main St
Adobe Rd
© 2018 Google

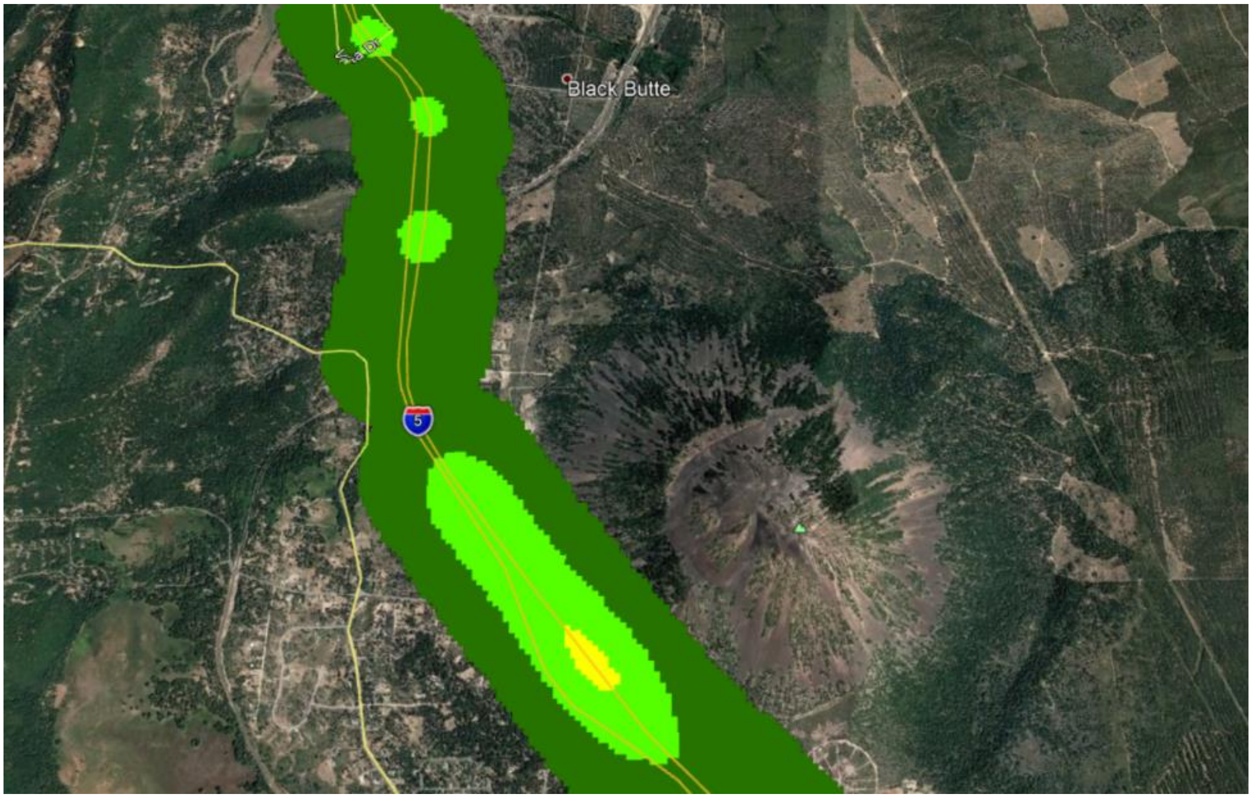
2f


Beegum Rd
Wilcox Rd
Adobe Rd
Monroe Ave
Antelope Blvd
Main St
Cascade Wonderland Hwy
Monroe St
Red Bluff
5
Baker Rd
Walnut St
Jackson St

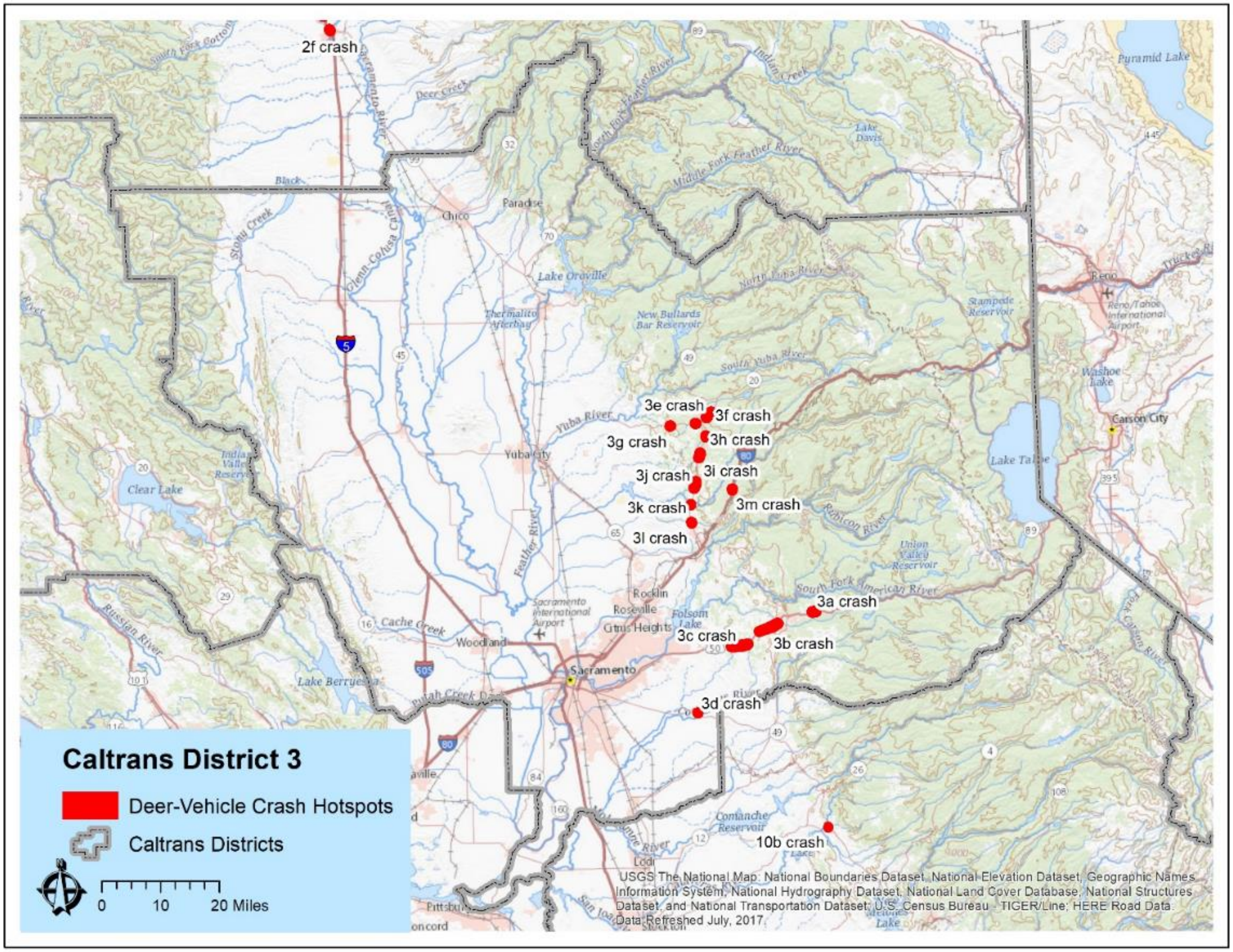
2g



2h

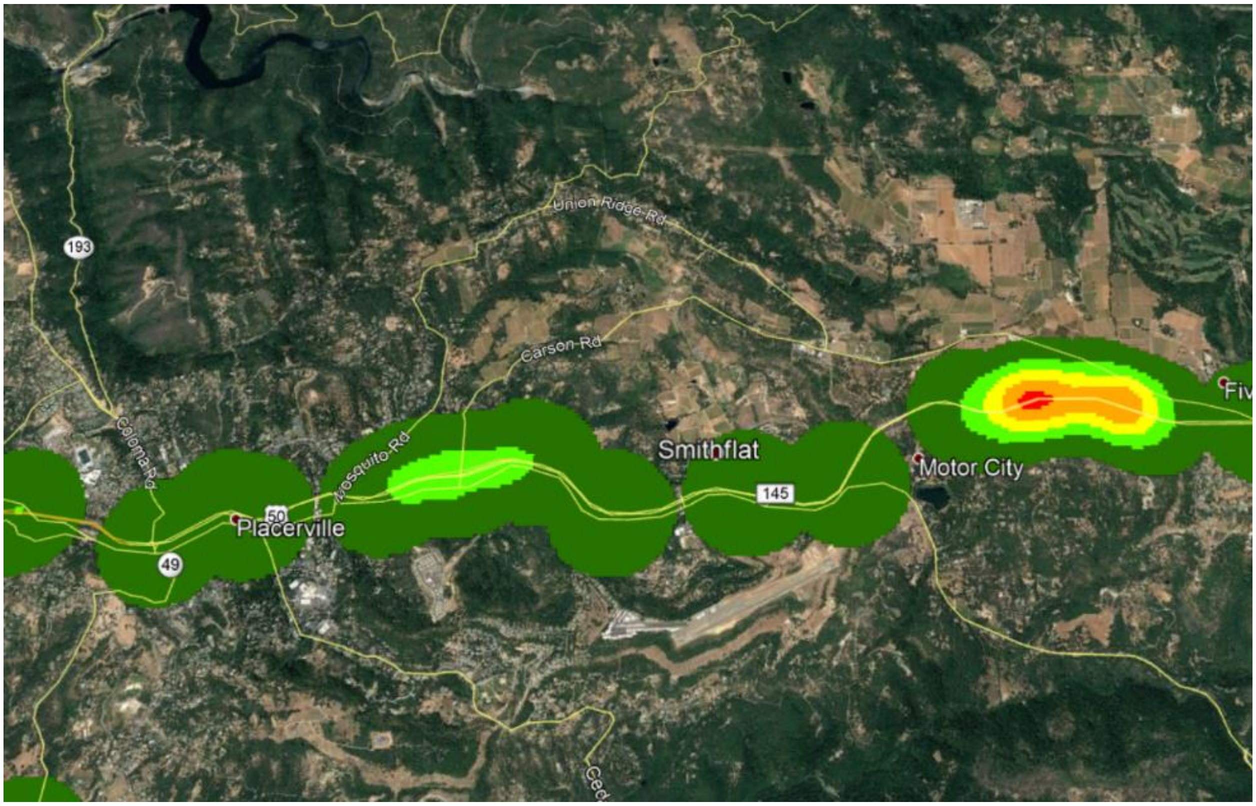


CRASH DATA DISTRICT 3

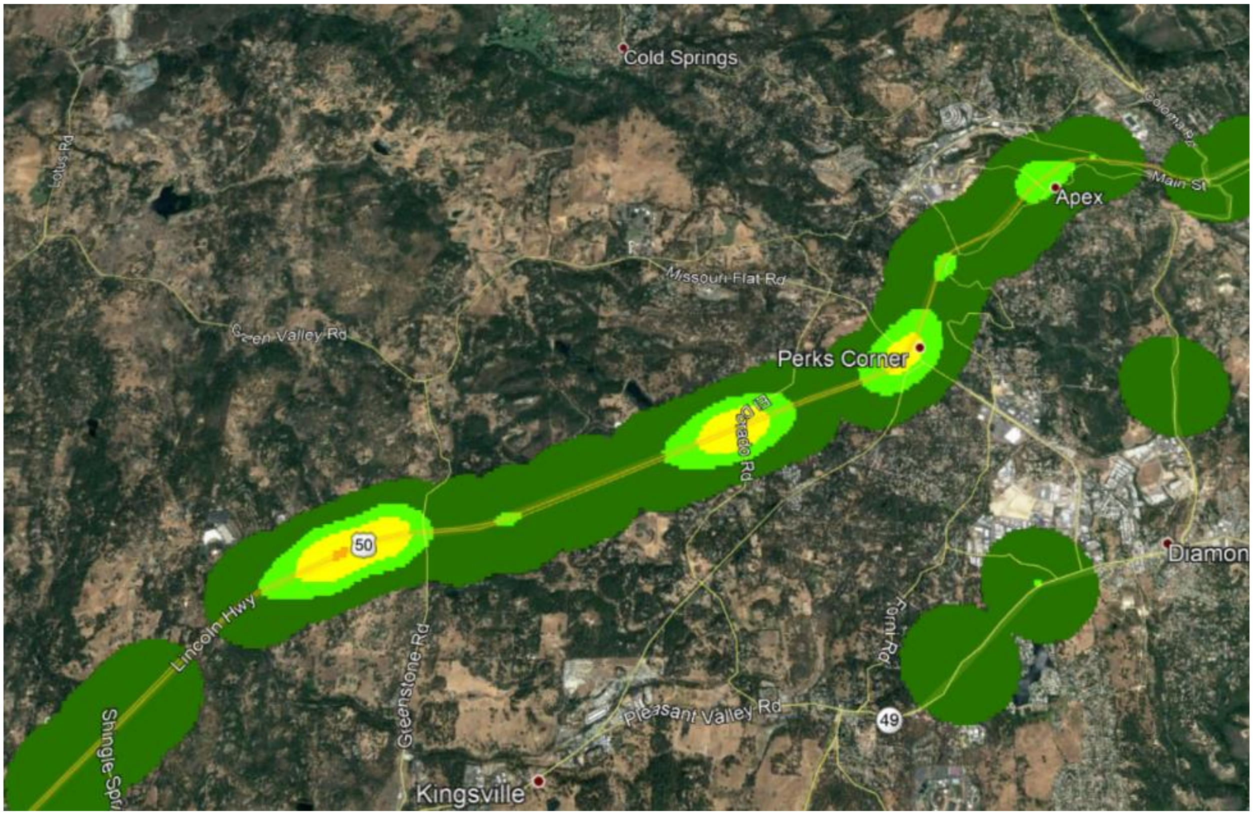


Hot spots in District 3 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

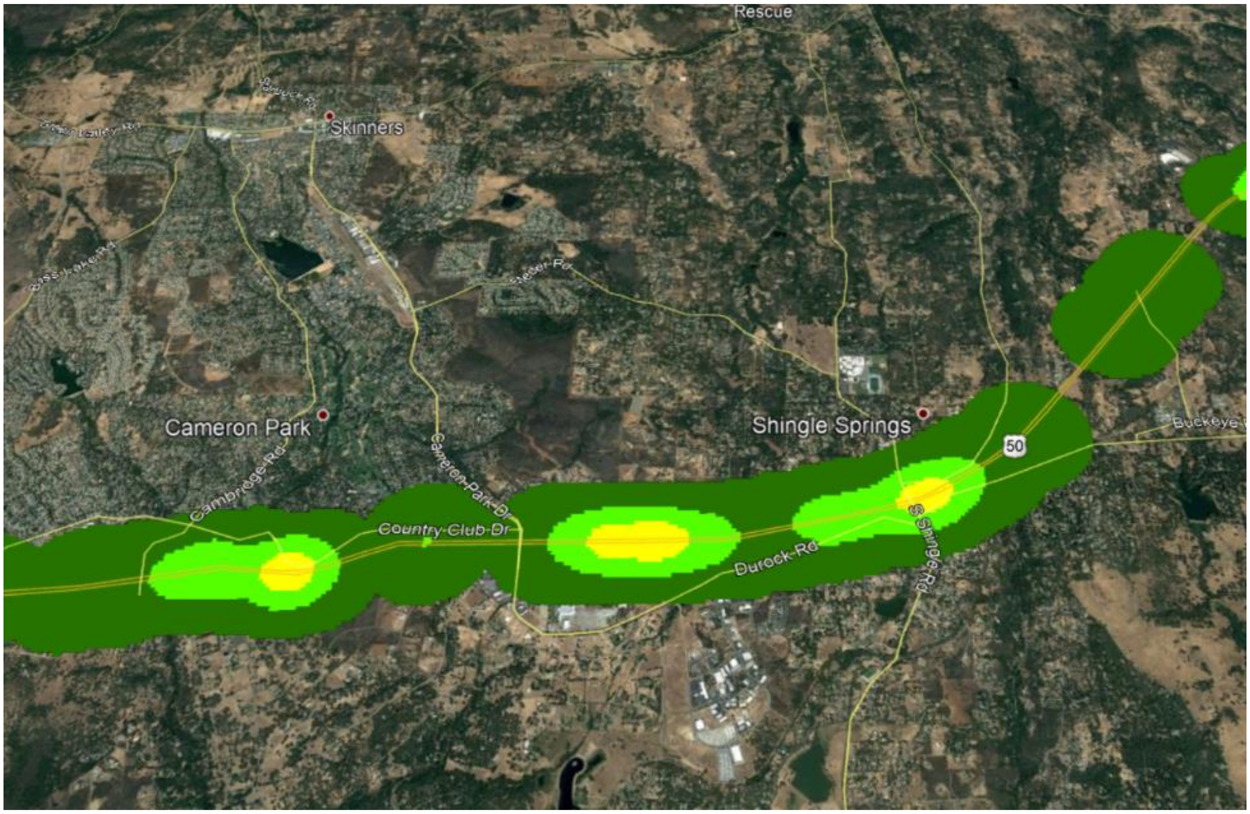
3a


Union Ridge Rd
193
Carson Rd
Coloma Rd
Mosquito Rd
Smithflat
Motor City
50
Placerville
145
49

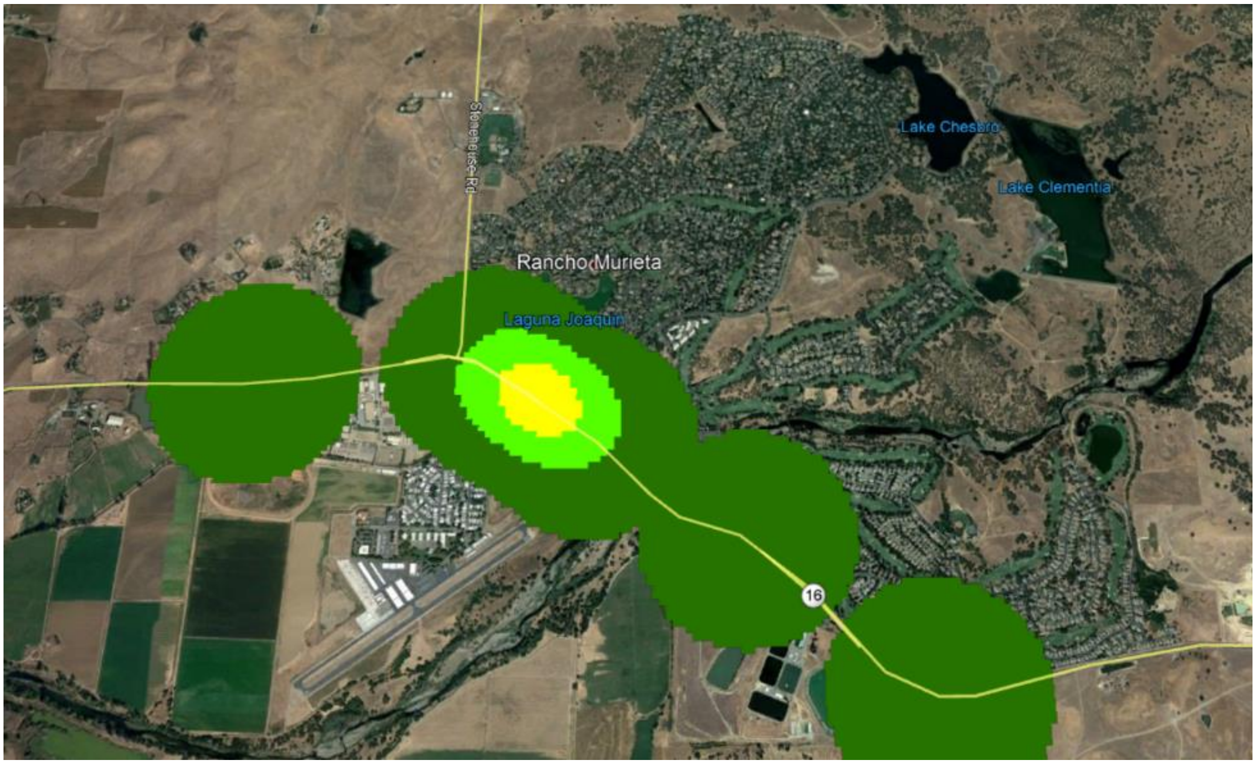
3b


Cold Springs
Lotus Rd
Colonial Rd
Apex
Main St
Missouri Flat Rd
Green Valley Rd
Perks Corner
El Dorado Rd
50
Diamon
Lincoln Hwy
Greenstone Rd
Forni Rd
Pleasant Valley Rd
49
Shingle-Spr
Kingsville

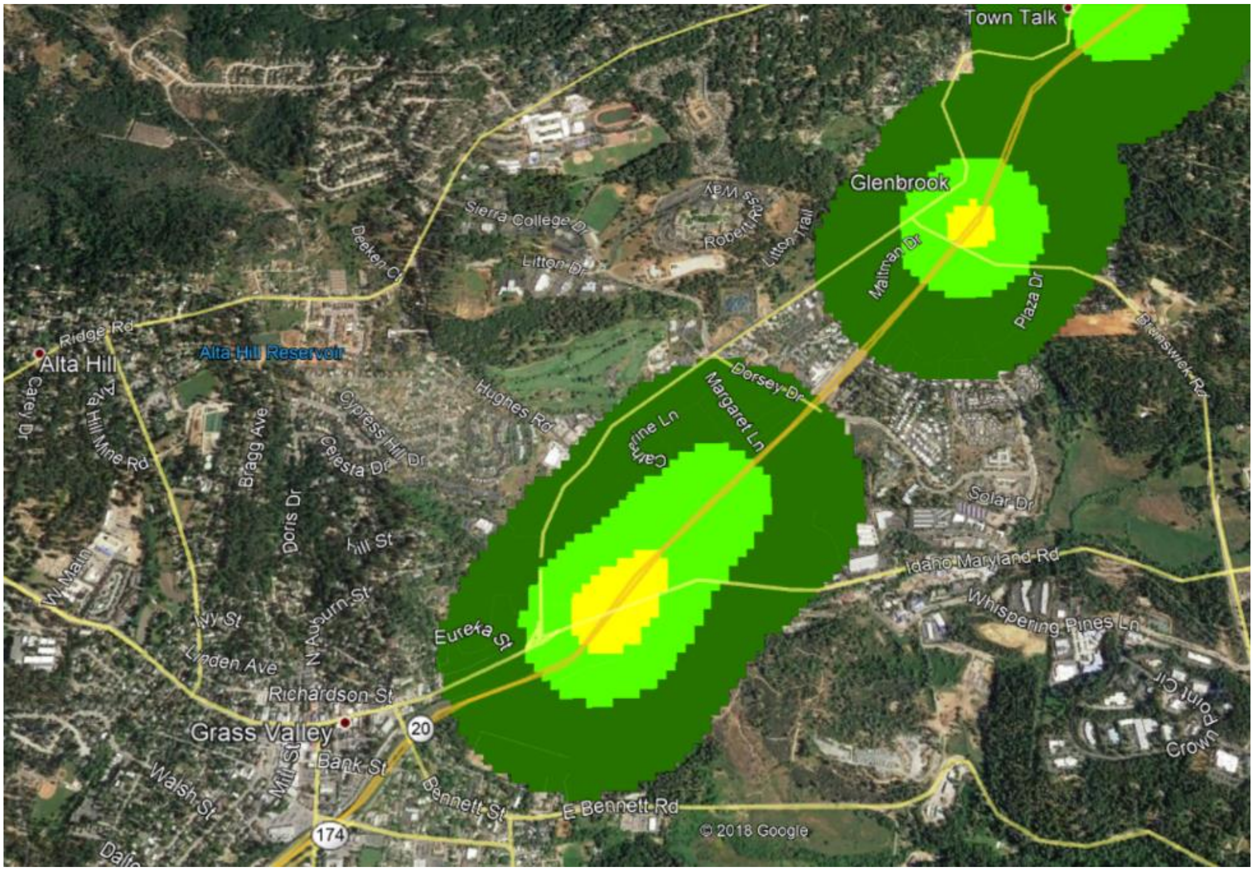
3c


Rescue
Skinners
Cameron Park
Shingle Springs
Cambridge Rd
Cameron Park Dr
Country Club Dr
Durock Rd
S Shingle Rd
50

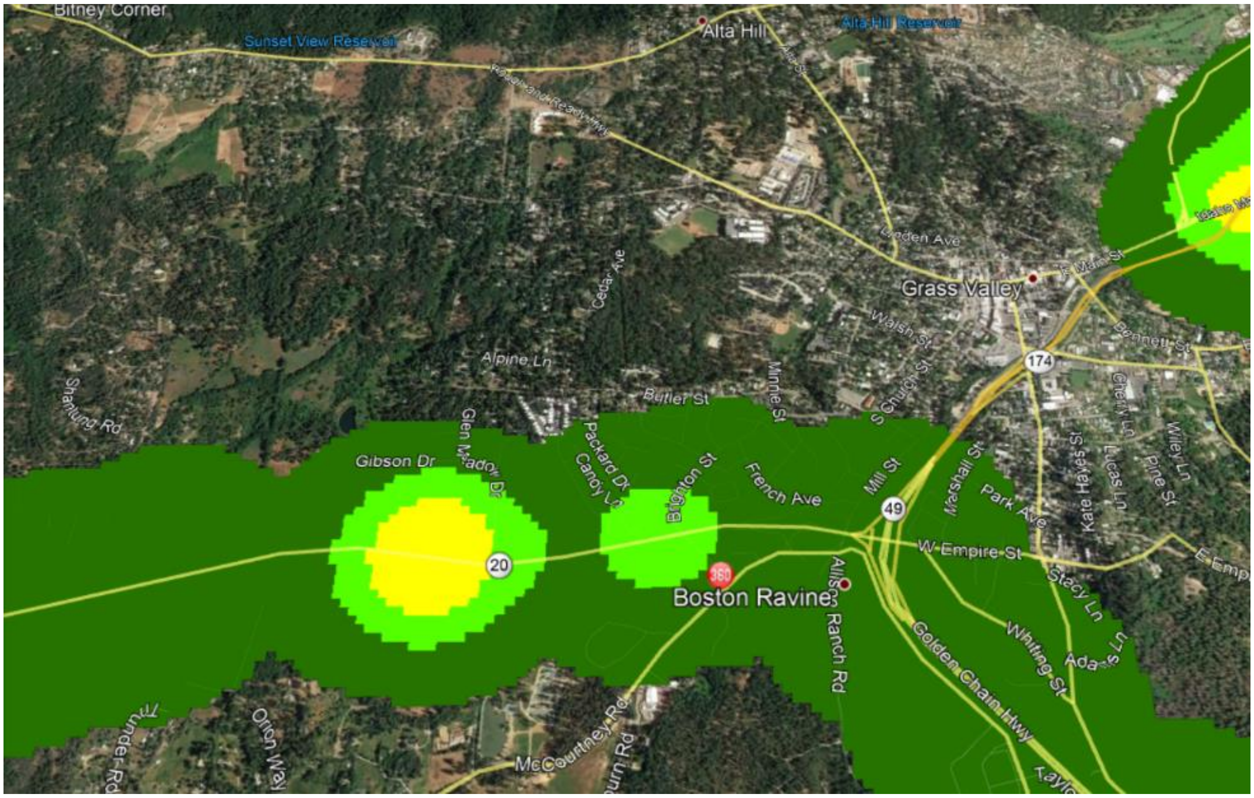
3d


Stonehouse Rd
Lake Chesbro
Lake Clementia
Rancho Murieta
Laguna Joaquin
16

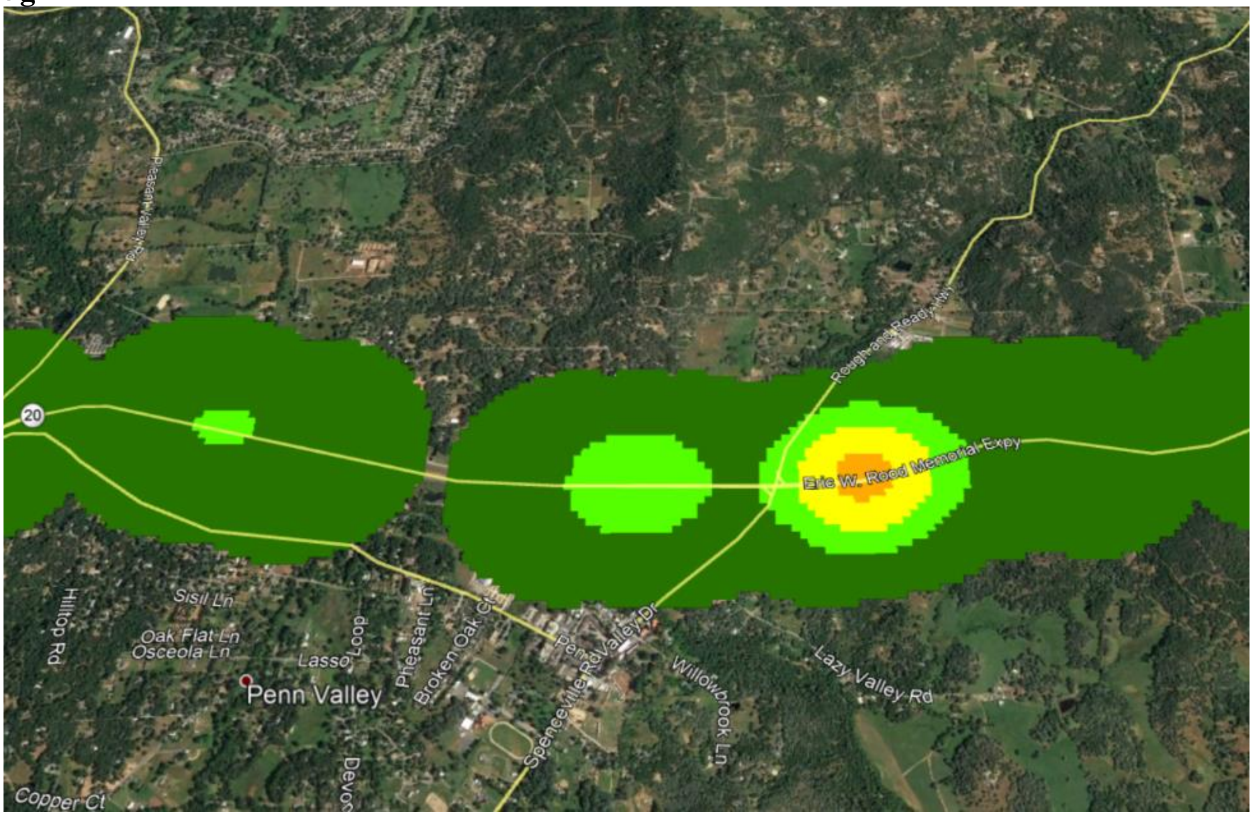
3e


Town Talk
Glenbrook
Sierra College Dr
Litton Dr
Litton Trail
Deeken Ct
Maltman Dr
Plaza Dr
Brunswick Rd
Ridge Rd
Alta Hill
Alta Hill Reservoir
Hughes Rd
Dorsey Dr
Margaret Ln
Cypress Hill Dr
Celesta Dr
Bragg Ave
Alta Hill Mine Rd
Carey Dr
Doris Dr
Hill St
Solar Dr
Idaho Maryland Rd
Whispering Pines Ln
N Auburn St
Ivy St
Linden Ave
Eureka St
Richardson St
Grass Valley
20
Bank St
Mill St
Walsh St
Bennett St
E Bennett Rd
174
Crown Point Cir
© 2018 Google

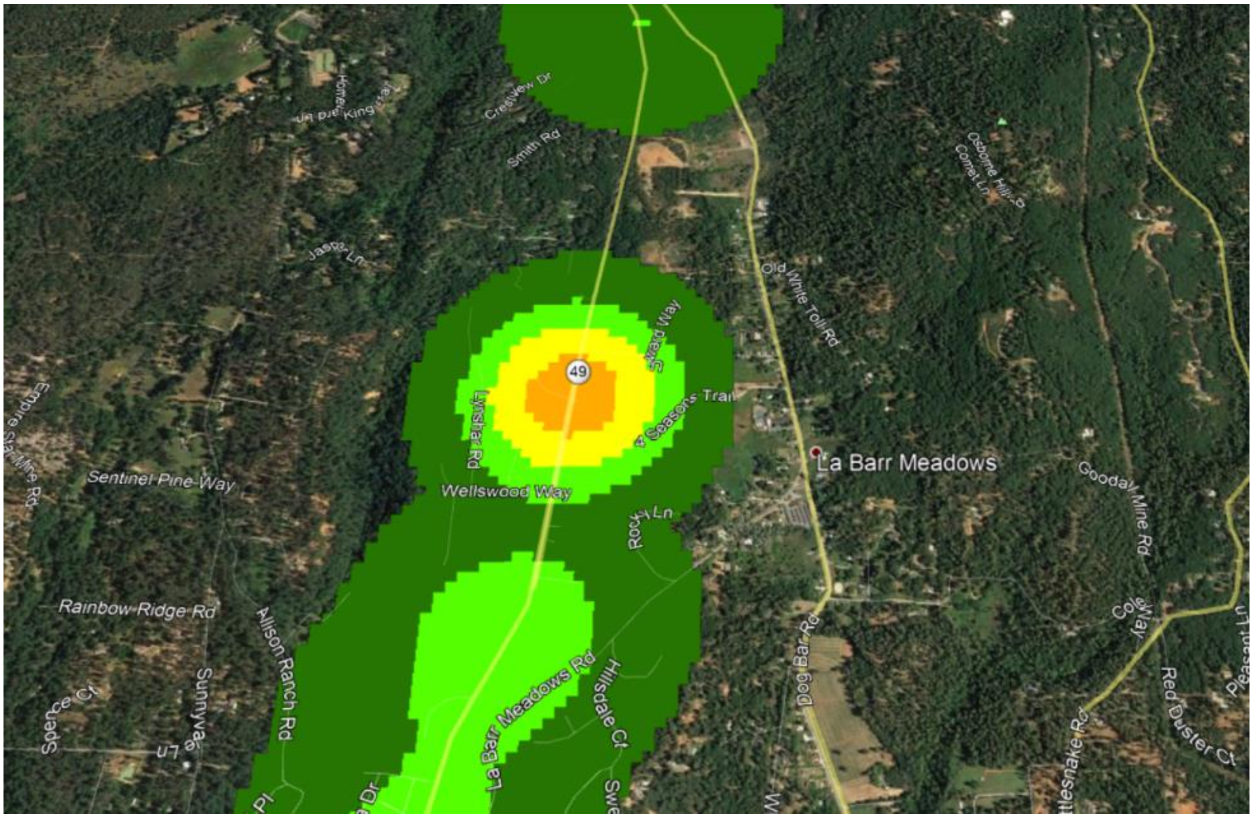
3f


Bitney Corner
Sunset View Reservoir
Alta Hill
Alta Hill Reservoir
Grass Valley
Cedar Ave
Alpine Ln
Butler St
Minnie St
Walsh St
S Church St
Bennett St
Gibson Dr
Glen Meadow Dr
Packard Dr
Candy Ln
Brighton St
French Ave
Mill St
Marshall St
Park Ave
Kate Hayes St
Cherry Ln
Lucas Ln
Wiley Ln
Pine St
W Empire St
Stacy Ln
Whiting St
Boston Ravine
Allison Ranch Rd
Golden Chain Hwy
McCourtney Rd
Orion Way
Thunder Rd
Shanlung Rd
174
49
20
360

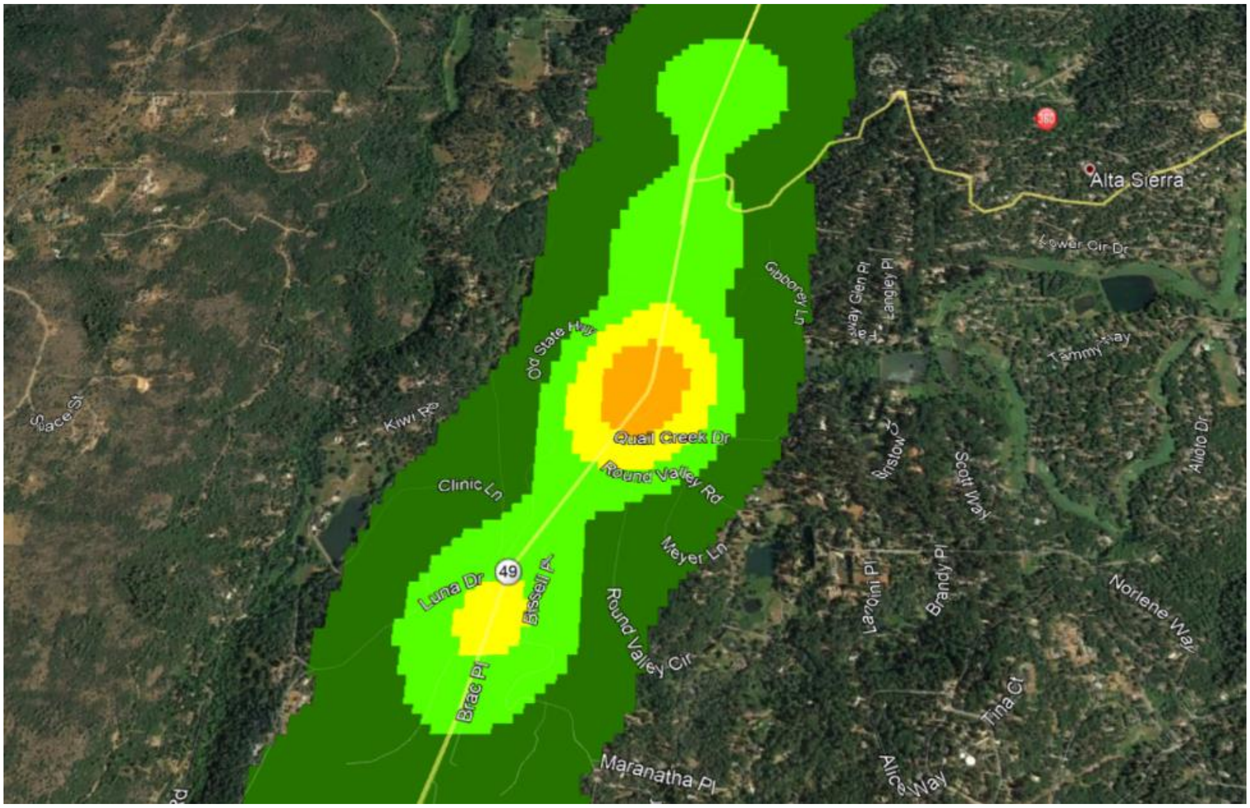
3g


20
Eric W. Rood Memorial Expy
Rough and Ready Hwy
Sisil Ln
Hilltop Rd
Oak Flat Ln
Osceola Ln
Lasso
Loop
Penn Valley
Pheasant Ln
Broken Oak Ct
Spenceville Rd
Willowbrook Ln
Lazy Valley Rd
Copper Ct

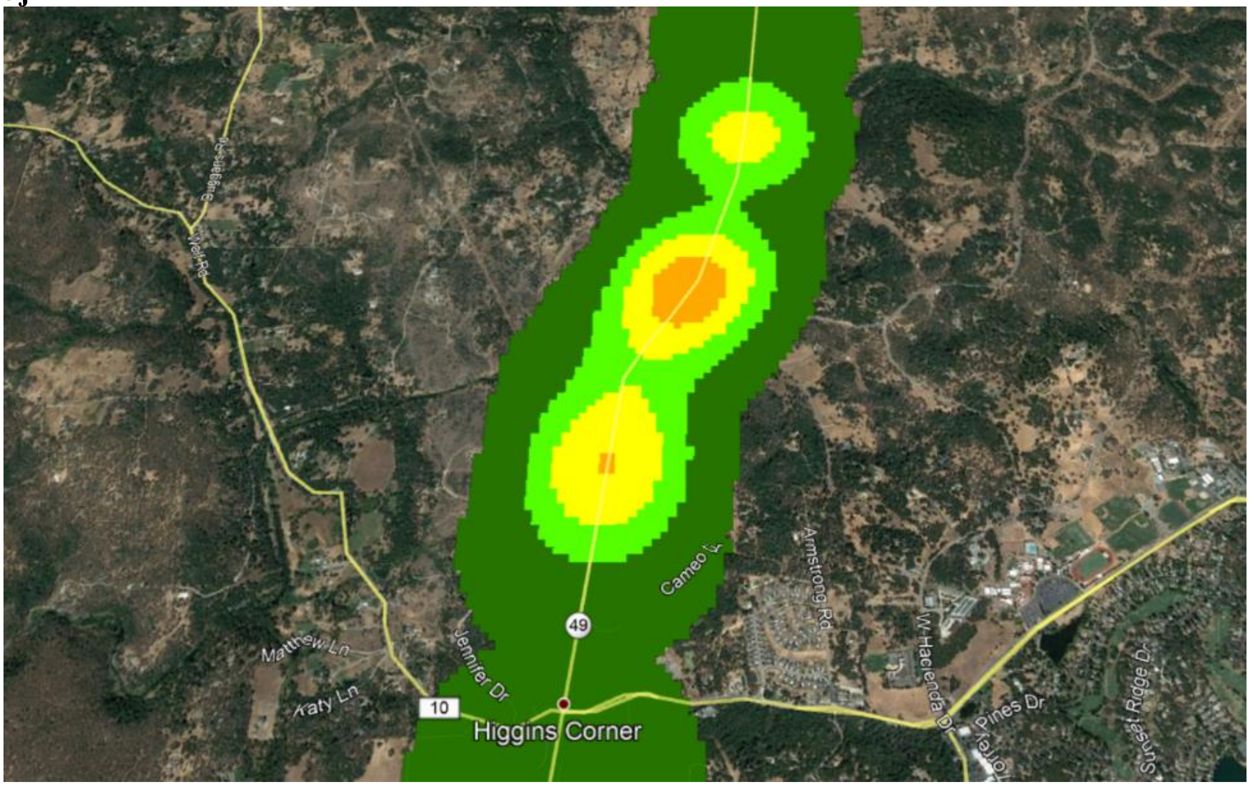
3h


Crestview Dr
Smith Rd
Jaspar Ln
Old White Toll Rd
49
Lyshar Rd
Wellswood Way
4 Seasons Trail
La Barr Meadows
Sentinel Pine Way
Rock Ln
Goodall Mine Rd
Rainbow Ridge Rd
Allison Ranch Rd
Sunnyvale Ln
Spence Ct
La Barr Meadows Rd
Hillsdale Ct
Dog Bar Rd
Red Duster Ct
Rattlesnake Rd

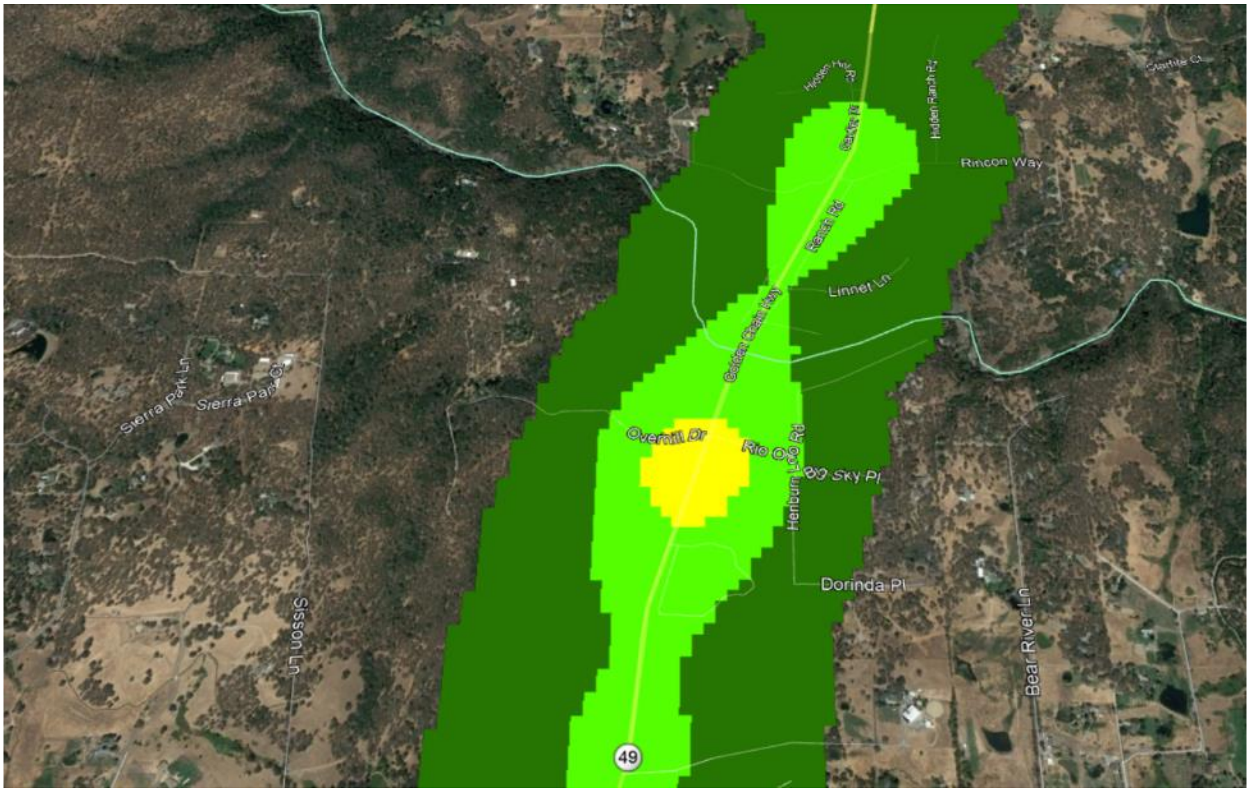
3i


Alta Sierra
Gibboney Ln
Old State Hwy
Kiwi Rd
Quail Creek Dr
Round Valley Rd
Clinic Ln
Luna Dr
49
Bissell Pl
Round Valley Cir
Meyer Ln
Brac Pl
Maranatha Pl
Scott Way
Brandy Pl
Norlene Way
Tina Ct
Alice Way
Langley Pl
Tammy Way
Bristow Ct
Alidio Dr
Space St

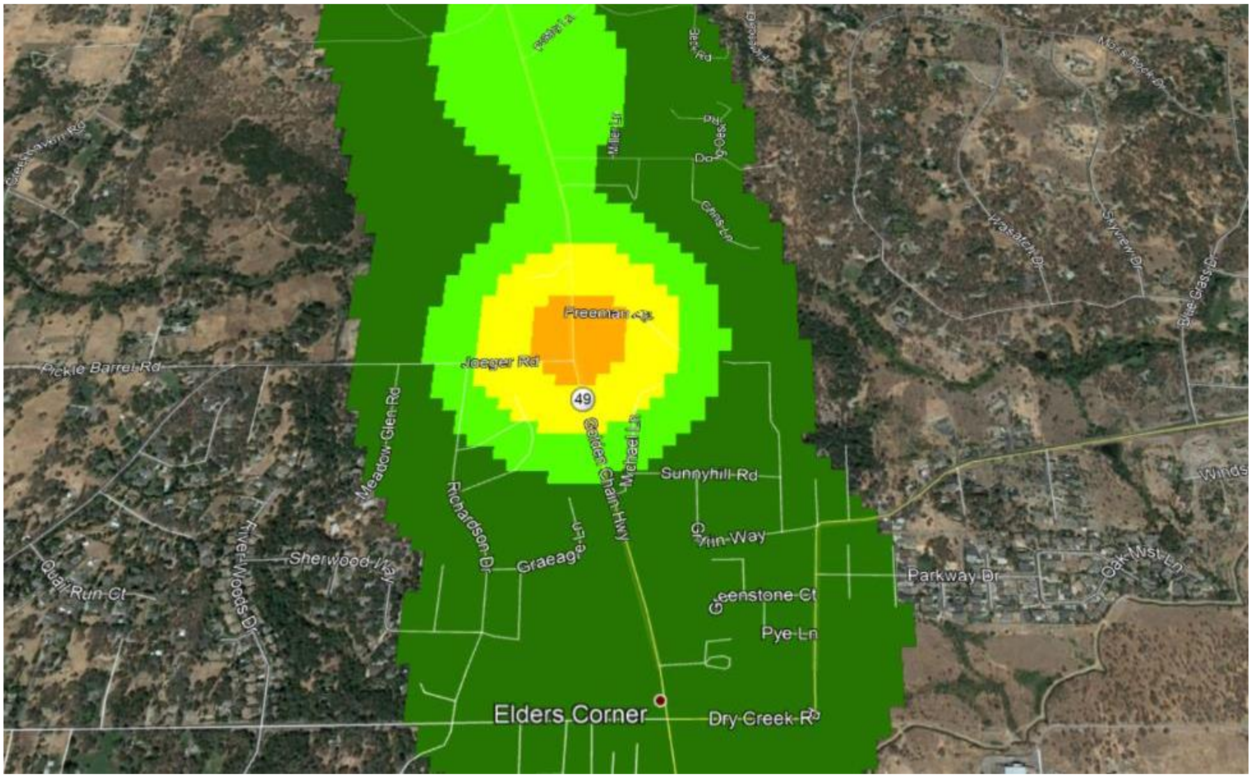
3j


Matthew Ln
Katy Ln
10
Jennifer Dr
Higgins Corner
49
Cameo Dr
Armstrong Rd
W Hacienda Dr
Pines Dr
Sunset Ridge Dr

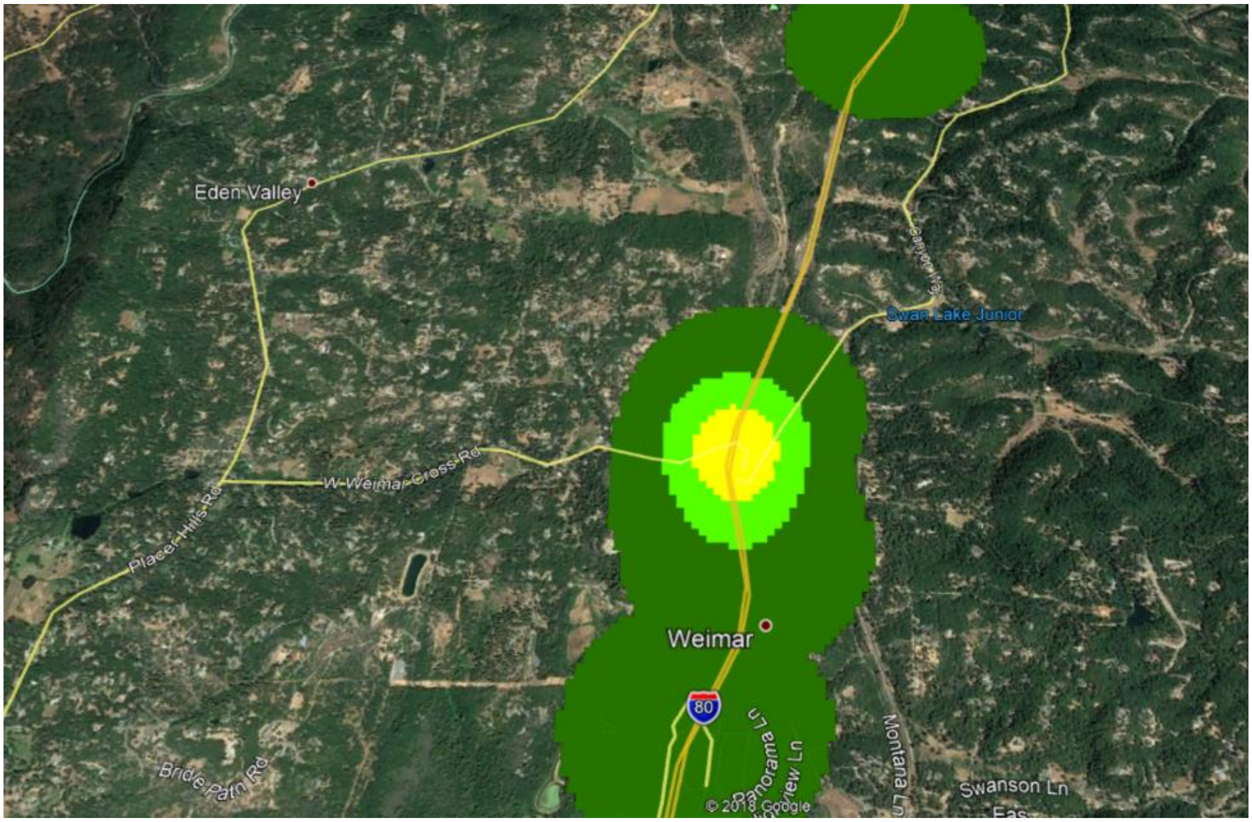
3k


Hidden Ranch Rd
Rincon Way
Ranch Rd
Linnet Ln
Golden Chain Hwy
Overhill Dr
Henburn Log Rd
Big Sky Pl
Dorinda Pl
Sierra Park Ln
Sissoh Ln
Bear River Ln
49

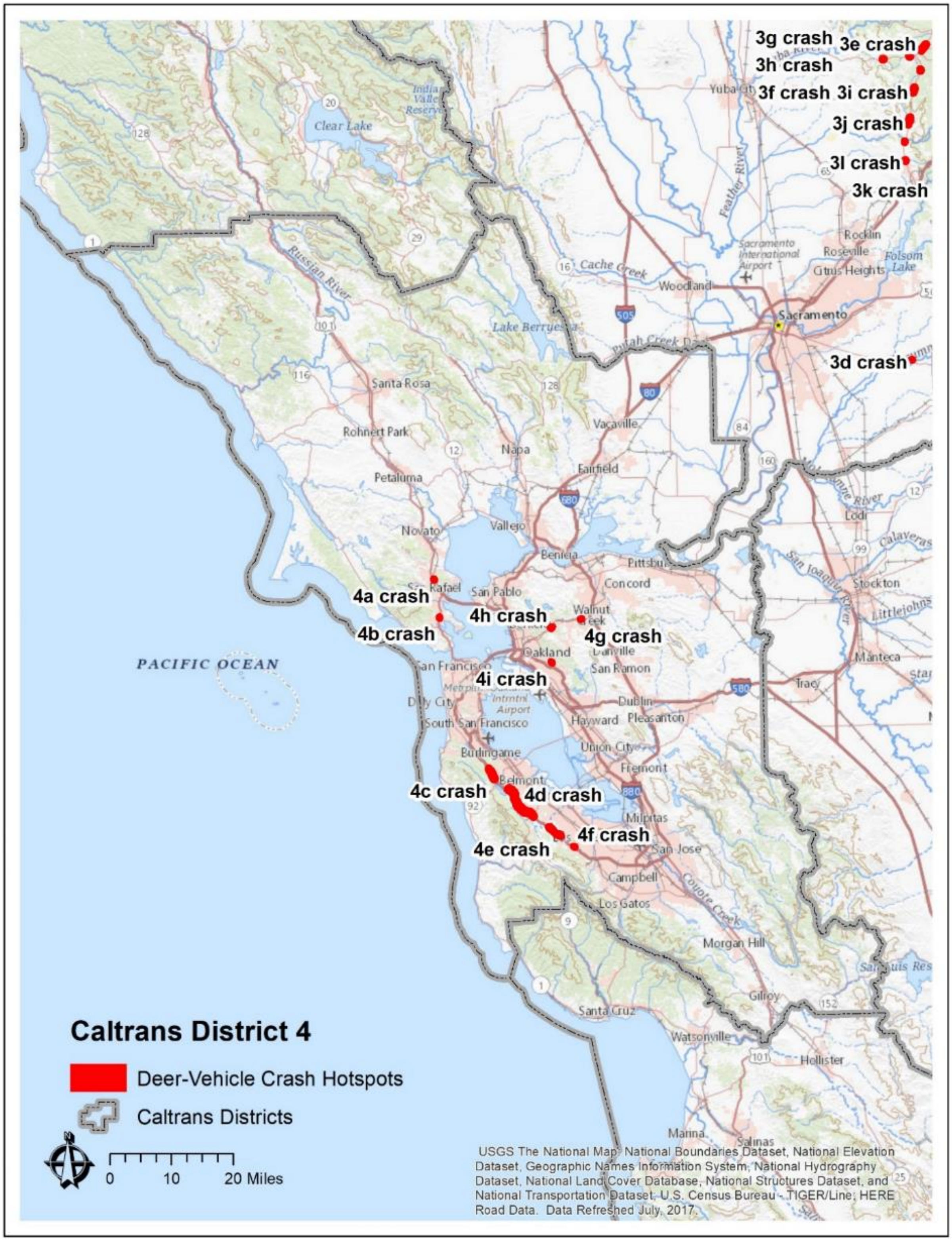
3l


Pickle Barrel Rd
Joeger Rd
Freeman
49
Golden Chain Hwy
Meadow Glen Rd
Richardson Dr
Sunnyhill Rd
Glynn Way
Sherwood Way
Quail Run Ct
River Woods Dr
Graeagle Ln
Greenstone Ct
Pye Ln
Elders Corner
Dry Creek Rd
Parkway Dr
Wasatch Dr
Skyview Dr
Blue Grass Dr

3m

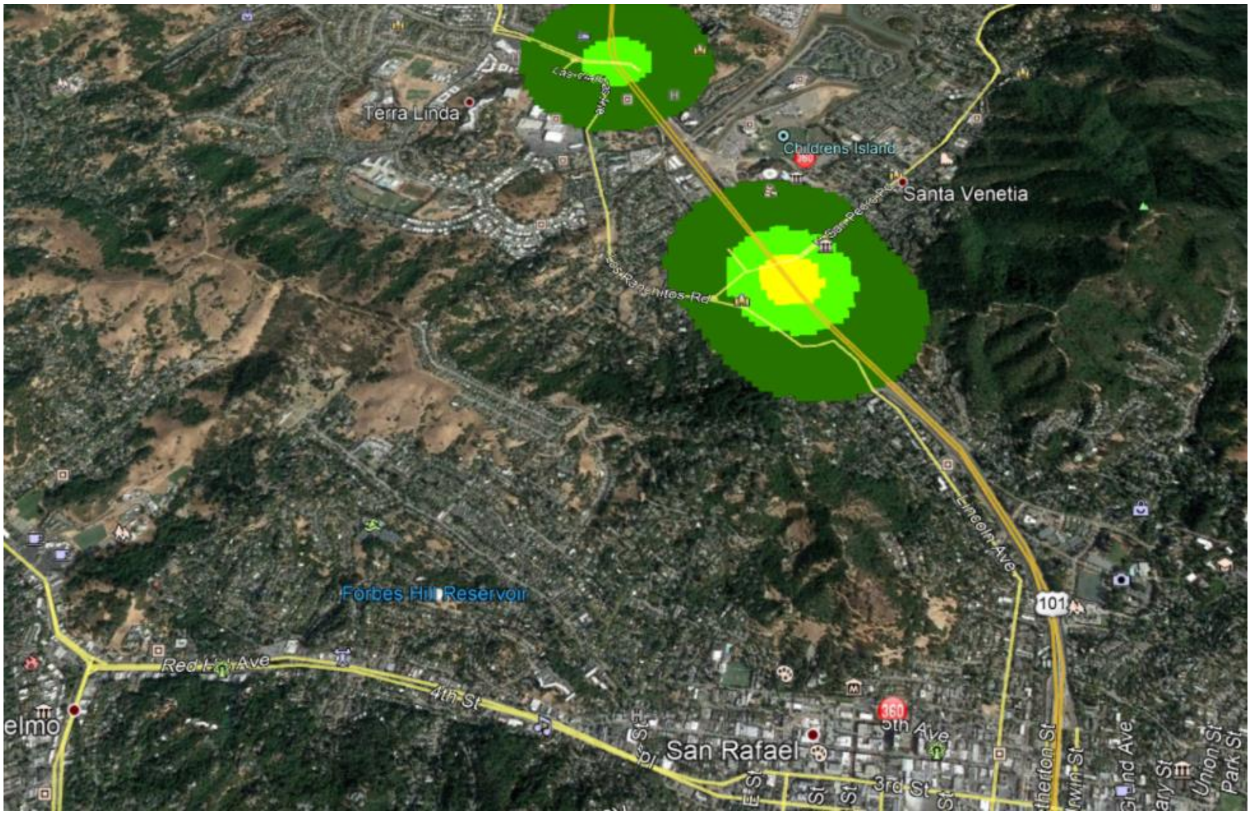

Eden Valley
Swan Lake Junior
W Weimar Cross Rd
Placer Hills Rd
Weimar
80
Panorama Ln
Montana Ln
Swanson Ln
Bride Path Rd
© 2018 Google

CRASH DATA DISTRICT 4

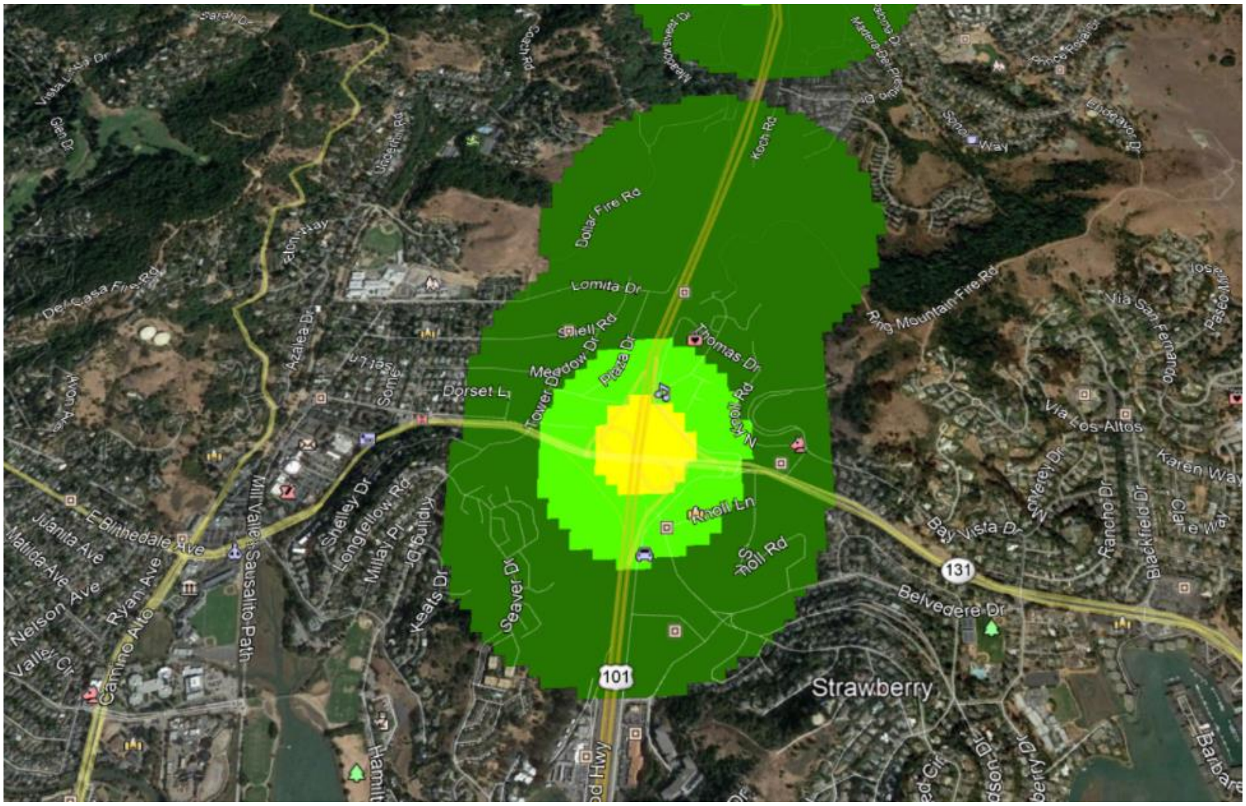


Hot spots in District 4 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

4a


Terra Linda
Childrens Island
Santa Venetia
Forbes Hill Reservoir
Red Hill Ave
4th St
San Rafael
5th Ave
3rd St
Lincoln Ave
101
elmo

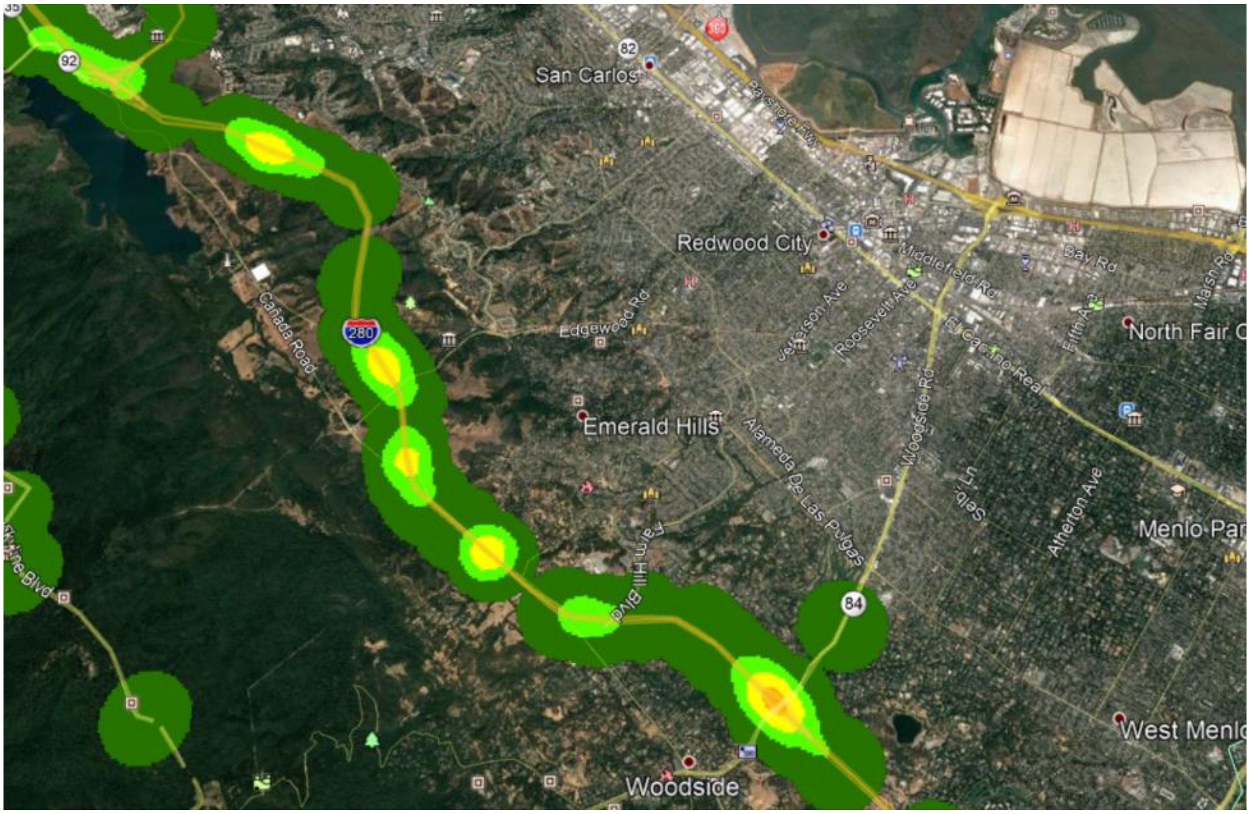
4b


Lomita Dr
Dollar Fire Rd
Koch Rd
Shell Rd
Meadow Dr
Thomas Dr
Dorset Ln
Tower Dr
Knoll Ln
Knoll Rd
Seaver Dr
Keats Dr
Shelley Dr
Longfellow Rd
Millay Pl
E Blithedale Ave
Juanita Ave
Matilda Ave
Nelson Ave
Ryan Ave
Camino Alto
Valley Cir
Mill Valley Sausalito Path
Azalea Dr
Ring Mountain Fire Rd
Via San Fernando
Via Los Altos
Karen Way
Bay Vista Dr
Belvedere Dr
Rancho Dr
Blackfield Dr
Strawberry
101
131

4c


Lower Crystal Springs Reservoir
Dam Reservoir
Crystal-Springs-Rd
Polhemus-Rd
Highlands-Baywood Park
280
35
Junipero-Serra-Fwy

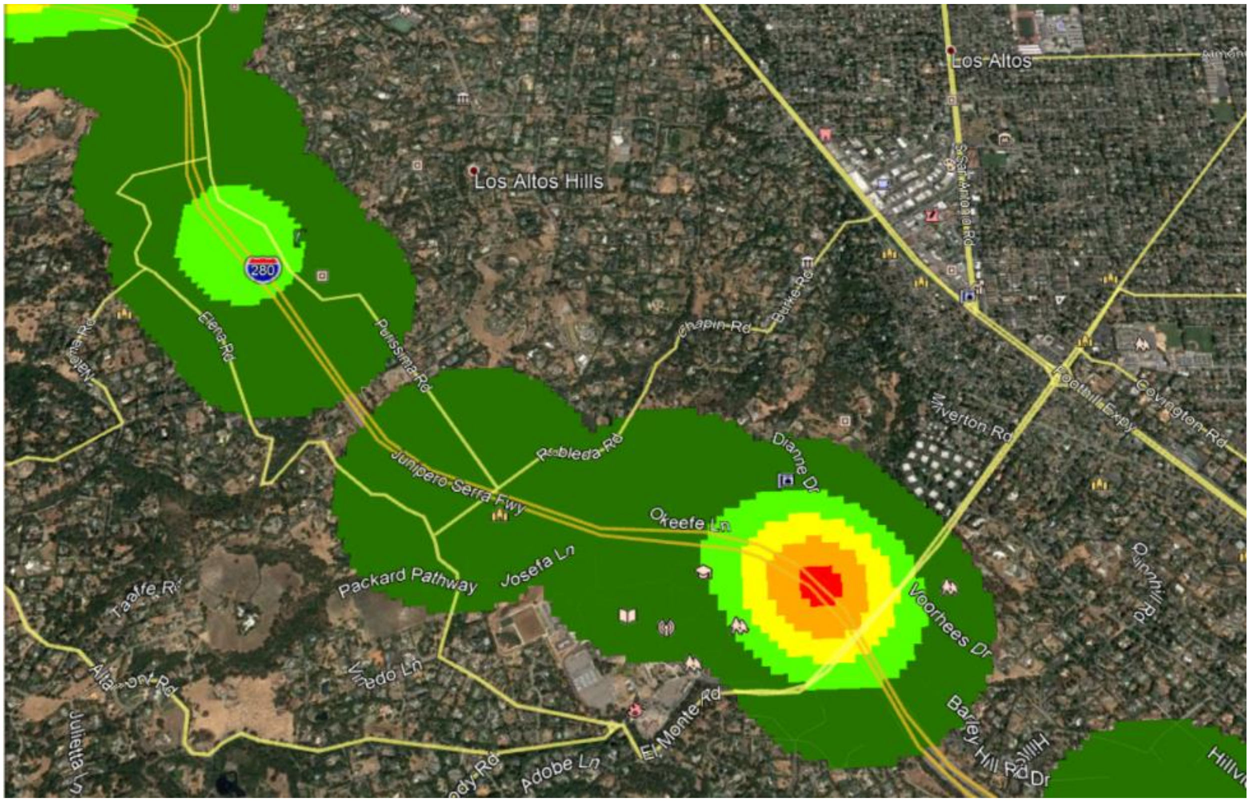
4d


San Carlos
Redwood City
Emerald Hills
Woodside
North Fair O
Menlo Par
West Menlo
Canada Road
Edgewood Rd
Farm Hill Blvd
Alameda De Las Pulgas
Woodside Rd
Jefferson Ave
Roosevelt Ave
Middlefield Rd
El Camino Real
Atherton Ave
Bay Rd
Marsh Rd
Fifth Ave
280
84
92
82

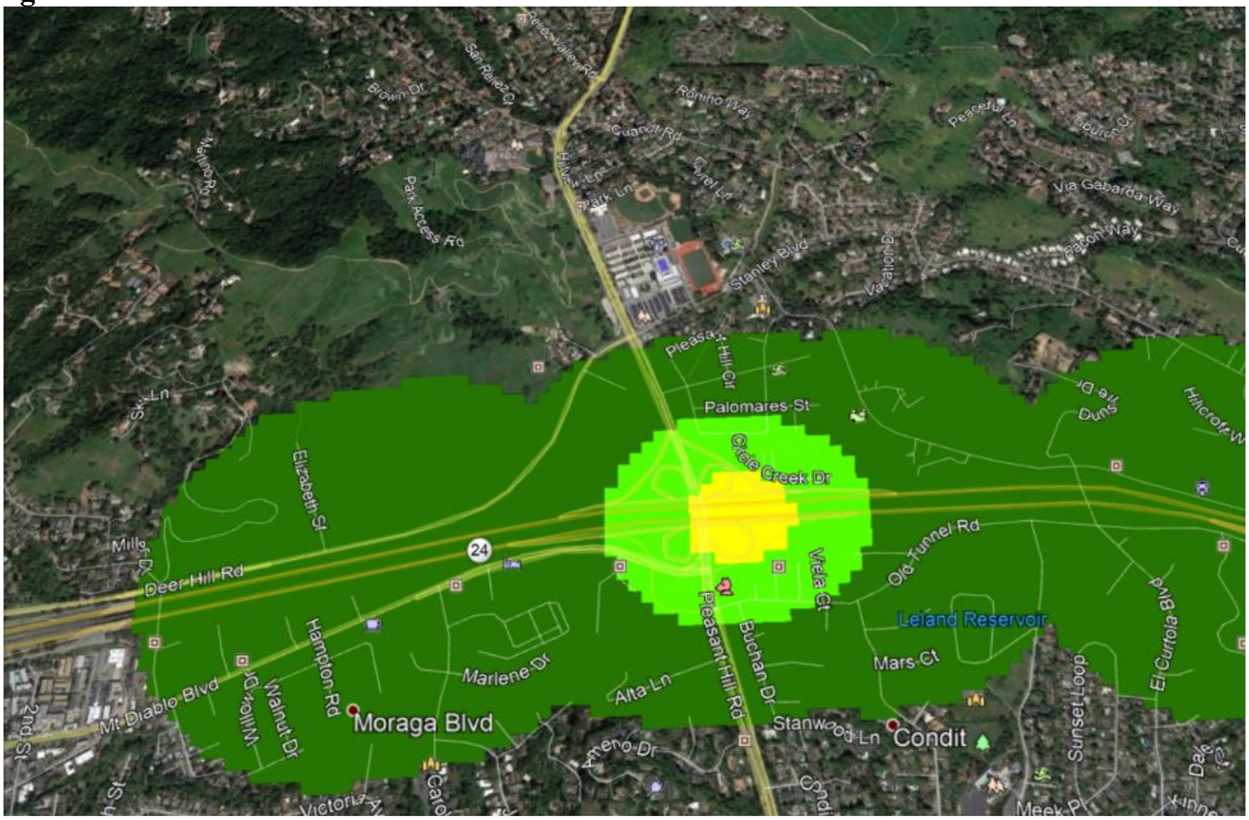
4e


West Menlo Park
Stanford
Junipero Serra Blvd
Stanford Ave
G3
280
82
Westridge Dr
Alpine Rd

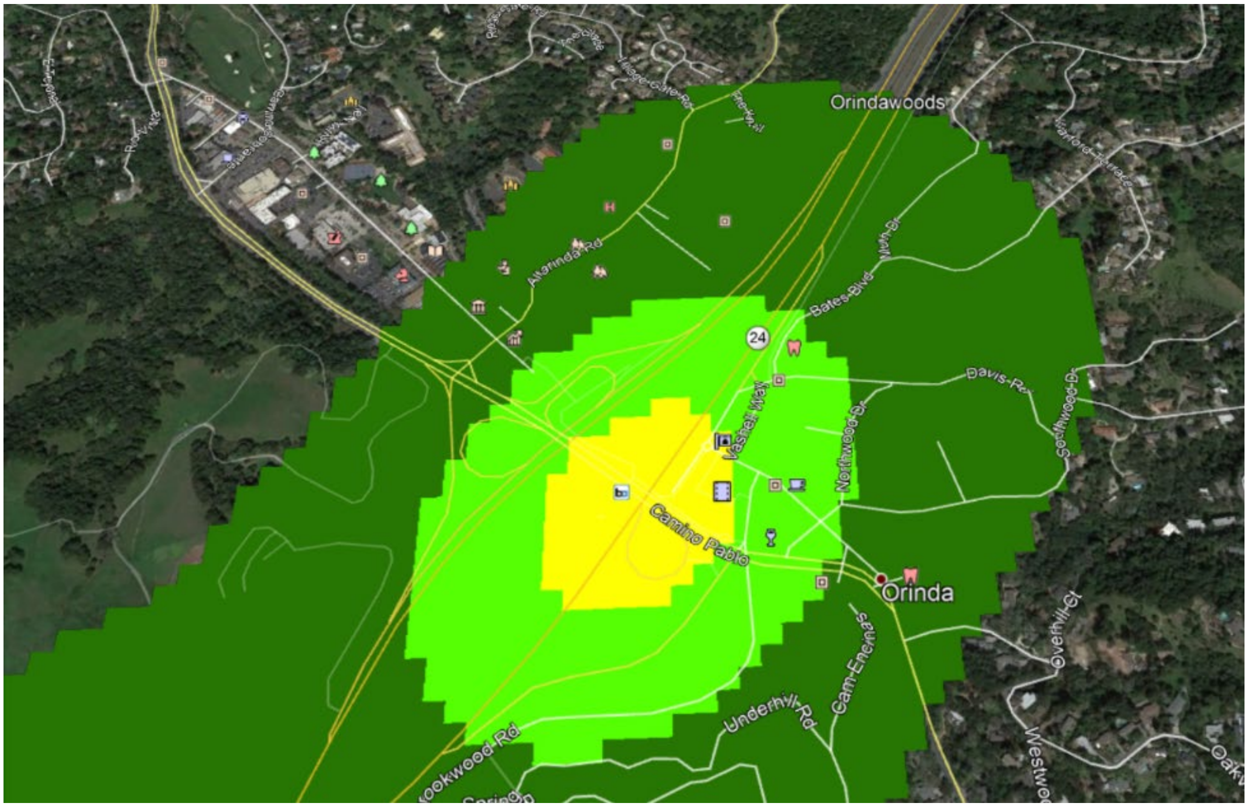
4f


Los Altos
Los Altos Hills
280
Elena Rd
Purissima Rd
Chapin Rd
Burke Rd
Robleda Rd
Junipero Serra Fwy
Dianne Dr
Okeefe Ln
Packard Pathway
Josefa Ln
Taaffe Rd
Voorhees Dr
El Monte Rd
Adobe Ln
Barley Hill Rd
Foothill Expy
Covington Rd
Quinhill Rd
Julietta Ln

4g


Palomares St
Circle Creek Dr
Elizabeth St
Deer Hill Rd
24
Old Tunnel Rd
Leland Reservoir
Hampton Rd
Marlene Dr
Alta Ln
Pleasant Hill Rd
Buchan Dr
Mars Ct
Mt Diablo Blvd
Walnut Dr
Moraga Blvd
Stanwood Ln
Condit
Sunset Loop
El Curtola Blvd
Stanley Blvd
Via Gabarda Way
Park Access Rd
Brown Dr
Ski Ln

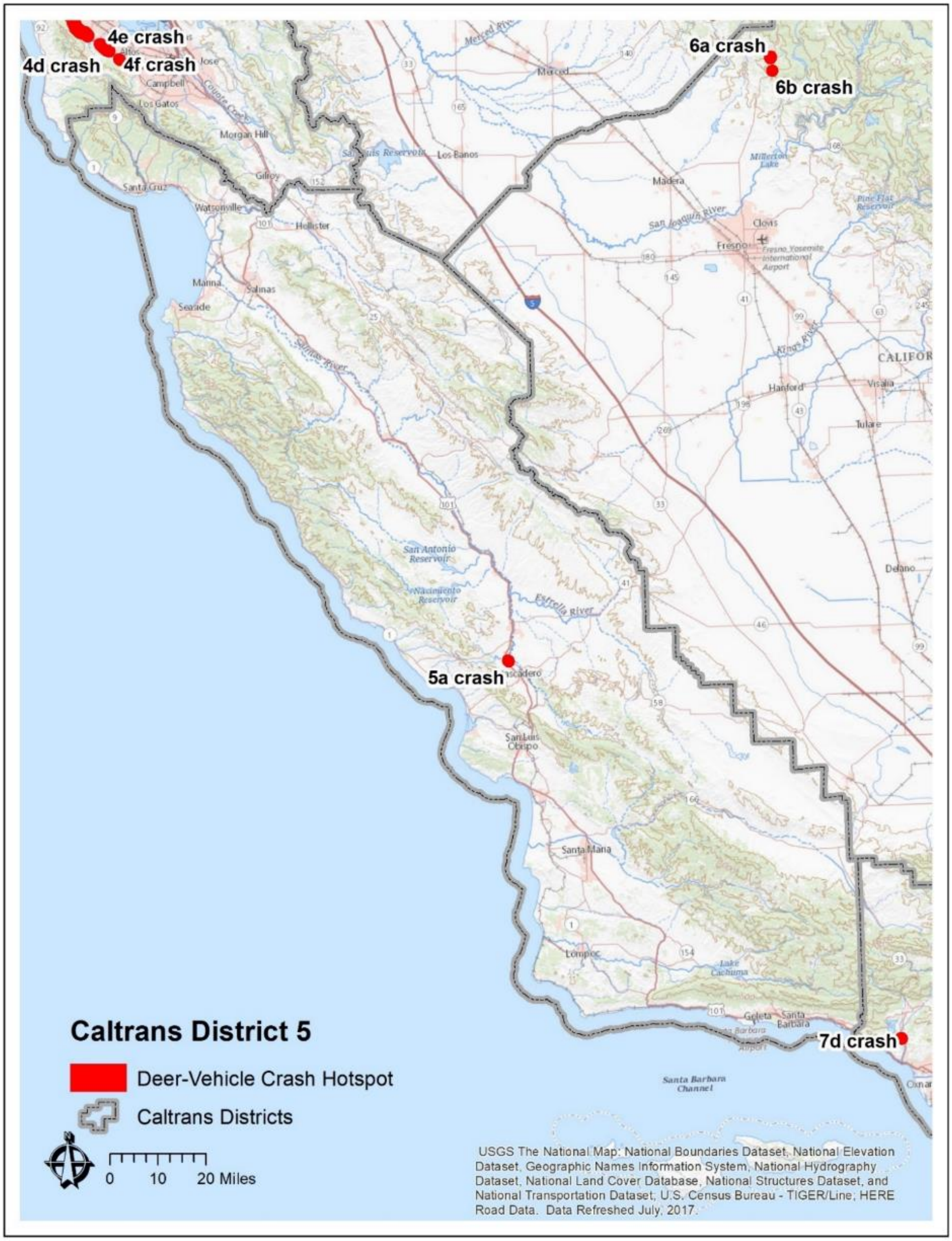
4h


Orindawoods
Altarinda Rd
Bates Blvd
24
Davis Rd
Vashell Way
Northwood Dr
Southwood Dr
Camino Pablo
Orinda
Cam Encinas
Underhill Rd
Overhill Ct
Brookwood Rd

4i

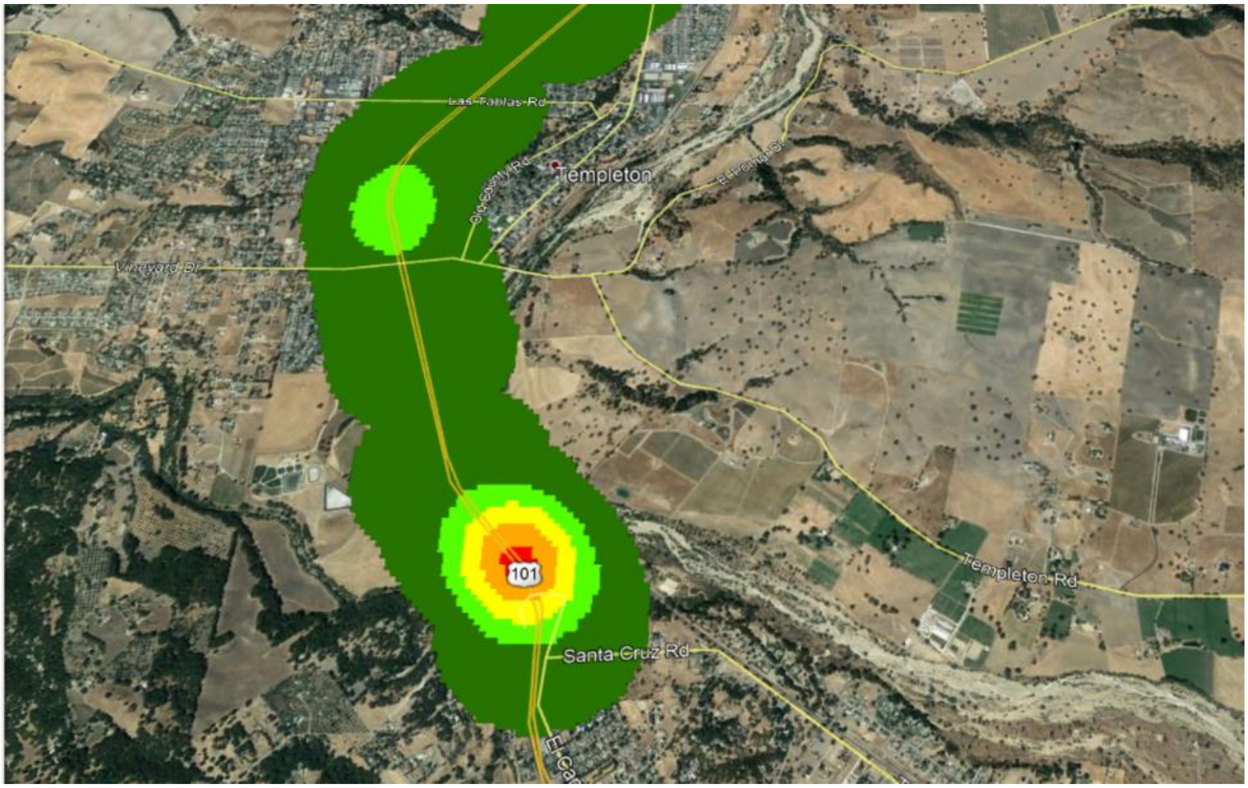

Woodminster
Crestmont
Redwood Heights
Thirtyninth Avenue Reservoir
Serpentine Prairie Trail
Chadbourne Way
Creighton Way
Detroit Ave
Dunsmuir Ave
Anderson Ave
Gregory St
Carson St
Mountain Blvd
Belfast Ave
Sereno Cir
35th Ave
Victor Ave
Magee Ave
Loma Vista Ave
California St
39th Ave
Vale Ave
Kansas St
Wisconsin St
13

CRASH DATA DISTRICT 5

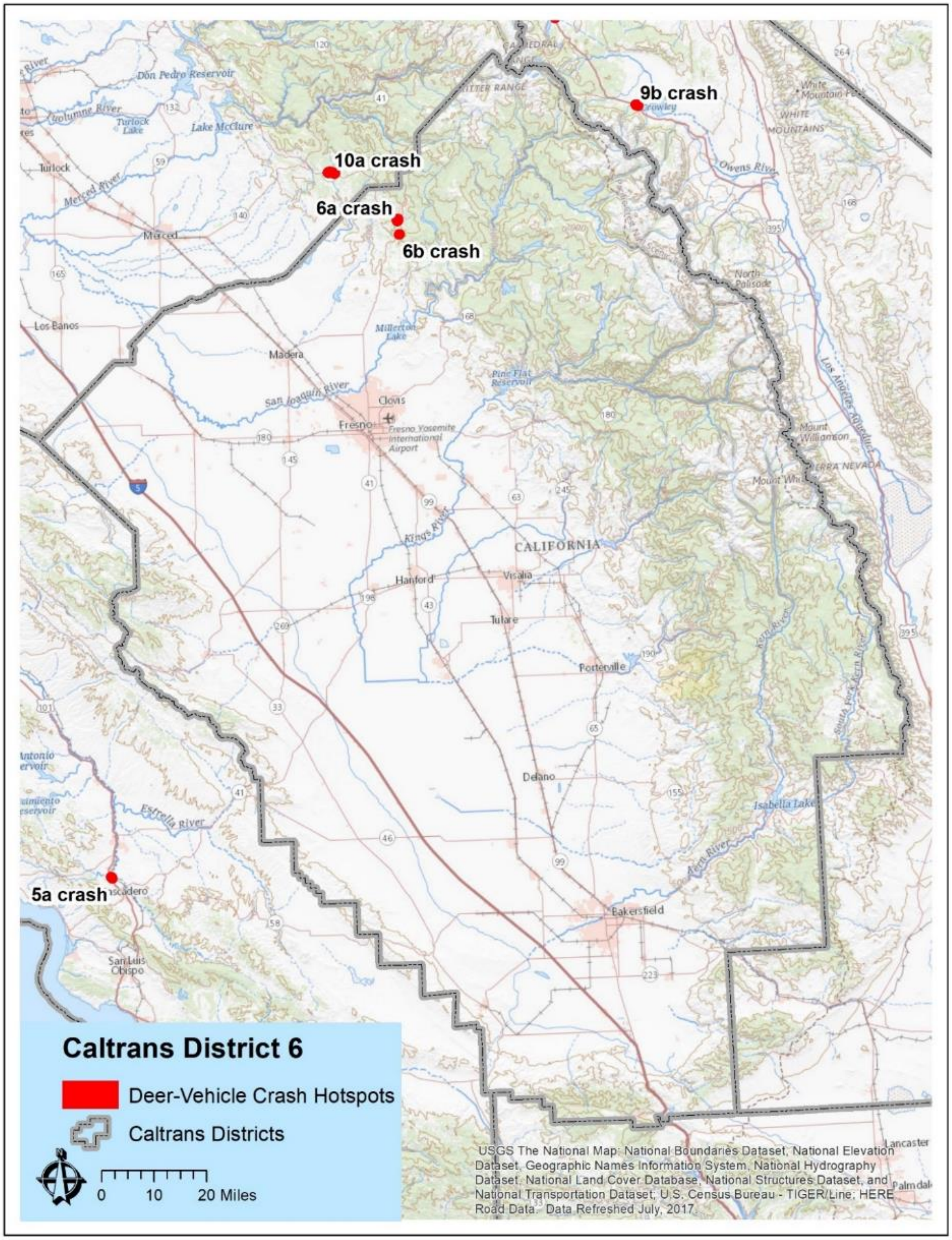


Hot spots in District 5 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

5a

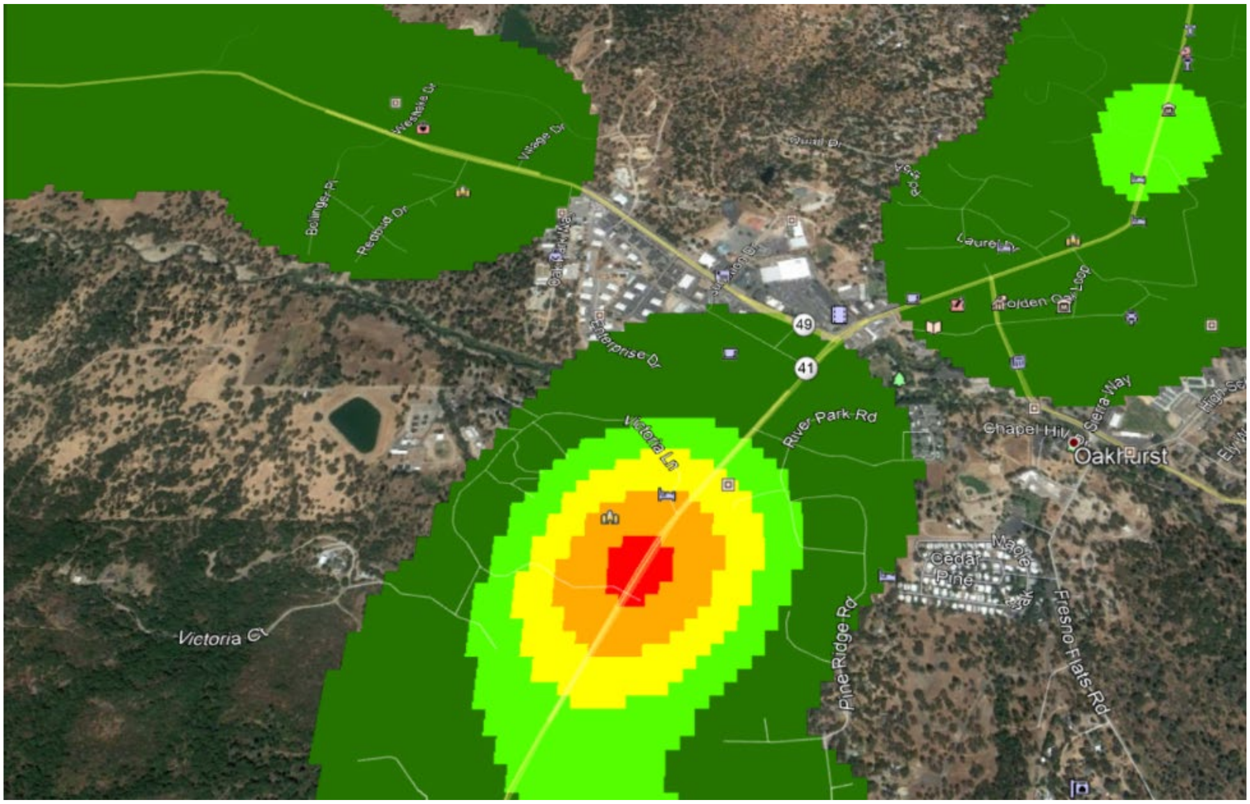

Las Tablas Rd
Templeton
Old County Rd
Vineyard Dr
101
Santa Cruz Rd
Templeton Rd

CRASH DATA DISTRICT 6

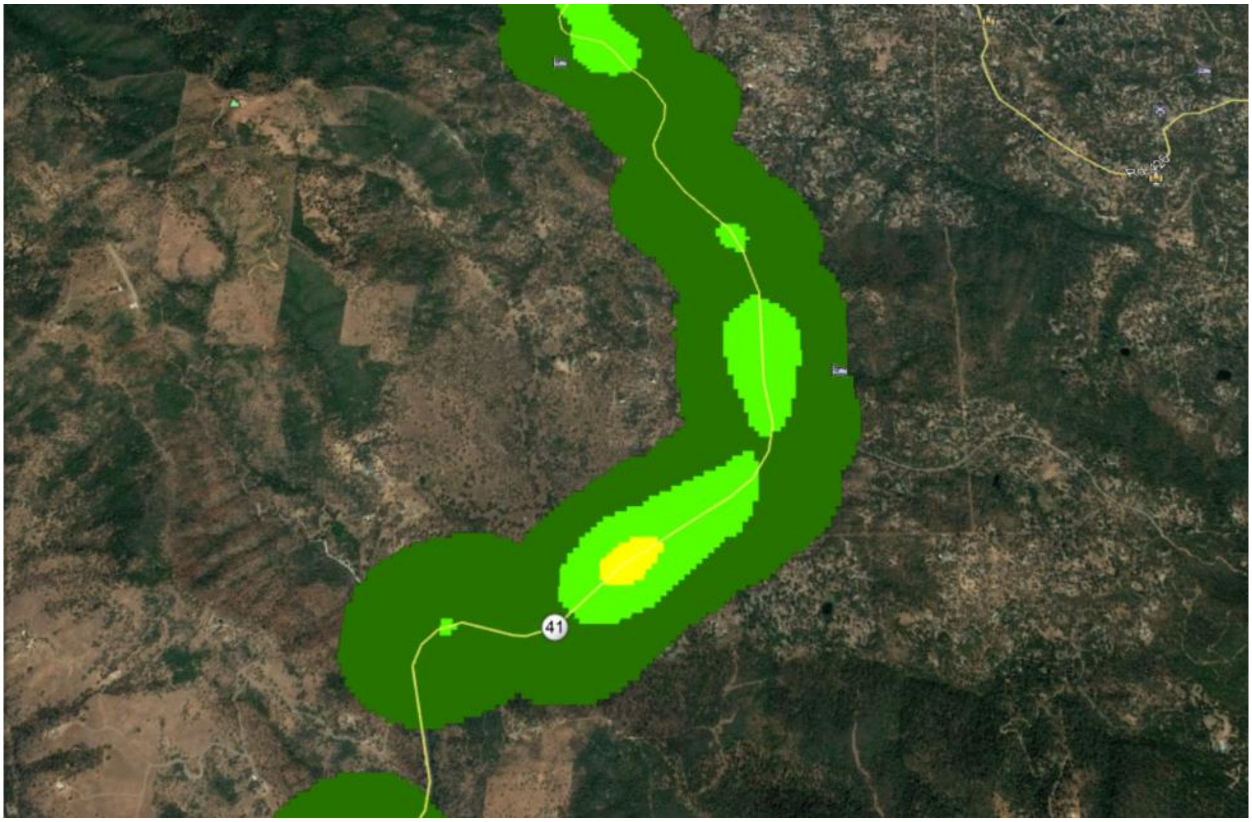


Hot spots in District 6 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

6a


49
41
River Park Rd
Victoria Ln
Oakhurst
Chapel Hill
Cedar Pine
Pine Ridge Rd
Fresno Flats Rd
Victoria Ct
Enterprise Dr
Laurel Dr
Serra Way

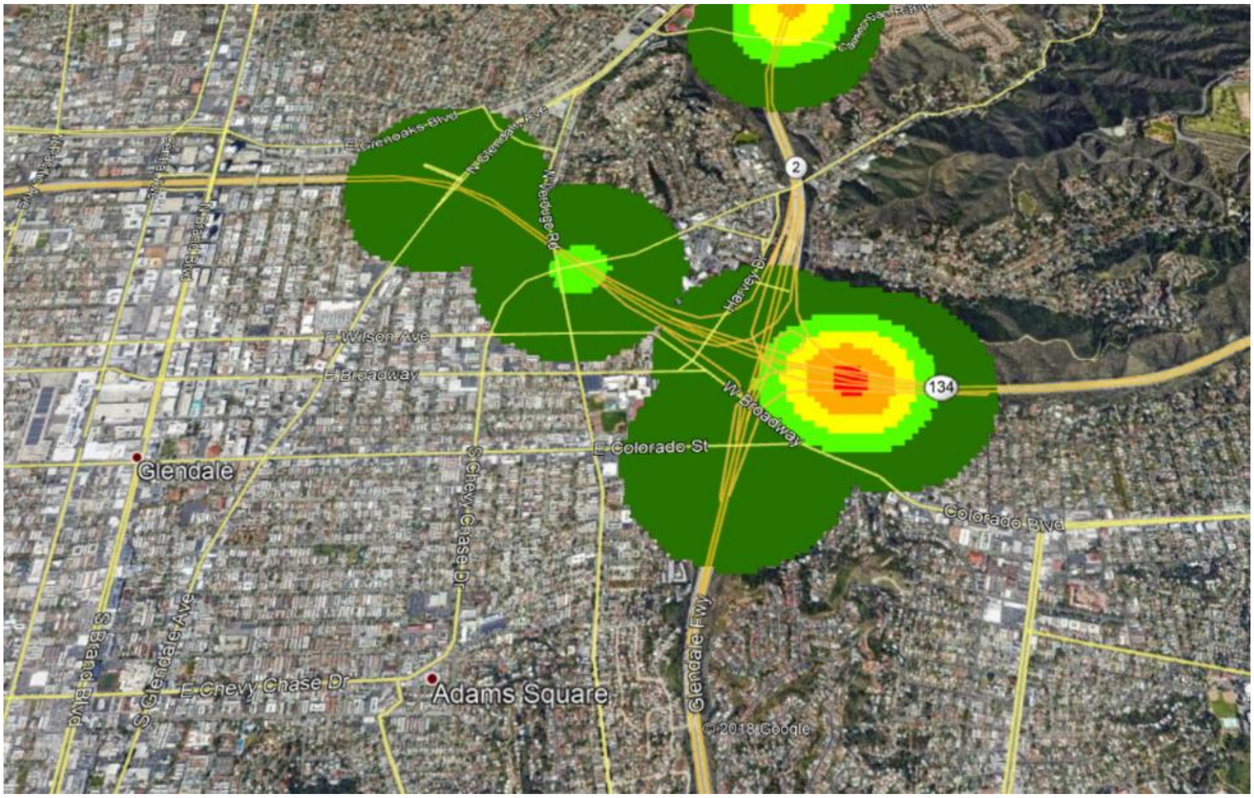
6b



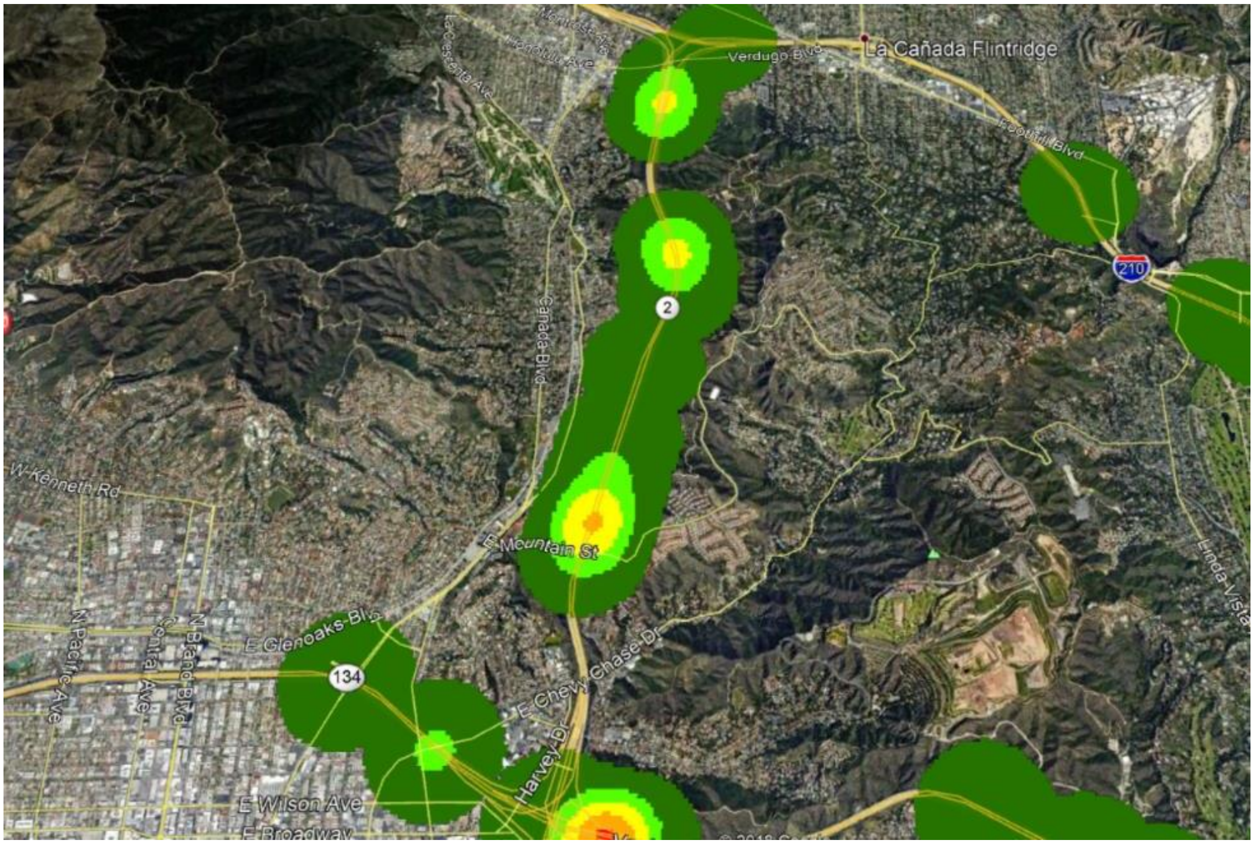
CRASH DATA DISTRICT 7

Hot spots in District 7 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

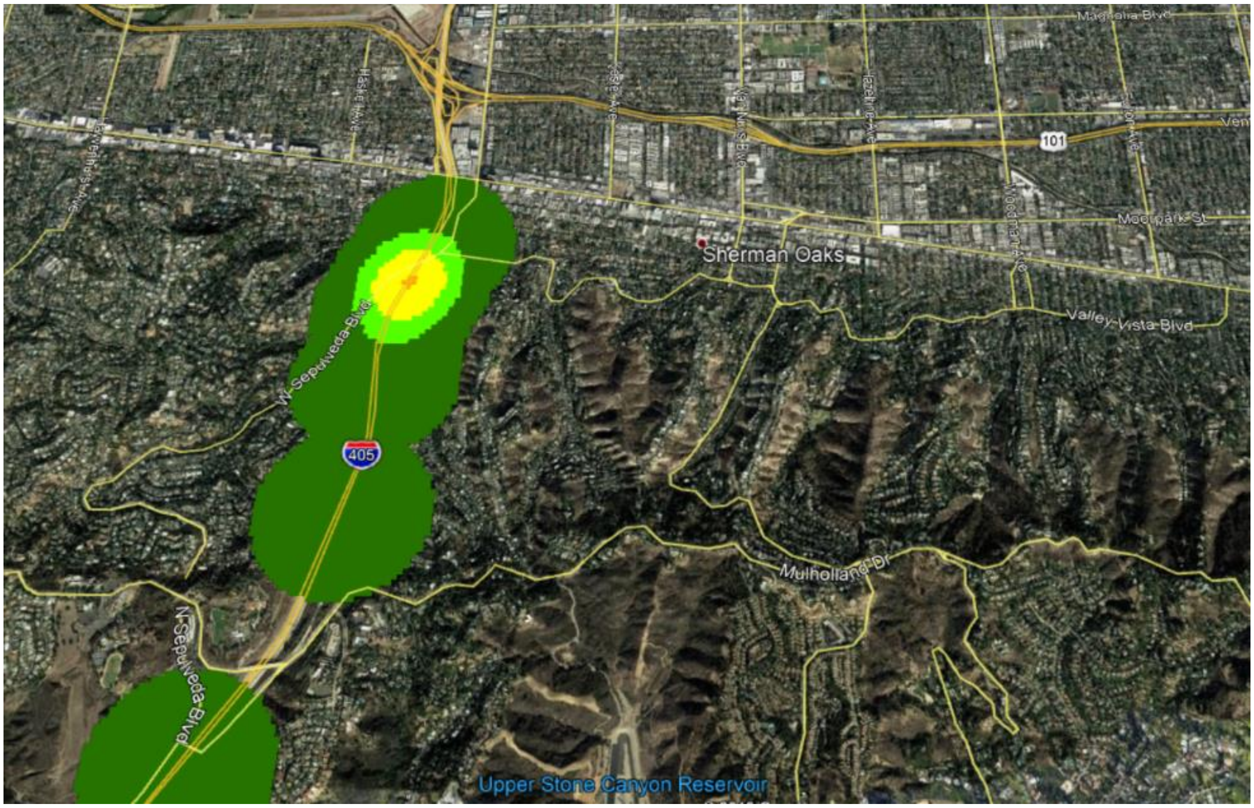
7a


E Verdugo Blvd
N Glendale Ave
Harvey Dr
E Wilson Ave
E Broadway
W Broadway
E Colorado St
Colorado Blvd
Glendale
S Chevy Chase Dr
S Brand Blvd
S Glendale Ave
E Chevy Chase Dr
Adams Square
Glendale Fwy
2
134
© 2018 Google

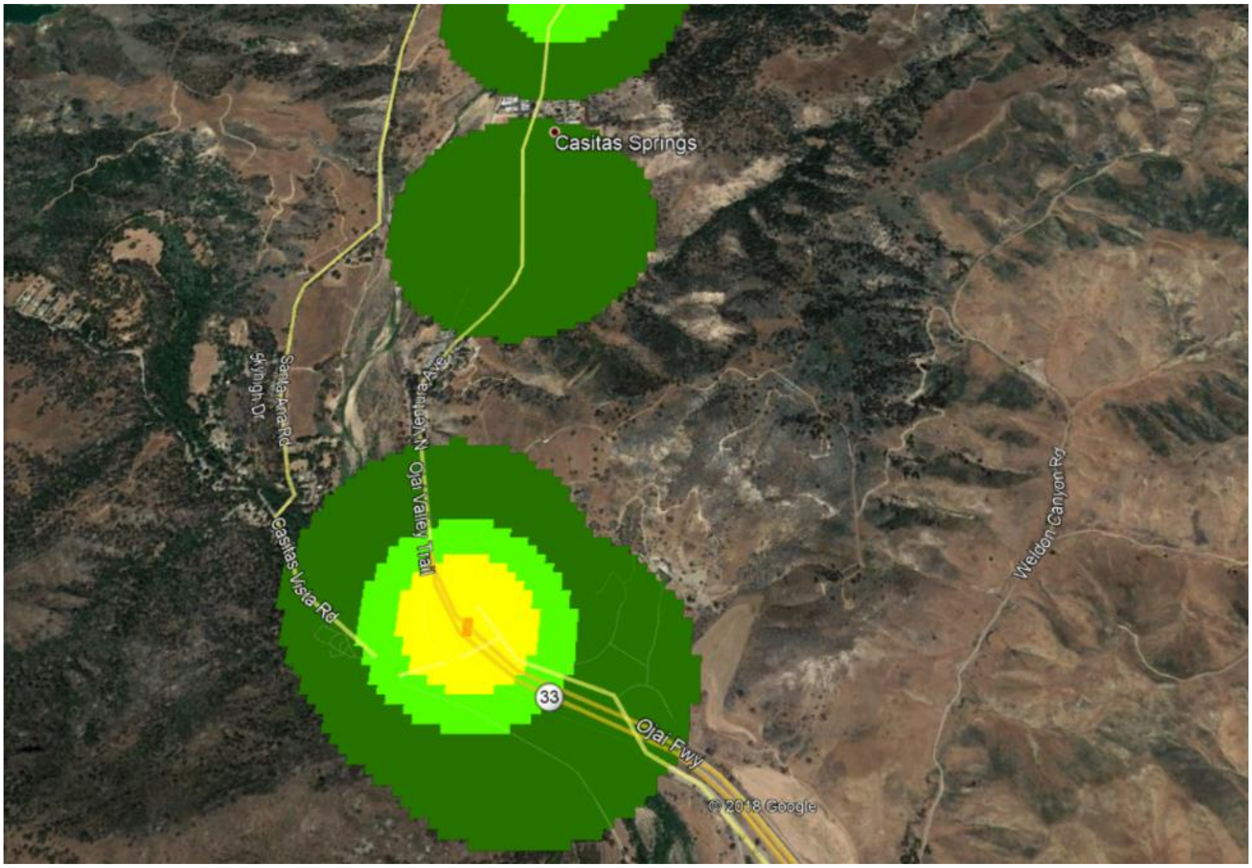
7b


La Cañada Flintridge
Verdugo Blvd
Foothill Blvd
210
2
Cañada Blvd
W Kenneth Rd
E Mountain St
E Glenoaks Blvd
134
E Chevy Chase Dr
Harvey Dr
E Wilson Ave
E Broadway
N Pacific Ave
Central Ave
N Brand Blvd
Linda Vista

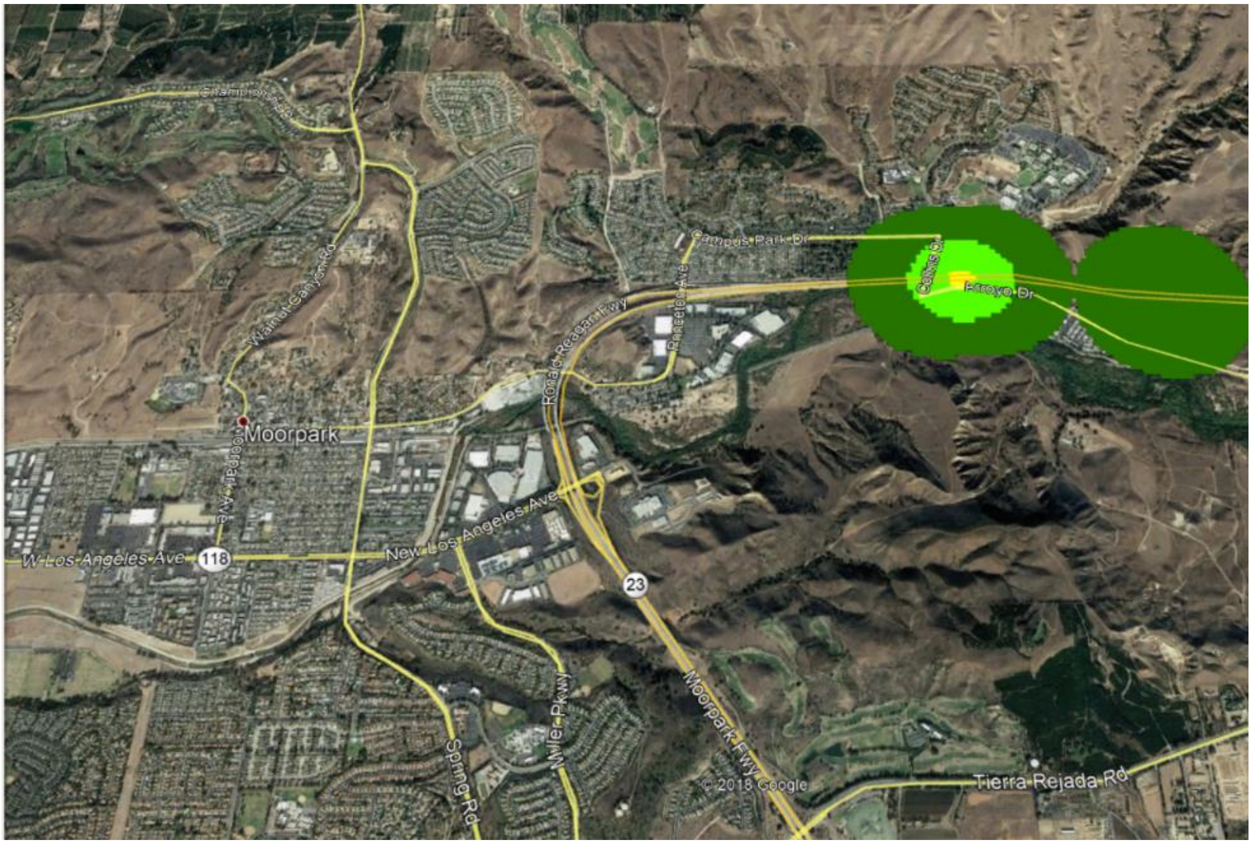
7c


Magnolia Blvd
101
Moorpark St
Sherman Oaks
Valley Vista Blvd
W Sepulveda Blvd
405
Mulholland Dr
N Sepulveda Blvd
Upper Stone Canyon Reservoir

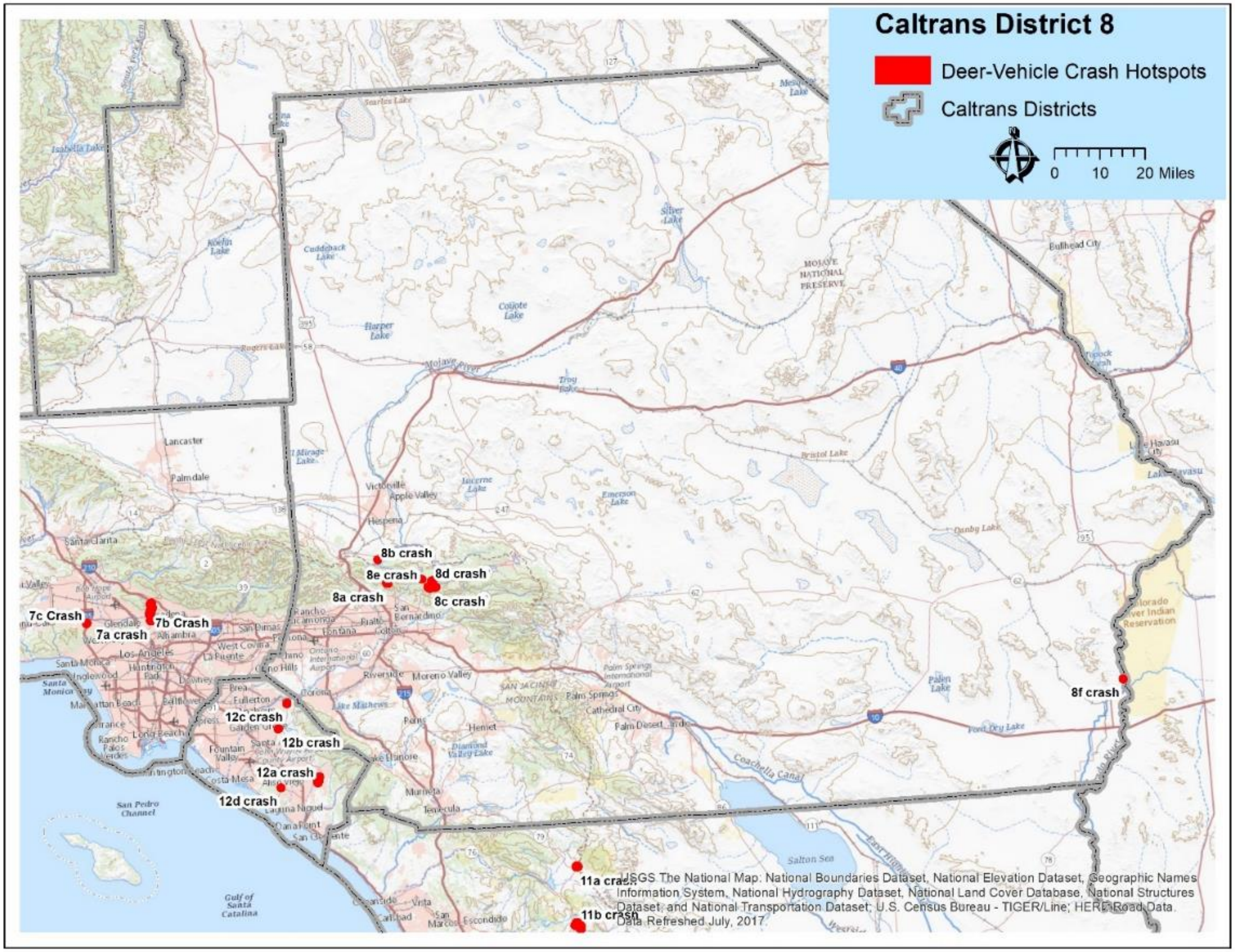
7d


Casitas Springs
Santa Ana Rd
Skyhigh Dr
N Ventura Ave
Ojai Valley Trail
Casitas Vista Rd
33
Ojai Fwy
Weldon Canyon Rd
© 2018 Google

7e

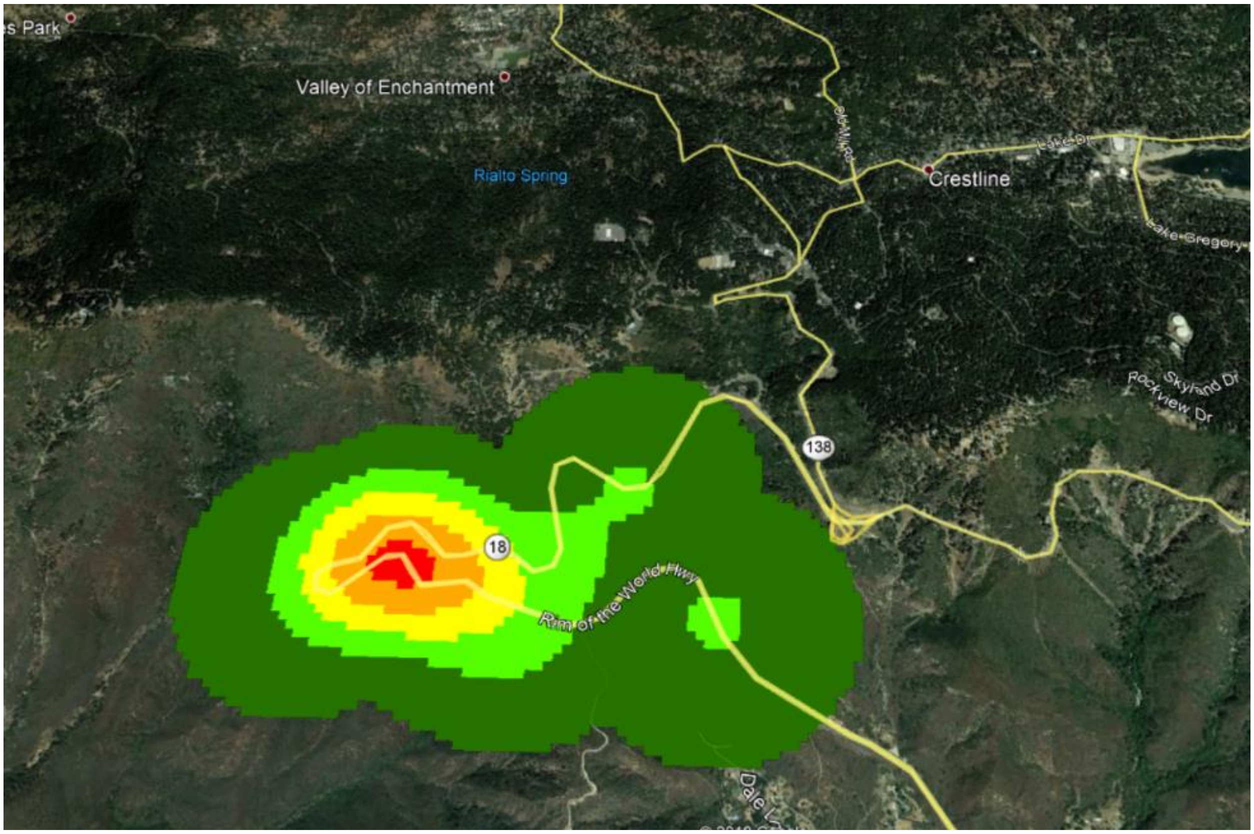

Campus Park Dr
Collins Dr
Arroyo Dr
Walnut Canyon Rd
Princeton Ave
Ronald Reagan Fwy
Moorpark
Moorpark Ave
New Los Angeles Ave
W Los Angeles Ave
118
23
Moorpark Fwy
Spring Rd
Miller Pkwy
Tierra Rejada Rd
© 2018 Google

CRASH DATA DISTRICT 8

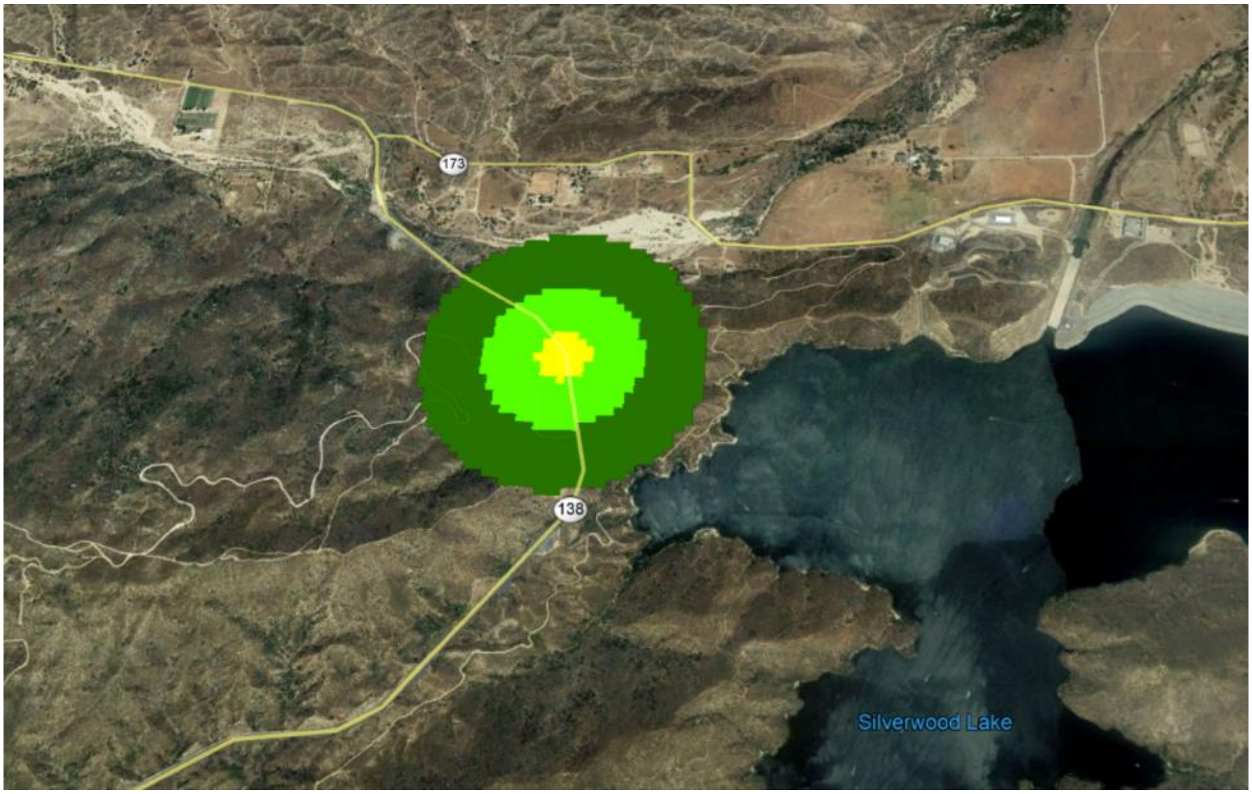


Hot spots in District 8 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

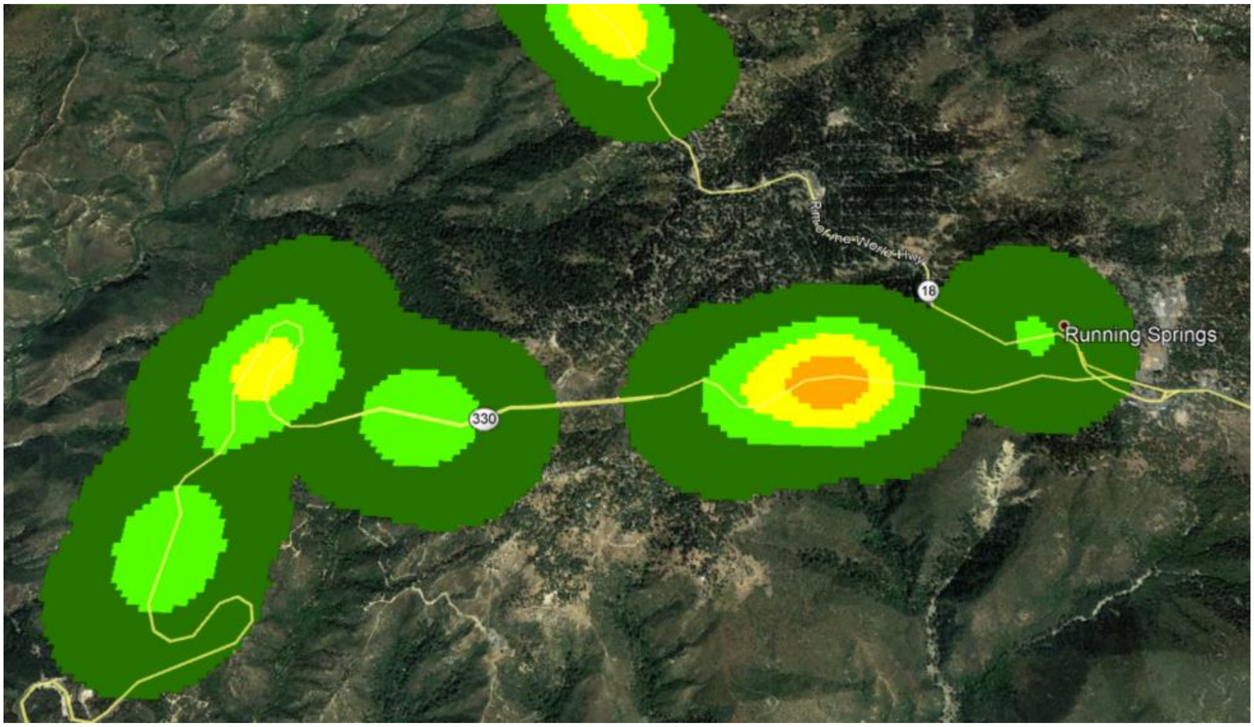
8a


Valley of Enchantment
Rialto Spring
Crestline
Lake Gregory
138
18
Rim of the World Hwy
Skyland Dr
Rockview Dr

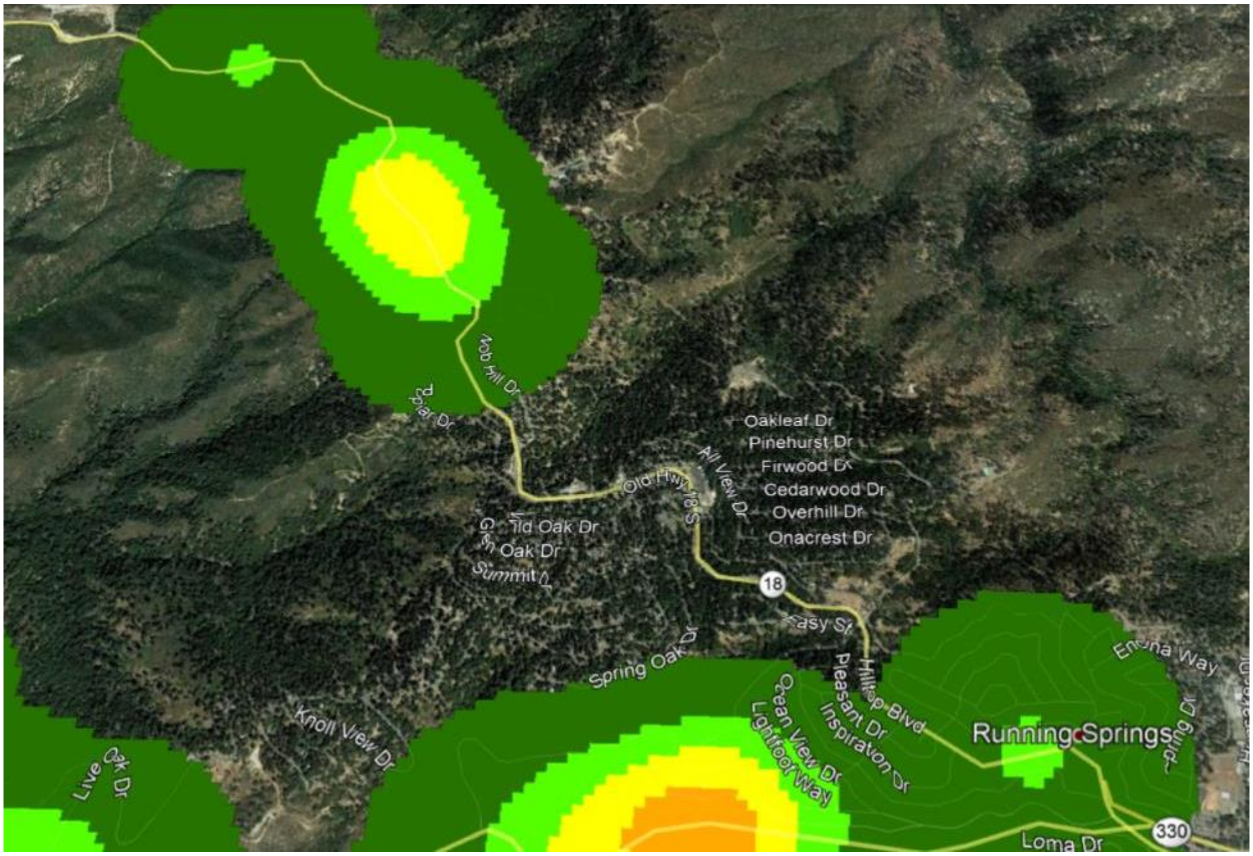
8b



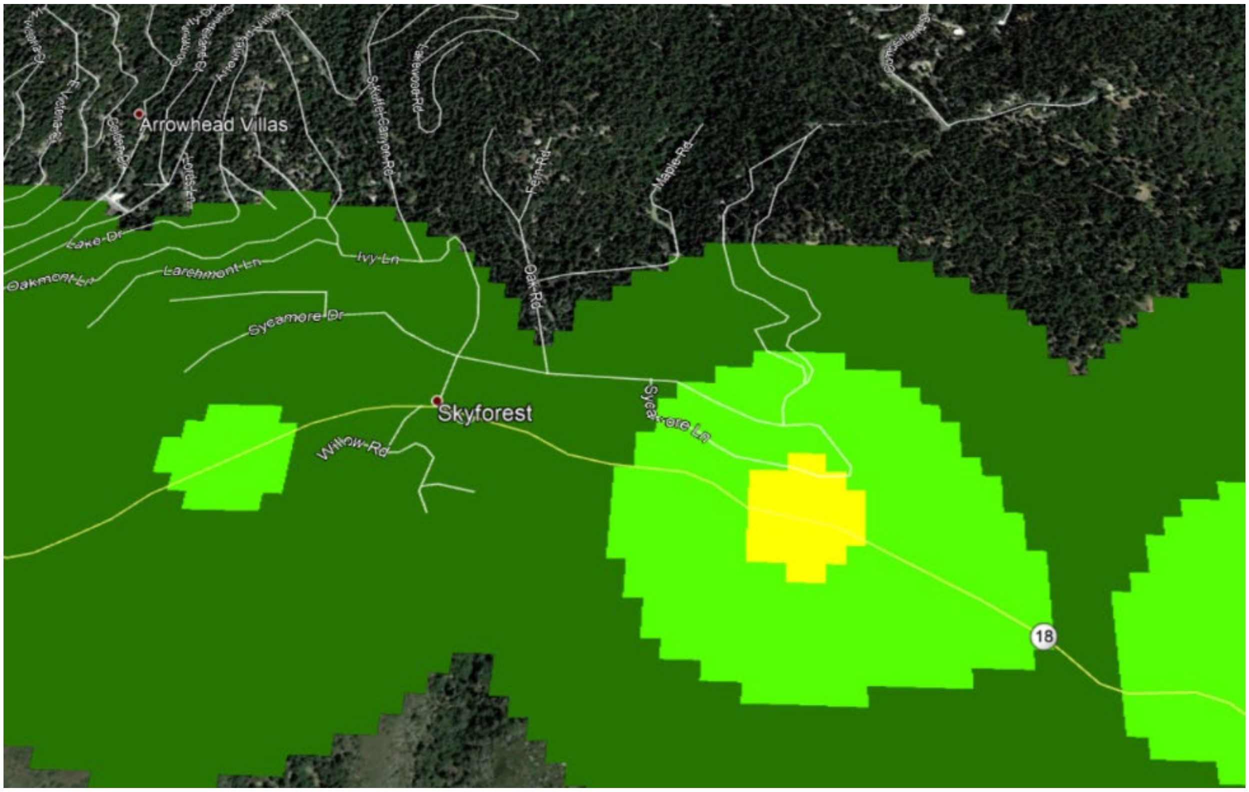
8c



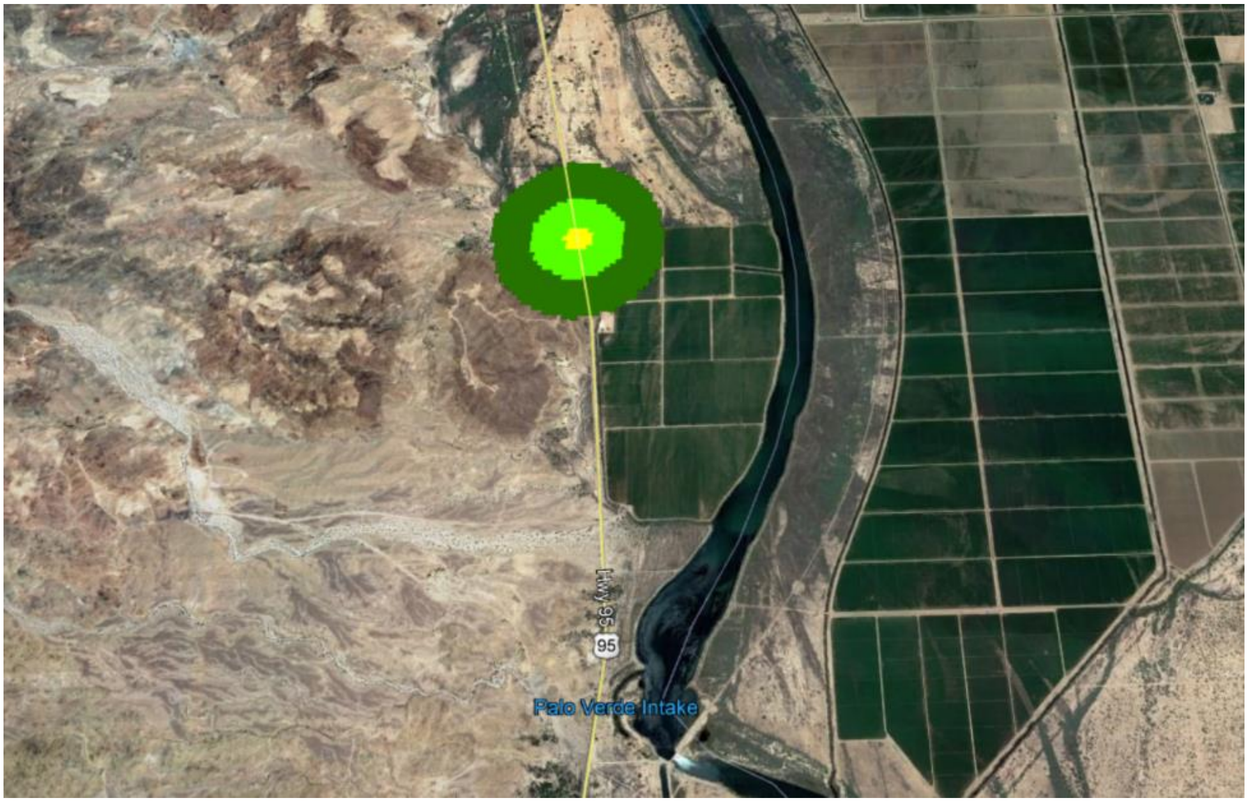
8d


Oakleaf Dr
Pinehurst Dr
Cedarwood Dr
Overhill Dr
Onacrest Dr
All View Dr
Spring Oak Dr
Knoll View Dr
Live Oak Dr
Ocean View Dr
Lightfoot Way
Pleasant Dr
Inspiration Dr
Hilltop Blvd
Running Springs
Loma Dr
18
330

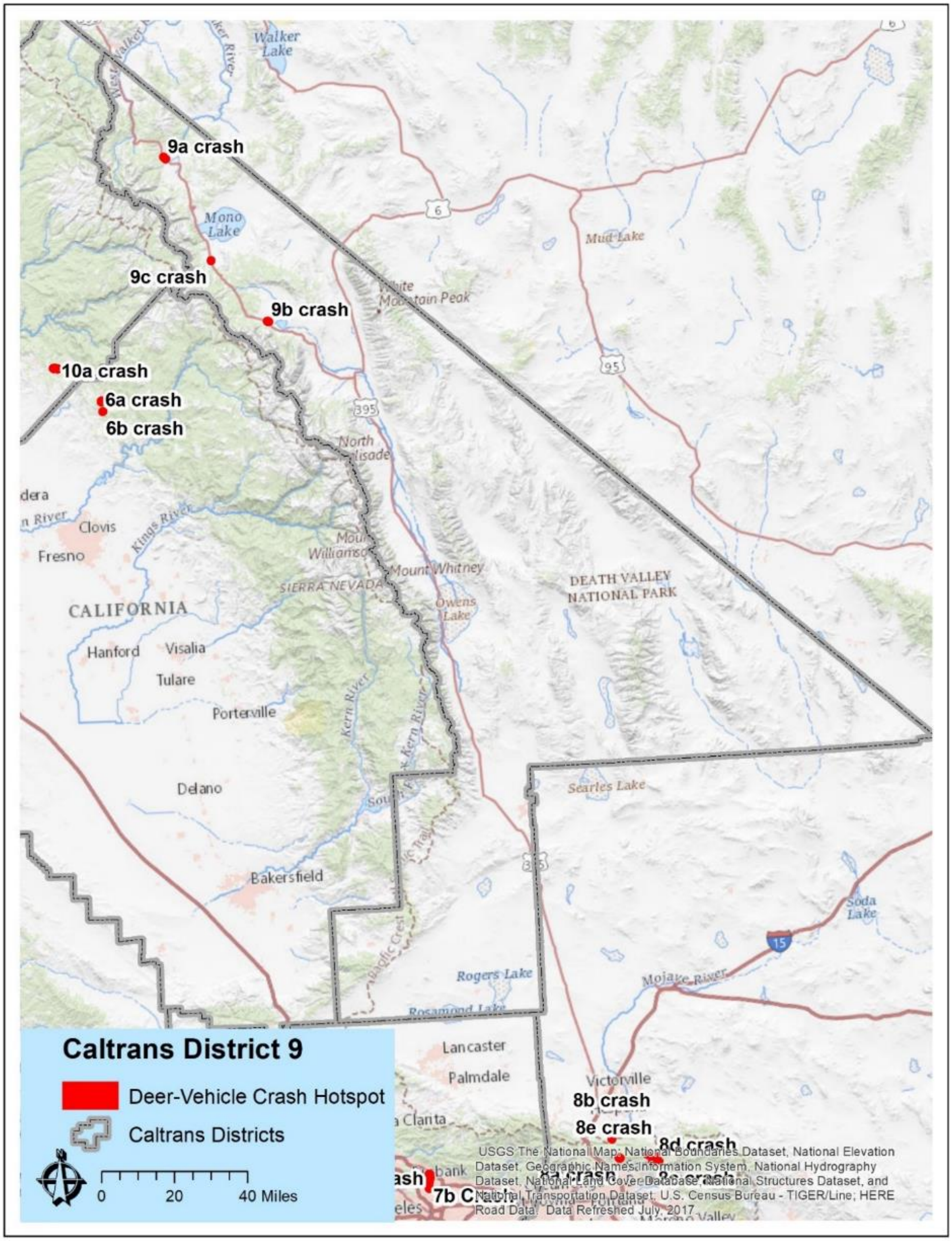
8e


Arrowhead Villas
Lake Dr
Oakmont Ln
Larchmont Ln
Ivy Ln
Sycamore Dr
Oak Rd
Fern Rd
Maple Rd
Skyforest
Willow Rd
Sycamore Ln
18

8f

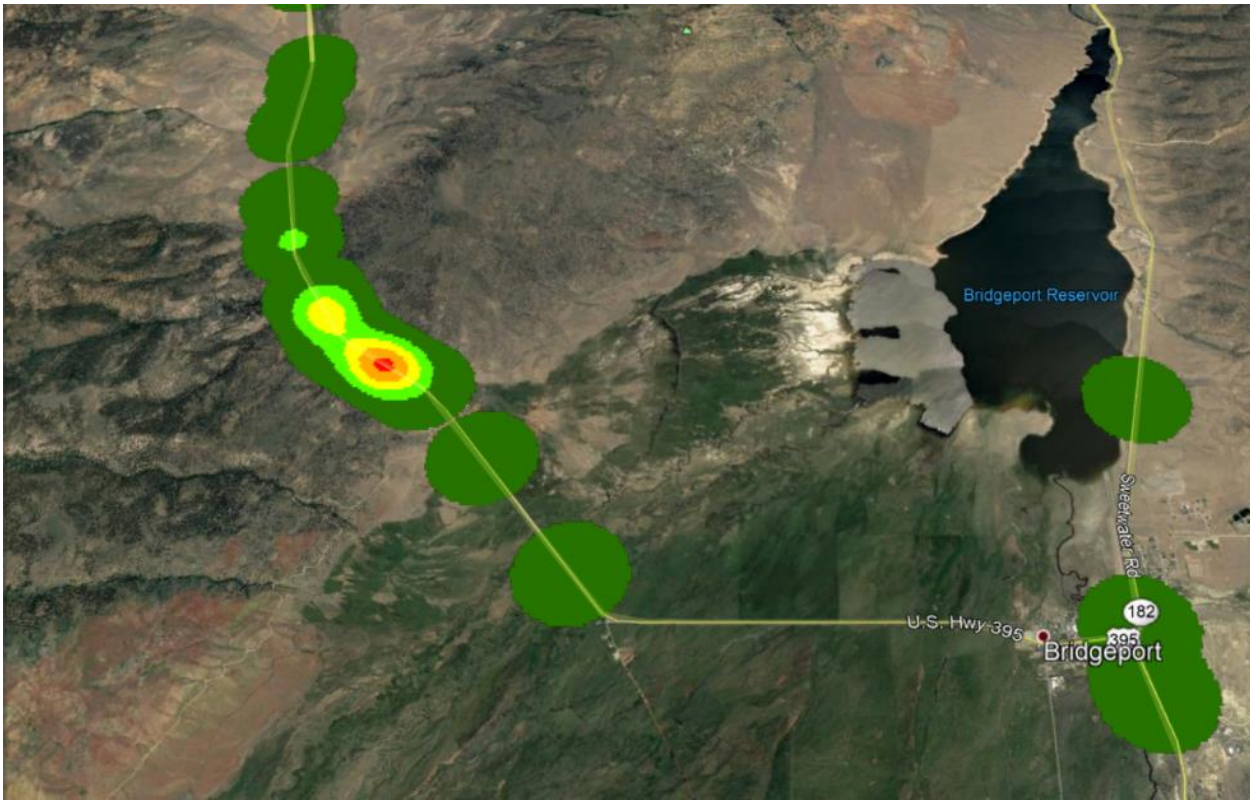


CRASH DATA DISTRICT 9

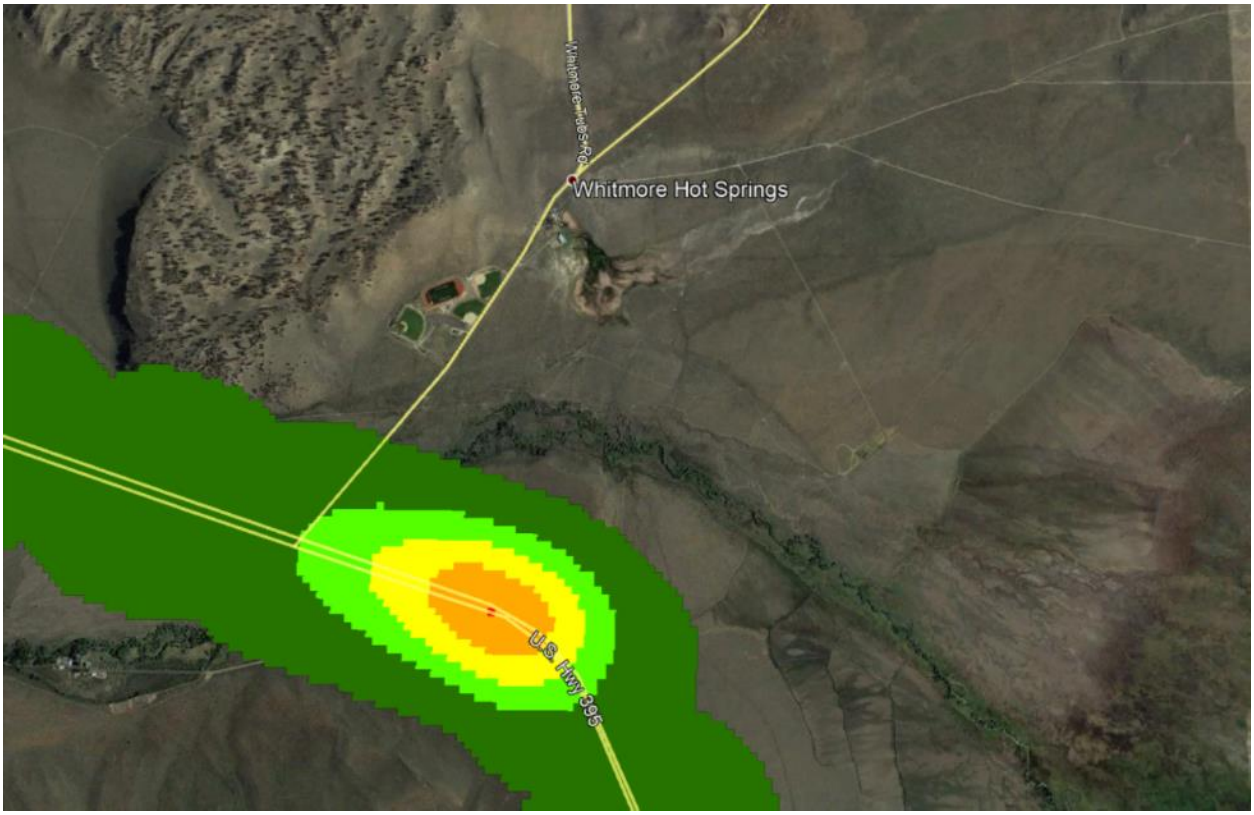


Hot spots in District 9 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

9a

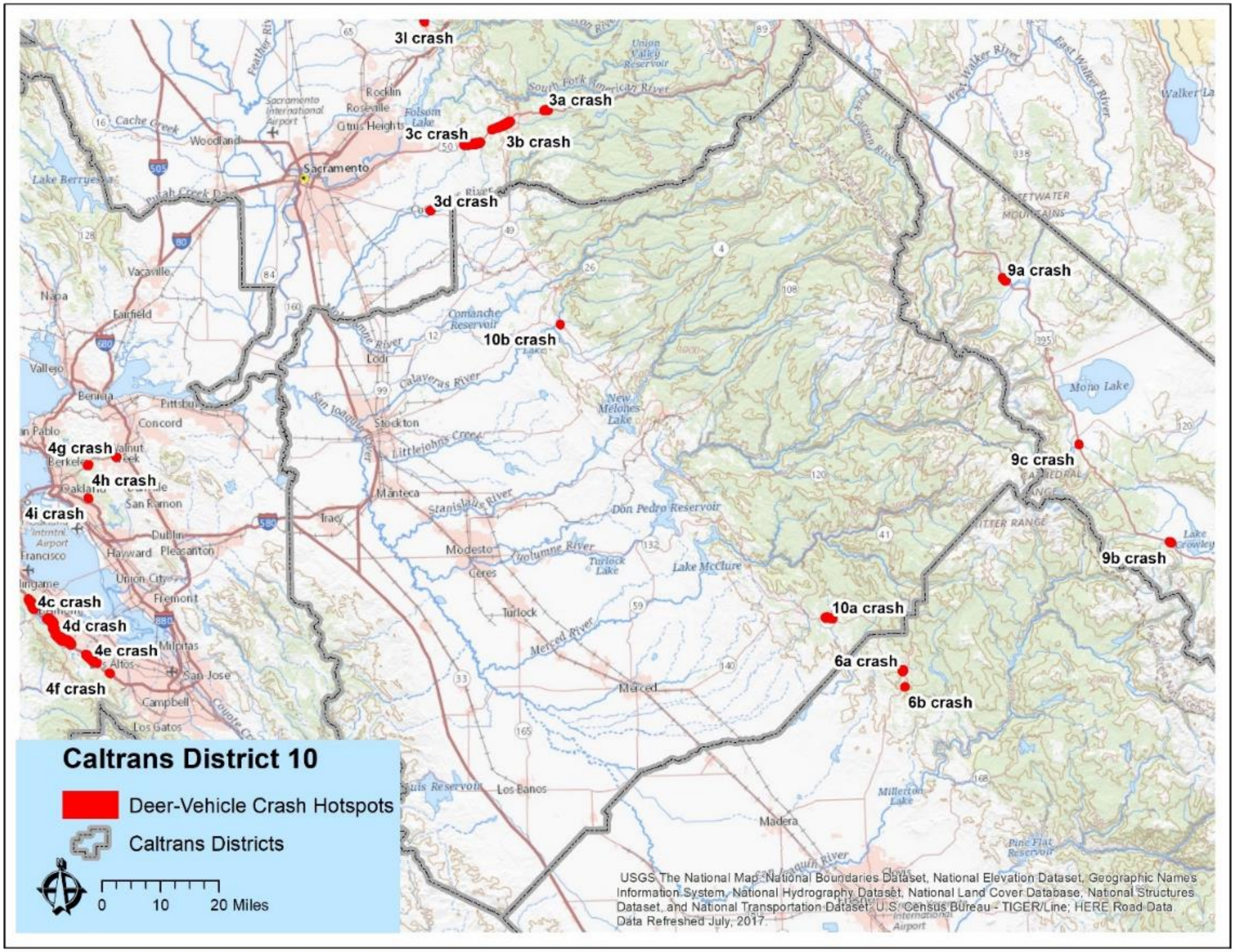

Bridgeport Reservoir
Sweetwater Rd
182
U.S. Hwy 395
395
Bridgeport

9b



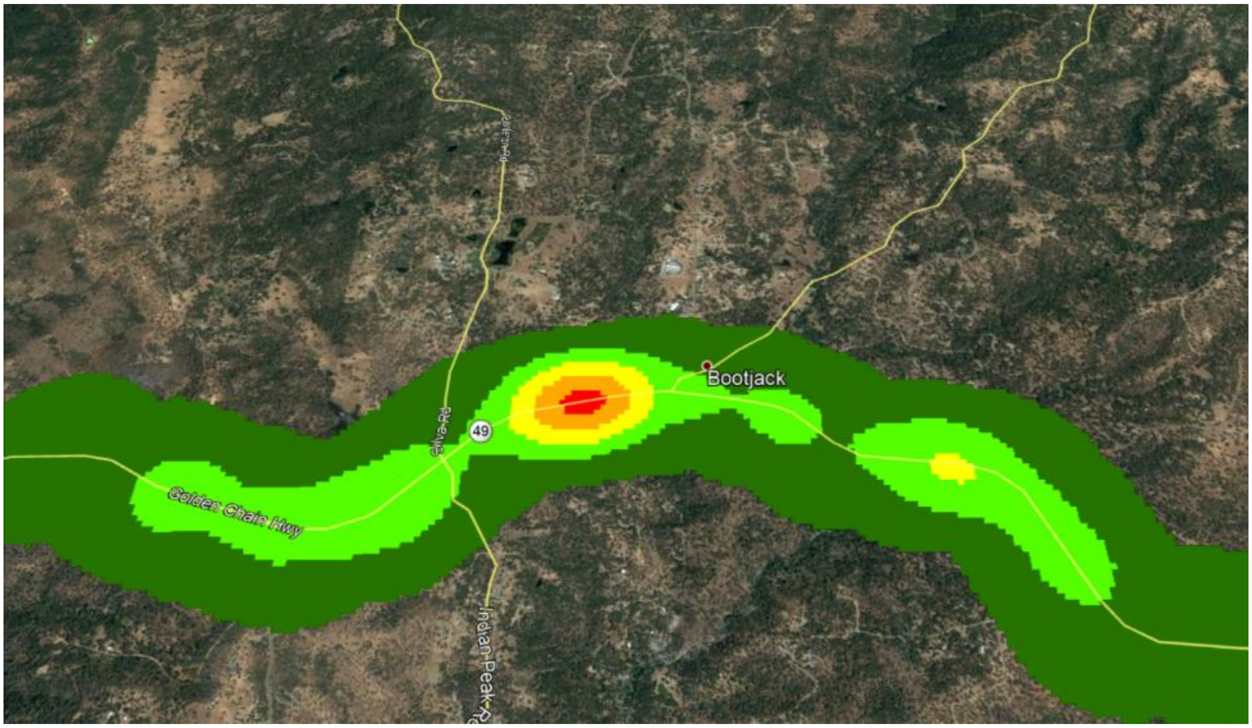
9c

CRASH DATA DISTRICT 10

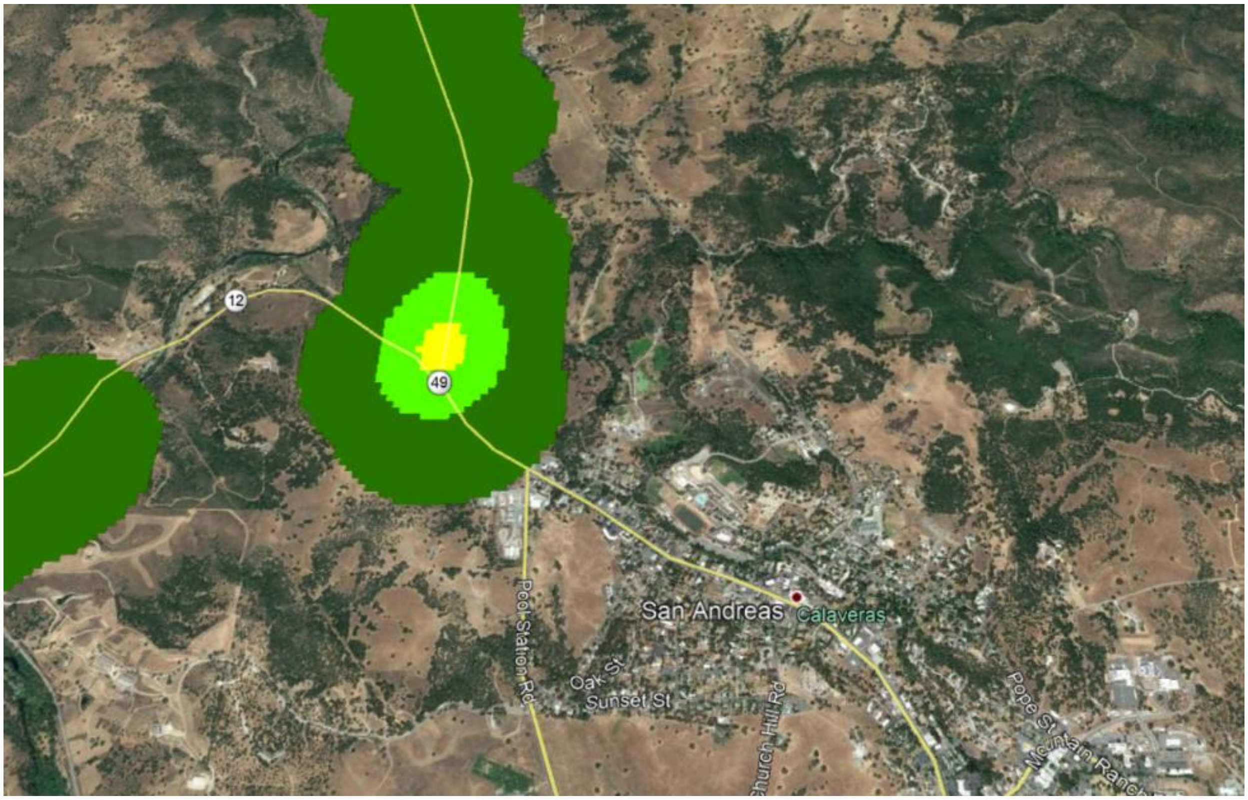


Hot spots in District 10 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

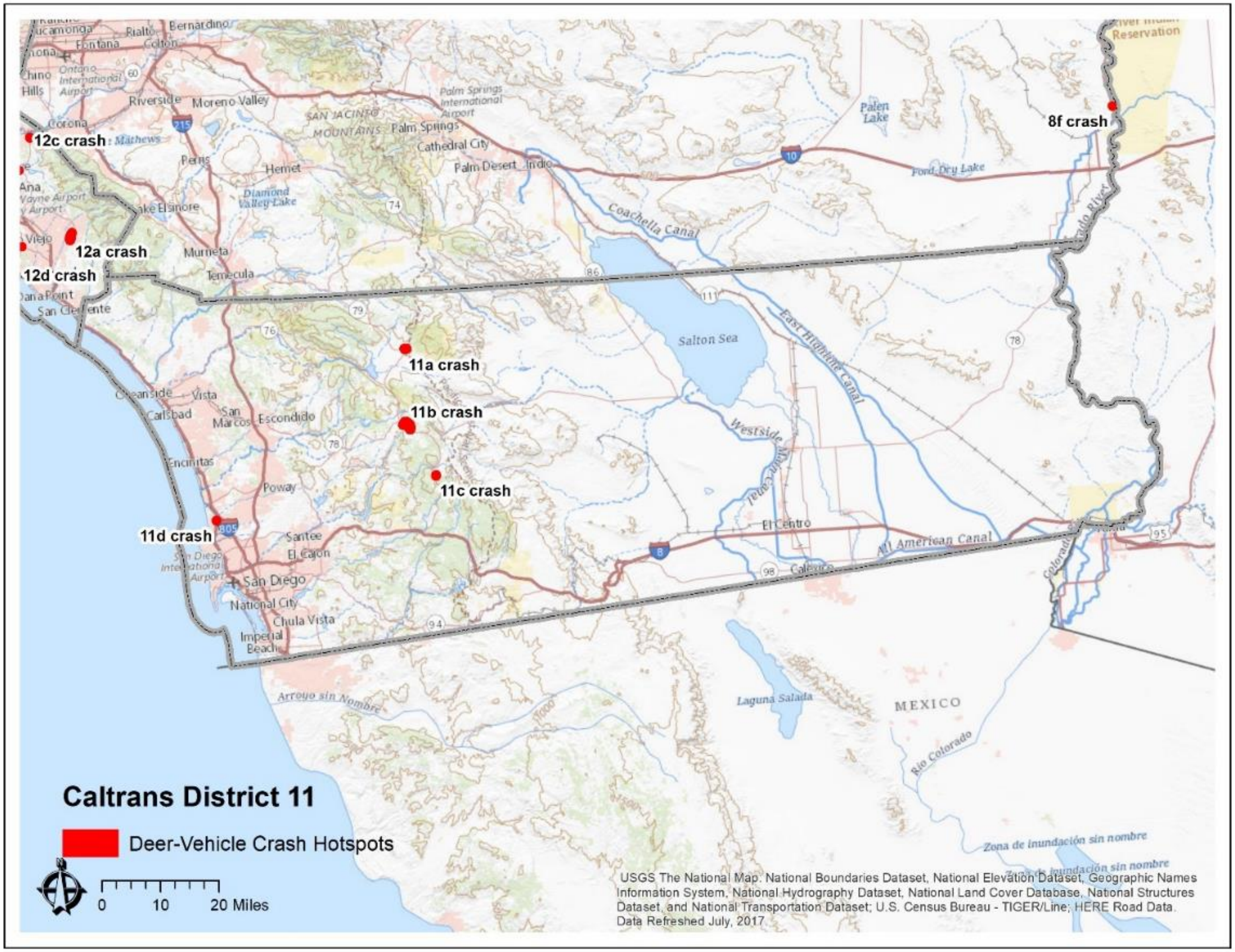
10a



10b

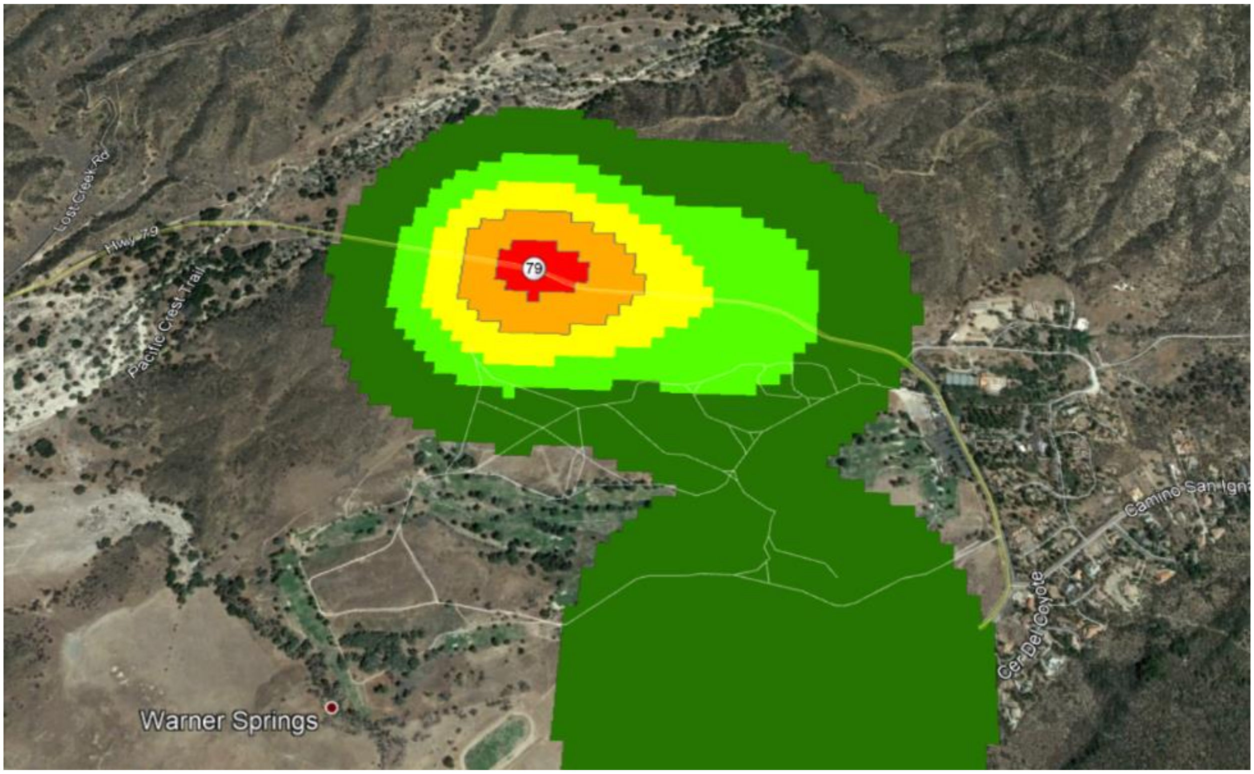

12
49
San Andreas
Calaveras
Pool Station Rd
Oak St
Sunset St
Church Hill Rd
Pope St
Mountain Ranch

CRASH DATA DISTRICT 11

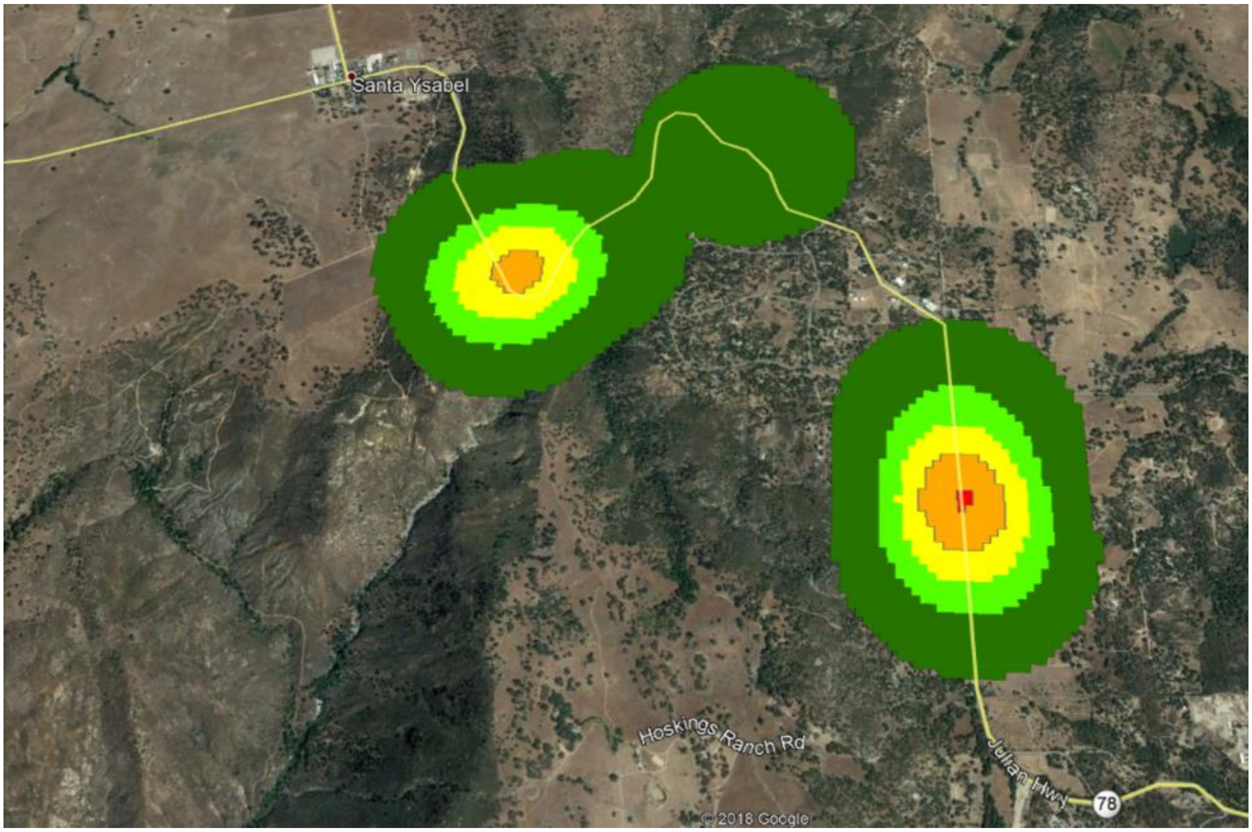


Hot spots in District 11 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

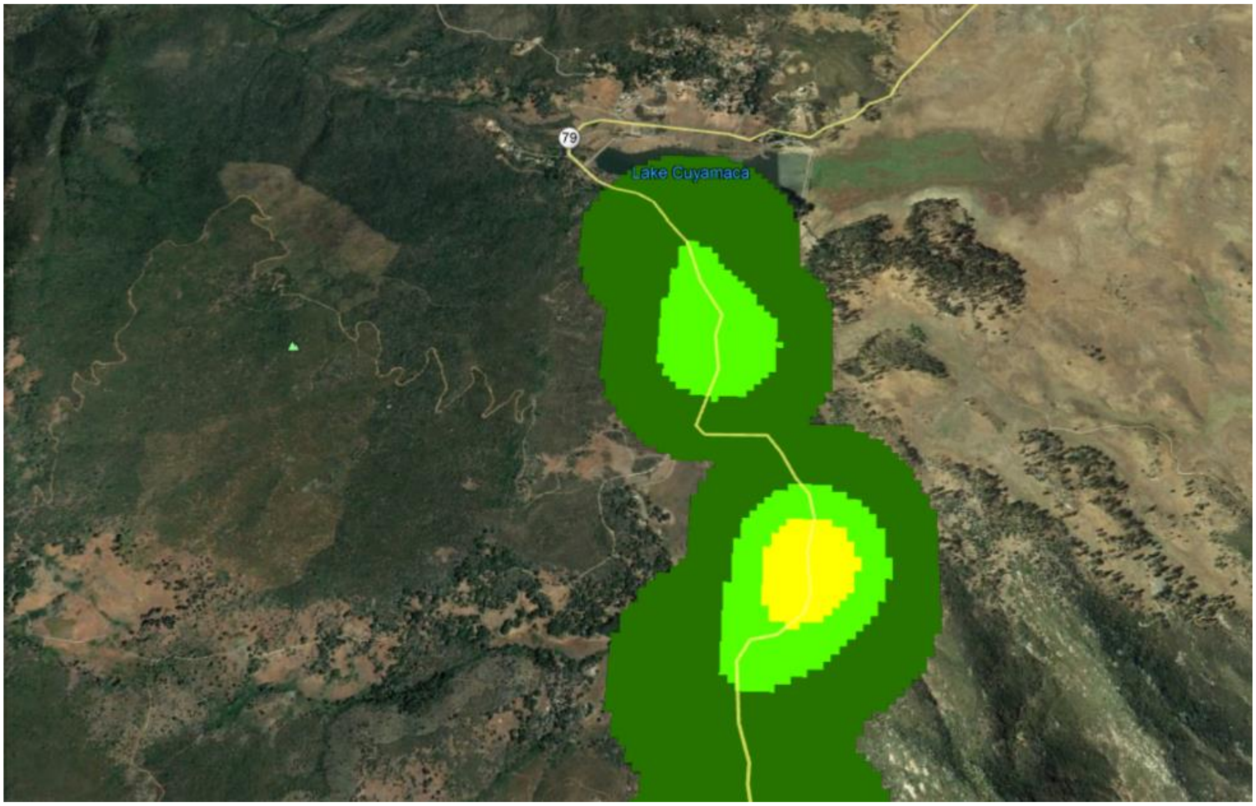
11a


Lost Creek Rd
Hwy 79
Pacific Crest Trail
79
Warner Springs
Camino San Igna
Cer Del Coyote

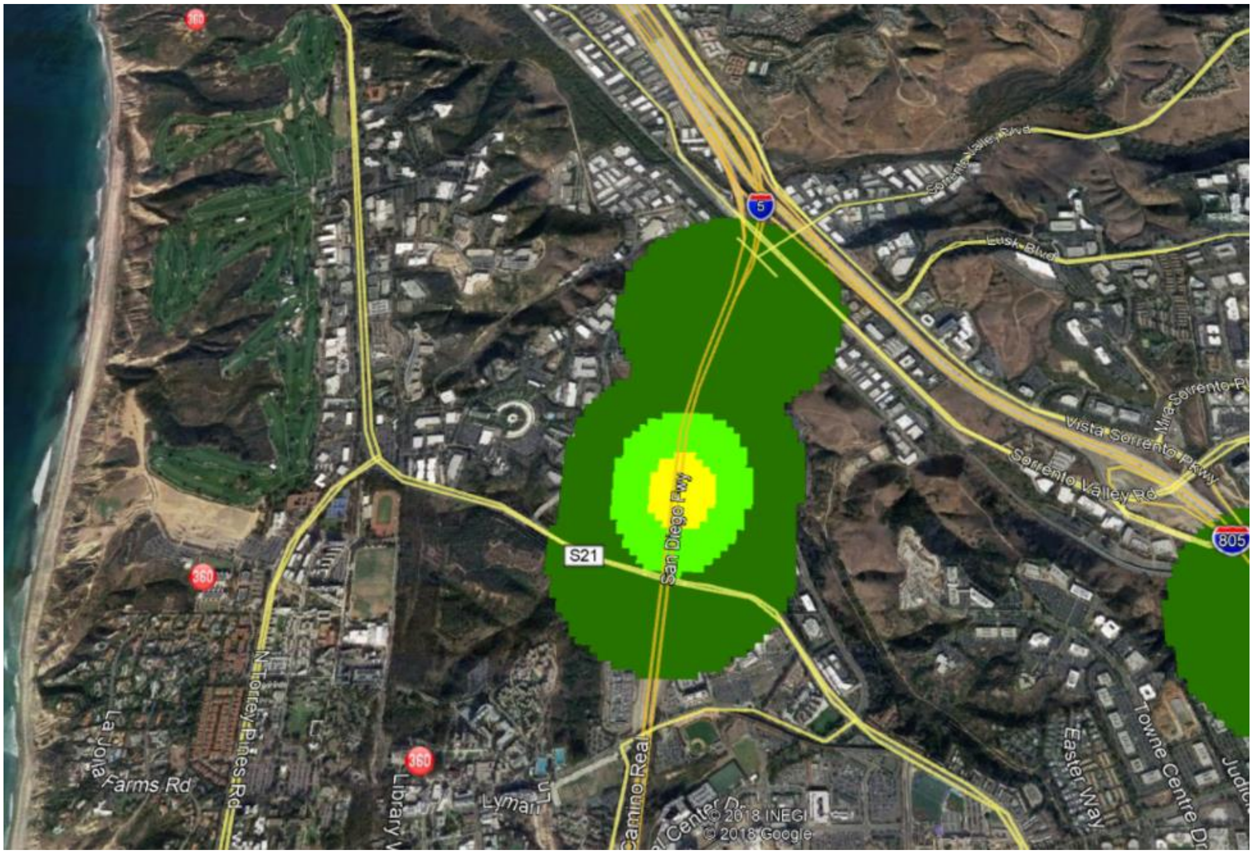
11b



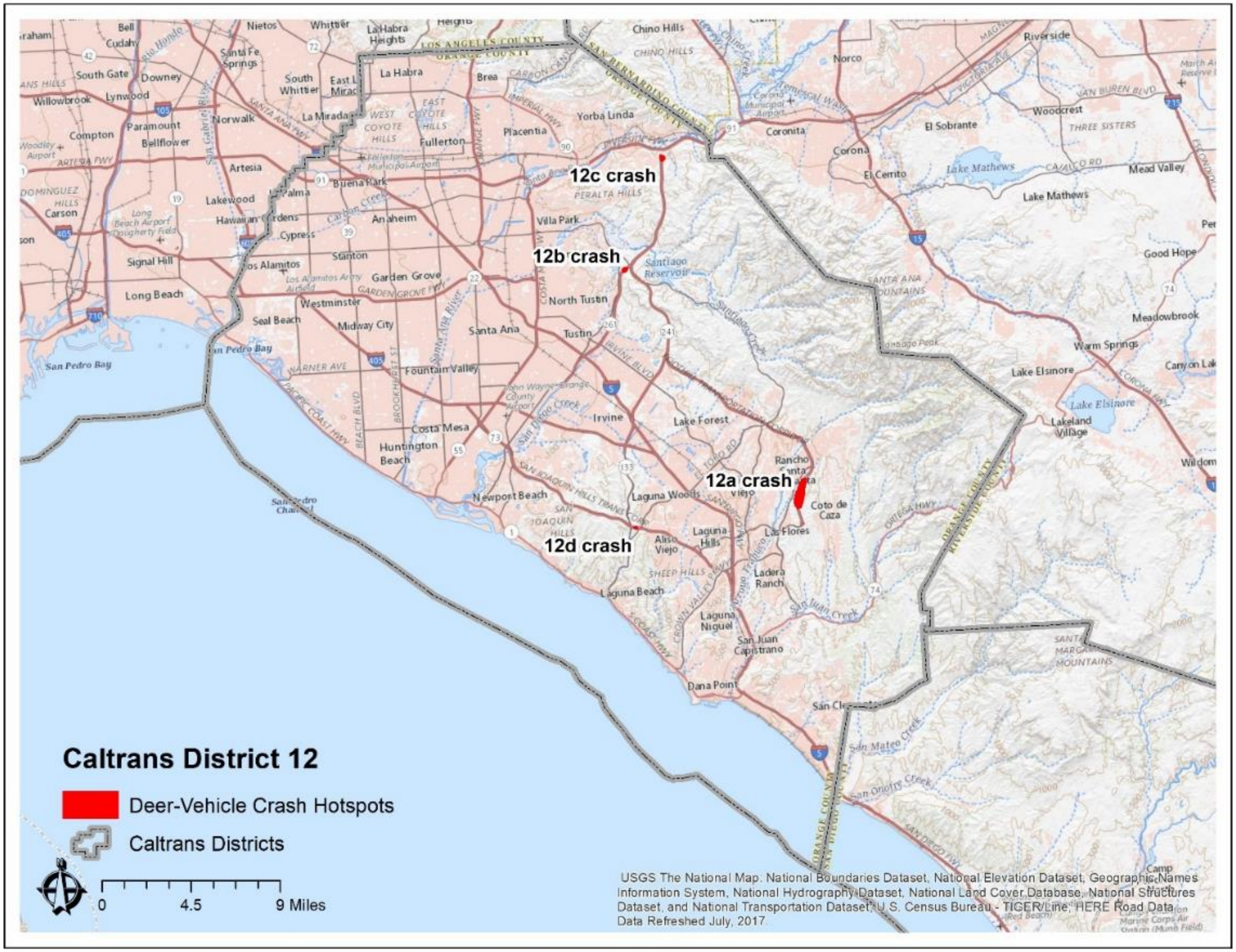
11c



11d

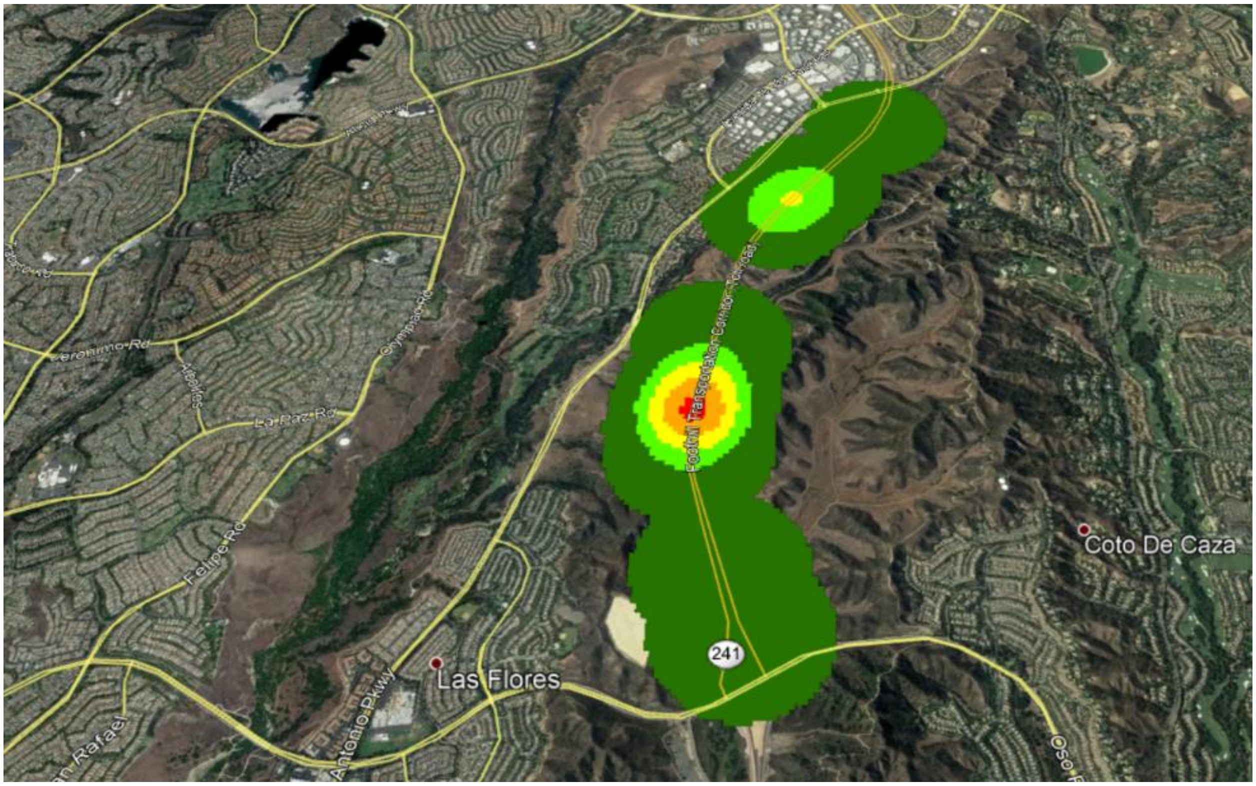

Sorrento Valley Blvd
Lusk Blvd
Vista Sorrento Pkwy
Sorrento Valley Rd
Mira Sorrento Pl
S21
San Diego Fwy
N Torrey Pines Rd
La Jolla Farms Rd
Library W
Lyman Ln
Camino Real
Eastgate Way
Towne Centre Dr
5
805
360
© 2018 INEGI
© 2018 Google

CRASH DATA DISTRICT 12

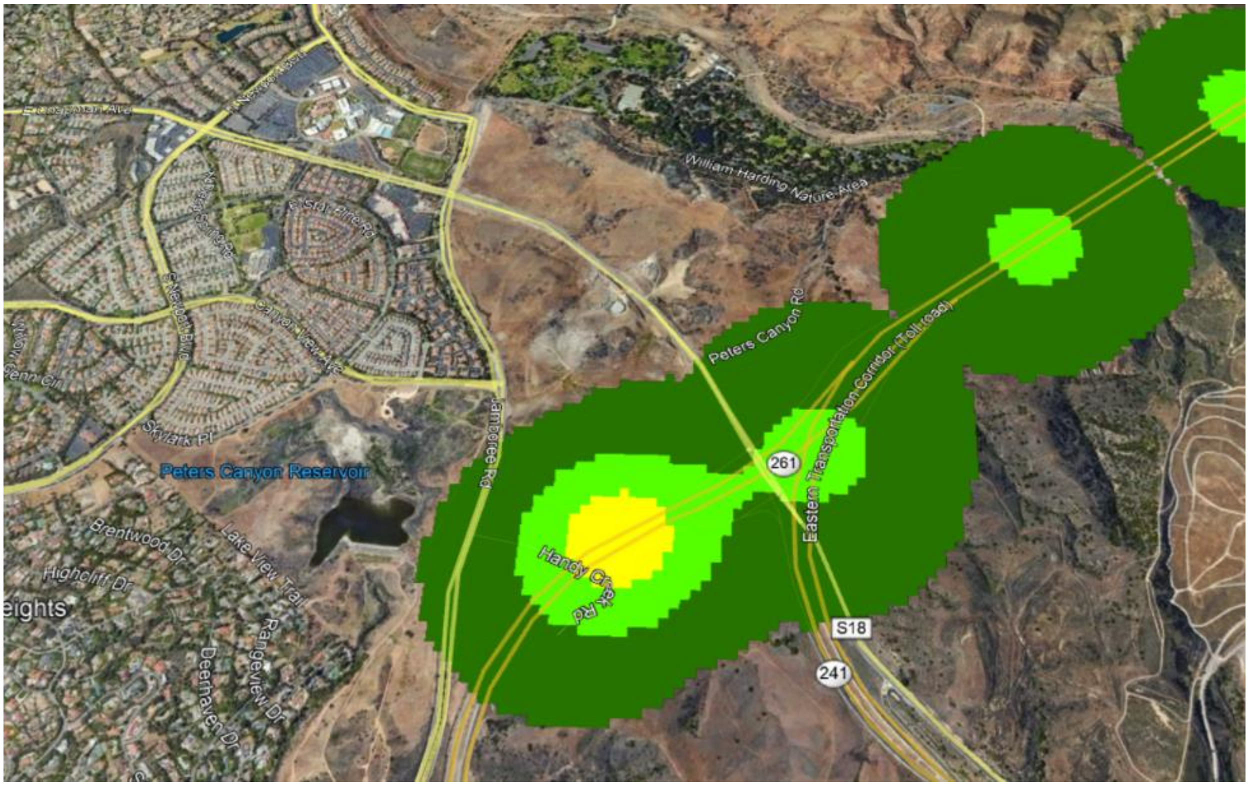


Hot spots in District 12 based on per district deer-vehicle crash data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix B) and the detailed maps on the following pages.

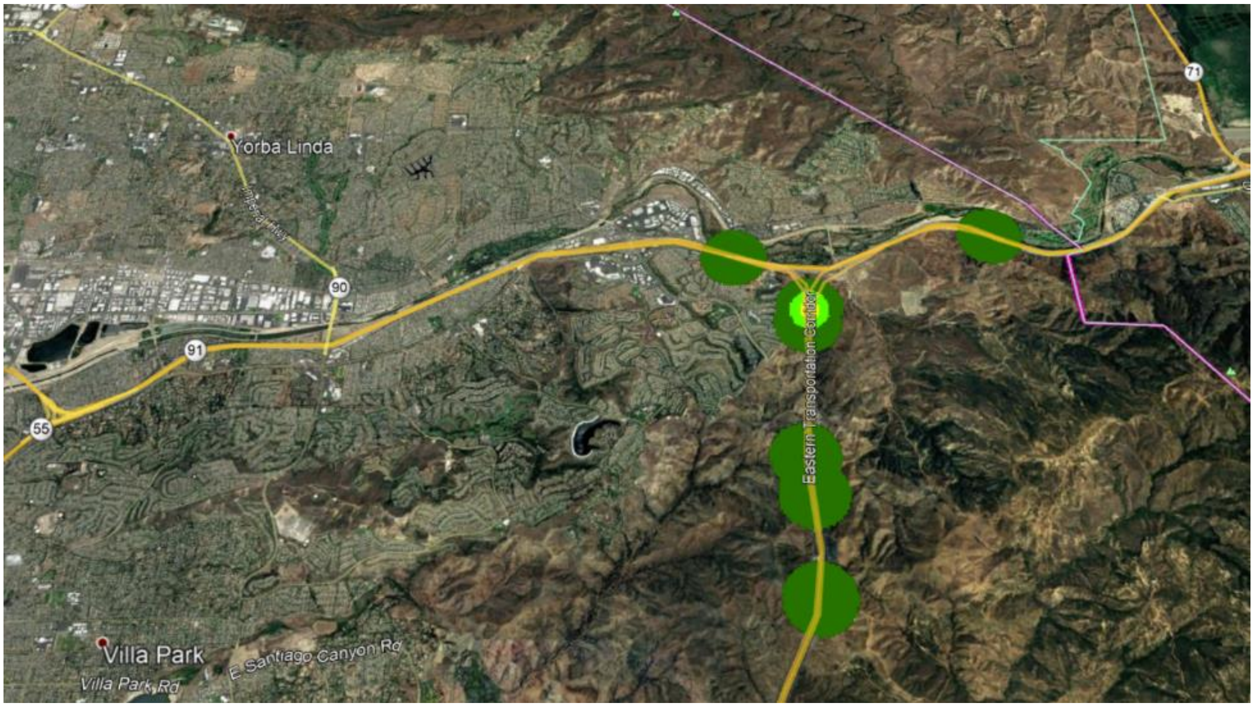
12a



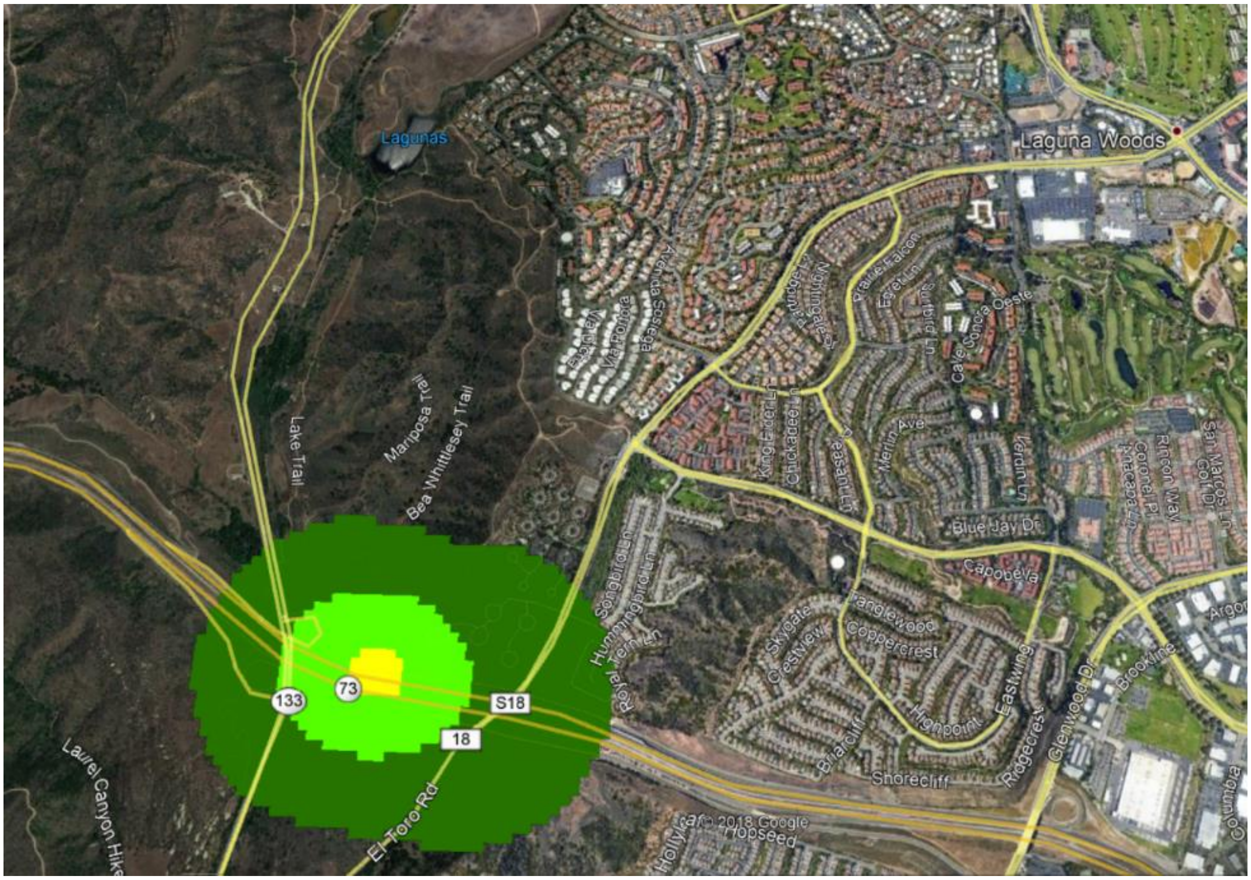
12b


William Harding Nature Area
Peters Canyon Rd
Eastern Transportation Corridor (Toll road)
261
Peters Canyon Reservoir
Skylark Pl
Brentwood Dr
Lake View Trl
Highcliff Dr
Rangeview Dr
Deerhaven Dr
Handy Creek Rd
S18
241
eights

12c


Yorba Linda
90
91
55
71
Eastern Transportation Corridor
Villa Park
Villa Park Rd
E Santiago Canyon Rd

12d


Lagunas
Laguna Woods
Lake Trail
Mariposa Trail
Bea Whittlesey Trail
Laurel Canyon Hike
El Toro Rd
133
73
S18
18
Blue Jay Dr
Merlin Ave
Kingfisher Ln
Chickadee Ln
Capobella
Tanglewood
Coppercrest
Skygate
Crestview
Highpoint
Eastwing
Briarcliff
Shorecliff
Ridgecrest
Glenwood Dr
Brookline
Hummingbird Ln
Royal Tern Ln
Songbird Ln
Via Sosiega
Calle Concha Oeste
Rincon Way
Coronel Pl
San Marcos Ln
©2018 Google

10.APPENDIX C: ANALYSES PER DISTRICT MULE DEER CARCASSES

CARCASS DATA PER DISTRICT

The numbers in the table on the following page correspond with the detailed maps per district and maps of the individual hot spots within a district on the following pages.

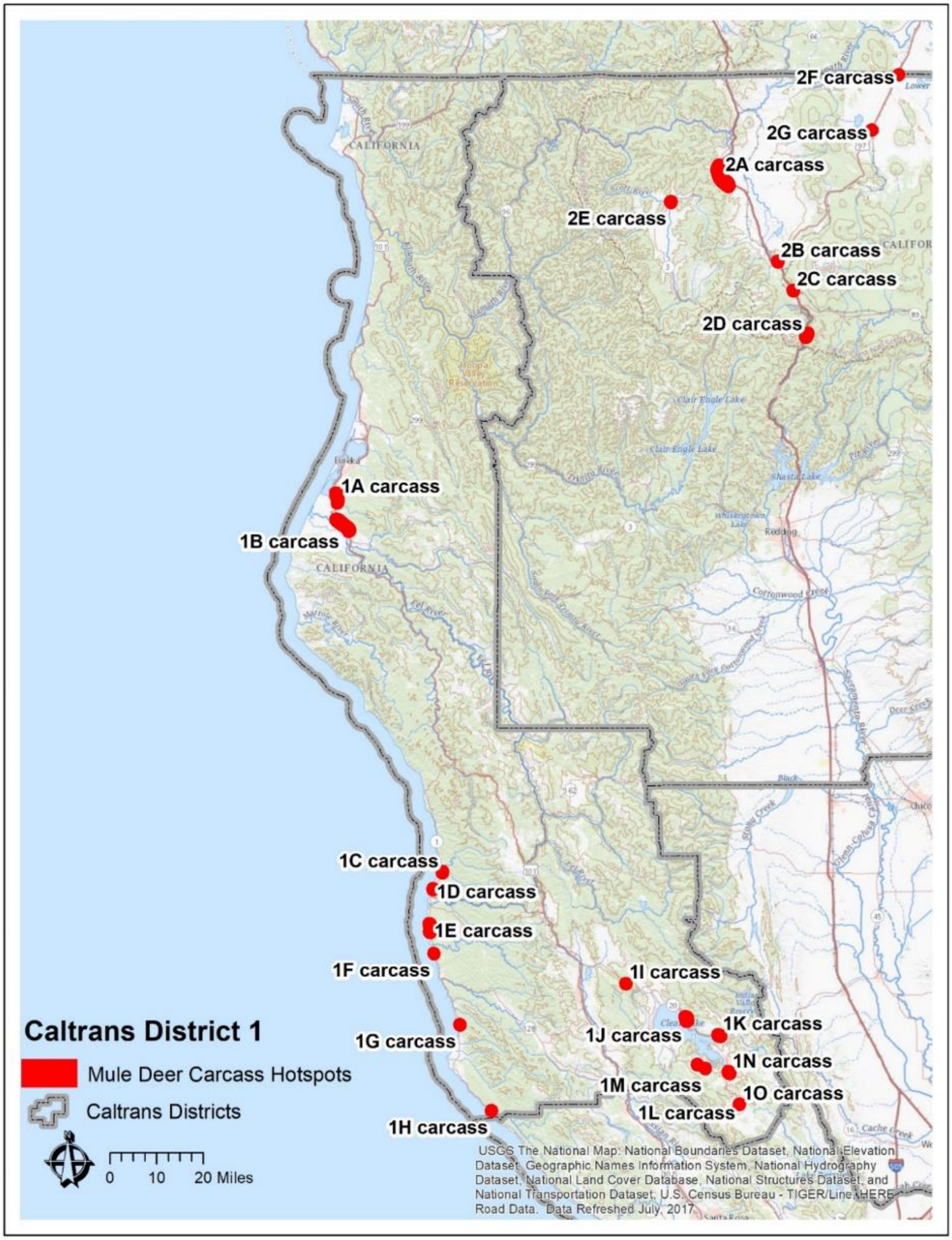
The "worst" hot spots based on analyses for mule deer carcasses per Caltrans district. Note: AADT = Annual Average Daily Traffic.

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
1A	1	Humboldt	Eureka	US Hwy 101	1_HUM_101_704	1_HUM_101_681	red	2.3	0.9	0.7	0.1	4	yes	24150
1B	1	Humboldt	Fortuna	US Hwy 101	1_HUM_101_641	1_HUM_101_601	yellow	4.0	1.5	0.0	0.0	4	yes	24000
1C	1	Mendocino	Inglenook	Hwy 1	1_MEN_1_685	1_MEN_1_681	yellow	0.4	0.4	0.0	0.0	2	No	4925
1D	1	Mendocino	Fort Bragg	Hwy 1	1_MEN_1_640	1_MEN_1_636	yellow	0.4	0.4	0.0	0.0	2	No	4925
1E	1	Mendocino	Caspar	Hwy 1	1_MEN_1_554	1_MEN_1_534	yellow	2.0	0.5	0.0	0.0	2	Yes	10200
1F	1	Mendocino	Little River	Hwy 1	1_MEN_1_483	1_MEN_1_479	yellow	0.4	0.4	0.0	0.0	2	Yes	3750
1G	1	Mendocino	Elk	Hwy 1	1_MEN_1_275	1_MEN_1_272	yellow	0.3	0.3	0.0	0.0	2	No	1300
1H	1	Mendocino	Anchor Bay	Hwy 1	1_MEN_1_30	1_MEN_1_28	yellow	0.2	0.2	0.0	0.0	2	No	3500
1I	1	Lake	Blue Lakes	Hwy 20	1_LAK_20_10	1_LAK_20_12	yellow	0.2	0.2	0.0	0.0	2	No	9650
1J	1	Lake	Pepperwood Grove	Hwy 20	1_LAK_20_180	1_LAK_20_192	yellow	1.2	0.6	0.0	0.0	2	No	8100
1K	1	Lake	Clearlake Oaks	Hwy 20	1_LAK_20_289	1_LAK_20_297	yellow	0.8	0.6	0.0	0.0	2	No	8150
1L	1	Lake	Riviera Estates	Hwy 281	1_LAK_281_167	1_LAK_281_169	yellow	0.1	0.1	0.0	0.0	2	No	6400
1M	1	Lake	Jct Hwy 281	Hwy 29	1_LAK_29_262	1_LAK_29_259	yellow	0.3	0.3	0.0	0.0	2	No	9350
1N	1	Lake	Lower lake	Hwy 29	1_LAK_29_207	1_LAK_29_198	yellow	0.9	0.6	0.0	0.0	2	No	10900
1O	1	Lake	Hidden Valley L.	Hwy 29	1_LAK_29_112	1_LAK_29_110	yellow	0.2	0.2	0.0	0.0	2	No	9900
2A	2	Siskiyou	Yreka	I-5	2_SIS_5_471	2_SIS_5_418	red	6.3	1.3	0.3	0.2	4	Yes	19000
2B	2	Siskiyou	Weed	I-5	2_SIS_5_202	2_SIS_5_199	yellow	0.3	0.3	0.0	0.0	4	No	17050
2C	2	Siskiyou	Mt. Shasta	I-5	2_SIS_5_126	2_SIS_5_122	yellow	0.4	0.4	0.0	0.0	4	No	23900
2D	2	Siskiyou	Dunsmuir	I-5	2_SIS_5_15	2_SIS_5_4	yellow	1.1	0.5	0.0	0.0	4	No	20350
2E	2	Siskiyou	Ft. Jones	Hwy 3	2_SIS_3_332	2_SIS_3_329	yellow	0.3	0.3	0.0	0.0	2	No	3625
2F	2	Siskiyou	Indian Tom Lake	US Hwy 97	2_SIS_97_540	2_SIS_97_524	yellow	0.3	0.3	0.0	0.0	2		665
2G	2	Siskiyou	Macdoel	US Hwy 97	2_SIS_97_405	2_SIS_97_403	yellow	0.2	0.2	0.0	0.0	2	No	1190
2H	2	Modoc	Hannchen	Hwy 139	2_MOD_139_391	2_MOD_139_385	yellow	0.6	0.6	0.0	0.0	2	No	1625
2I	2	Modoc	Hannchen	Hwy 139	2_MOD_139_356	2_MOD_139_353	yellow	0.3	0.3	0.0	0.0	2	No	1625
	3	Insufficient data												
4A	4	San Mateo	Highlands-Baywood P.	Hwy 92	4_SM_92_96	4_SM_92_79	orange	1.7	0.9	0.1	0.0	4	No	77200
4B	4	Santa Clara	Los Altos Hills	I-280	4_SCL_280_165	4_SCL_280_144	orange	2.1	0.6	0.2	0.0	8	No	131500
4C	4	Alameda	Mission San Jose	I-680	4_ALA_680_67	4_ALA_680_64	red	0.5	0.2	0.2	0.1	6	No	155400

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
4D	4	Contra Costa	Orinda	Hwy 24	4_CC_24_27	4_CC_24_19	orange	0.8	0.2	0.6	0.0	8	No	188000
4E	4	Contra Costa	Alamo	I-680	4_CC_680_116	4_CC_680_110	orange	0.6	0.3	0.3	0.0	6	No	153850
	5	Insufficient data												
6A	6	Madera	Oakhurst	Hwy 41	6_MAD_41_393	6_MAD_41_196	red	19.7	2.6	0.6	0.3	2	No	19000
6B	6	Tuolumne	Three Rivers	Hwy 198	6_TUL_198_374	6_TUL_198_369	red	0.5	0.2	0.2	0.1	2	Yes	4525
6C	6	Tuolumne	Three Rivers	Hwy 198	6_TUL_198_440	6_TUL_198_400	yellow	4.4	0.6	0.0	0.0	2	Yes	3175
6D	6	Kern	Alta Sierra	Hwy 155	6_KER_155_491	6_KER_155_469	yellow	2.2	0.2	0.0	0.0	2	No	355
	7	Insufficient data												
	8	Insufficient data												
9A	9	Mono	Topaz Lake	US Hwy 395	9_MNO_395_1201	9_MNO_395_1178	orange	2.3	0.6	0.3	0.0	2	No	3900
9B	9	Mono	Walker	US Hwy 395	9_MNO_395_1143	9_MNO_395_1058	red	8.5	1.7	1.2	0.8	2	Yes	3550
9C	9	Mono	Walker	US Hwy 395	9_MNO_395_1032	9_MNO_395_1008	orange	2.4	0.5	0.1	0.0	2	No	3425
9D	9	Mono	Sonora Junction	US Hwy 395	9_MNO_395_989	9_MNO_395_878	orange	11.1	3.6	0.7	0.0	2	Yes	3425
9E	9	Mono	Mono City	US Hwy 395	9_MNO_395_641	9_MNO_395_579	orange	6.2	0.8	0.1	0.0	4	Yes	3350
9F	9	Mono	Whitmore Hot Sprs.	US Hwy 395	9_MNO_395_282	9_MNO_395_134	red	15.6	2.4	0.6	0.1	4	Yes	7200
10A	10	Amador	Pine Grove	Hwy 88	10_AMA_88_377	10_AMA_88_149	red	22.6	10.8	10.2	0.5	2	No	8250
10B	10	Amador	Jackson	Hwy 49	10_AMA_49_58	10_AMA_49_0	orange	5.8	0.2	1.6	0.0	2	No	8100
10C	10	Tuolumne	Mono Vista	Hwy 108	10_TUO_108_154	10_TUO_108_0	orange	15.4	5.3	0.2	0.0	2	Yes	3975
10D	10	Tuolumne	Moccasin	Hwy 120	10_TUO_120_244	10_TUO_120_219	orange	3.0	2.0	0.2	0.0	2	Yes	4425
10E	10	Tuolumne	Groveland	Hwy 120	10_TUO_120_410	10_TUO_120_303	orange	10.7	2.1	0.1	0.0	2	No	6225
10F	10	Mariposa	Bootjack	Hwy 49	10_MPA_49_196	10_MPA_49_78	orange	11.8	3.0	0.3	0.0	2	Yes	5200
10G	10	Mariposa	Bootjack	Hwy 49	10_MPA_49_38	10_MPA_49_9	orange	2.9	1.1	0.1	0.0	2	No	3500
	11	Insufficient data												
12A	12	Orange	Peters Canyon Reservoir	Hwy 241	12_ORA_241_339	12_ORA_241_321	red	1.8	0.8	0.2	0.1	6	Yes	40150
12B	12	Orange	Las Flores	Hwy 241	12_ORA_241_170	12_ORA_241_150	orange	2.0	0.5	0.1	0.0	4	Yes	6900
12C	12	Orange	San Joaquin Hills	Hwy 73	12_ORA_73_198	12_ORA_73_173	orange	2.5	1.0	0.2	0.0	8	Yes	67650
12D	12	Orange	Peters Canyon Reservoir	Hwy 241	12_ORA_241_373	12_ORA_241_369	yellow	0.4	0.4	0.0	0.0	7	Yes	47800

Hot spot ID#	Dis-trict	County	Nearby town	Highway	Start hot spot	End hot spot	Most severe category	Total length (mi)	Length yellow (mi)	Length orange (mi)	Length red (mi)	Lanes (n)	Existing structure	AADT
12E	12	Orange	Rancho Mission Viejo	Hwy 74	12_ORA_74_97	12_ORA_74_93	yellow	0.4	0.4	0.0	0.0	2	No	11100

CARCASS DATA DISTRICT 1



Hot spots in District 1 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

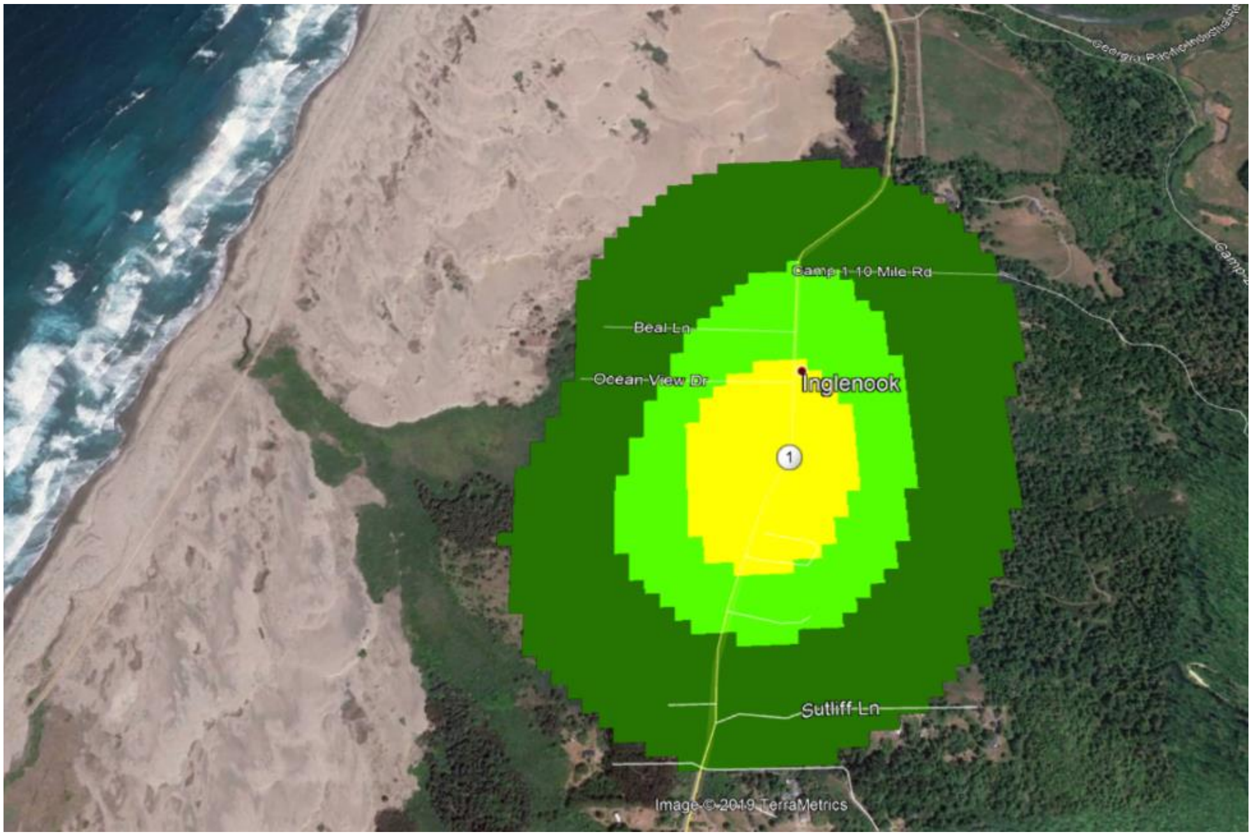
1A


Indian Island
Daby Island
Woodley Island
255
Eureka
101
Bayview
Cutten
Redwood Hwy
Ridgewood
Humboldt Hill
Fields Landing
Southport Landing
Teal Island
Beatrice

1B

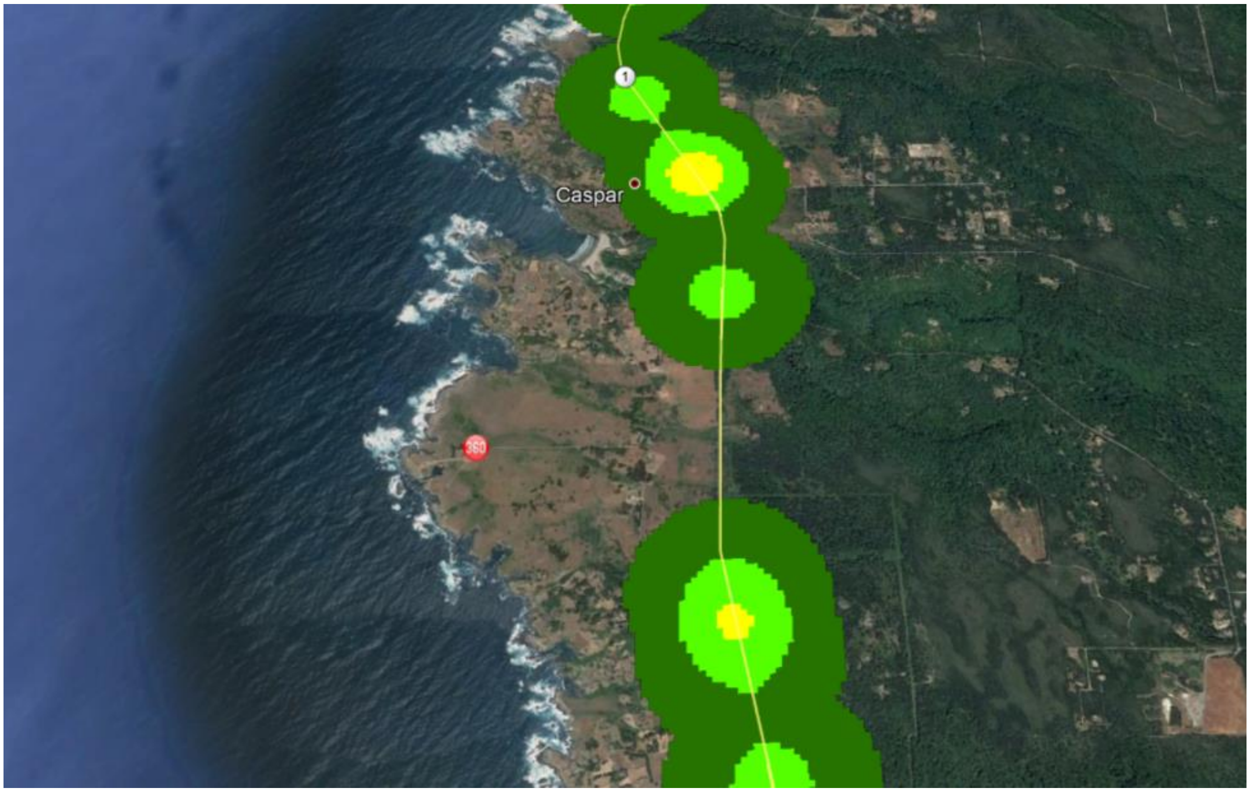

Loleta
Loleta Dr
345
Singley Rd
211
BUS
101
Fortuna
Newburg
12th St
S Fortuna Blvd
Kenmar Rd
Redwood
S Rohnerville
Grizzly

1C

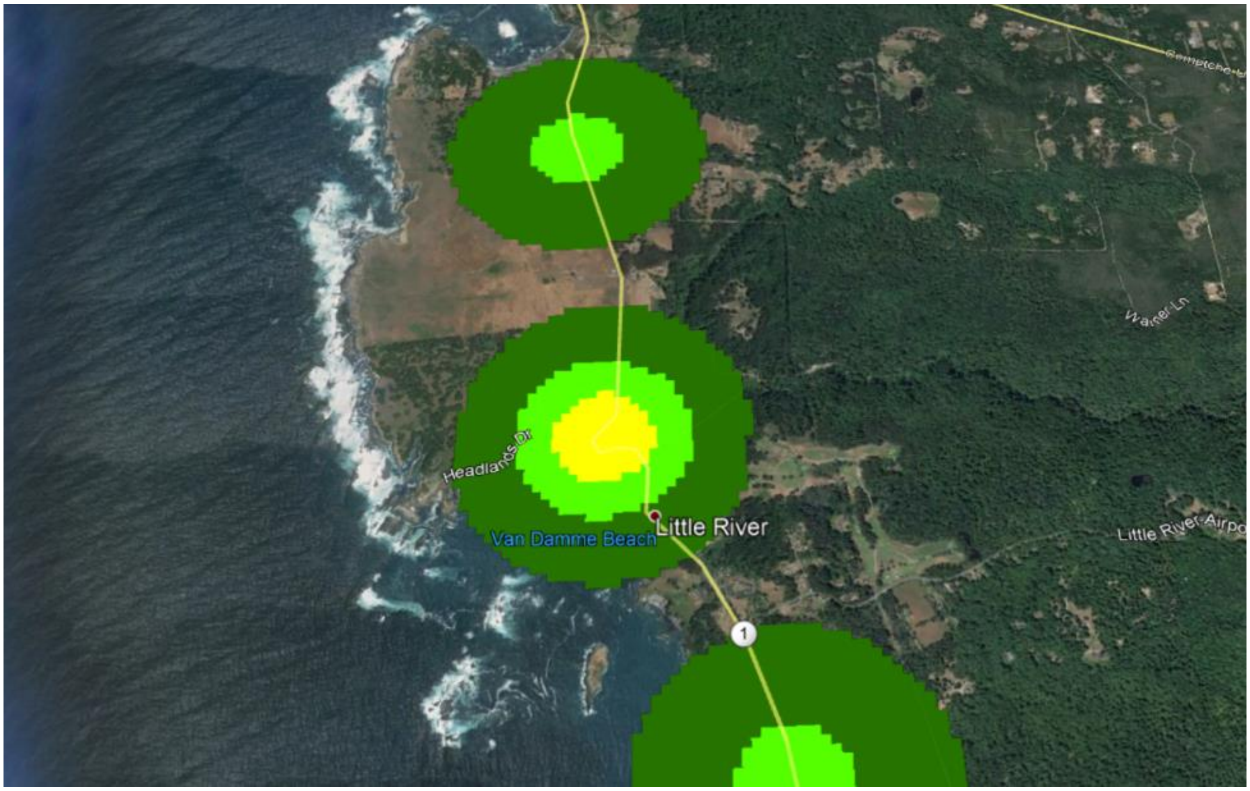

Camp 1-10 Mile Rd
Beal Ln
Ocean View Dr
Inglenook
1
Sutliff Ln
Image © 2019 TerraMetrics

1D

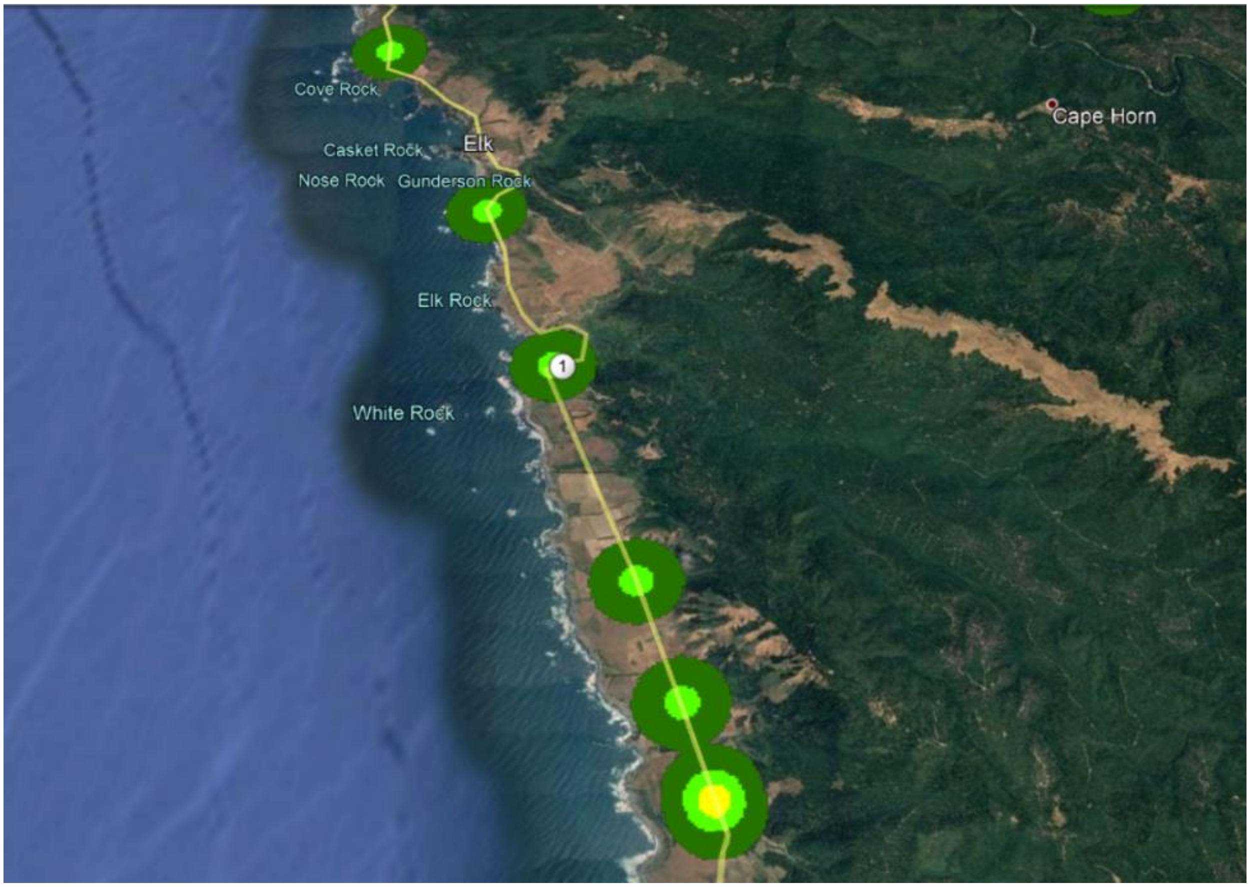
1E



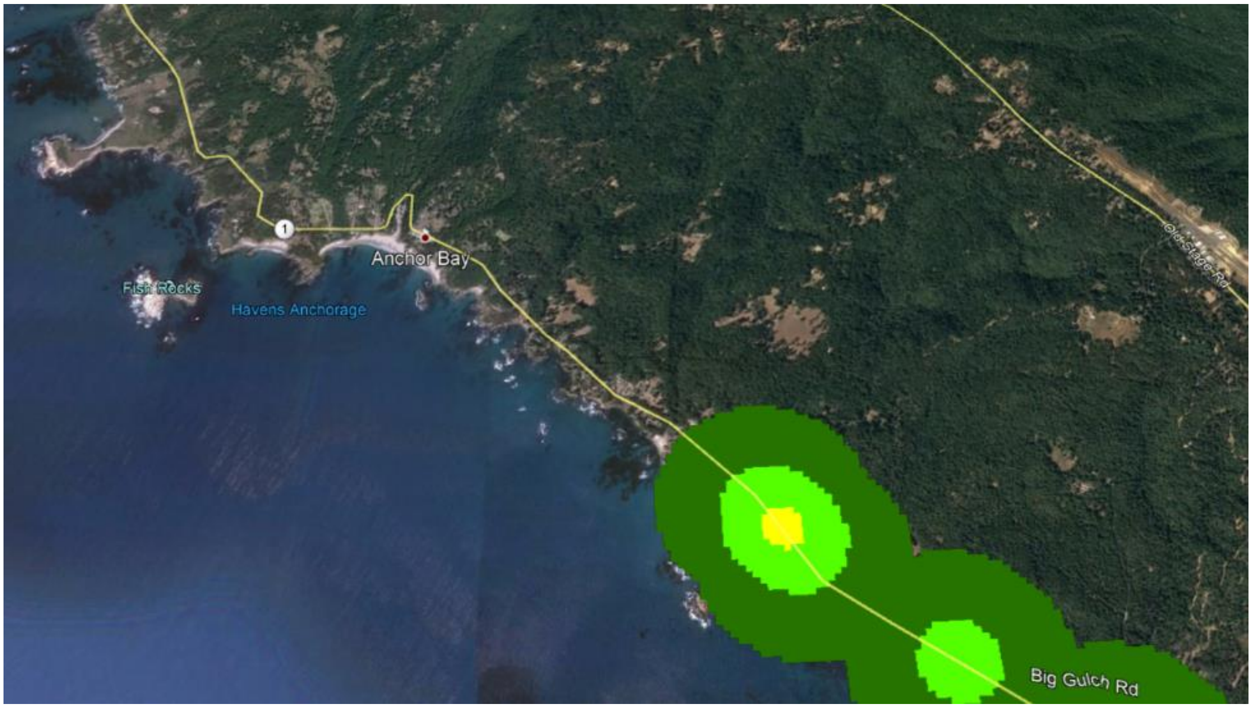
1F


Headlands Dr
Little River
Van Damme Beach
Little River Airpo
Wainer Ln
1

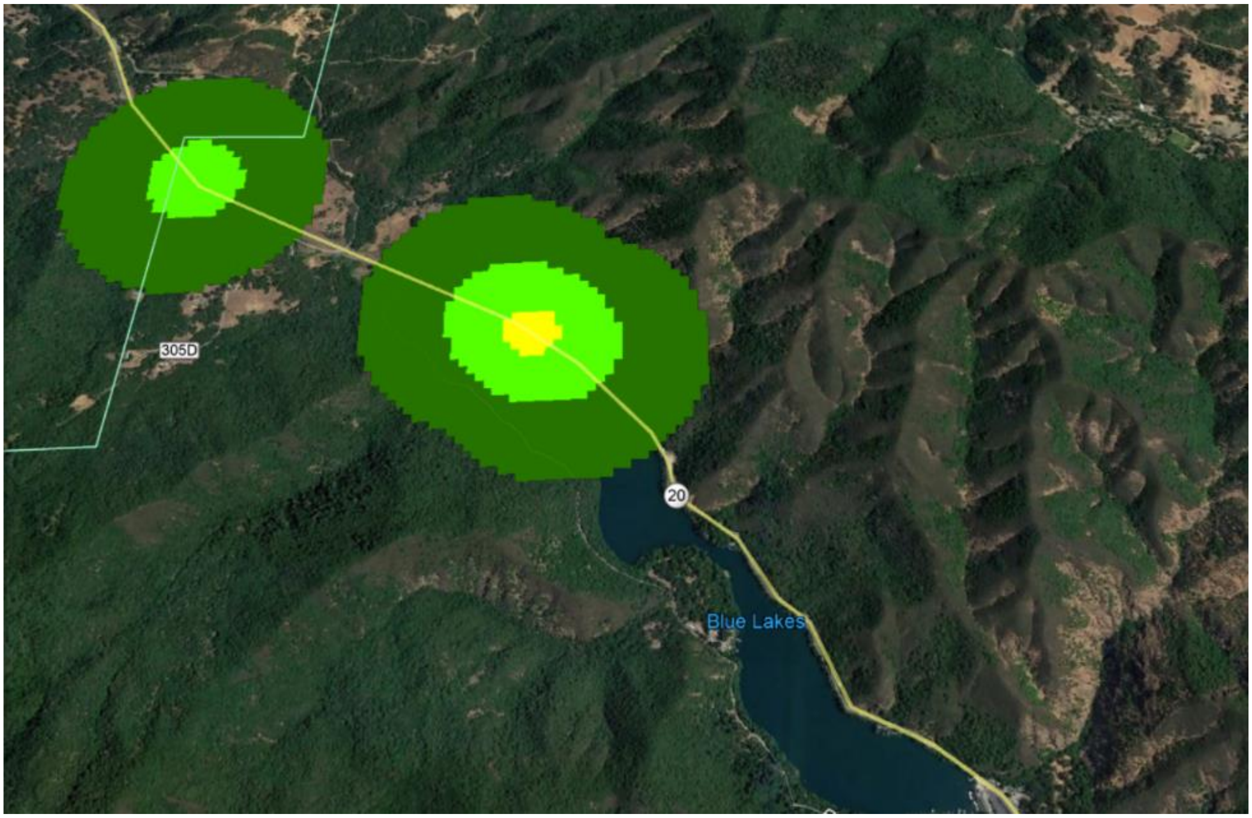
1G


Cove Rock
Casket Rock
Elk
Nose Rock
Gunderson Rock
Cape Horn
Elk Rock
1
White Rock

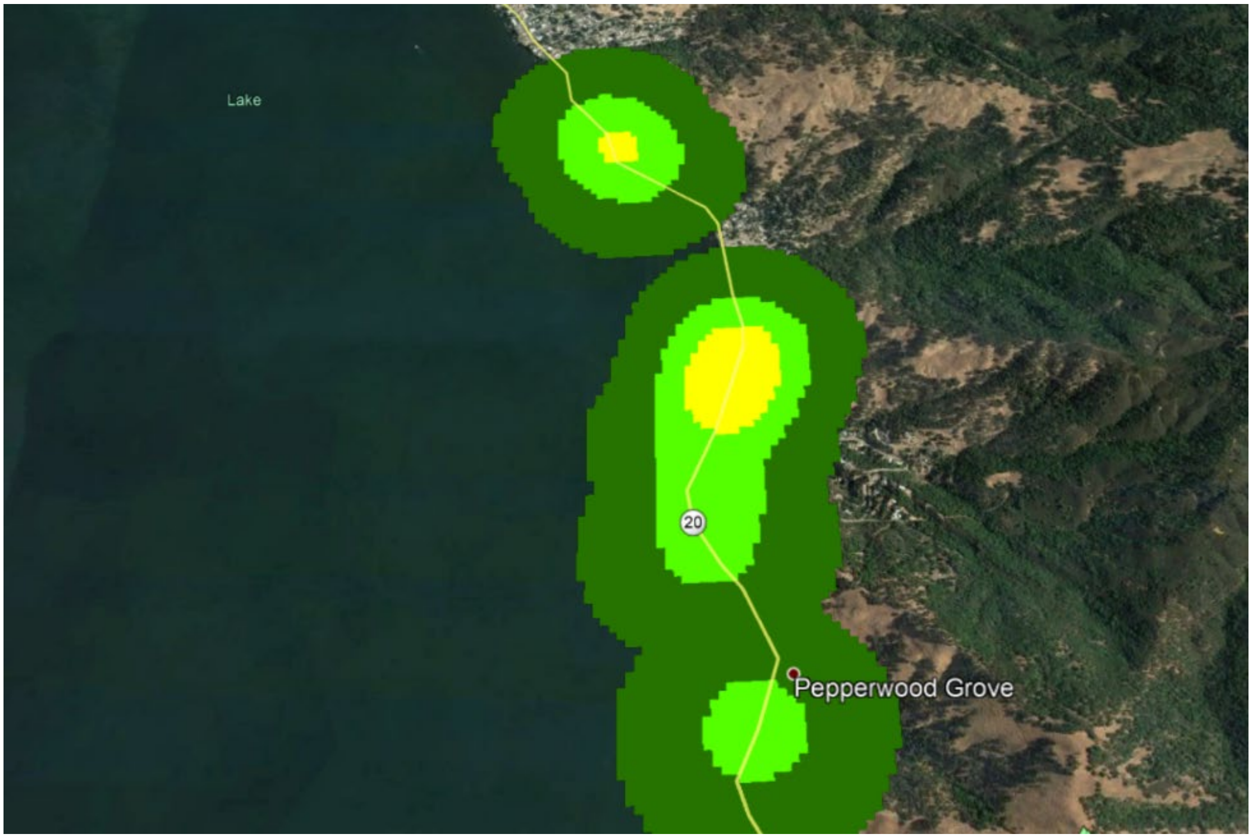
1H



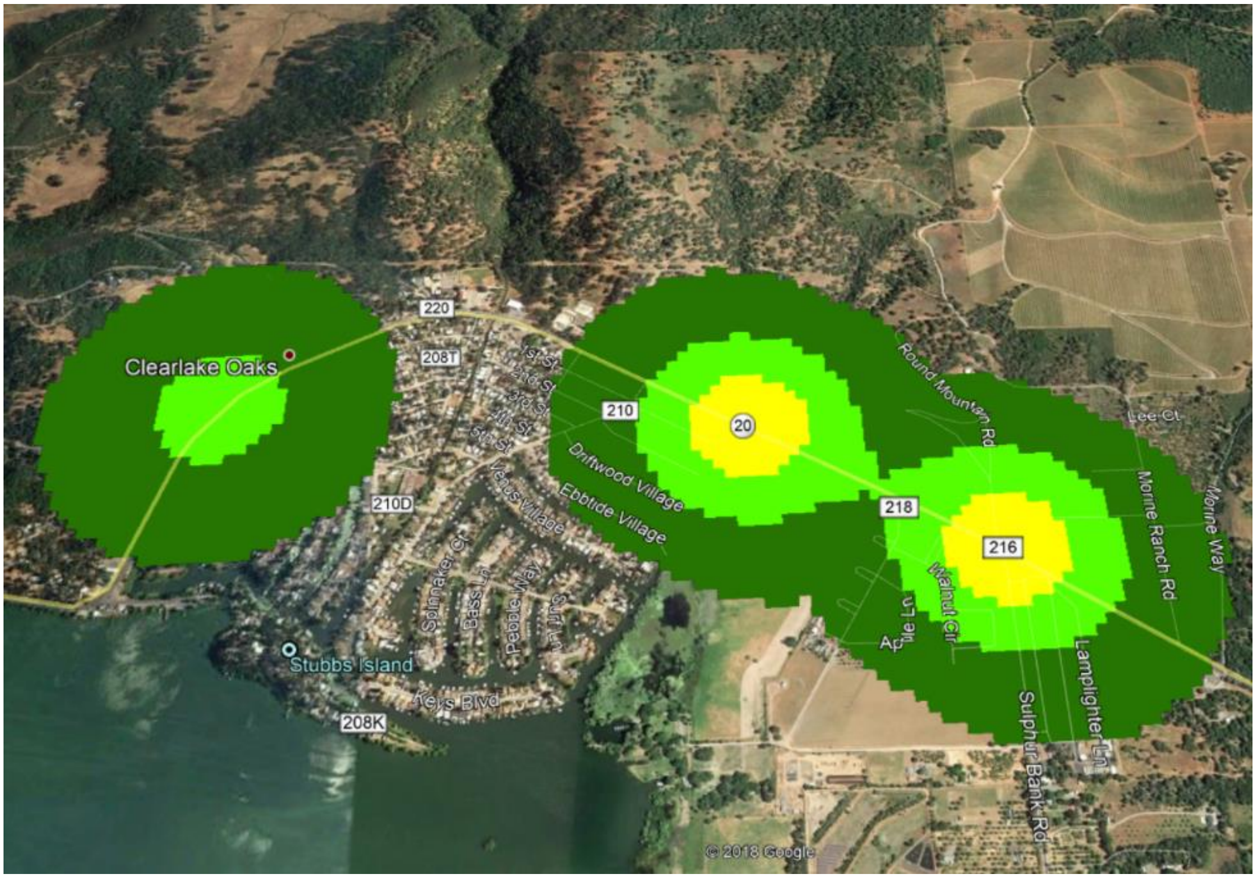
1I



1J



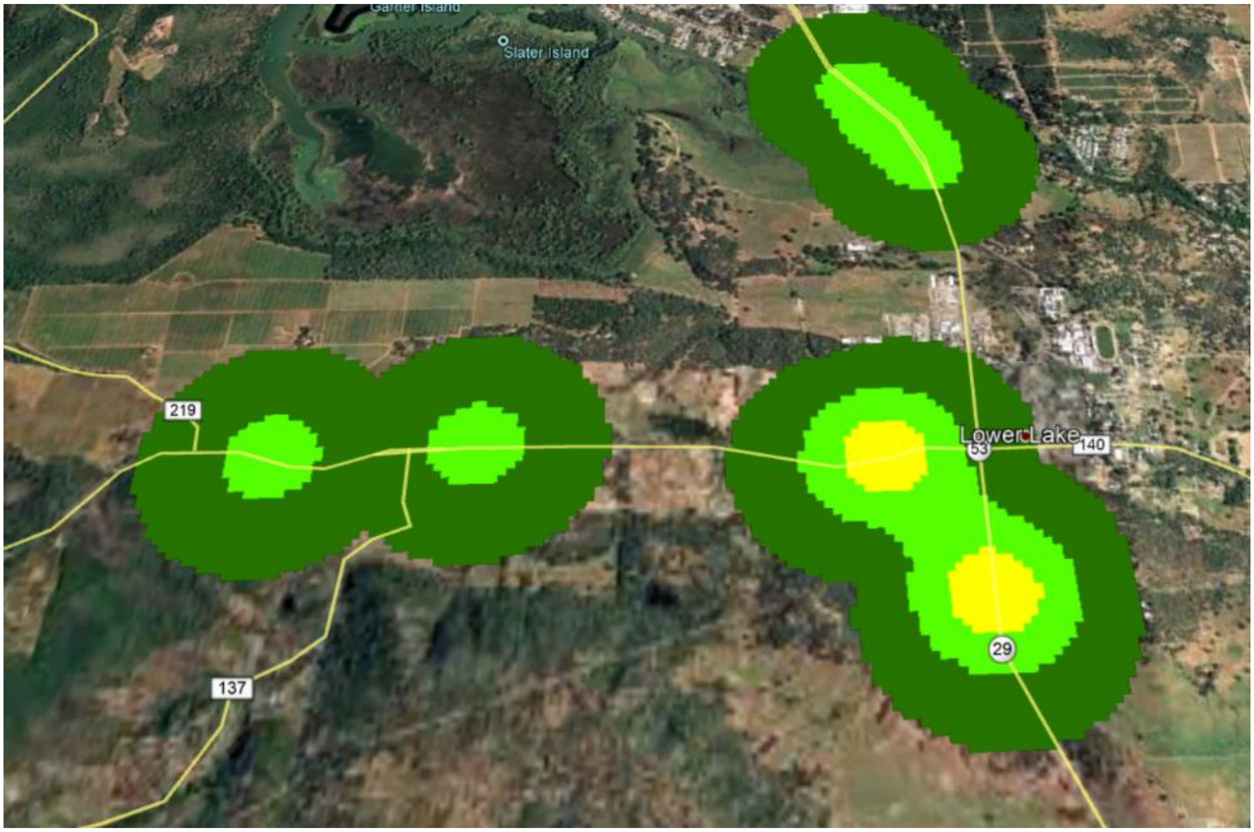
1K


220
208T
Clearlake Oaks
210
20
210D
Driftwood Village
Ebbtide Village
Round Mountain Rd
Lee Ct
218
216
Walnut Cir
Morine Ranch Rd
Morine Way
Lamplighter Ln
Sulphur Bank Rd
Spinnaker Cir
Bass Ln
Pebble Way
Stubbs Island
Keys Blvd
208K
© 2018 Google

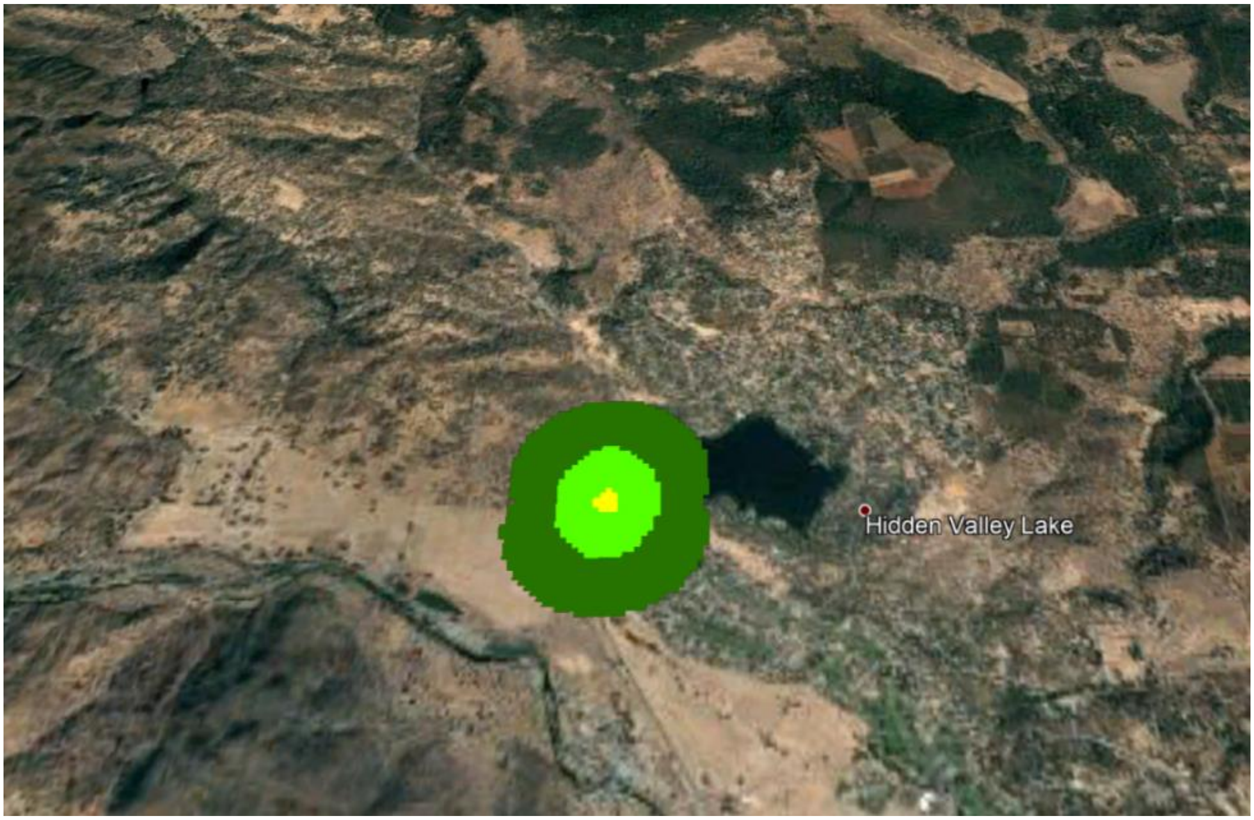
1L

1M

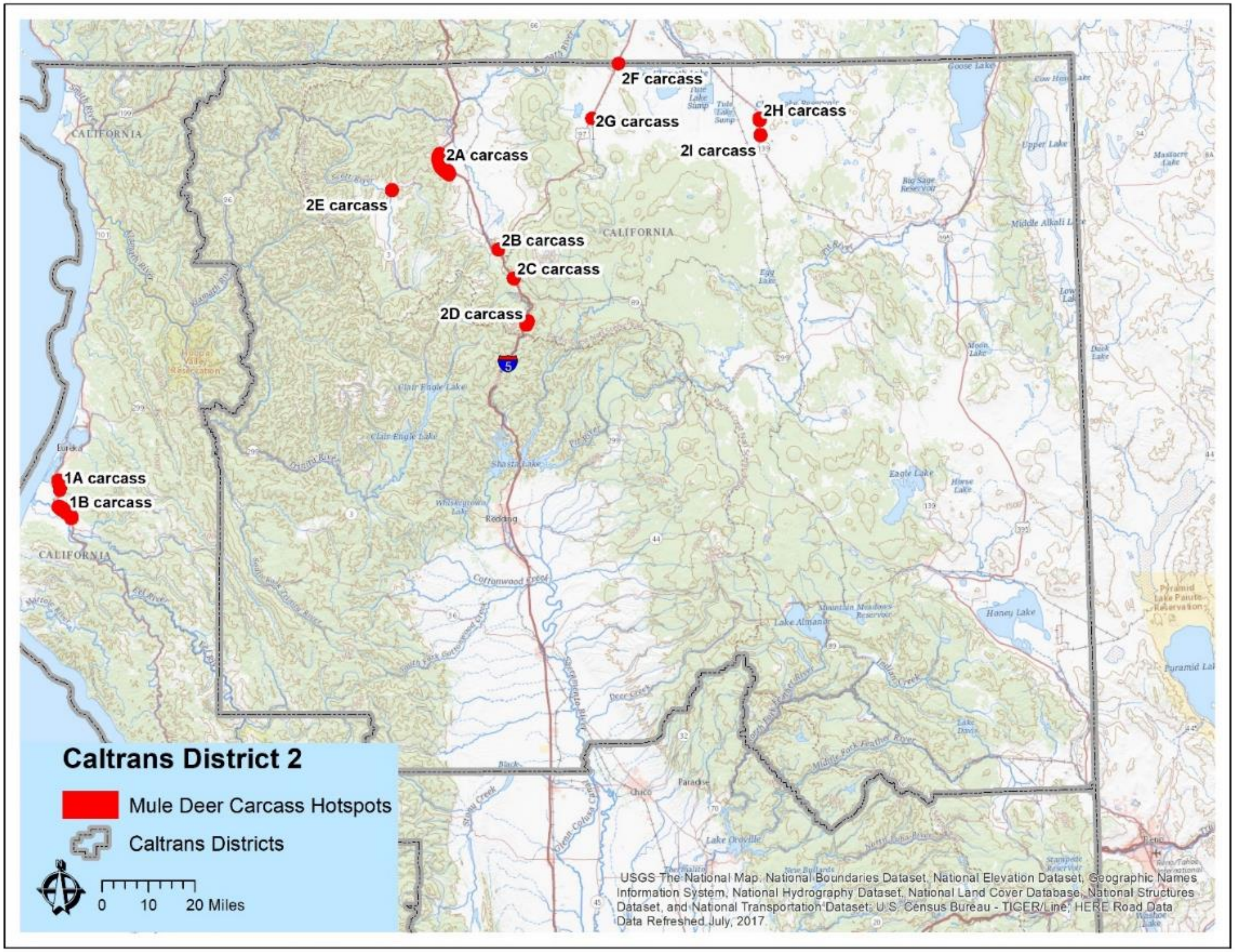
1N



1O



CARCASS DATA DISTRICT 2



Hot spots in District 2 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

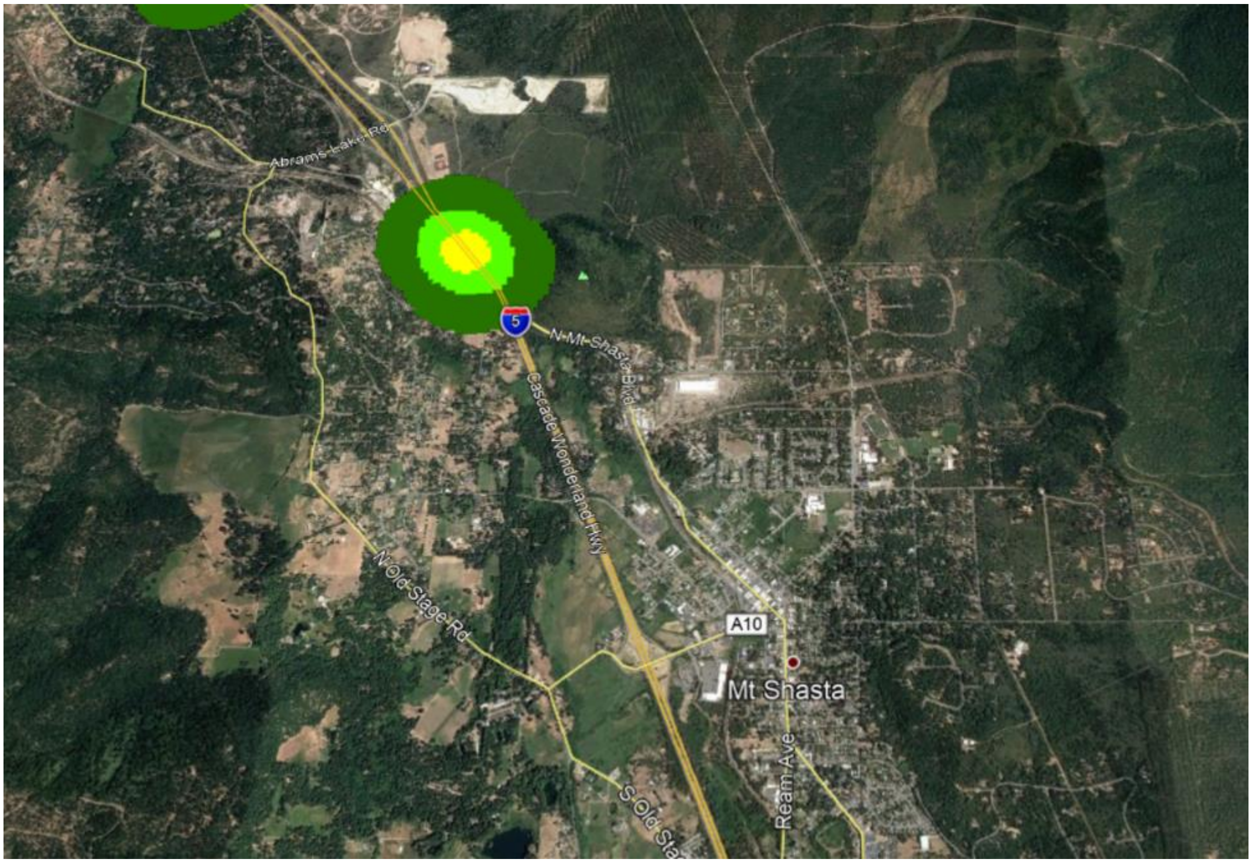
2A


263
Montague Rd
Yreka
Montague
3
S Main St
Fort Jones Rd
5
Old Hwy 99

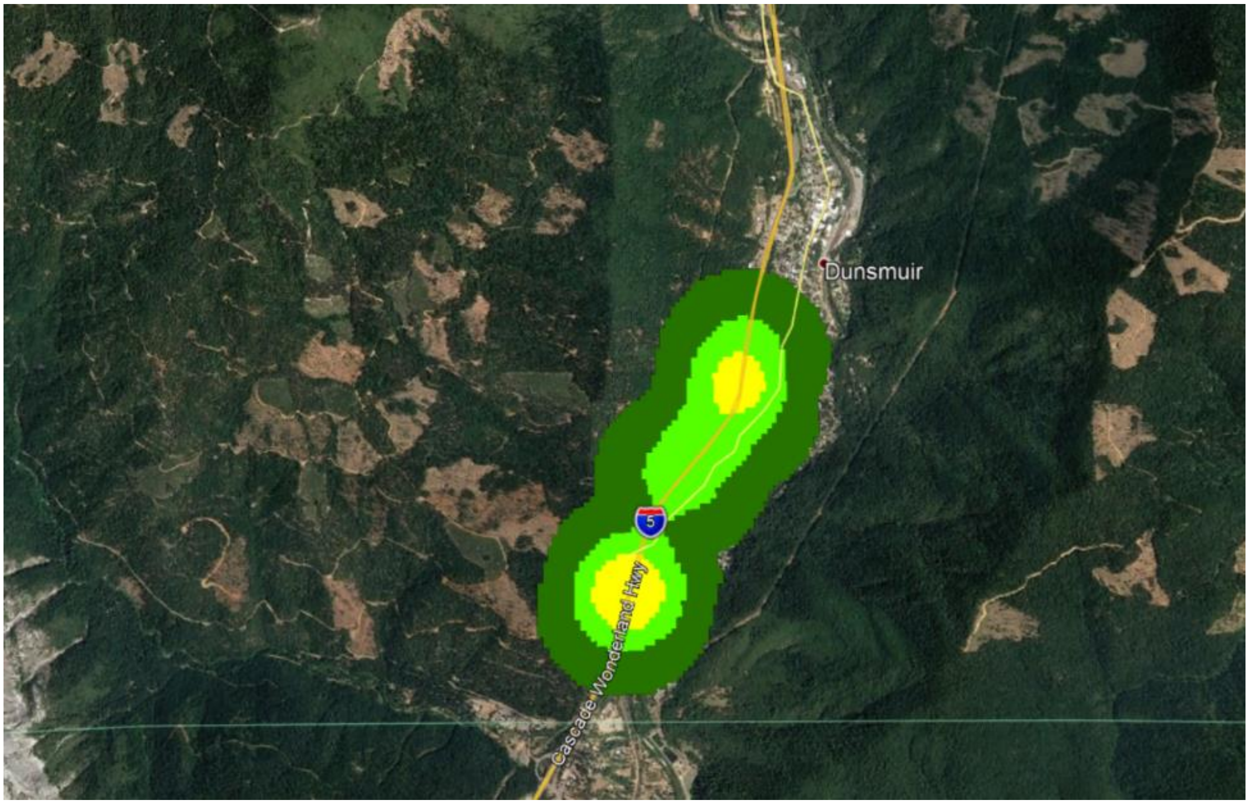
2B


Carrick
Stewart Springs Rd
97
5
265
Weed
N Old Stage Rd
College Ave

2C


Abrams Lake Rd
N Mt Shasta Blvd
Cascade Wonderland Hwy
N Old Stage Rd
A10
Mt Shasta
Ream Ave
S Old Sta

2D

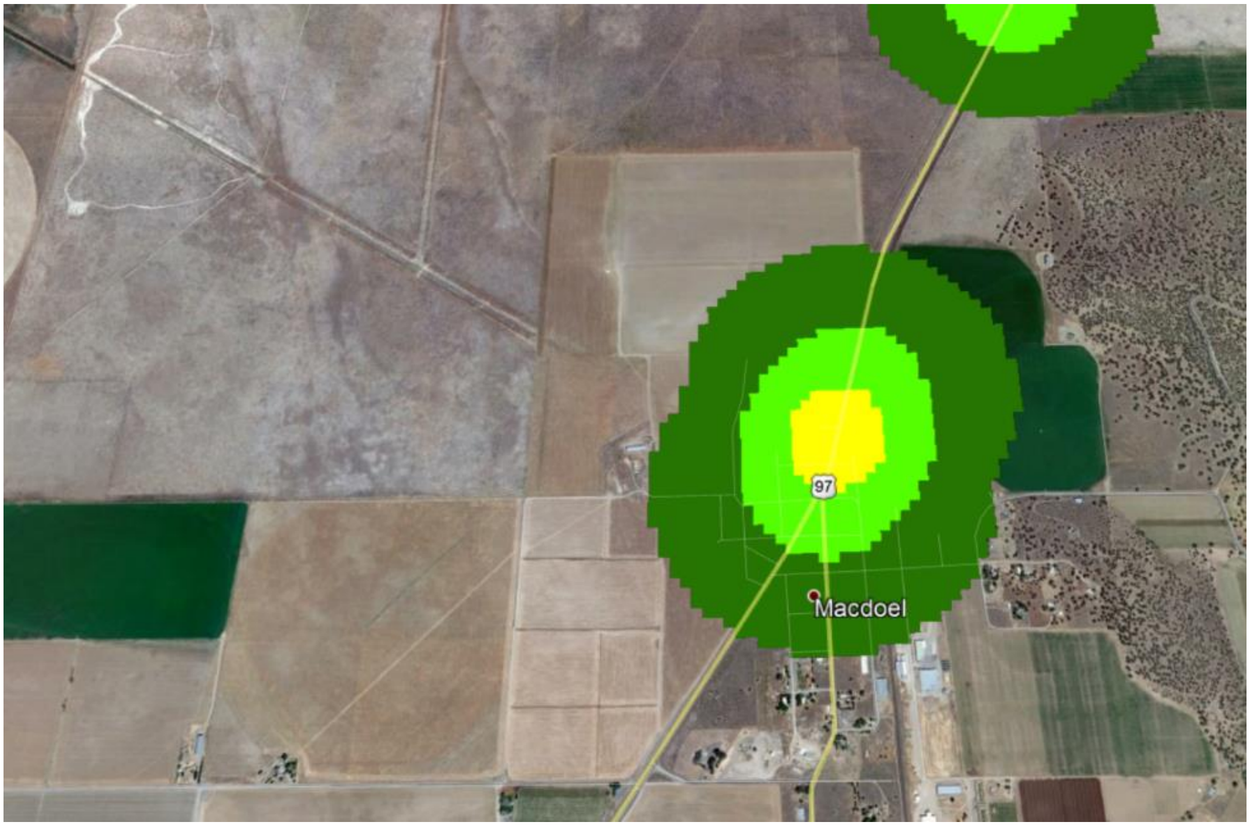


2E


Fort Jones Rd
3
Douglas St
N Main St
Don St
Butte St
Fort Jones
Newton St
Carlock St
East St
Scott River Rd

2F

2G



2H

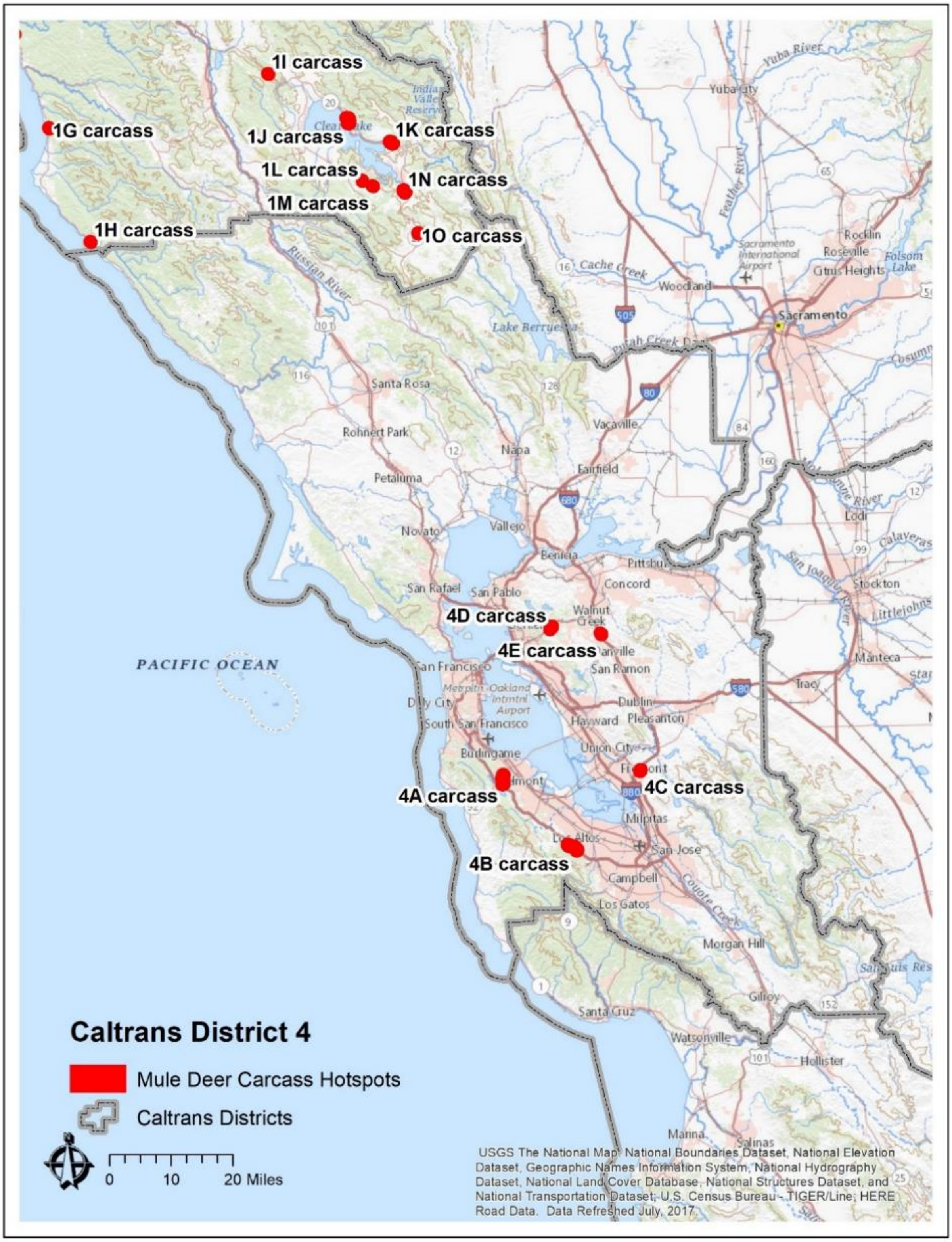

Great Northern Rd
Hannchen
Stone Island
140
121
120
111
139
© 2018 Google

2I

CARCASS DATA DISTRICT 3

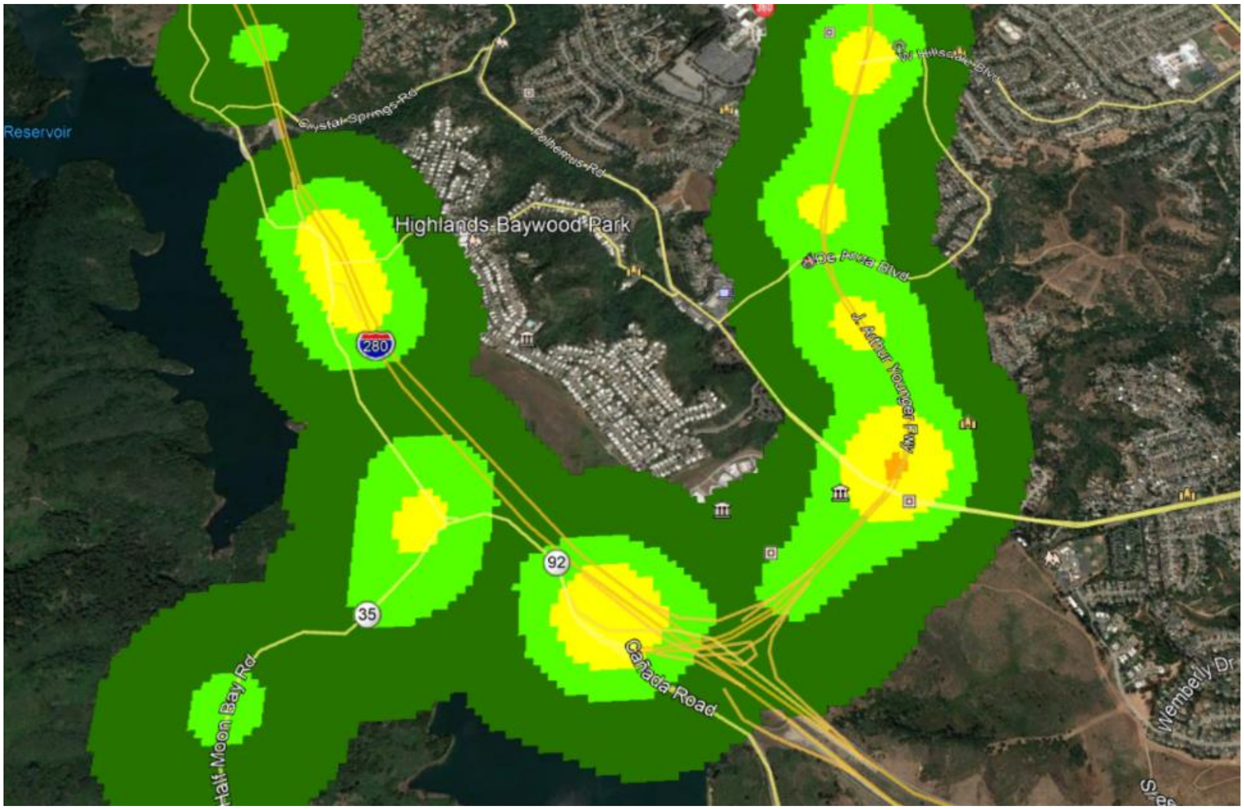
Insufficient data

CARCASS DATA DISTRICT 4

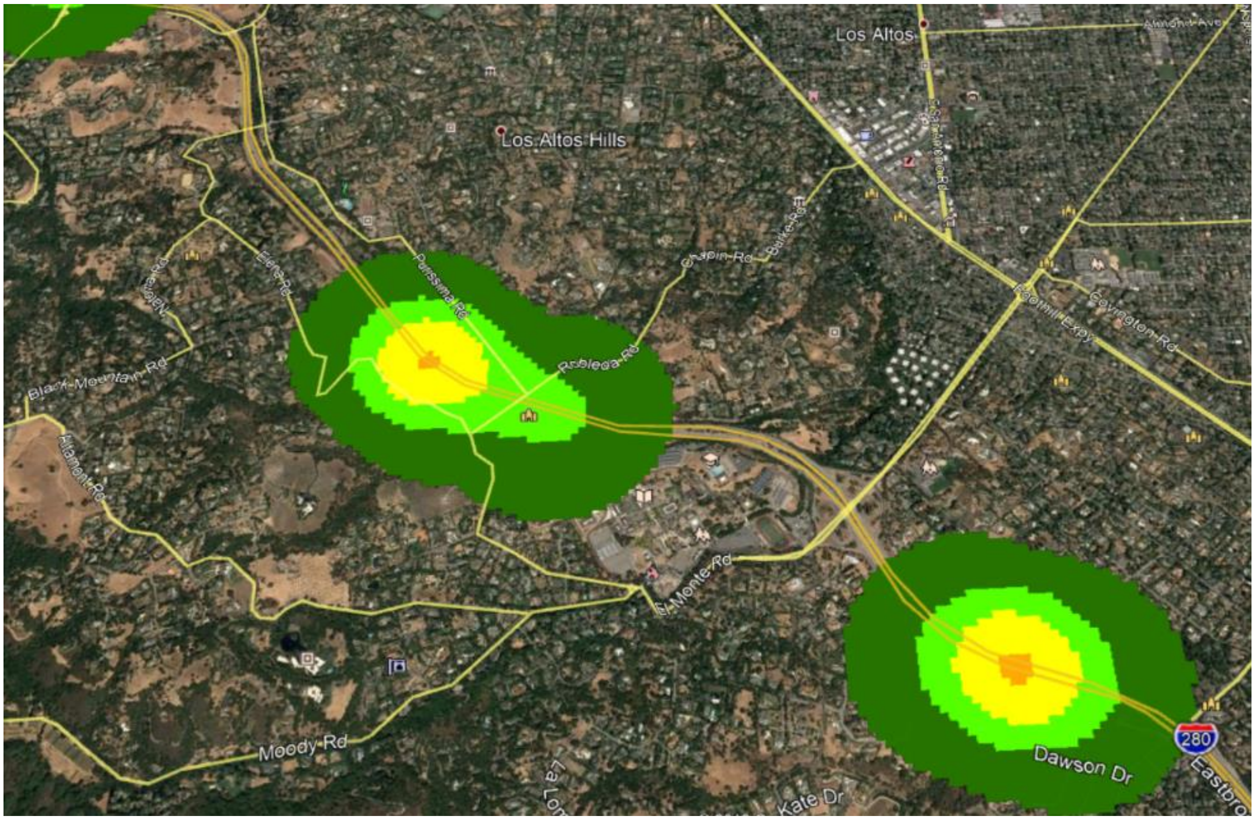


Hot spots in District 4 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

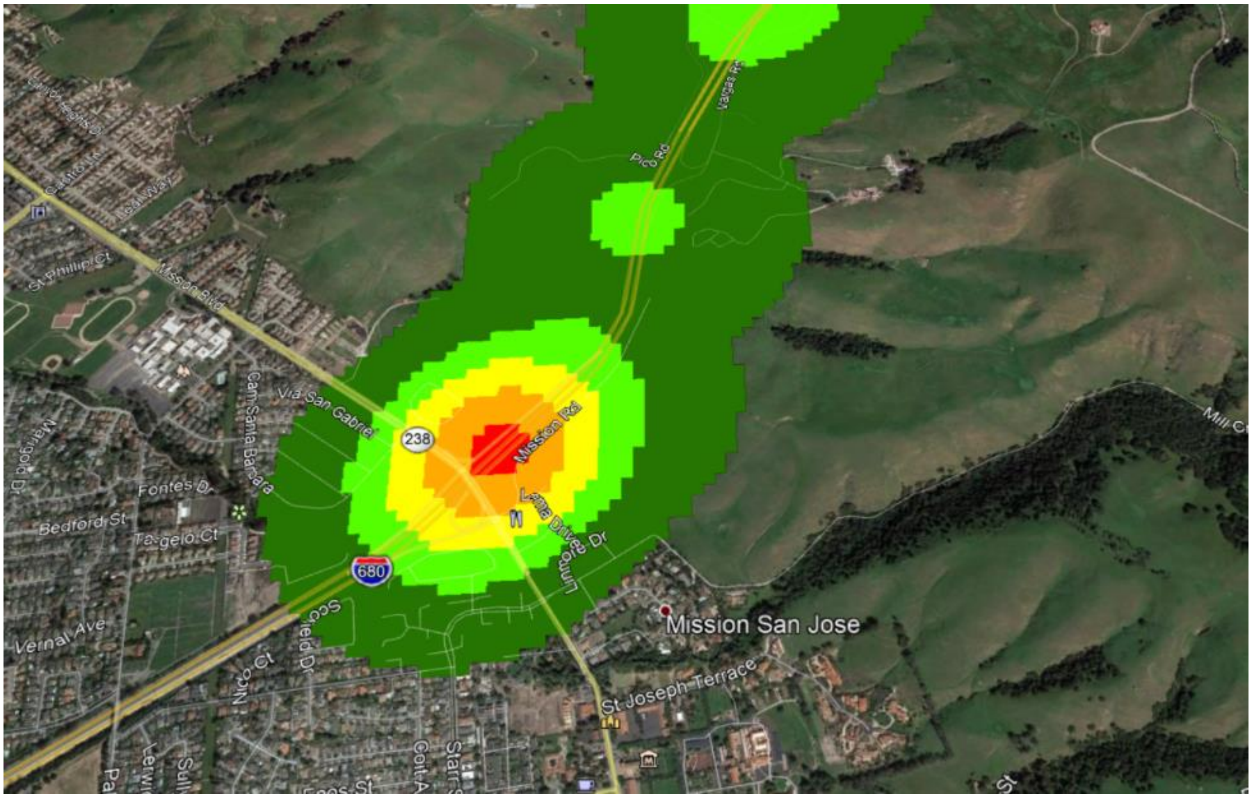
4A


Reservoir
Crystal Springs Rd
Polhemus Rd
Highlands-Baywood Park
De Anza Blvd
J. Arthur Younger Fwy
280
92
35
Half Moon Bay Rd
Cañada Road
Wemberly Dr

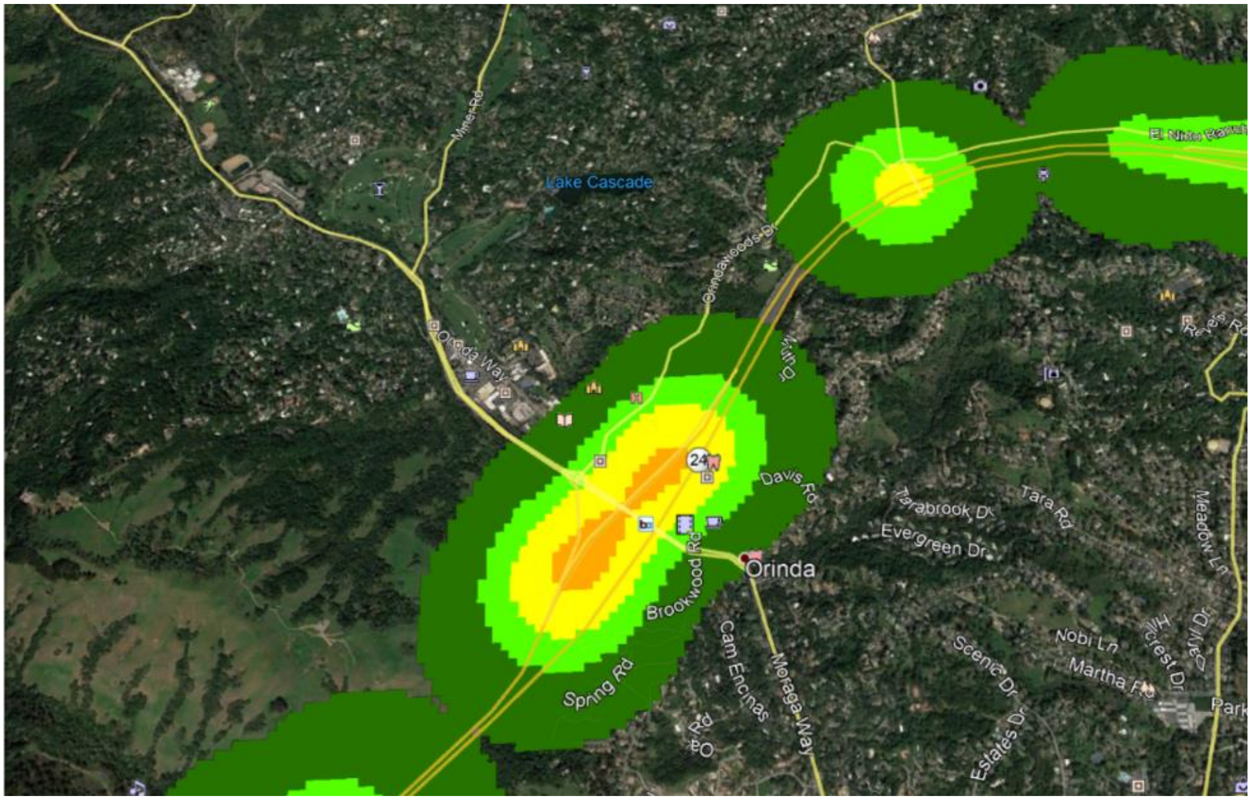
4B


Los Altos
Los Altos Hills
Chapin Rd
Foothill Expy
Covington Rd
Purissima Rd
Robleda Rd
Black Mountain Rd
Moody Rd
Dawson Dr
Kate Dr
280

4C


Mission Rd
Pico Rd
238
680
Mission San Jose
St Joseph Terrace
Via San Gabriel
Cam Santa Barbara
Fontes Dr
Bedford St
Vernal Ave
St Phillip Ct
Mission Blvd

4D


Lake Cascade
Orinda Way
Orindawoods Dr
Muth Dr
24
Davis Rd
Brookwood Rd
Orinda
Spring Rd
Cam Encinas
Moraga Way
Tarabrook Dr
Tara Rd
Evergreen Dr
Scenic Dr
Estates Dr
Nobi Ln
Martha Rd
Meadow Ln
El Nido Ranch

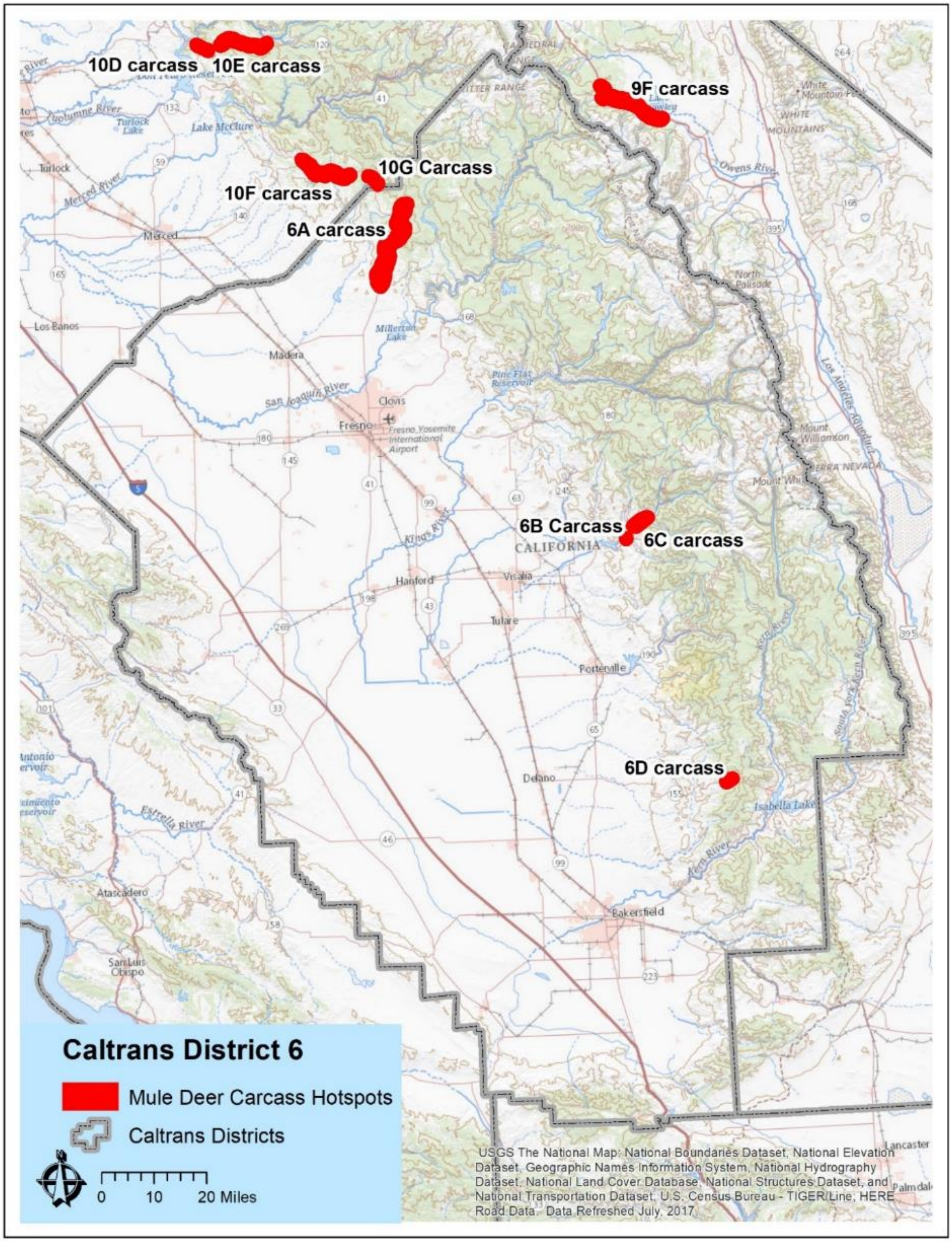
4E


Hillgrade Ave
Castle Crest Rd
Arbor Ln
Glade Ln
Livorna Rd
Vine Ln
Stephanie Ln
Vernal Dr
Vernal Ct
Jennifer Ln
Livorna Rd W
Laurenita Way
Entrada Verde
Casa Vallecita
Ramona Way
Finley Ln
Bunce Meadows Dr
Ina Dr
Ina Ct
David Dr
Litina Dr
Cedar Ln
N Jackson Way
Via Don Jose
Gran Via
680
Alamo Way
Ridgewood Rd
Doris Pl
Orchard Ct
Stone Valley Rd
Donald D. Doyle Hwy
Lunada Ln
Via Larga
Alamo

CARCASS DATA DISTRICT 5

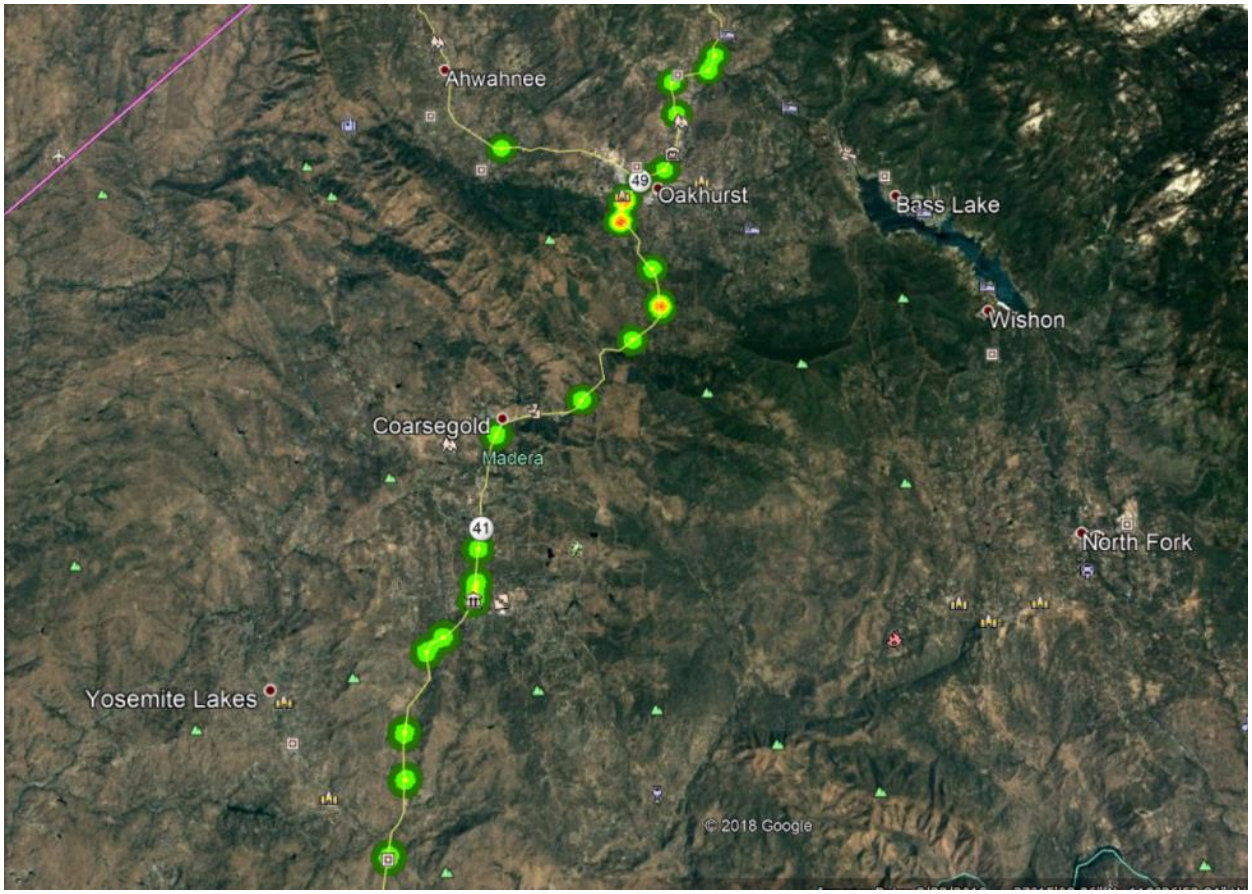
Insufficient data

CARCASS DATA DISTRICT 6

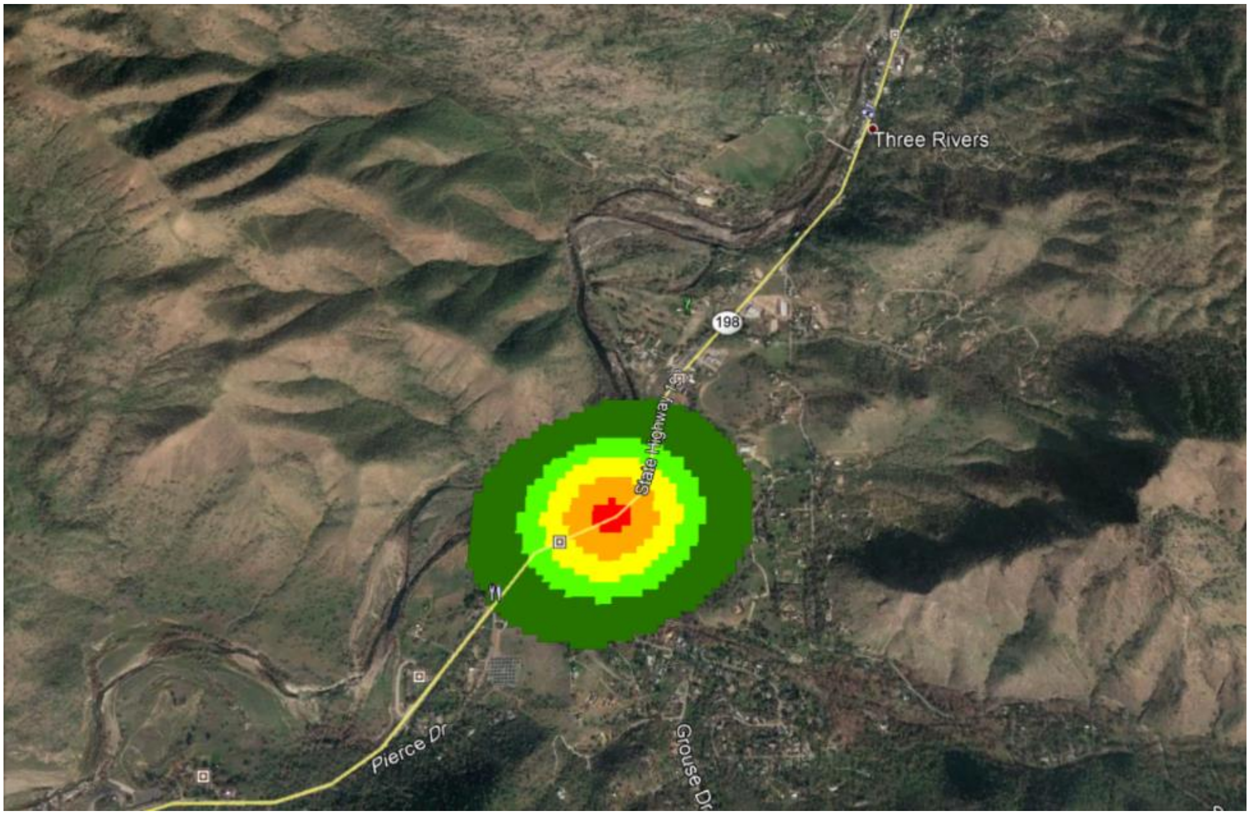


Hot spots in District 6 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

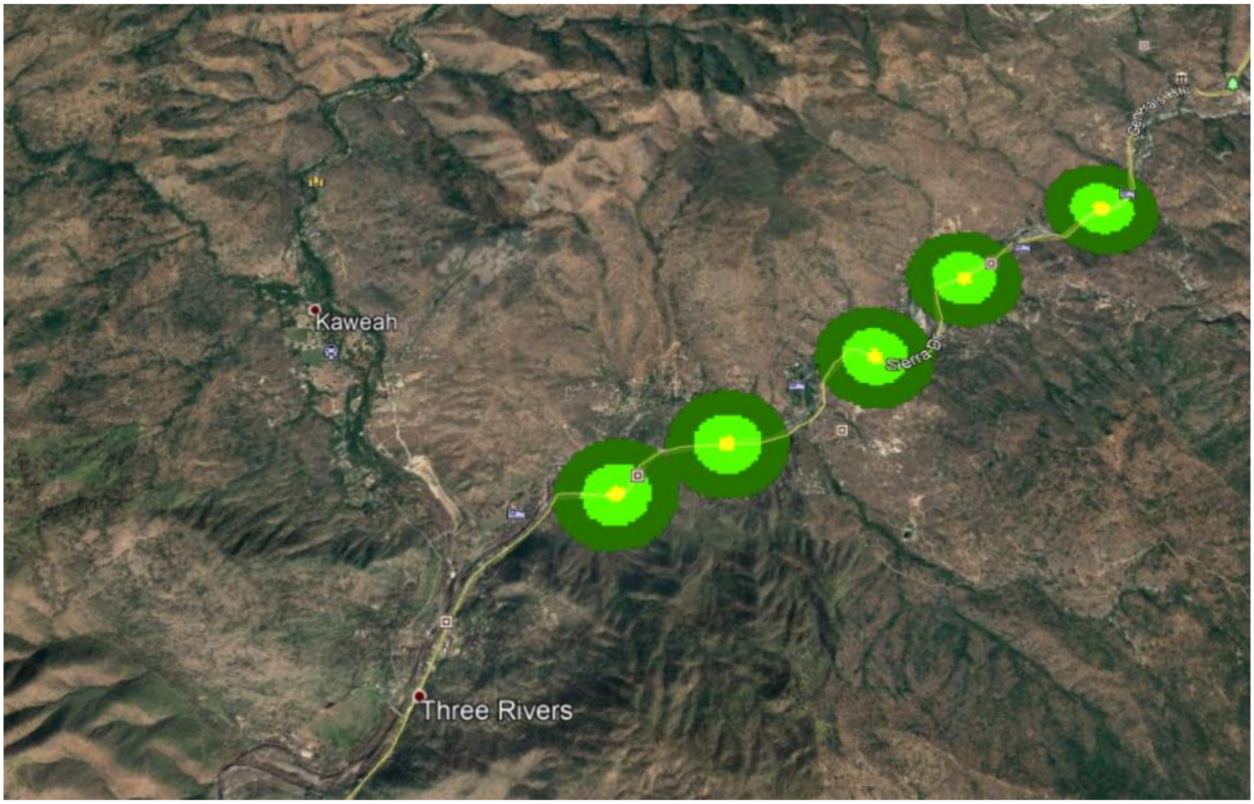
6A


Ahwahnee
49
Oakhurst
Bass Lake
Wishon
Coarsegold
Madera
41
North Fork
Yosemite Lakes
© 2018 Google

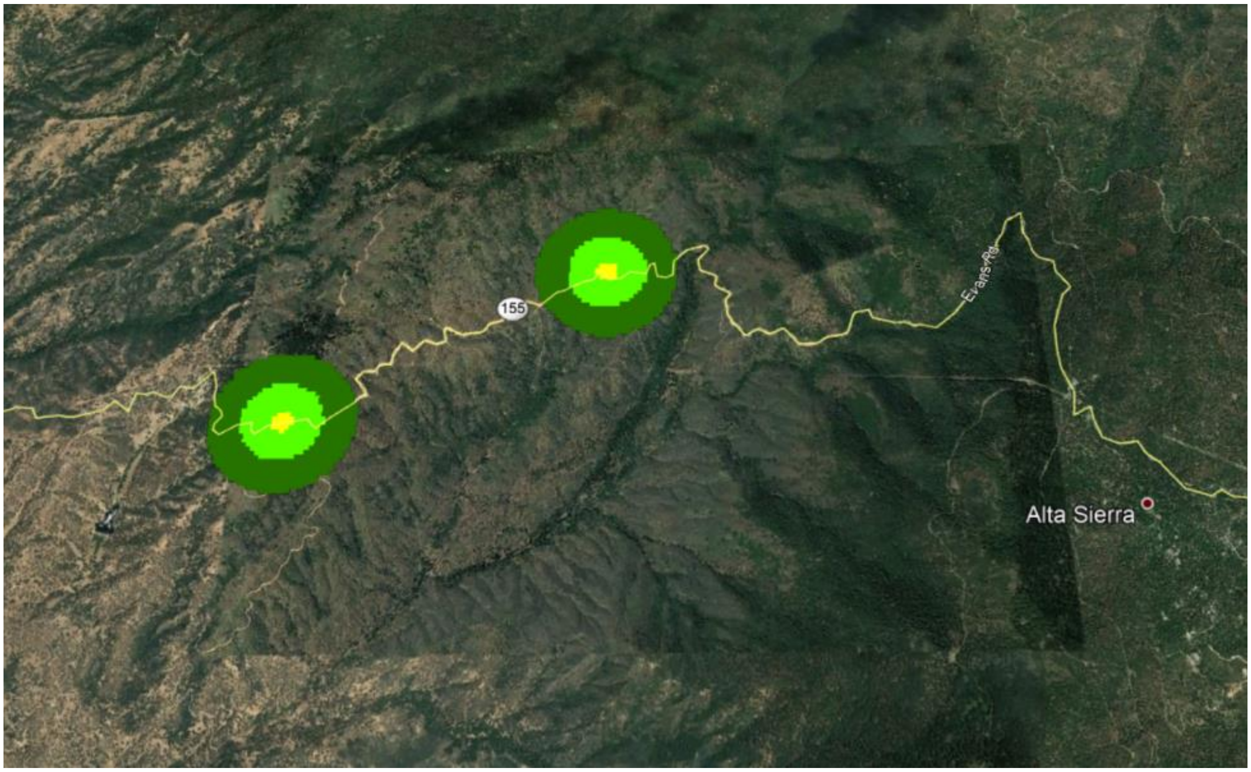
6B



6C



6D



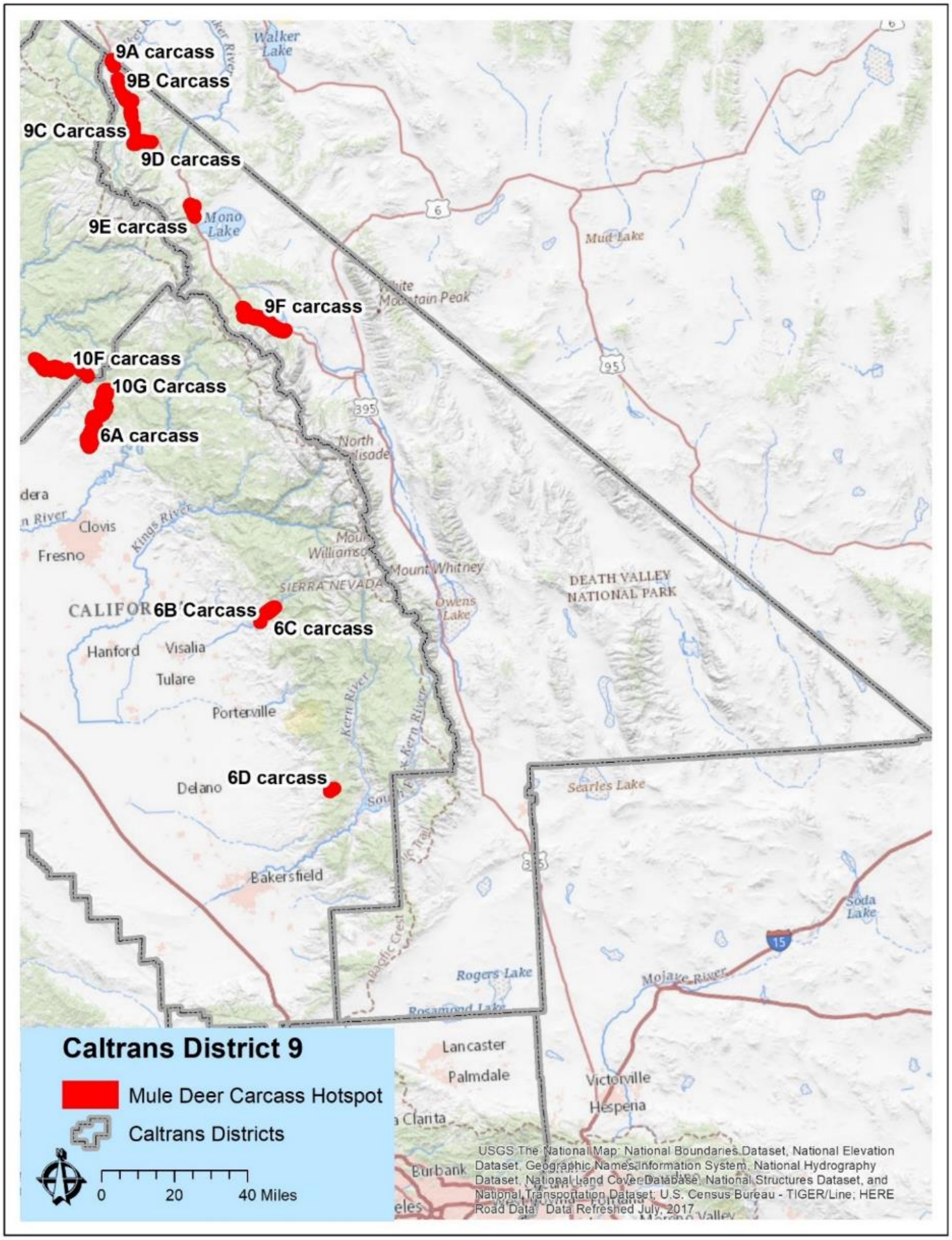
CARCASS DATA DISTRICT 7

Insufficient data

CARCASS DATA DISTRICT 8

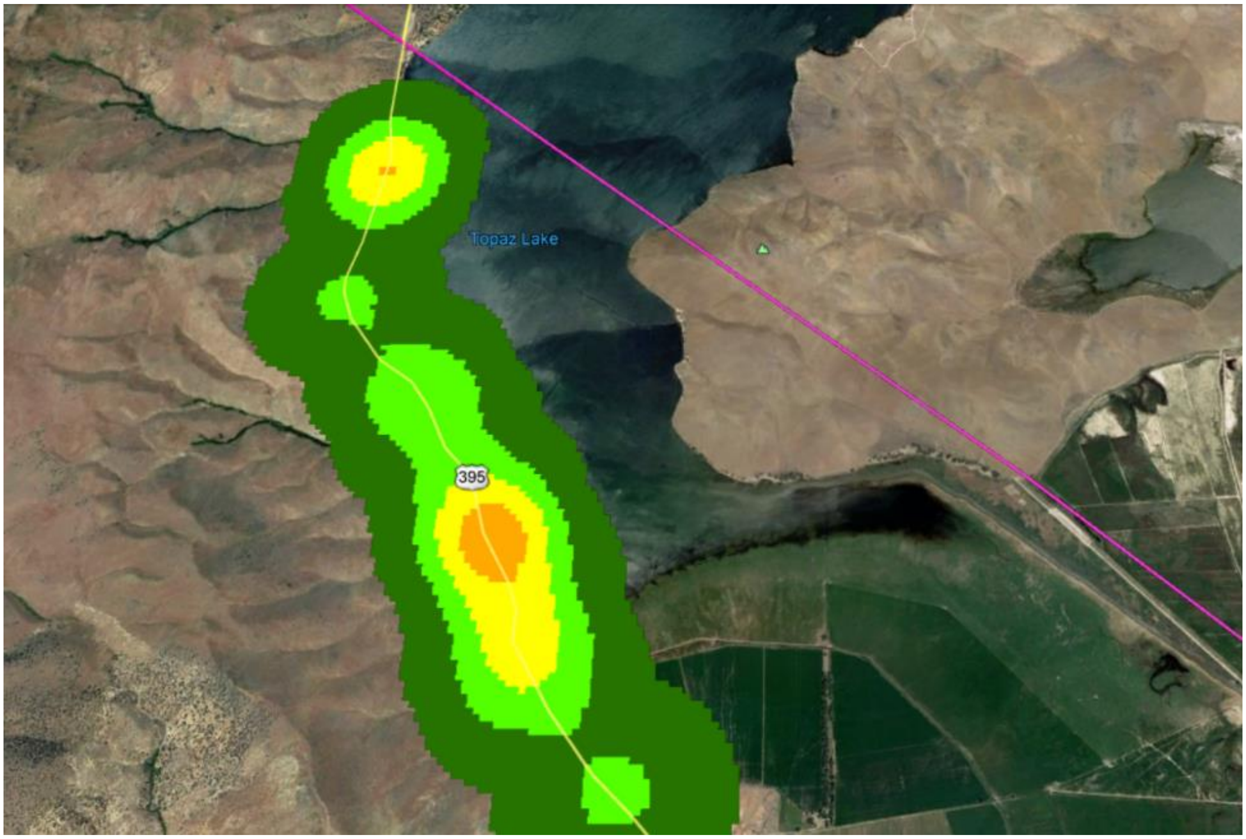
Insufficient data

CARCASS DATA DISTRICT 9

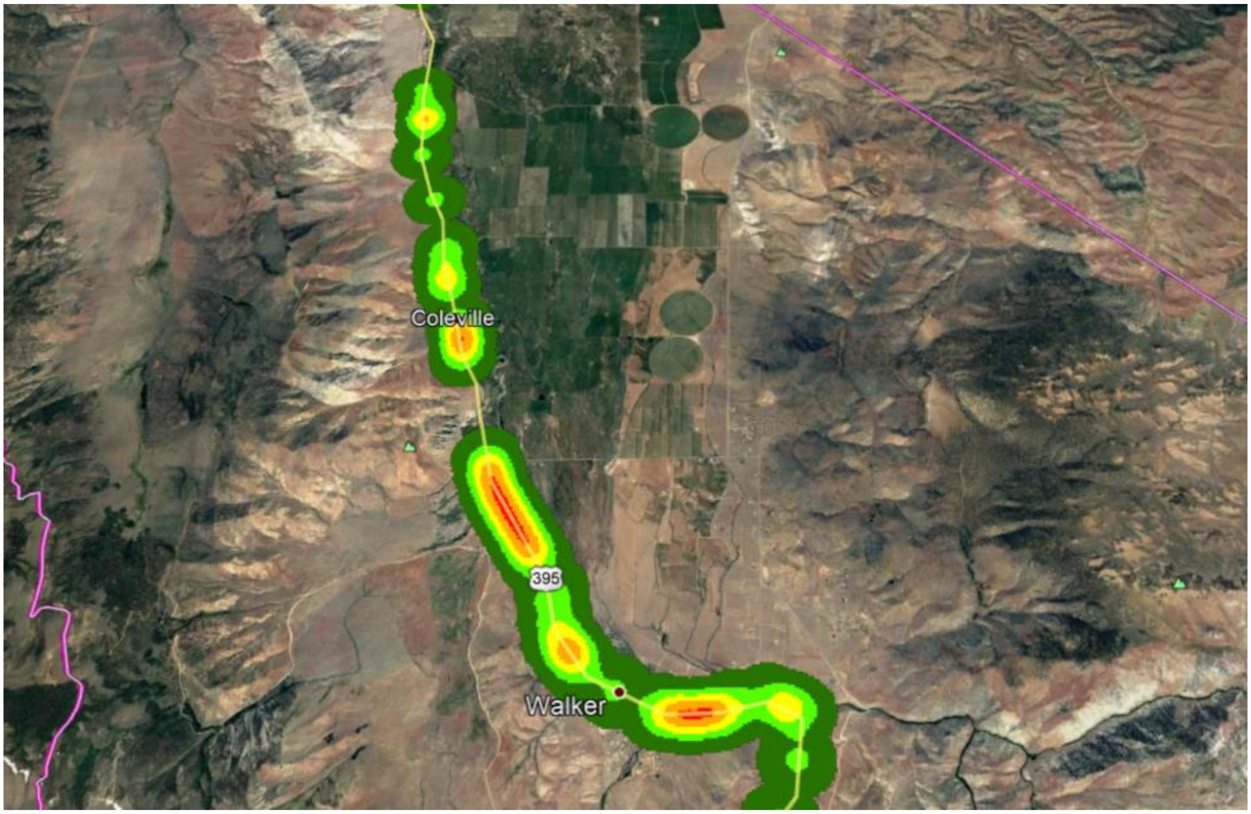


Hot spots in District 9 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

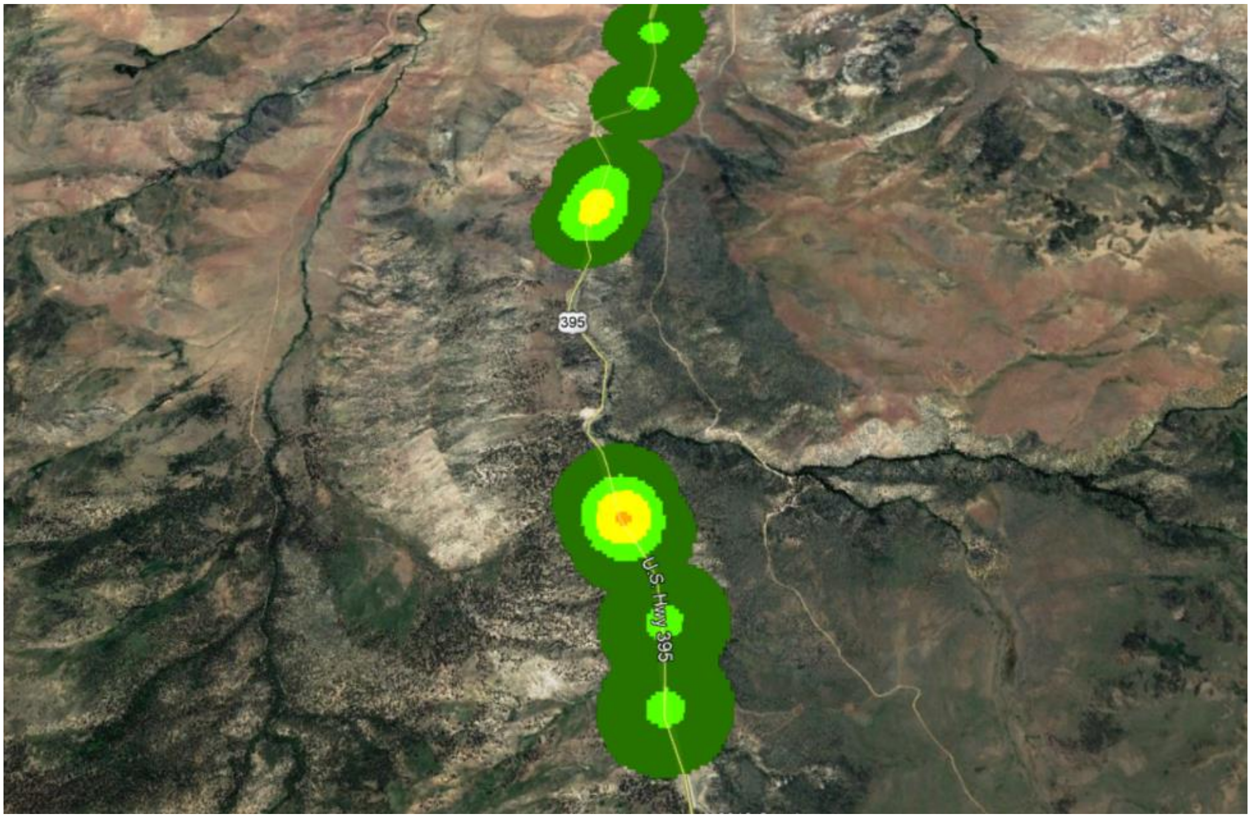
9A



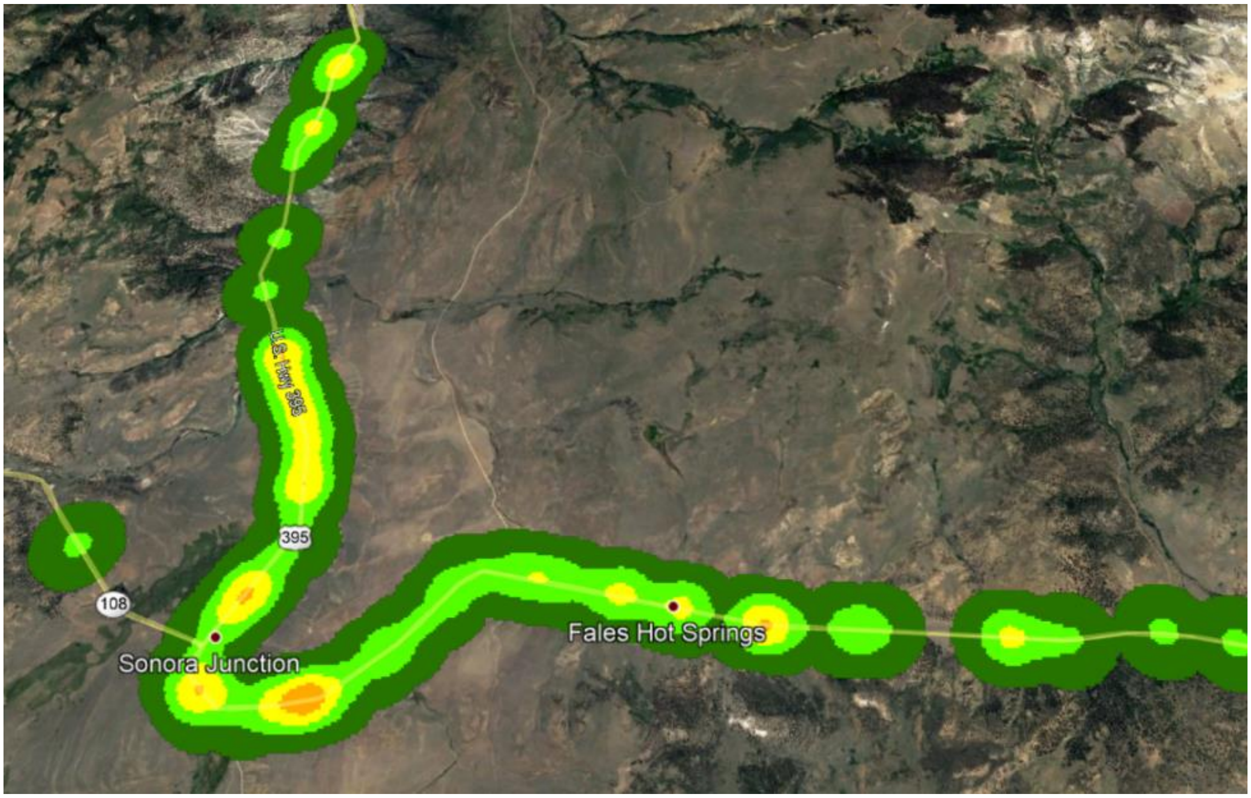
9B



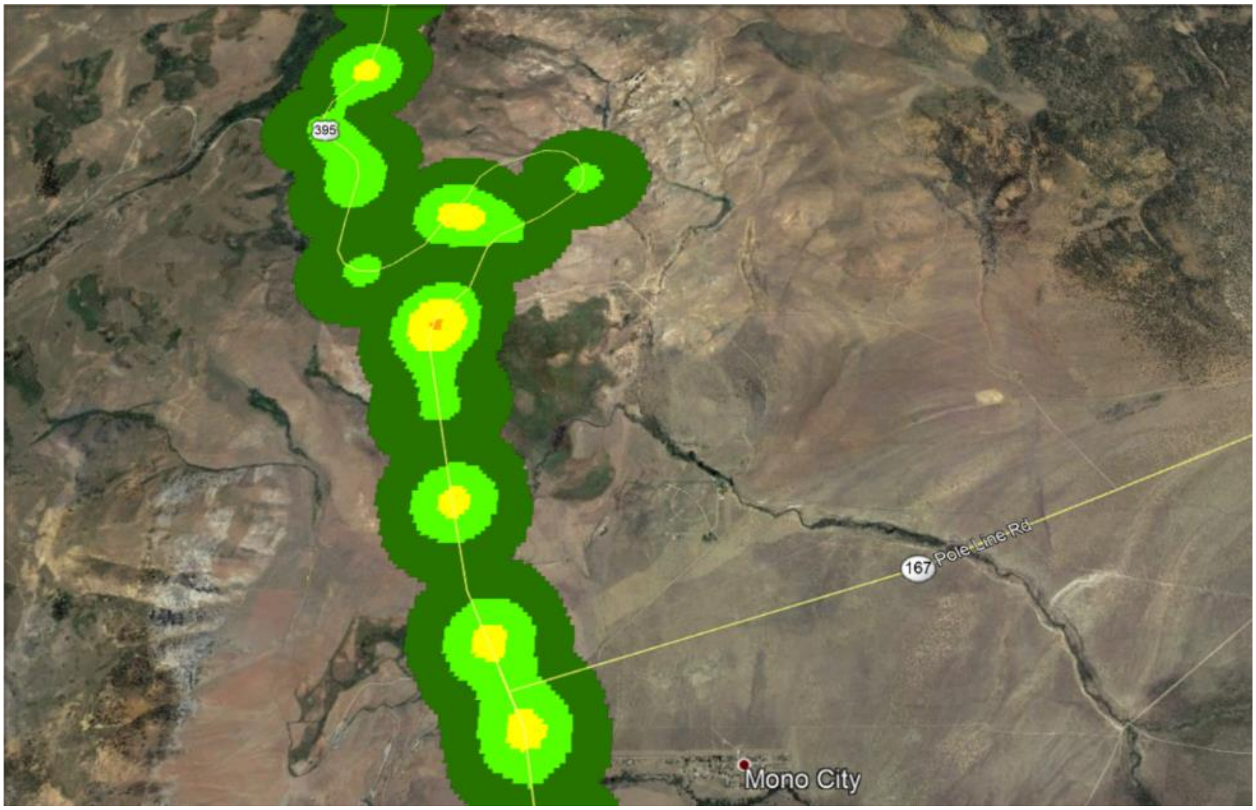
9C



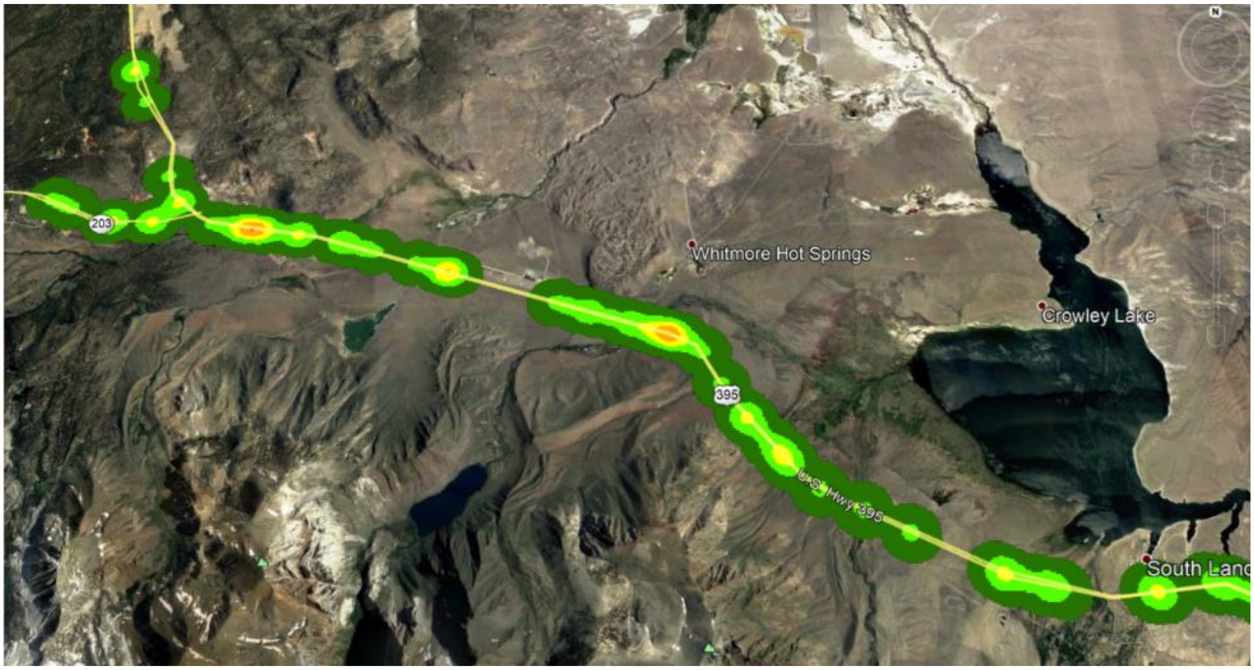
9D



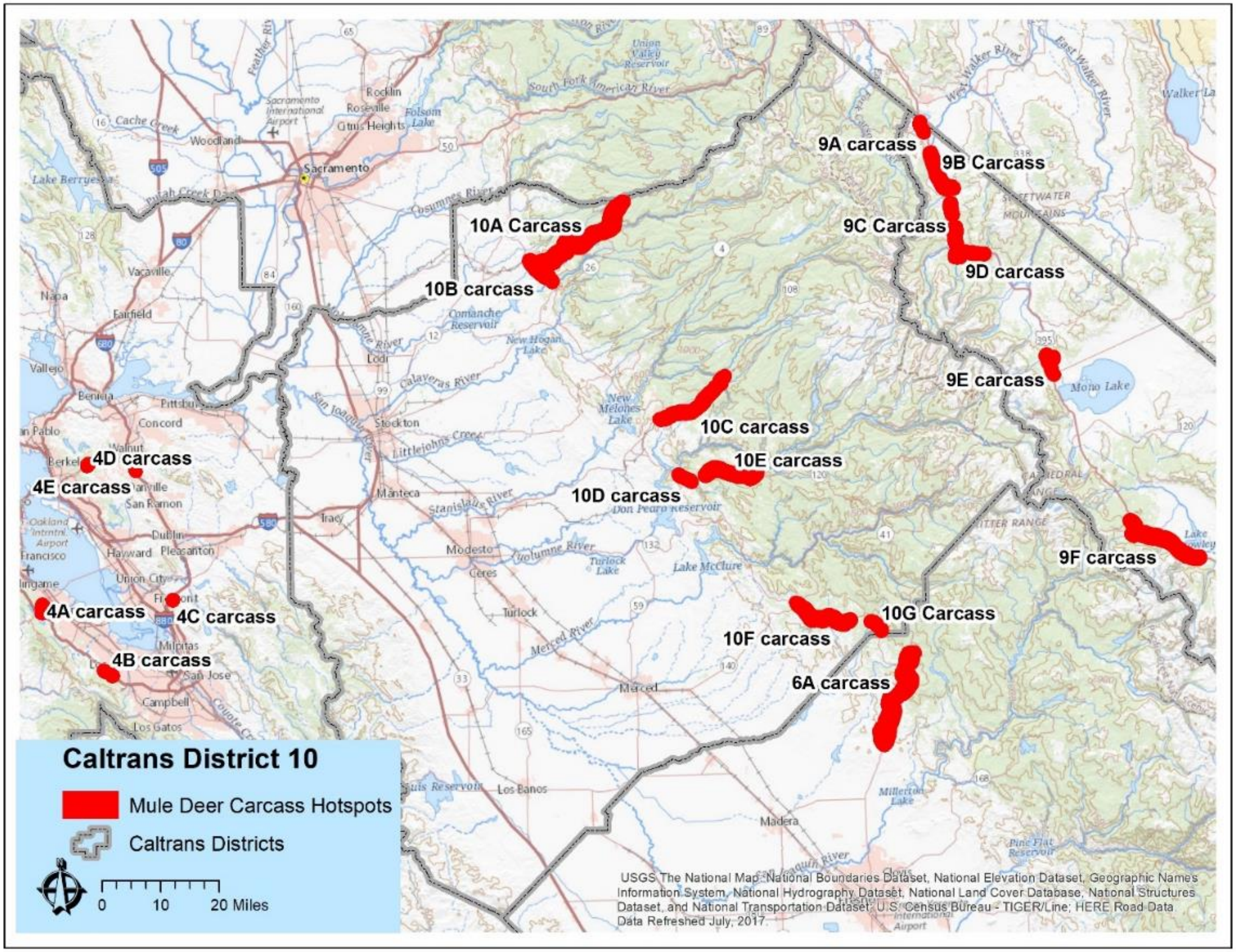
9E



9F

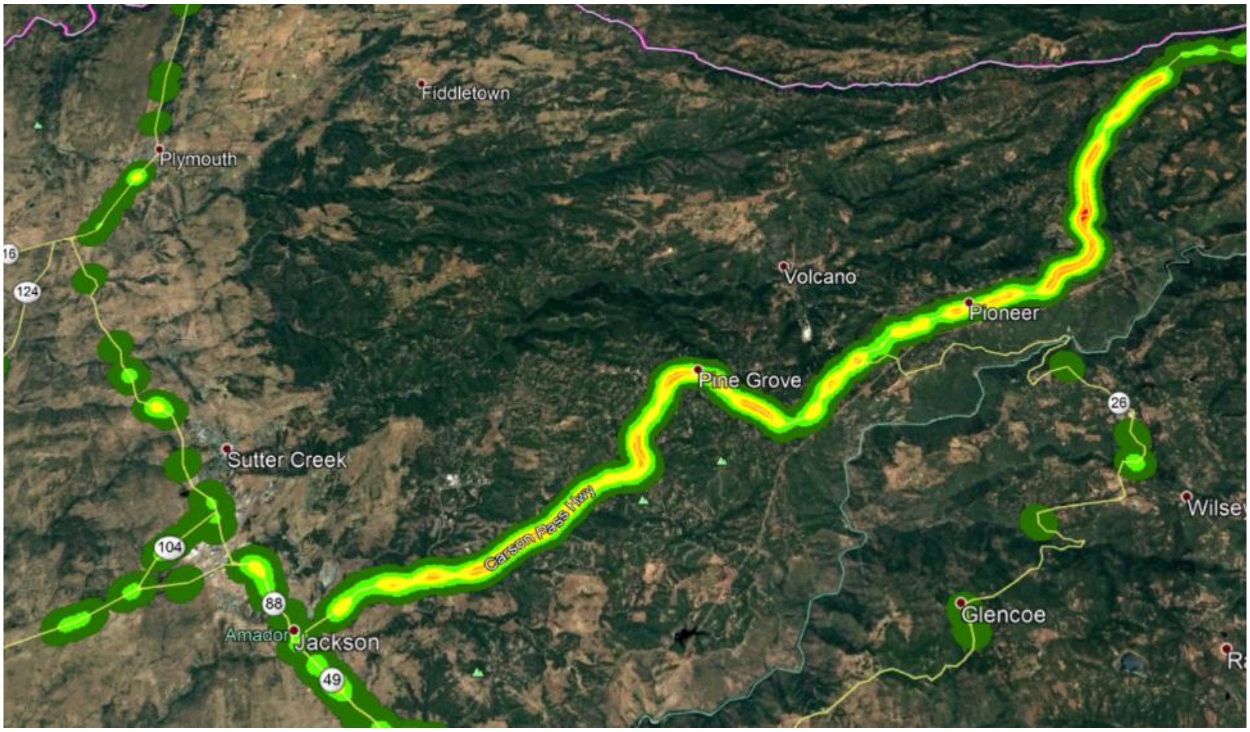

203
Whitmore Hot Springs
Crowley Lake
395
U.S. Hwy 395
South Land

CARCASS DATA DISTRICT 10

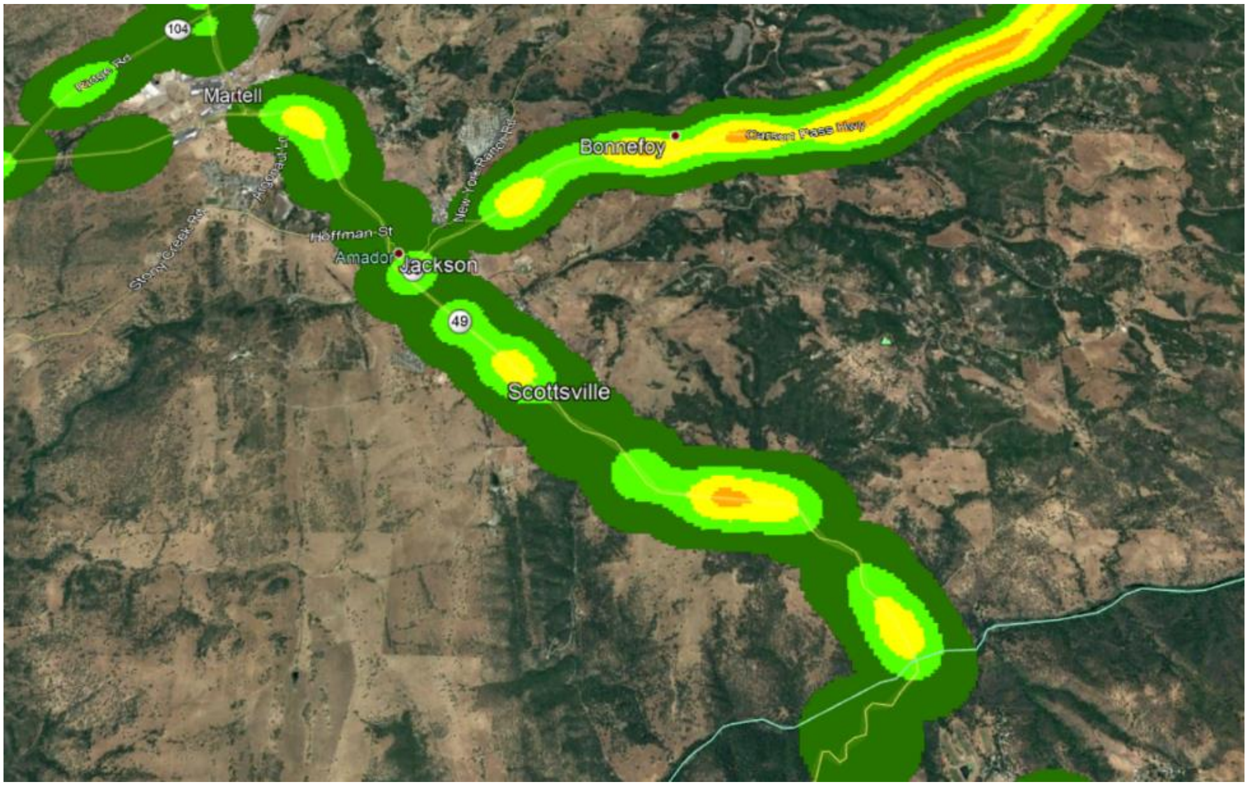


Hot spots in District 10 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

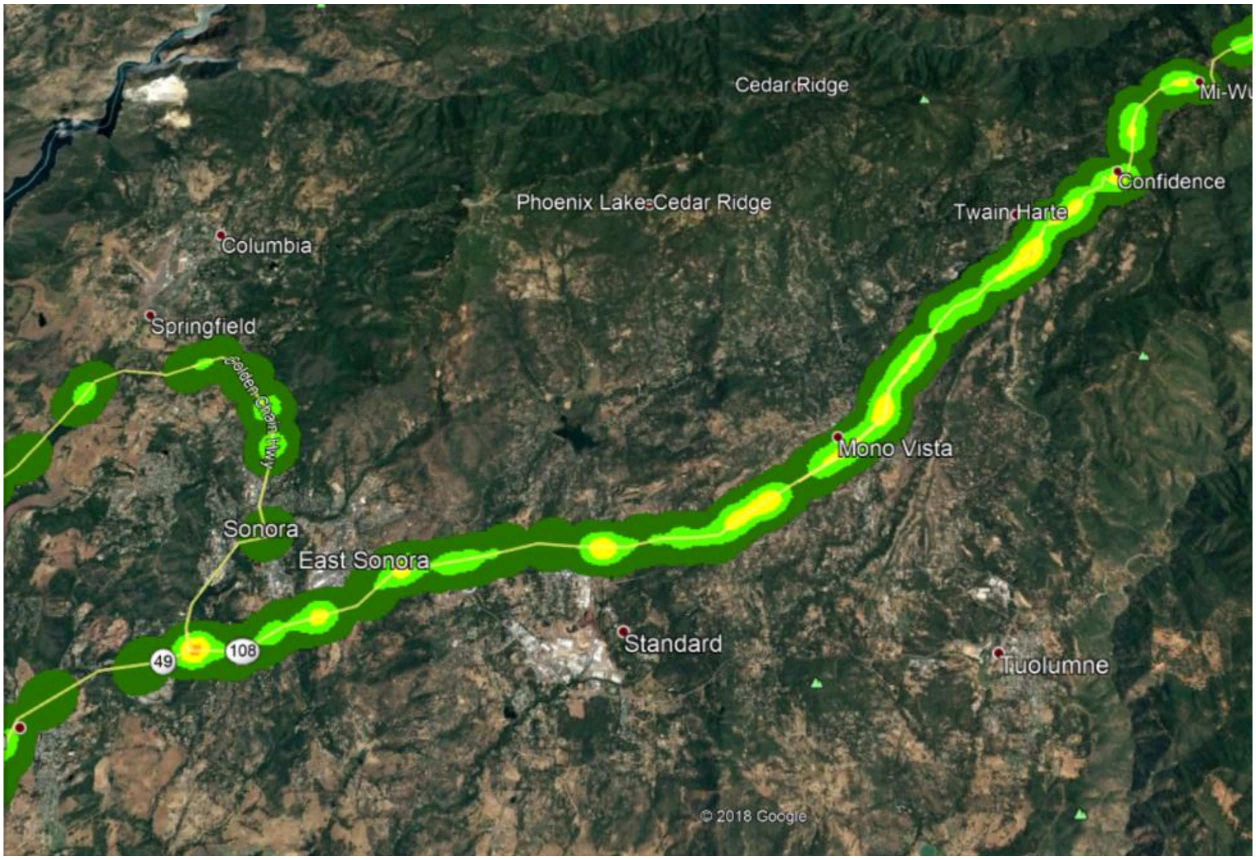
10A


Fiddletown
Plymouth
124
Volcano
Pioneer
Pine Grove
26
Sutter Creek
Wilsey
104
Carson Pass Hwy
88
Glencoe
Amador
Jackson
49

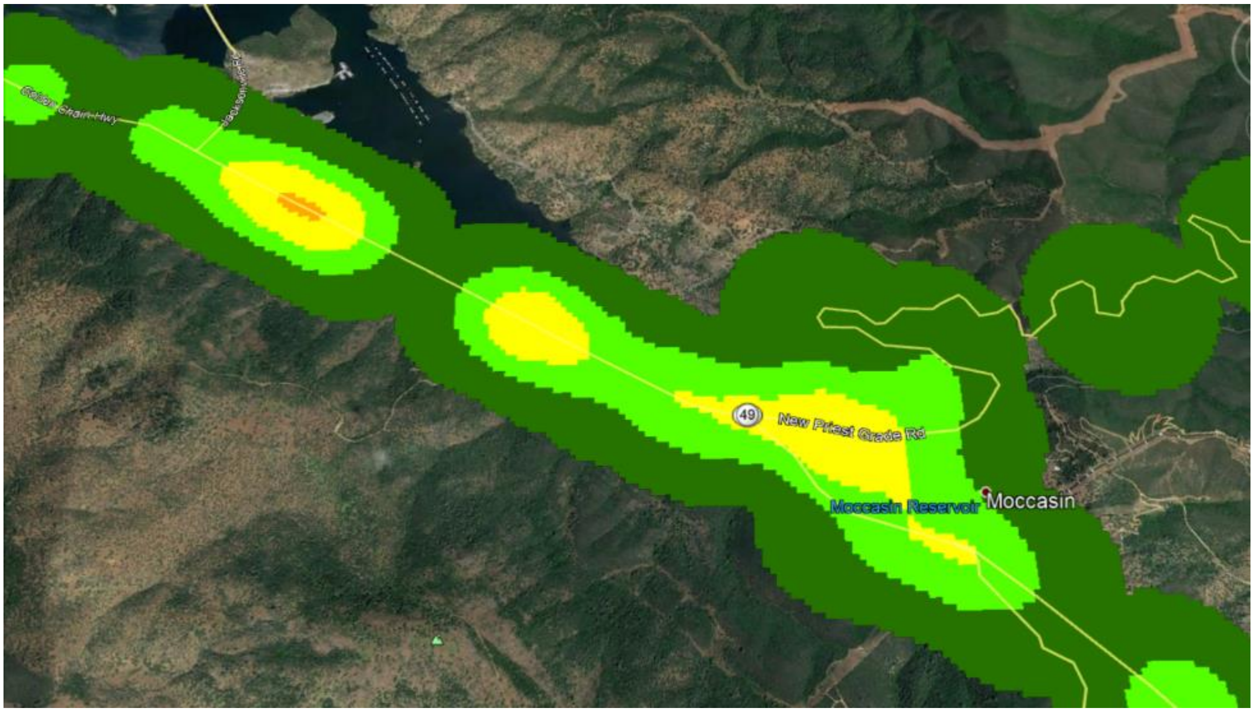
10B


104
Martell
Bonnefoy
Hoffman St
Amador
Jackson
49
Scottsville

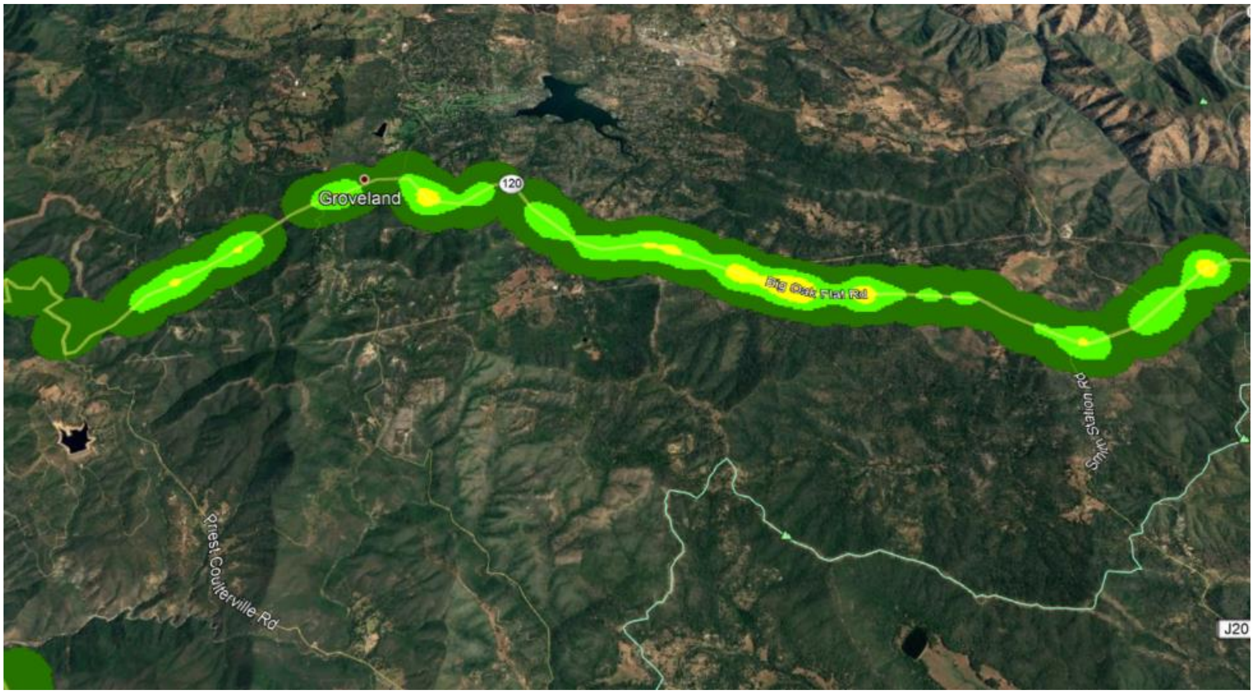
10C


Cedar Ridge
Mi-Wu
Confidence
Phoenix Lake-Cedar Ridge
Twain Harte
Columbia
Springfield
Golden Chain Hwy
Mono Vista
Sonora
East Sonora
Standard
49
108
Tuolumne
© 2018 Google

10D


Golden Chain Hwy
Jacksonville Rd
49
New Priest Grade Rd
Moccasin Reservoir
Moccasin

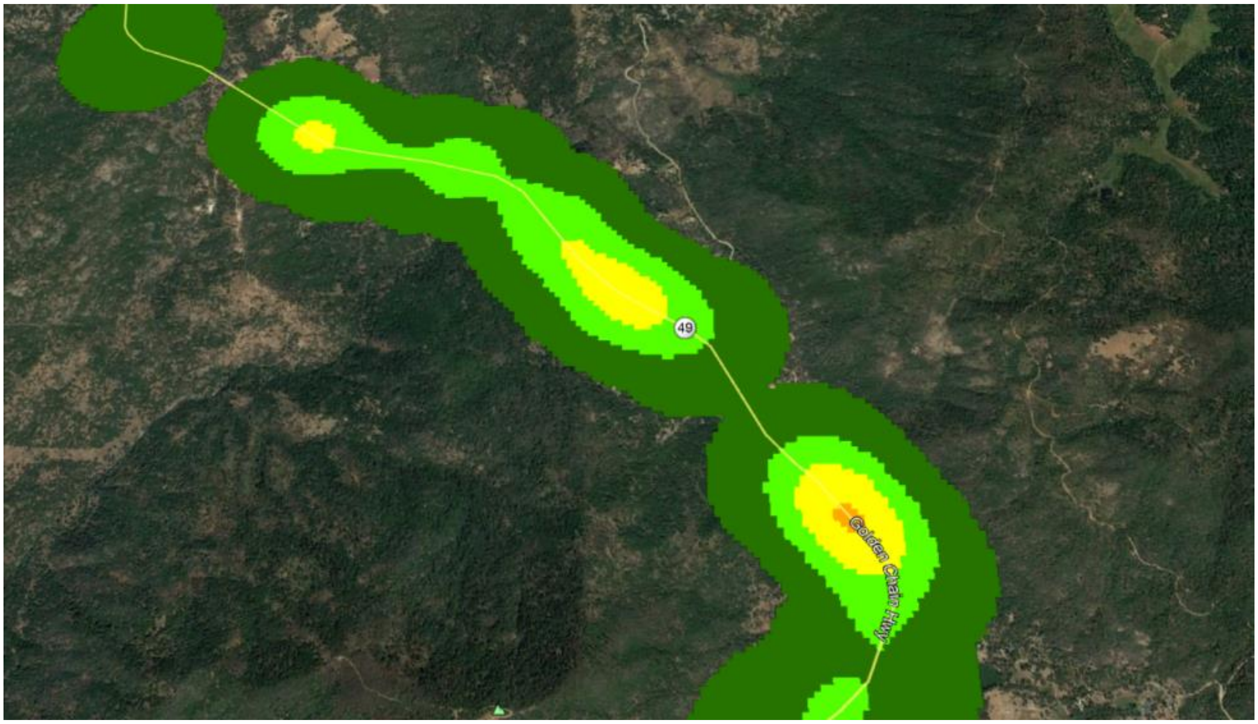
10E


Groveland
120
Big Oak Flat Rd
Smith Station Rd
Priest Coulterville Rd
J20

10F


Midpines
Darrah
140
49
Mariposa
Mariposa
Agua Fria
Mormon Bar
Bootjack
Bridgeport

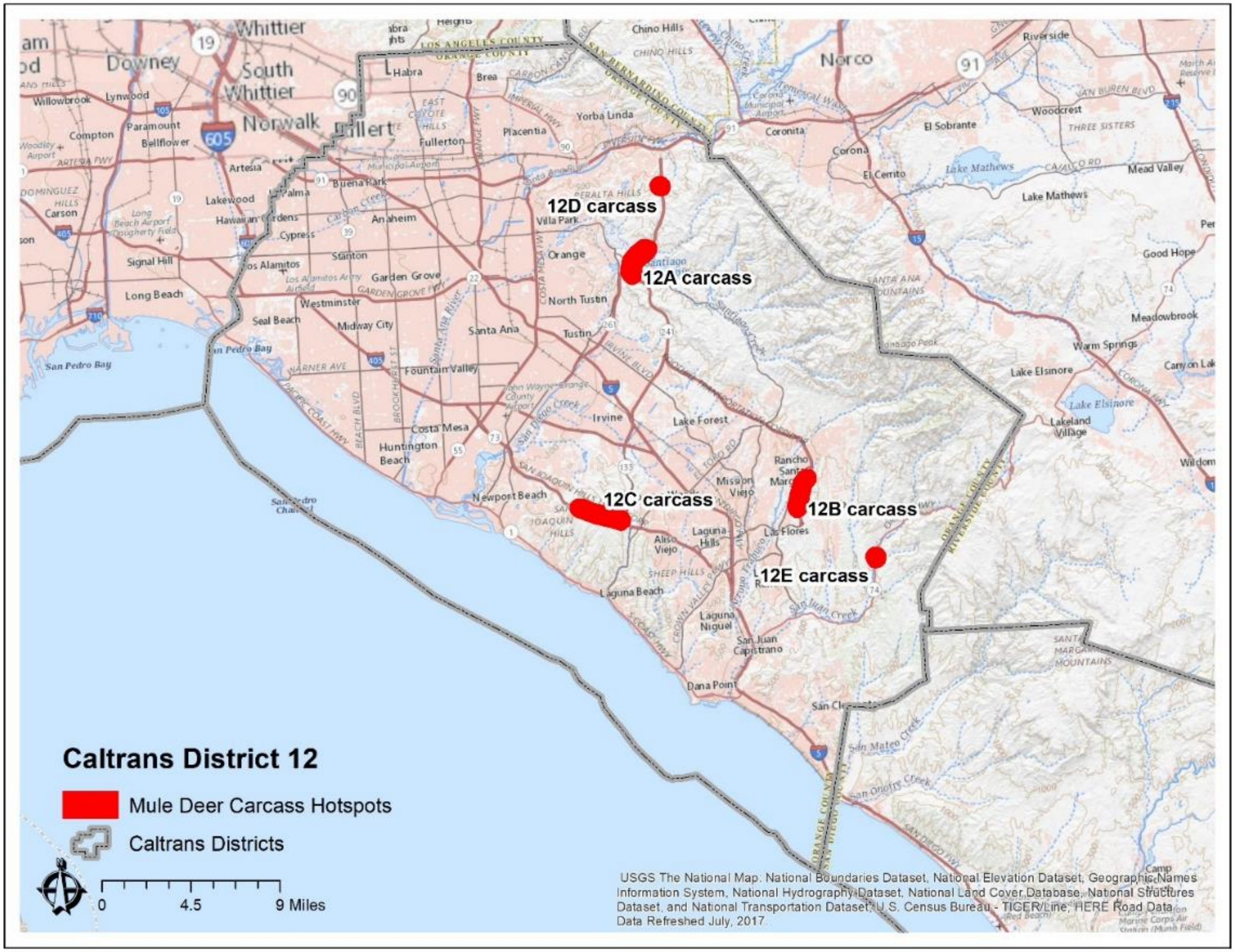
10G



CARCASS DATA DISTRICT 11

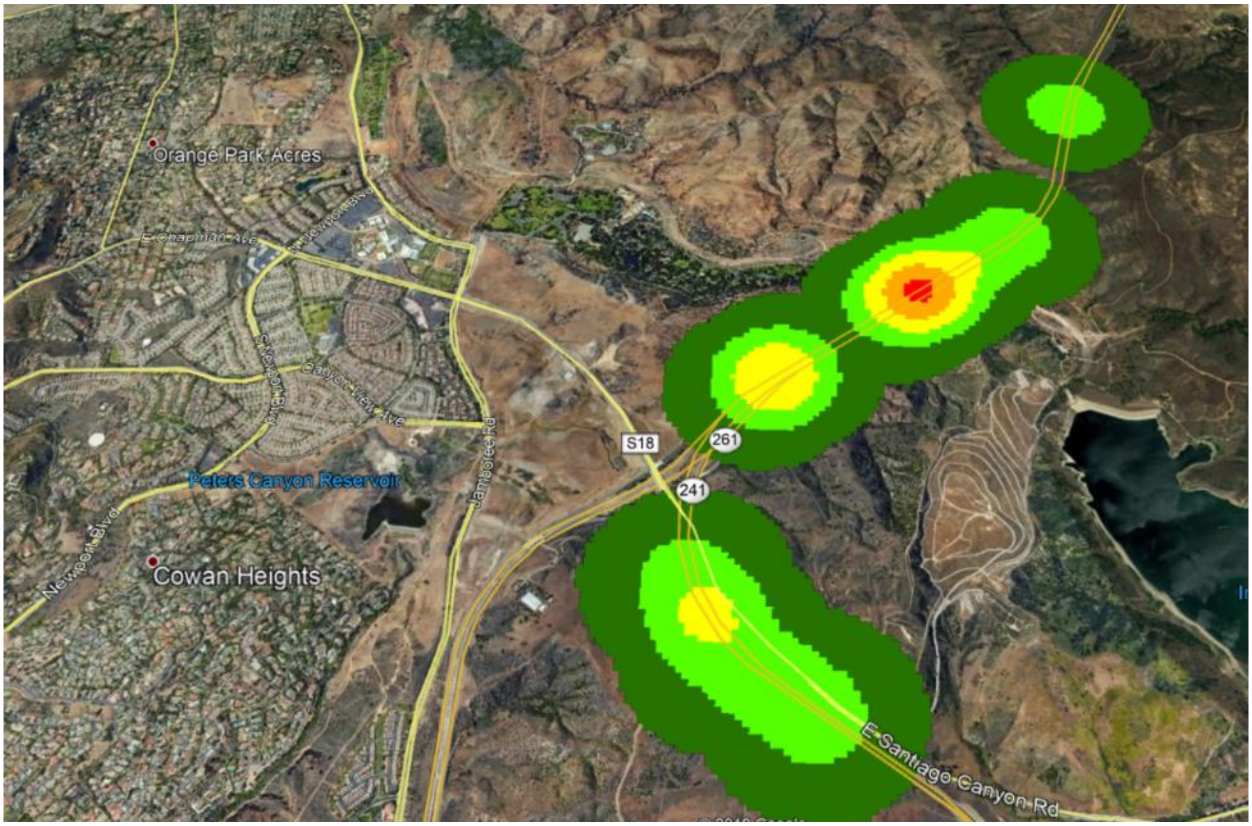
Insufficient data

CARCASS DATA DISTRICT 12

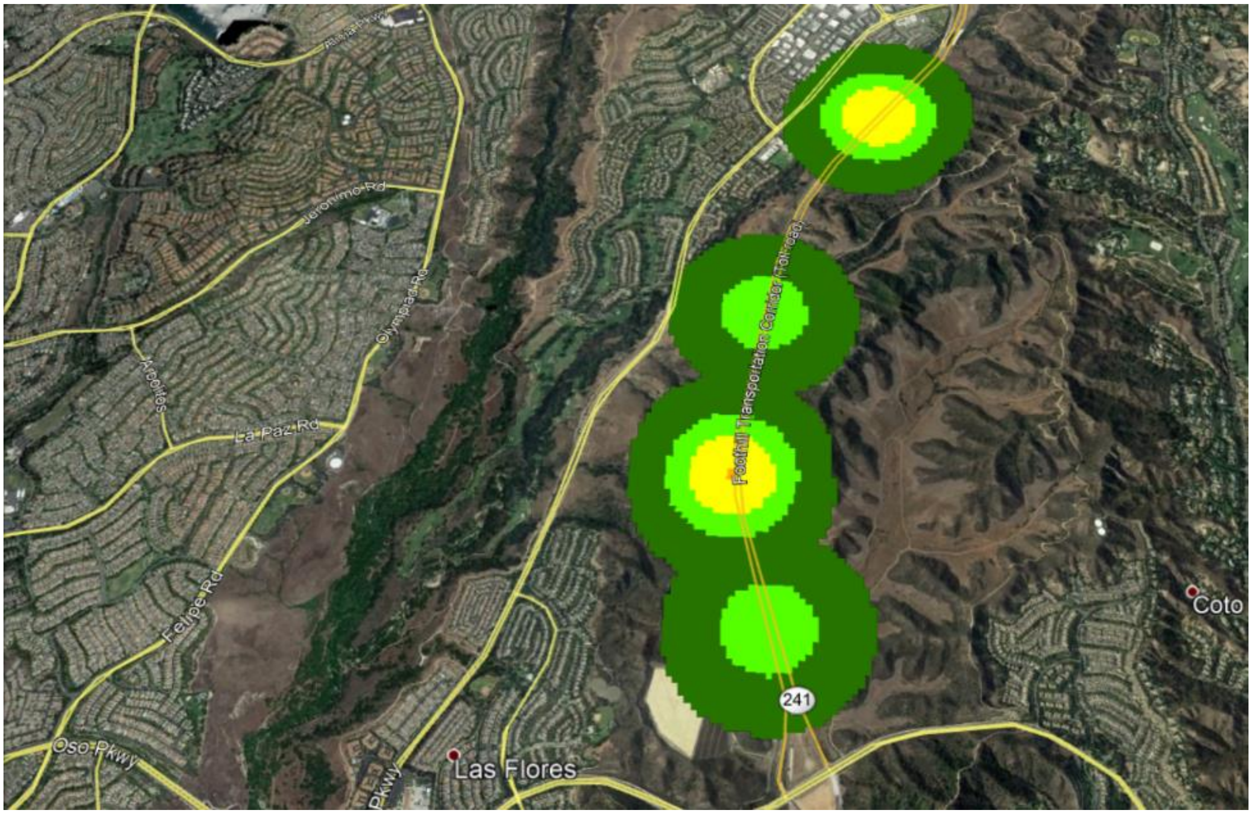


Hot spots in District 12 based on per district mule deer carcass data (see Figure 1, page 13 for the location of the districts in CA). The numbers correspond with the table (second page of Appendix C) and the detailed maps on the following pages.

12A


Orange Park Acres
E Chapman Ave
Cowan Heights
Peters Canyon Reservoir
Jamboree Rd
Newport Blvd
S18
261
241
E Santiago Canyon Rd

12B



12C


San Joaquin Hills
San Joaquin Hills Rd
Newport Coast
Laguna Canyon Rd
Lake Forest Dr
Aliso Creek Rd
El Toro Rd
133
73
S18
18
405
5

12D


E La Palma Ave
S Serrano Ave
E Canyon Rim Rd
Serrano Ave
Eastern Transportation Corridor (Toll road)
241

12E