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Technical Memorandum:

Patterns of Vehicle-Based Vertebrate Mortality in the Ballona Wetlands Ecological Reserve, Los Angeles, CA

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Introduction

Roads have become ubiquitous features on our landscapes, with approximately 20% of all land within the conterminous United States within 150 meters of a roadway (Riitters and Wickham 2003). Within these areas, the movement of cars at medium and high speeds may negatively affect wildlife populations and behavior through direct mortalities, habitat fragmentation, and behavior change (Forman and Alexander 1998, Coffin 2007, Charry and Jones 2009). Traffic volume, or the number of cars on a stretch of road during a given time period, and speed have been associated as key parameters influencing the quantity of direct wildlife mortalities along a given roadway (S. Anderson, *unpublished data,* 2011). Vertebrate mortality surveys of frequently-traveled roadways help identify wildlife movement patterns and the impacts of habitat fragmentation on a given area.

Over the past decade, concerned stakeholders anecdotally noticed a high frequency of animal kills along the major roadways adjacent to the Ballona Wetlands Ecological Reserve ("BWER" or "Reserve") (L. Fimiani, *personal communication,* 2011). This memorandum was developed to quantify the vertebrate mortality along Reserve-adjacent roadways. Additionally, it will provide information and data to the ongoing CEQA process regarding wildlife-vehicle collisions and subsequent direct vertebrate mortality through surveys conducted along roads bisecting the BWER from 2010-2013.

City of Los Angeles traffic-count data across a 24-hour interval during the week calculated that approximately 20,000-60,000 cars travel along roadways bisecting and adjacent to the Reserve, including Culver Boulevard, West Jefferson Boulevard, and Lincoln Boulevard (CoLA 2014). High traffic volumes combined with 45 mile per hour (mph) speed limits may pose significant risks to wildlife within the BWER. Analyzing these data may help evaluate opportunities to minimize or reduce harm and impacts to fauna, as well as reducing hazards to drivers.

Specific survey goals included:

1) Comparison of vertebrate mortality along three road transects bisecting the Reserve,
2) Identification of animal type most vulnerable to vehicle-based mortality, and
3) Identification of locations demonstrating higher frequency wildlife-vehicle collisions ("hotspots").

These data and research summaries are a product of California State Coastal Conservancy grant 11-086 and volunteer time donated by the Friends of Ballona Wetlands.

Methods

The survey area was evaluated using three transects, each approximately one mile in length. These transects delineate the primary roads bisecting the Reserve (Figure 1). The "Lincoln Transect" (Transect 1) extended along Lincoln Boulevard from Loyola Marymount University Drive to Fiji Way; the "Culver-East Transect" (Transect 2) extended along Culver Boulevard from its intersection with West Jefferson Boulevard to the 90 Freeway; the "Culver/Jefferson Transect" (Transect 3) began on Culver Boulevard in Playa del Rey and extended to the intersection of Culver and Jefferson Boulevards, and then on to Lincoln Boulevard (Figure 1). Surveys were conducted biweekly from October 2010 through September 2013. Friends of Ballona Wetlands staff and The Bay Foundation staff and interns conducted surveys based on protocols developed by Sean Anderson's PIRatE Laboratory at California State University Channel Islands.

Transects were surveyed by resetting a vehicle's odometer at the start of each transect and subsequently driving each transect with a passenger noting the type of carcass, the odometer reading, and the direction of travel on a datasheet. Both lane directions of each transect were surveyed (e.g. Transect 1 was surveyed driving both north and south). Data are reported in miles, or frequency of mortality per tenth of a mile, based on the accuracy of the odometer survey method.

Figure 1. Map of survey transects bisecting the Ballona Wetlands Ecological Reserve.

The survey datasheet included several animal categories for all potential vertebrates found in the BWER. When possible, kills were identified to species (e.g. California kingsnake), but when damage prevented detailed identification, broader categories were used based on gross animal size. Large animals were coyote or larger sized. Medium size animals were raccoon or cat sized. Small sized animals were rabbit or squirrel sized. When a deceased animal was observed, its location was recorded using mileage measured from the beginning of each transect to a tenth of a mile and based on odometer accuracy. Occasionally, kills were also recorded using a handheld GPS, if there were unusual circumstances such as multiple adjacent kills or rare species. Importantly, the survey efforts provide realistic estimates of the overall kill rate via assessing the survey effort (number of surveys) and not merely the location of particular kills.

Supplemental site-specific data was provided by motion cameras located in the Reserve ("Critter Cams"). Detailed methods and protocols are available in the Ballona Wetlands Baseline Reports (Johnston et. al 2011, 2012) or in the draft Standard Operating Protocol (SMBRF 2014).

Error Avoidance and Assumptions

While the survey methodology provides informative data on the frequency of vehicle-based vertebrate mortality along the BWER-adjacent roads, there is also the potential for error within the quantification techniques. Care was taken to reduce observer effect error through the consistent use of the same surveyors for as many surveys as possible. If the regular surveyors were not available, trained substitutes conducted the survey. The protocols and surveyors underwent quality control and observer bias checks once annually through a trial run-through of each transect with all observers. Additional quality control was performed on the entered data though a third-party reviewer.

Errors relating to double-counting, or identifying the same kill on repeat surveys for a falsely-inflated count, was reduced by conducting a pilot study during the first month of the program. Surveys were conducted weekly for one month. Carcass removal rates vary significantly depending upon location and species (S. Anderson, *unpublished data*). For this study, every two weeks was determined to be an appropriate length of time for the kills to either be removed by county services, desiccated to the point of non-visibility, or consumed by scavengers. Additionally, errors were further reduced through specific recordings of the location and type of kill to allow for identification of repetitive counts. If the same type of kill was seen in consecutive surveys in the same location, best professional judgment based on the level of desiccation was used to determine if the kill was a repeat sighting, or new since the previous survey.

Error may still be incurred in three ways: 1) natural or anthropogenic removal of carcasses between surveys, 2) washing away or removal from a storm event, or 3) undercounting based on visibility restrictions or the movement of the animal off of the roadway after being hit but before mortality occurred. All of these potential contributors of error would result in underestimations of vehicle-based vertebrate mortalities. Regardless of such error, the data provide a robust, and possibly conservative estimate of kill rates to initiate discussions of the ecological and socioeconomic impacts of roads on Reserve wildlife.

Analysis Methods

Basic summary statistics were calculated for the data including averages, standard error, frequency graphs, and one-way ANOVAs. Polygon length boundaries used for map figures and geospatial analyses were identified by GPS, where end points were tagged for every one-tenth mile increment according to the vehicle's odometer along each transect. Polygons within map figures are 55 m wide for ease of viewing and are not accurate representations of road edges.

Results

A high rate of mortality was documented with kills found regularly and frequently along all three transects. In three years of surveys, a total of 654 kills were recorded during 70 surveys of each of the three transects. During the first survey year, 231 kills were recorded; 208 in the second survey year; and 215 in the third survey year. A significantly higher number of kills were found on both the Culver-East and the Culver/Jefferson Transects than the Lincoln Transect (ANOVA, $F = 31.48$, $p < 0.001$; Table 1).

Table 1. Frequency of kills by transect and averaged over the total number of surveys (± SE). The kill rates can be inferred as either kill rates per day (liberal) or per week (conservative).

Transect	**Total # of Kills / mile**	**# of Surveys**	**Average # per Survey**	**Standard Error**
1: Lincoln	106	70	1.51	0.148
2: Culver-East	297	70	4.24	0.309
3: Culver/Jefferson	251	70	3.59	0.245

These results for the BWER transects are an order of magnitude, or in some cases two orders of magnitude, higher than regional survey kill rates (i.e. kills per mile; S. Anderson, *unpublished data,* 2011). The highest mortality throughout the evaluation period was desert cottontail rabbits (*Sylvilagus audubonii*) for a total of 192 kills or approximately 30% of the aggregate mortality (Figures 2 and 3). It is probable that a significant portion of the "unknown" and "small mammal" category (i.e. too damaged to definitively identify) were also cottontails. This would indicate that an estimate closer to 50-70% of the total kills were actually cottontails. Other vertebrates frequently sighted included squirrels (family Sciuridae) and the Virginia opossum (*Didelphis virginiana*). Larger mammals like raccoons (*Procyon lotor)* and coyotes (*Canis latrans)* were rarely seen; however, there were several anecdotal reports of coyote kills that were removed before the next scheduled survey took place. It is therefore possible that the larger fauna were underestimated. Occasionally, birds were also recorded. Figure 2 lists each species or animal group that was identified along the transects. Species with only one kill (or 0.2% of the aggregate mortality) included cat, coyote, California kingsnake, and rat. Common species were similar to those frequently identified on Critter Cam stations within the Reserve, especially for the smaller fauna and cottontail rabbits (Johnston et al. 2011, 2012).

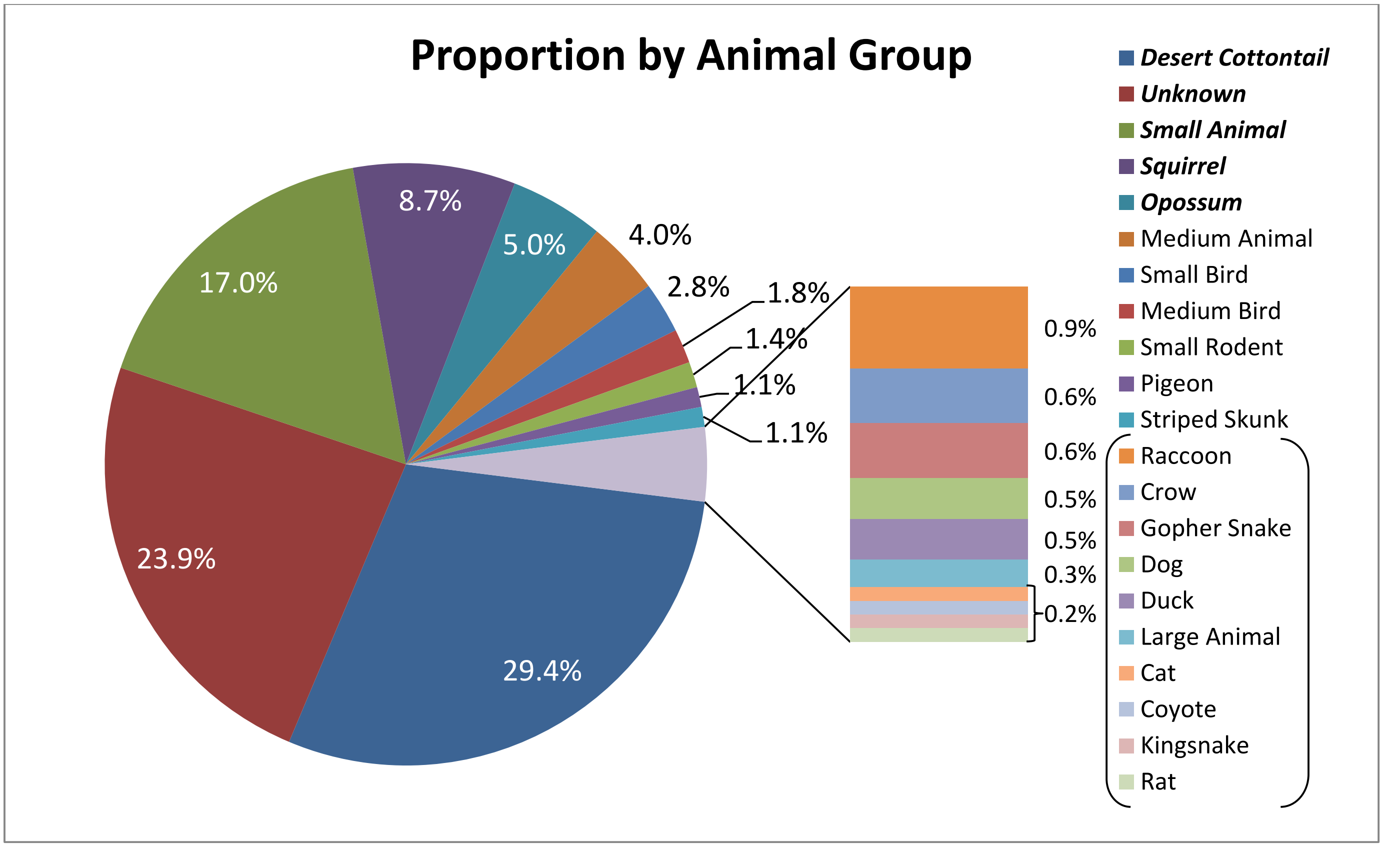

Figure 2. Proportion of animal mortality by group. Bold and italicized animal groups were the most common; animal groups in parenthesis each accounted for less than 1% of the total proportion.

Figure 3. Photographs of the most common vertebrate mortality species (desert cottontail rabbit) from Critter Cam stations within the Reserve.

When analyzed by month, the highest average mortality was seen during the warmer late spring and summer months from approximately May through June (Figure 4), consistent with broader regional patterns of kills (S. Anderson, *unpublished data,* 2014). The largest standard error was seen in January, due to one survey occurrence of a particularly high mortality count in 2010.

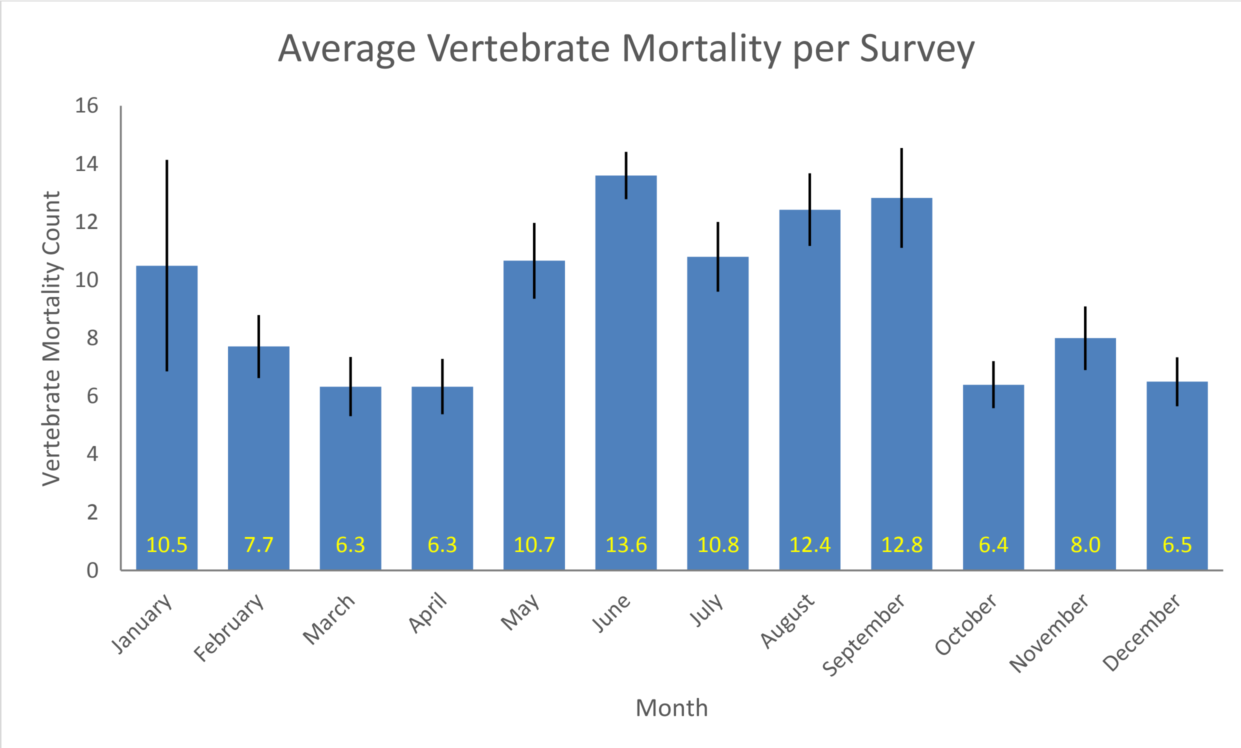

Figure 4. Vertebrate mortality counts averaged by total number of surveys for that month (± SE). Averages are analyzed using all three transects and all three years combined and are shown in yellow.

Figure 5 displays variable mortality rates (kills per tenth of a mile) based on transect, specific location, and side of the road. It also shows that the parallel sections of Culver and Jefferson along the perimeter of the “triangle” roughly in the center of the graph, are particularly hazardous to wildlife (Figure 5). This example location reinforces the trend that roads bisecting the Reserve with open space on both sides tend to display higher kill rates than Lincoln Boulevard, the third side of “triangle”, which is bordered by urban development on one side.

Additionally, the bidirectional survey methodology allows us to independently assess the vulnerability of vertebrates along both directions of car travel within a given stretch of road. Animals using the road adjacent to the North Area C parcel (along eastern Culver Boulevard) seem to be more susceptible to traffic collisions than those along the opposite direction. A similar trend is noticeable for wildlife crossing eastern Culver Boulevard from the south-eastern corner of Area B towards the salt pan habitat (Figure 5). Reasons for the increased susceptibility along specific directional road segments such as visibility or barriers to Reserve access were not analyzed as part of this survey.

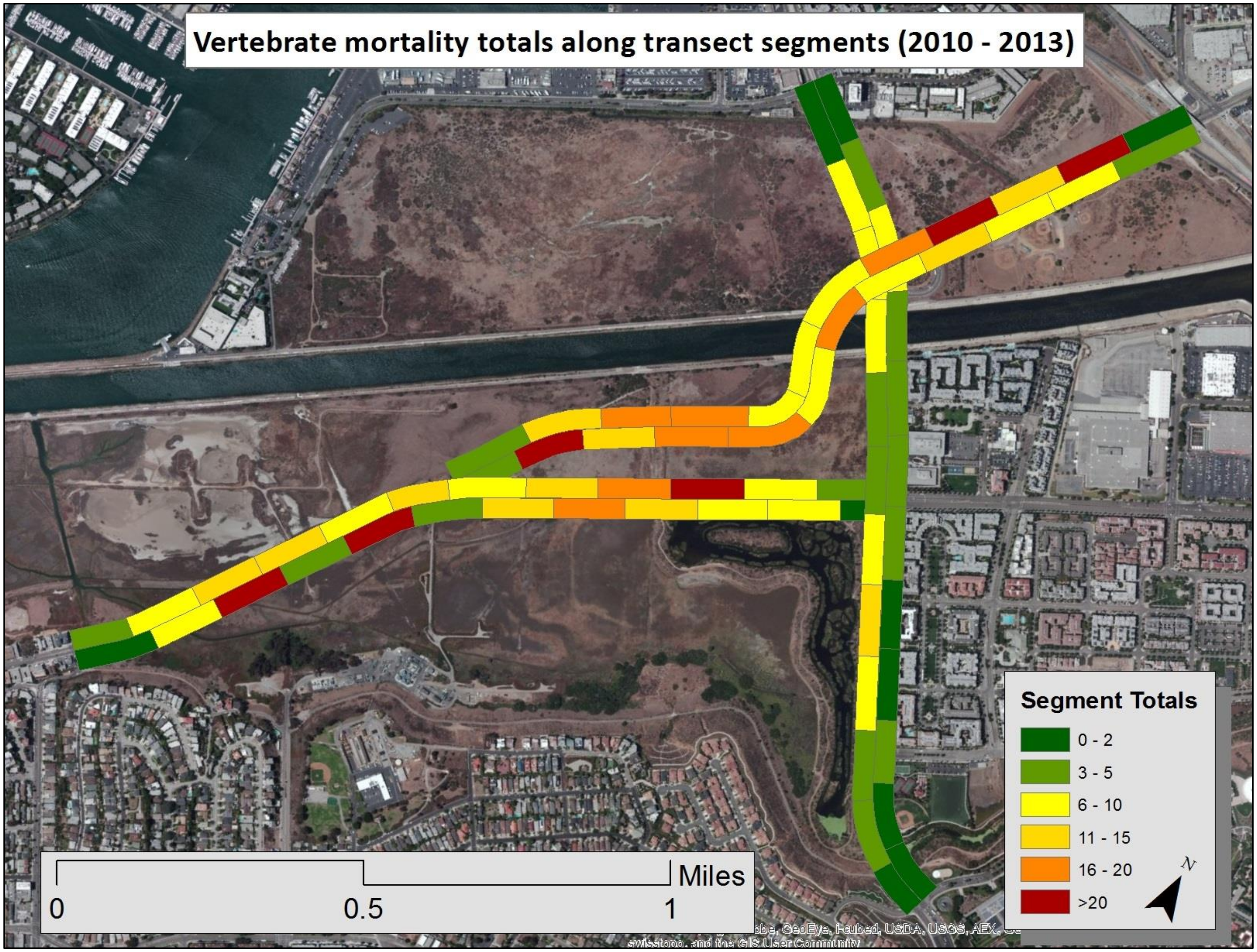

Figure 5. Map of total vertebrate mortality in 0.1-mile segments during the 2010-2013 surveys.

Conclusions

Roadways bisecting the BWER present a major obstacle to wildlife mobility, with specific segments of the roadways depicting higher kills rates than other segments. This survey, which identified roadway segments with higher kill rates and likely groups of impacted animals, could be used to inform future studies to identify or increase our understanding of the factors that differentiate the segments' kill rates. Examples of additional research and analysis could include an analysis of the data against high-resolution traffic patterns or wildlife cameras and an in-depth regional assessment for comparison. Additional data from municipalities tasked with roadkill removal would allow for an even higher degree of accuracy of the total mortality rates along the Reserve transects, especially for the larger fauna.

Additionally, underestimations of mortality may have occurred for some of the organism groups. Antworth el at. 2005 estimated that scavenging results in the removal of 60 – 97% of roadkill carcasses within the first 36 hours, with snakes exhibiting the highest disappearance rates. The results of this study may explain lower numbers of snakes identified on surveys, ultimately leading to an underestimation. The anthropogenic removal, particularly of larger wildlife species, also occurs through active collection by municipalities between surveys. While smaller carcasses (e.g. squirrels and rabbits) may go relatively unnoticed by passing motorists, the obstacle and dangers presented by carcasses of larger wildlife species (e.g. coyotes and dogs) is more noticeable and may prompt phone calls from drivers or immediate action by city workers. This process may help explain the lower relative frequency of observations of larger animals in the data.

The proximity of these major roadways to the Reserve, an undeveloped open space, increase the possibility of vehicle-related mortalities on wildlife and increase the potential costs and environmental effects associated with those incidences. The phenomenon of wildlife-vehicle collisions is not unique to the Reserve. In fact, wildlife vehicle collisions are an issue across the United States and even globally. Scientific literature exists on the topic and provides examples of potential measures for addressing it such as lowering speed limits and displaying cautionary signage. Measures such as those presented in the literature could be considered for the roadways within the Reserve.

Socioeconomic and Public Safety Concerns

In addition to the negative ecological effects, there are socioeconomic and public safety considerations associated with vertebrate mortality relating to collisions with wildlife and other vehicles. Nearly one quarter (26%) of Unites States drivers do not carry the necessary comprehensive insurance to cover vehicle damage as a result of collisions with larger wildlife species (IIS 2013). As a result, the socioeconomic ramifications associated with these situations results in these individuals incurring out-of-pocket expenses to repair wildlife-related vehicle damage.

A larger consideration involves drivers accidentally colliding with other motorists from last second evasive maneuvers to avoid wildlife collisions. Collisions between vehicles substantially increases the risk of bodily injury and vehicle damage when compared to collisions with wildlife (FWHA 2008, NHTSA 2014). In 2008, a study conducted by the U.S. Department of Transportation's Federal Highway

Administration estimated annual costs associated with wildlife-vehicles collisions to be $8,388,000,000 (FWHA 2008). Therefore, the interaction between vehicles and wildlife should be minimized where ever feasible and appropriate to reduce risks to both humans and wildlife.

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