Human and Vehicle Impacts on Wildlife Activity at Culverts

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Introduction

In a world that is becoming ever more urban, highways are a common fixture in nearly every developed area. As a consequence, roadways are fragmenting large swaths of habitat, creating the need for wildlife to cross them in order to mate, disperse, and find food (Ament et al. 2008). This leads to many animals dying in vehicle collisions, often causing massive damage to the vehicles that hit them and potentially leading to injury or death of both animals and drivers (McCollister and Manen 2010). In order for our roadways to be sustainable, we must minimize their impact on the surrounding environment, which necessitates the creation of pathways for wildlife to move freely across these roads and continue their normal dispersal patterns. Culverts underneath roadways are a common way for wildlife to cross unharmed, reducing the likelihood of wildlife-vehicle collisions, but often these culverts are not initially constructed for the purpose of wildlife crossings, and so are not designed to minimize the impacts of the road on wildlife who may be using them. Two of the biggest potential factors that impact how and when a culvert is used are human activity (Barrueto and Clevenger 2014) and road activity (Clevenger et al. 2001). Light and noise pollution from the road may discourage animals from utilizing these crossings, and spooked animals may run over the roadway instead, increasing the risk of a collision, or be repelled from the culvert and forgo crossing altogether, rendering them ineffective. Human activity can cause animals to avoid the culvert as well, as most animals will avoid areas of high human presence (Markovchick-Nicholls et al. 2008). Minimizing these impacts on wildlife at culverts will enable us to more effectively connect habitat, prevent collisions, and reduce the impact of roadways on wildlife.

Background

The Road Ecology Center has been monitoring wildlife presence at culverts for years, compiling the data in an online database called the Wildlife Observer Network (WON, https://wildlifeobserver.net). WON has records of wildlife use of major culverts along many highways across the United States, including several in California. At each of these culverts, one or more motion-activated cameras are set up to collect data on animal presence. Animal photos are uploaded to WON, where they are tagged with relevant data about the photo. WON keeps a record of each photo that is taken, noting the time it was taken, species, activity, travel direction, number, age, and gender of the animals in that photo. This compilation of data provides the framework for many different types of valuable analyses that can give insight into the ways that highways affect the wildlife around them. One such analysis that I will examine in this paper is animal activity. Because it gives information about when, and if, a culvert is being used and by what species, animal activity at culverts informs us about their effectiveness, and can give better insight into both the impacts of that road on wildlife and the potential collision risk at those sites when examined together with other factors. In this paper, I will be looking at the effects of traffic levels and presence of humans on animal activity at the culvert. Traffic levels can be used as a proxy for light and noise pollution levels, as vehicles are the source of this pollution, and number of humans is a direct measure of human activity. Animals tend to shift toward more nocturnal activity patterns in areas of human disturbance (Gaynor et al.
2018), and roadways should follow this pattern, as they are a result of human disturbance. I expect that as traffic level and number of humans increase, animal activity will shift away from mid-day (when these disturbances are greatest) and towards midnight (when these disturbances are at their lowest).

**Methods**

**Site Selection and Setup**

The majority of the cameras used in this project were Bushnell motion-activated camera traps. I looked at sites along California highways I-280, I-80, and I-680. These major highways have been monitored by the Road Ecology Center for several years, and could provide the data necessary to run the desired analyses. Sites were selected based on number of pre-existing observations in WON; sites with fewer than 5 observations per species were not used to avoid biased, overinflated data and inaccurate activity profiles. If a site only had data about one species, or had only one or two observations for multiple species, it was also excluded from this data set.

**Data Collection**

When setting up new sites, four cameras were placed at each culvert, two on each end. Cameras were left up for at least 30 days before being taken down and having collected images sorted through for upload onto WON. In addition to using this newly collected data, I also used historical data from WON going back to 2011. Complete data sets were taken from each of 13 sites along I-80, I-280, and I-680, and were sorted by species and then by hour of occurrence. I took a count of how many observations for each species occurred within each respective time bin from 0:00-1:00 to 23:00-24:00; I opted to use 24-hour times for simplicity. I then calculated the percentage of activity that occurred within each time bin, as different species had varying counts at a given site. Mule deer were especially common, with counts often numbering in the hundreds, while predators such as bobcats and coyotes are more elusive, and thus had fewer overall observations, creating the need for the use of percentages to make species-specific data comparable.

Due to insufficient data for single-species analyses, I opted to use two groupings for my analysis: carnivores and herbivores. Time of peak activity (the hour of the day in which the percentage of observations was highest) was noted for each carnivore and herbivore species. For species that had more than one maximum value (equal percentages), I selected the values closest to 12:00pm to avoid bias. I then graphed the percentage of observations within each hour bin to create an activity profile for each site.

Annual Average Daily Traffic (AADT) is a metric that allows for measurement of traffic levels. Two AADT values exist for each site, an “ahead” and a “back” value; I used both in my data. At each site, I obtained the AADT values and paired them with the peak activity values for carnivores and herbivores. To allow graphing, I assigned each hour bin a single number; 0 for 0:00-1:00, 1 for 1:00-2:00, etc. To measure human activity, I counted the number of humans

![NCST](image-url)
observed at each site and paired those values with the peak activity values for carnivores and herbivores.

**Analysis**

To perform my data analysis, I graphed carnivore and herbivore values against back and ahead AADT values. To allow for the use of a linear regression, I graphed peak activities after 12:00 pm and peak activities 12:00 pm and earlier separately. This would allow for easier analysis, as I could look for a linear trend earlier or later than 12:00 pm in either direction. I repeated this process with the human activity data, and performed a linear regression on each set of data to determine whether there was a significant correlation between traffic levels or number of humans and time of peak activity for carnivores and herbivores.

**Results**

**Activity Profiles**

At each site, graphing the percentage of observations which occurred in each time bin generated an activity profile for each site, as shown in Figure 1. Many sites showed a similar activity profile, with species showing higher activity percentages in the early morning and late night, and much less activity during the day.

*Figure 1: An example of an activity profile at the Casa Loma culvert.*
AADT

AADT was analyzed against activity times pre and post - 12:00 for all carnivores and herbivores respectively. The back and ahead AADT regressions for carnivores pre - 12:00 showed a positive, although non-significant correlation (back AADT $p = 0.09$; ahead AADT $p = 0.08$; figure 2), while the back and ahead AADT regressions for carnivores post - 12:00 were non-significant (back AADT $p = 0.43$; ahead AADT $p = 0.47$; figure 3). The back and ahead AADT regressions for herbivores pre - 12:00 were non-significant (back AADT $p = 0.36$; ahead AADT $p = 0.40$; figure 4), while the back and ahead AADT regressions for herbivores post - 12:00 were also non-significant (back AADT $p = 0.11$; ahead AADT $p = 0.13$; figure 5).

**Figure 2:** Graphs of traffic density given by back (left) and ahead (right) AADT against time of peak activity for carnivores 12:00 and earlier with trendlines.

**Figure 3:** Graphs of traffic density given by back (left) and ahead (right) AADT against time of peak activity for carnivores after 12:00 with trendlines.
Human Presence

Number of humans present in the sampling period was analyzed against activity times pre and post - 12:00 for carnivores and herbivores respectively. Human presence versus carnivore yielded non-significant results (pre - 12 activity $p = 0.1$, post - 12 activity $p = 0.14$; figure 6), as did human presence and herbivore activity (pre - 12 activity $p = 0.3$, post - 12 activity $p = 0.99$; figure 7).

**Figure 4:** Graphs of traffic density given by back (left) and ahead (right) AADT against time of peak activity for herbivores 12:00 and earlier with trendlines.

**Figure 5:** Graphs of traffic density given by back (left) and ahead (right) AADT against time of peak activity for herbivores after 12:00 with trendlines.
Discussion

Due to limited time and resources, I was only able to sample 13 sites, which is quite a small number for statistical analysis and therefore could be considered a limiting factor here, potentially responsible for the non-significant $P$ values. However, while these regressions did not have $P$ values low enough to be deemed statistically significant, with further study and more sites to sample from a statistically significant correlation may be revealed between traffic levels and animal activity. The trend lines of the scatterplots seem to suggest a potential correlation worth exploring. These results can be helpful despite the high $P$ values; the regressions relating traffic levels to carnivore activity pre - 12:00 had values close to 0.05, which

Figure 6: Graphs of human activity given by number of humans against time of peak activity of carnivores before (left) and after (right) 12:00.

Figure 7: Graphs of human activity given by number of humans against time of peak activity of herbivores before (left) and after (right) 12:00.
suggests that there could be a correlation between the two that is worth investigating. Carnivores tend to be particularly sensitive to the impacts of human activity, including roads (Darnell and Leberg 2018), and therefore it is possible that carnivore activity would be more impacted by increased traffic levels. Human presence reduces predation risk for herbivores (Muhly et al 2011) as we displace these carnivores, which both discourages carnivores from occurring in areas of high human activity and encourages herbivores to remain near those areas, suggesting that herbivores may in fact have an opposite trend to carnivores in relation to disturbances such as roadways. I had predicted that as traffic levels increased (toward midday), the time of peak animal activity would move away from 12:00 pm (and appear more similar to Figure 1), but the regression graphs (Figures 2 through 5) indicated a different trend, as peak activity seemed to shift slightly closer to 12:00 as traffic level increased for all except the herbivore after 12:00 graphs. It is possible that this was simply a function of a small dataset, but could also indicate that night time noise and light pollution is driving animals away more than light and noise pollution during the day. More study is certainly needed, as well as real-time traffic loads broken down by day vs. night to get a more accurate picture of what traffic looks like at these culverts.

The trendlines relating to human activity were more aligned with my predictions; though the $P$ values were too large for the correlation to be deemed statistically significant, the trendline direction of the scatterplots (Figures 6 and 7) suggest that animals are shifting their time of peak activity toward 0:00 and 24:00 as human activity level increases. This is consistent with avoidance behavior, which is common when wildlife and humans interact (Markovchick-Nicholls et al 2008, Darnell and Leberg 2018, Muhly et all 2011). This is an area of research worth exploring; the fact that human activity tends to have a negative impact on wildlife is well known, but assessing how human activity impacts animal activity along roadways offers important information about why certain culverts may be effective or ineffective in allowing for the safe passage of wildlife.

The trendlines I found in my data suggest that traffic impacts on wildlife may be more complex than I initially thought; the trends were opposite what I had predicted, and merit further observation. Time of day that traffic peaks may be an important variable, and one worth incorporating into the analysis. Breaking down both traffic data and animal occurrence into finer time scales, as opposed to the hour bins used in this study, could provide clearer insight into the relationship between them. Additionally, more data including culverts with very low traffic levels is needed to obtain a better analysis and more conclusive results. Running analysis using log(AADT), rather than raw AADT, would be another way to further refine the data, and could be more useful with a wider range of AADT values. Finally, gathering enough data to do single-species analysis rather than grouping species together as herbivores and carnivores would add an additional dimension to the analysis, and give species-specific data that could inform how to manage culverts for particular animals. With additional time and resources, these are methods that could be used in future studies on this topic to yield significant results.

Reduction of traffic impacts, however, can and should be undertaken if possible, as it would be beneficial regardless of trend direction with regard to animal activity. Construction of sound walls both to reduce noise pollution and discourage animals from crossing the road are one
such way that action could be taken. The impacts of human activity on wildlife activity that my data suggested could be helpful in more effectively managing culverts. Reducing human presence at culverts will only help wildlife in the area, and encourage them to utilize those crossings and not run across the road. This could be done through fencing at culverts, or placement of new crossings. For example, crossing structures that are placed in ravines or other hard-to-access areas will discourage human use and potentially encourage wildlife to use them. Using methods such as these to make wildlife crossing structures more appealing to animals is especially important for reducing the impact our roads have on the environment while still allowing us to use them for transportation; and continuing to explore the different ways that these roads affect animals is crucial for our understanding of how to improve them.
References


