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A Test of Simple Ledges for Facilitating Mammal Passage through Inundated Culverts

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Abstract

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Culverts under roadways can provide safe crossings for many animal species and are readily available, numbering over 12 million in the United States. In this pre and post construction study, I added a simple wooden ledge to 7 culverts in Saratoga County, New York to investigate their effect on wildlife crossings. A motion sensor camera was used to monitor each culvert for 2 consecutive summers, 2012 summer without a ledge and 2013 with a ledge. Six species of small mammals accounted for the 55 culvert crossings in 2012 and 58 crossings in 2013. The ledges did not increase culvert crossings or species diversity. Raccoons were the only species observed using the ledge, which they did 58% of the time in 2013. Animals appeared to recognize the roads as danger, as we found a nearly significant positive relationship ($p = 0.07$, $r = 0.71$) between traffic volume and crossings.

Introduction

Ecologists worldwide are interested in safeguarding wildlife, while highway departments are trying to carefully accommodate ever-growing traffic needs. Recently some highway departments are approaching roadways with more of an ecological perspective and trying new mitigation measures. Motorists and road crews would like to reduce wildlife collisions, especially deadly ones such as those involving motorcycles or large ungulates. Roads also fragment habitat, leading to small isolated wildlife populations that are more vulnerable to local extinctions. Wildlife mortality, habitat fragmentation, and motorist safety are common issues that have been challenging to wildlife biologists, highway engineers and road users for the past 50 years with still much work to be done (Forman et al. 2003). Vehicle collisions with vertebrates were estimated to be as high as 1 million a day in the United States 15 years ago (LaPoint et al. 2003). This is especially a concern when endangered or threatened species are at risk for collisions. For example, during a reintroduction attempt in the 1990's, 50% of the Canadian Lynx (*Lynx Canadensis*) were killed on the Adirondack Northway (I-87) between Albany, NY and Montreal, QC (LaPoint et al. 2003). In North America, there are an estimated at 1-2 million collisions a year with large mammals alone, costing between 6 and 12 billion dollars (Ament et al 2011). Collisions seem inevitable since there are 4 million miles of public roads and many hundreds of thousands of private. This includes logging roads, ATV roads, driveways, etc. (Foreman et al. 2003). In fact, Jenkins (2002) estimated that there is only one place in the lower 48 where one can get more than 20 miles from a road, in Yellowstone National Park. Roads are said to impact an astonishing 22% of the land in the United States (USGS 2005).

As early as the 1920's people began documenting wildlife fatalities caused by motor vehicles (Foreman et al. 2003). Since 80% of our road system lies in rural areas, the amount of wildlife affected is huge. Large animals are often more noticed but in reference to biomass, small mammals may suffer the most. For some species, their largest source of mortality may be from motor vehicles (Clevenger et al. 2001, Foreman et al. 2003, Glista et al. 2009). In the United States, there are an estimated 720,000 white-tailed deer (*Odocoileus virginianus*)-vehicle collisions per year. This includes over 200 human deaths per year and an average cost of $1,577 per collision in property damage (Foreman et al. 2003). In New York State $350,000 was spent on road-kill clean up in 2006, while New Jersey averaged $750,000 (on just white-tailed deer) when the state stopped collecting and disposing of road-kill in 2006. New Jersey hauls their deer carcasses, depending on level of degradation, to landfills while New York composts theirs to reduce cost and lower environmental impact (Schweber 2007). Several studies have documented unbelievable amounts of road kill. For example, on a Florida road that has since been enhanced with a barrier wall and culverts, the pre-mitigation road kill measured total for 1 year was 2,411 animals in 3.2 km (2mi). At times of high wildlife mortality, the highway actually became slippery, adding to the already present danger of motorists swerving to avoid animal collisions (Dodd et al. 2004).

Highways also cause a negative impact on wildlife by creating a barrier effect, isolating wildlife populations, therefore reducing gene flow (Brudin et al. 2003, Clevenger et al. 2001, Clevenger 2005, Foreman et al. 2003, LaPoint et al. 2003, Meaney et al. 2007, Yanes et al. 1994). However, the permeability of the road as a barrier (and the amount of wildlife mortality) differs greatly depending on many variables including road type (surface, width, etc.), landscape, vehicle speed, species and behaviors unique to those species. Some species are attracted to the micro-habitat of the road such as reptiles wanting to bask. Herbivores such as porcupines (*Erethizon dorsatum*) and moose (*Alces alces*) are often attracted to roads in early spring, lapping up road salt to supplement their sodium deficient diets. On the other side there are species that avoid roadways, particularly large carnivores and some forest rodents, which appear to recognize the danger (Clevenger 2003, Foreman et al. 2003, Sparks and Gates 2012). Seasonality and weather patterns also affect road wildlife mortality. Road-associated pollution (herbicides and road salt) and vehicle exhaust pollution also deter some species, even noise levels can affect many species. This is especially true of grassland songbirds, which often defend their territory with songs that cannot be heard over traffic noise (Clevenger et al. 2001, Foreman 2002, Glista et al. 2009). Road-avoidance behaviors have been documented in a diverse array of species, from snakes to caribou (Clevenger 2003, Foreman 2002, Glista et al. 2009, Meaney et al. 2007). Ecologically these factors are associated with loss of species genetic diversity, gene flow, and species richness, as well as ecosystem and population stability. Because of the many variables involved, assessing highway mitigation effects is very difficult.

The seriousness of the problem has not gone unnoticed and many types of highway passages have been built to safely aid wildlife in crossing, reducing the human, financial and ecological costs of collisions. In North America alone, highway engineers have designed approximately 200 types of highway passages. However, of these passages, few functional designs have been implemented to aid wildlife and rarely has there any follow through on effectiveness, especially long term (Clevenger 2005).

Recently the Western Transportation Institute developed the “Road kill Observation Collection System” (ROCS) for the primary purpose of collecting road kill information (Ament et al. 2011). This software system will allow for identification of specific high road kill areas, where mitigation measures may be most effective. A handheld device also equipped with global positioning system or GPS supports the software. Having a consistent method of obtaining more accurate road kill data and being able to deploy the devices to any organization or group is a great improvement for tracking road kill through time and pinpointing locations needing mitigation.

Most of the 11 mitigation measures commonly used focus on reducing vehicle-large mammal (mainly white-tailed deer) collisions. Unfortunately, the least expensive and most often employed techniques – public awareness, signs, reduced speed, etc. – are the least effective. Wildlife fencing, overpasses and underpasses are expensive but are highly effective at reducing deer-vehicle collisions (Forman et al. 2003). Culverts are tunnels under roadways for water to pass through and allow for drainage from one side to the other. Since they are necessary to the structural stability of the road, they do not require new expenditure. They often provide safe roadway crossing for many species of wildlife, particular smaller wildlife (Clevenger et al. 2001, Glista et al. 2009). In the United States there are as many as 12.5 million culverts averaging 1 every quarter mile (Foreman et al. 2003). Culverts may be inundated year round or be primarily dry except during excessive wet periods or during spring runoff. With a recent push to restore marine ecosystem connectivity, especially allowing for fish to move freely under roads (Januchowski-Hartly et. al. 2013), it is likely more culverts will be inundated with water. Thus it will become more important to have adaptations to allow for dry crossing. When terrestrial animals that are accustomed to using seasonally dry culverts encounter these upgraded, inundated culverts, they might be forced to cross over the road. Climate change may also affect the usefulness of culverts as wildlife crossings. With annual precipitation increasing 10% in the last century throughout much of the world, more culverts will contain water for more of the year (union of concerned scientists 2013). More severe weather events (storms with heavy precipitation) of both long and short duration are also predicted, likely affecting the usefulness of unimproved culverts to wildlife (Foreman et al. 2003).

Culverts, containing water or dry, are common and can provide a vital habitat connection under potentially hazardous roadways for many species of small mammals (Clevenger et al. 2001, Foreman et al. 2003, Meaney et al. 2007). In a Florida study, Dodd et al. (2003) documented 51 vertebrate species using a culvert in conjunction with a barrier fence that guided animals toward the culvert, and road kill was reduced by 94%. In Maryland, 265 culverts were monitored throughout the year and 57 species used the culverts (Sparks and Gates 2012). There is a real need for cost effective mitigations that will make culverts more attractive to wildlife, as well as pre and post construction studies with long-term follow through to assess multifaceted effectiveness (Brudin 2003, Clevenger 2005, Meaney et. al. 2007, Sparks and Gates 2012). My study is based on a simple cost effective culvert alteration thought to aid wildlife safe crossing: a dry ledge within inundated culverts; similar to 2 other studies in Montana and Colorado (Foresman 2004, Meaney et al. 2007). The ledge is a perpendicular appendage to the wall of a culvert, wide enough to allow for small to medium-sized animals to travel on it. A ramp from the dry shore of the stream leading up to the ledge is also provided. Installing these simple, small wooden ledges (rather than creating and installing specialized tunnels for smaller animals) will create a safe, dry wildlife passage, reducing road kill and increasing motorist safety.

Several studies have worked specifically with seasonally inundated culverts to reduce wildlife mortality (Foresman 2004, Dodd et al. 2003 and Meaney et al. 2007). In Montana, 14 species of mammals used a ledge within a culvert to cross under highways and 9 mammal species did the same in Colorado (Foresman 2004, Meaney et al. 2007). The Colorado study (Meaney et al. 2007) hoped to facilitate the safe crossing of the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) by adding dry ledges and ramps to inundated culverts. Their results were promising with 443 individual mammals on the ledge with ramps on and 262 mammals on the ledge without ramps. My study monitored culverts in summer 2012 lacking both ramps and ledges to acquire baseline data for controls. Ledges and ramps were only installed for the treatment period of the study, summer of 2013. This was a significant difference from the design of Meaney et al., since they found that many animals jumped or climbed onto their ledges during the control mode of "ramps off." They also experienced difficulty in collecting data for animals using the floor of the culvert because of the position of the cameras, which were mounted to the sidewall of the culverts.

The Montana study (Foresman 2004) installed two 1.2 m adjacent culverts, one with a ledge, one without. One could assume it not to be cost effective to install 2 culverts side by side. Their culverts were not always inundated and the initial ledges were made out of a much wider, 25-inch metal mesh material, rather than a solid one. Of the 15 species of mammals that used the ledge, many only traveled on the very edge where there was a solid strip of metal. Foresman also used 3 cameras per culvert to ensure accurate data collection (2004). I am investigating improving existing structures to reduce costs rather than installing new structures. In my study the only variable is the presence of ramps and ledges within the same inundated culverts during the same 12 week period in two consecutive years, in an attempt to rule out seasonal differences. This study focused on culverts typically containing water year round, such as small streams and swampy areas, and involved pre and post construction observation periods to truly evaluate the effectiveness of the mitigation measures.

This study design is unique because it has only 1 variable, the ledge with ramp, within the same culvert, accurately indicating if this improvement facilitates small mammal passage. Each culvert is completely unique especially when considering the vegetation and surrounding habitat. A culvert as a wildlife passage is only as good as the habitat it lies within. Due to the importance of these many habitat variables, no culvert can be compared to another as equals (Clevenger et al. 2001, Sparks and Gates 2012, Yanes et al. 1994). I suspected that many small mammals cross roads to avoid swimming or wading through water-containing culverts. I predicted that the diversity of species and the number of crossings would increase once the culverts were equipped with a dry ledge available for wildlife to use via a ramp.

Study area

The culverts used in this study are located in Saratoga County in upstate New York, a humid temperate region. New York State is rich in biodiversity with 3,333 known species of plants and animals, 91 of these being mammals (NYSdec.com 2013). Saratoga County is a mix of rural and suburban areas. Habitat adjacent to the culverts includes swamps and small lakes, deciduous forest streams and farmland. The 3 northern culverts are located in a remote private hunting camp (Omar) with much less human activity/development compared to the 4 southern, suburban culverts (Figure 1). Summer average low and high temperatures are 56 and 80 degrees Fahrenheit and monthly summer rainfall averages 4.1 inches (40 inches annually) (weather.com 2013 and NYSdec.com 2013). I purposely chose culverts with diverse habitats and traffic volume.

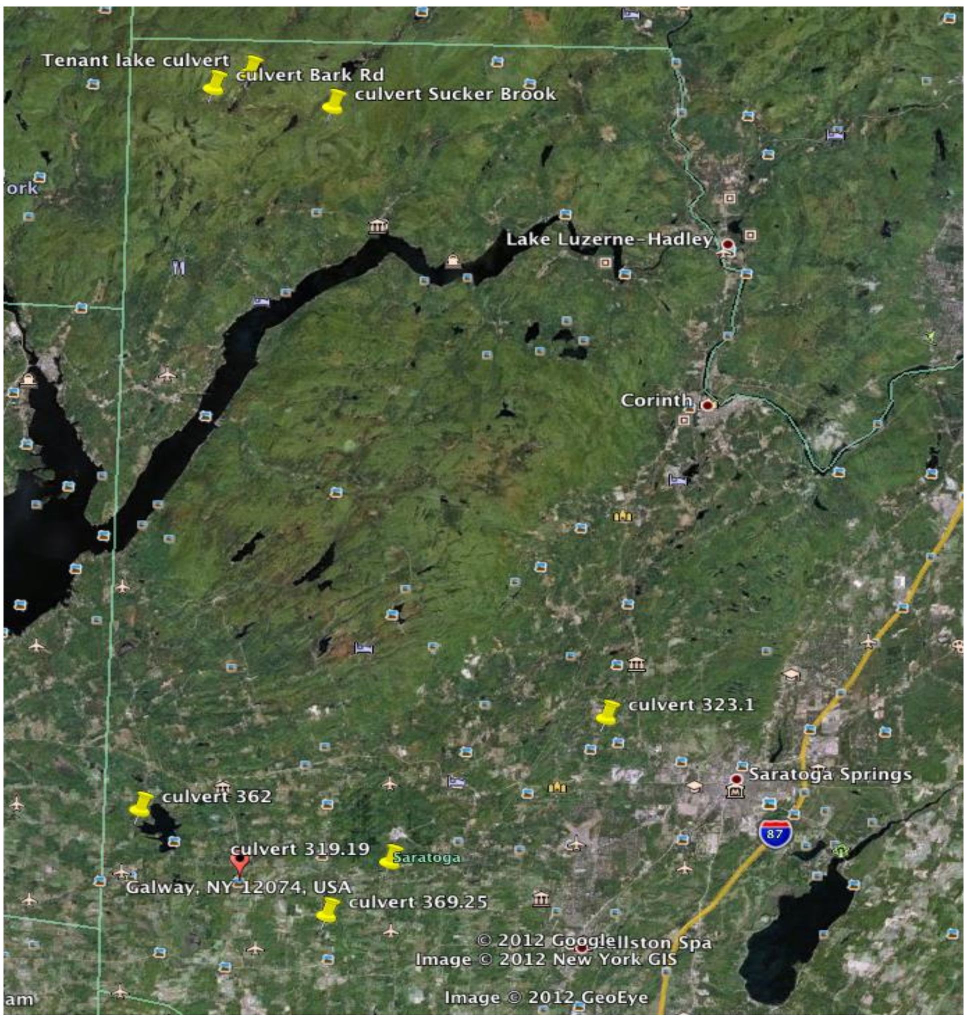

Figure 1. Map of a portion of Saratoga County, New York with the 7 culverts used in this study indicated by pins

Methods

Using a map of all the culverts in Saratoga County, approximately 90 culverts were investigated and 8 were chosen for study (see Figure 1 for locations). One culvert was eliminated because of human tampering. Culverts were selected based on size (approximately 4-6 feet in diameter), location, degree of inundation during typically drier summer months, amount of vegetative cover (most studies show animals require cover; Brudin 2003, Clevenger et al. 2001, Foreman et al. 2003,Foresman 2004, Glista et al. 2009, Sparks and Gates 2012, Yanes et al. 1994), accessibility (lack of poison ivy and impassable terrain) and availability of camera mounting sites. Game cameras have been reported to be an effective method for recording most species (Foresman 2004, Meaney et al. 2007, Sparks and Gates 2012). One Reconyx Hyperfire™ HC 500 Trail Camera was installed at each culvert between mid-June and July 5th 2012 using default trail settings to collect baseline data. The default settings are: high sensitivity, 3 pictures per trigger, 1 second interval between pictures, and no delay between triggers. The delay between triggers was later adjusted to a 1 minute and number of pictures per trigger changed to 5. Cameras were checked for pictures and proper function on a roughly biweekly basis for over 12 weeks to obtain baseline data. Each crossing was recorded and species was identified when possible. Raccoon families spending hours in the culvert hunting were considered as one crossing.

The ledges and ramps were made of half inch weathered plywood ripped into 5½-inch widths. Ideally cedar planks could be used, but the short duration of this experiment did not justify the cost. The plywood ledges and ramps were attached end to end using 2”x4”x18” support blocks. During the months of May and June 2013 the support blocks were mounted to the inside wall of the culvert just above the high water mark using screws or epoxy (Liquid Nails) depending on location and culvert material (I used screws in private culverts and Liquid Nails in county-owned culverts, as requested by the county). The blocks were also duct taped (Gorilla Tape) to allow time for the adhesive to dry. Once the support blocks adhered, the ledges and access ramps were attached end to end with screws into support block (see Figure 2). The ramps were positioned to allow animals to access the ledges from dry land. Cat food was placed on ramps and ledges just once to encourage acclimation. During the last week in June 2013, after a month acclimation period, the cameras were installed for the same 12 week period in the same locations. Screwing the brackets into trees and/or wooden stakes helped eliminate some camera positioning issues. Culverts and cameras were checked on a roughly biweekly basis to collect data, remove vegetation in front of camera, ensure ledge and ramp stability and make sure cameras were functioning properly.

Figure 2. Ledge (5½" wide) with support blocks installed in Sucker Brook culvert, Edinburgh, NY. Also represents atypical flash flood June 2013.

Results

All together approximately 21,256 pictures were analyzed, 17,678 in the 2012 season and 3,578 pictures in 2013 season. The difference in the number of pictures, in 2012 and 2013, is indicative of the learning curve involved with camera use. Moving vegetation was really a problem, but removing too much of it can be disruptive to the animals. In addition, some animal activity can cause excessive numbers of photos; on 2 nights a raccoon family foraging/playing in a culvert resulted in 2700 pictures. Species photographed included humans, black bear (*Ursus americanus*), white-tailed deer (*Odocoileus virginianus*), great blue heron (*Ardea Herodias*), eastern chipmunk (*Tamias striatus*), raccoon (*Procyon lotor*), mink (*Neovison* (or *Mustela*) *vison*), muskrat (*Ondatra zibethicus*), woodchuck (*Marmota monax*) , domestic cats (*Felis catus*), eastern gray squirrel (*Sciurus carolinensis*), red squirrel (*Sciurus vulgaris*), river otter (*Lontra canadensis*), Canada geese (*Branta canadensis*), eastern cottontail (*Sylvilagus floridanus*), and several other species of passerine birds. Several species that were observed had nothing to do with the culvert – cats, woodchucks, and bears and thus were not included in crossing

Figure 3. Raccoon using ledge in culvert #369.25 Jockey St, Galway, NY.

data. All birds, such as geese and herons, were also excluded. Finally, the only beavers observed were damming one of the culverts and therefore were excluded. The crossing species were then narrowed down to raccoons, otters, muskrats, mink, squirrels and chipmunks.

A crossing was counted as one despite how many individuals were present. For example, mothers and kits that were photographed hunting in the culvert for a 20 minute period were considered 1 crossing. There were 55 crossings in 2012 and 58 crossings in 2013. Raccoons were the only mammals actually photographed on the ledge (Figure 3). There were 47 raccoon crossings in 2012 and 41 in 2013. However, out of 41 raccoon crossings in 2013, 24 were on the ledge (58%). The ledges did not increase the number of crossings nor did they increase crossing species diversity.

Table 1. Dimension of each of the 7 culverts, constructed material, average water level, ledge use in 2013 and average traffic volume in cars per day for 2011.

Culvert	**dimen-sions**	**material**	**avg water depth**	**ledge use (2013)**	**traffic vol (cars/day 2011)**
Omar - tenant lake	10'Wx4'Hx20'L	concrete	5"	0	~10
Omar - bark rd	8'Wx6'Hx42'L	corrugated metal	9.5"	0	~10
Omar - sucker brook	6'5"Wx5'Hx38'L	corrugated metal	4"	0	~10
#323.10 middle grove	9'9"Wx6'7"Hx81'L*	corrugated metal	5.2" *	Unclear	3927 *
#362 crooked	4'Wx4'Hx51'L *	corrugated metal	2" *	20	726 *
#319.19 golf course	5'Wx5'Hx64'L *	corrugated metal	4" *	1	2422 *
#369.25 jockey	4'Wx4'Hx56'L *	plastic	3" *	3	955 *

*Information provided by Saratoga County Highway Department.

Table 1 summarizes the details of the 7 individual culverts used. Of particular importance is differentiation between the first 3 culverts located in a northern remote private hunting camp (Omar) and the last 4 culverts, owned by Saratoga County. Generally the Omar culverts are shorter, have very low traffic volume and dirt roads. I estimated cars at 10 per day for occasional logging and hunting activity.

Flash flooding was a challenge in June 2013 and prompted research into precipitation amounts. The amount of rainfall was obtained from the nearest, consistent National Weather Station in Albany (approx. 30 miles south of culverts). Monthly rainfall was compared to total monthly crossings in seven culverts. A non-significant negative relationship was found (p=0.18, r=0.62; Figure 4).

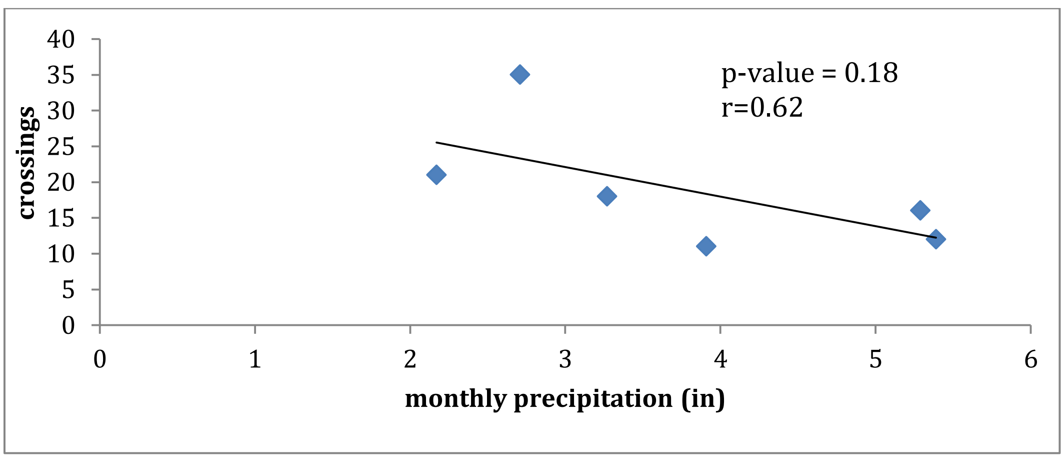

Figure 4. Total monthly crossings from 2012 and 2013 in 7 culverts plotted against monthly precipitation.

Traffic patterns were also investigated and correlated to total crossings for 2012 and 2013 combined in each of the 7 culverts. The analysis found a nearly significant positive correlation between crossings and traffic volume (p=0.07, r=0.71; Figure 5). It should be noted that ledges were only used in crossings in the southern 4 culverts, where traffic volume was the highest.

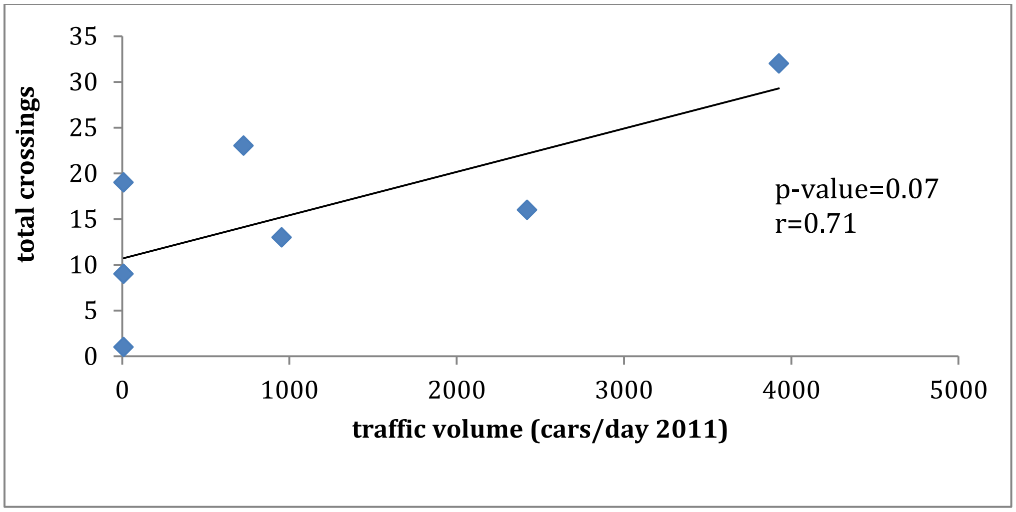

Figure 5. Total crossings for 7 culverts in 24 weeks for summers 2012 and 2013 plotted against traffic volume data from 2011 in cars per day.

Discussion

The results from this short duration study show that ledges did not increase the number of species using the culverts as passages as predicted. Nor did the number of crossings increase. However, Clevenger (2003, 2005) recommended 4 years as the ideal time necessary for acclimation and suggested that studies less than 2 years were insufficient for wildlife to adapt to mitigations. In hindsight, it would likely take a very long acclimation period to lure in non-stream foraging species, such as grey fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), etc. Human activity also hinders the acclimation process, so much so that in some cases of consistent human activity, animals will not use the culverts or underpasses at all (Clevenger 2003, LaPoint 2003). In addition to my activity in all culverts, cameras documented other human activity in 4 out of the 7 culverts. While animals are clearly using the ledge (Figure 3) despite the narrow acclimation window and common human activity, a lengthier study would be ideal. However, 58% of the raccoon crossings in 2013 were on the ledge indicating some species do not need a long acclimation period. This could be because of the raccoon's naturally adaptive behavior and/or comfort level around humans and frequent use of stream corridors.

We suspected that the unusual flash flooding in June 2013 might have had an impact on culvert use. This is supported by the negative relationship between precipitation and the number of crossings. It is not surprising that when water is readily available or streams are high, animals would be less likely to forage in stream corridors and therefore would not use culverts. Dodd et al. (2004) suggested experiments could be conducted in the lab where environmental factors (precipitation, temperature, water level) and traffic volume and noise could be controlled. Obviously, natural wildlife movement cannot be duplicated in a lab scenario, but maybe experiments for specific culvert characteristics could be conducted on a small scale, such as allowing mice to choose a type of culvert material or different sized ledges. Since accuracy in collecting data, reproducibility and validity in testing mitigations is very difficult in the field, some small-scale lab experiments could add some insight. Improvements in all these areas are necessary and could be enhanced with lab work.

Most agree that the most important attribute when assessing highway mitigations is location – surrounding habitat (Foresman 2004, Glista et al. 2009, Yanes et al. 1995). A mitigation to improve animal crossings is only as good as the habitat it lies within. After location, many other factors can affect wildlife using culverts as safe passages. Clevenger et al. (2001) found that road and landscape characteristics are more important factors when determining culvert use than actual culvert characteristics. Secondly physical elements, like road width and water depth are also important features when evaluating crossings (Clevenger 2005). When designing mitigations, we must realize there is no one size fits all solution. It is easy to design crossing structures or adaptations to existing underpasses with a single species in mind, but focus really needs to be on maintaining species diversity and habitat connectivity (Clevenger 2005). For example, sometimes culverts are combined with barricades to prevent wildlife from crossing roads, in these cases the culvert or underpass will have to be large enough to accommodate all species. However, this may make the crossing less effective for small species. These are some of the reasons why designing effective mitigations are so difficult and long-term study is vital. Care needs to be taken so that mitigation measures do not cause unintended detrimental ecological changes.

Even if the ledges did increase wildlife crossings within the culvert, therefore reducing road kill, one must consider at what cost. Many birds and bats roost and/or raise young in medium sized culverts. If a ledge is high enough, it could place the nests or bats in danger. Meaney et al. (2007) even equipped their study culverts with netting to deter birds from using the culverts during the latter part of their study. They suggested that the use of the netting in their second season was the reason for the observed increase in small mammal activity in that year, but it may have simply been due to the longer acclimation time (Clevenger 2003, 2005). Again, this is another example of why mitigations cannot be developed with a single target species in mind. We need to take an ecological, broad, bio-diverse approach to facilitating wildlife passage under our roadways.

From my small sample size, it appears that the animals are recognizing roads as hazards; Figure 5 shows a nearly significant positive relationship ($p = 0.07$, $r = 0.71$) between traffic volume and the number of crossings. This is in agreement with

Clevenger et al. (2001) who that reported higher traffic volume led to increased culvert use by pine martens (*Martes americana*), snowshoe hares (*Lepus americanus*) and red squirrels in Banff National Park, Alberta, Canada. Further evidence that the animals recognize the roads as hazards is the total lack of ledge use in the extremely low traffic sites in this study (Table 1). Although it should be noted that the road surfaces in Omar are dirt, a natural habitat, versus the more foreign pavement of southern/suburban culverts. This could impact the animals' tendency to cross the over the roads more readily. Clevenger et al. (2001) also reported that traffic noise deterred some species (coyotes (*Canis latrans*), snowshoe hares and red squirrels) from using culverts. Traffic noise does not necessarily coincide with traffic volume. For example, a high number of passenger cars may make less noise than many fewer heavy trucks, and vehicle speed can also impact noise level. I did not measure traffic noise, but that could also be affecting our culvert usage or road avoidance. Omar's large logging trucks, though few, could be extremely loud. It should be noted that even when the Omar sites are removed, there is still a non-significant positive relationship ($r = 0.66$) between traffic volume and the number of crossings. My results indicate animals are more likely to use culverts to cross under roads with higher traffic volume.

My count of ledge use (24 instances in total) is likely an underestimate since less than 20% of the length of the ledges was visible in the field of view of the cameras. Often a photo revealed an animal moving in the direction of the ledge, but it was unclear if it actually got on the ledge. It is very possible that animals could have used some parts of the ledge where the water was deeper or where the crossing was particularly hazardous. For example, in one culvert there were many rocks near the camera but very few at the far end of the culvert so it was impossible to know if the animals used the ledge at some point to navigate the half without rocks to aid in a dry crossing. It would be beneficial to construct lockable brackets to mount to the ceilings of the culverts to allow surveillance of the entire ledge. The use of multiple cameras per culvert, as done by Foresman (2004), might be beneficial as well. I cannot be sure that we did not miss animals crossing, but confidence could increase with additional cameras and/or ceiling mounting hardware.

I would have liked to investigate some culverts where road fencing guides animals toward using culverts. Glista et al. (2009) and Dodd et al. (2004) recommend using culverts and fencing to reduce wildlife mortality. A rare pre and post construction study in Florida mentioned earlier (Dodd et al. 2004) did reduce road kill by 93% on a stretch of road mitigated with culverts and fencing. It would also be interesting to monitor a few culverts with built-in ledges. Some culverts I encountered in Saratoga County had ledges similar to the ecoculverts used in Europe (Figure 6;Meaney et al. 2007). If these ledges are effective in preventing road-kill, a widespread adoption of this type of culvert could reduce wildlife mortality dramatically.

Figure 6. Example of European "ecoculverts" with built in ledge.
http://hansonprecast.co.uk/culverts/design-specification/

Finally, it seems that ledges might be utilized more in cold weather when water temperatures drop. I elected to conduct my study in the summer when, according to a yearlong study by Yanes et al. (1994) in Spain, the most culvert crossings occur. Meaney et al. (2007) also conducted their study over 2 summers. Logistical considerations including: proper camera function, winter hibernation for many species, and attempts to avoid heavy spring run off, all made summer field research more appealing. This study really could and should be expanded to include all seasons and several years of data collection to allow for acclimation and investigate seasonal differences.

I chose this study because there is a real need for pre and post construction studies on mitigations to improve safe animal passage. Adaptations to existing culverts can be much more cost effective than construction of large wildlife underpasses. This simple experiment has provided the groundwork for future mitigation study. The union forming between ecologists and transportation engineers is a step in the right direction in attempts at restoring habitat connectivity and reducing vehicle-wildlife collisions.

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