Stream fragmentation and infrastructure condition in the Great Plains

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Background

Rivers and streams within the Great Plains have undergone extensive levels of fragmentation by road culverts, which has led to habitat loss, degraded water quality, and a loss of aquatic biodiversity (Palmer et al. 2007, Perkins et al 2015). There is a pressing need to retrofit the most problematic structures to ensure aquatic organism passage. At the same time, a vast majority of road-stream crossing infrastructure is past its projected lifespan, and large investments are needed to keep this transportation infrastructure functional and safe (ASCE, 2013). Furthermore, by collecting information about the size and construction material of road stream crossings managers can make more accurate estimations on the cost of removing or restoring a barrier (Neeson et al. 2015). Currently In the Great Plains decision makers are lacking information about the condition and location of barriers. Historically, these two problems have been addressed separately. By identifying locations that are in need of repair for both of these parameters managers can pool their funds and restore more sites than previous operations.

Objective

The objective of this study is to identify road stream crossings that are both fragmenting river networks and in poor condition as transportation infrastructure. These crossings are high-priority locations where culvert replacement would have high ecosystem benefit and enhance the condition of transportation infrastructure with a high risk of failure.

Methods

At each location we measured / assessed

- road type and condition
- barrier type and condition
- barrier dimensions
- stream dimensions
- barrier and stream gradients
- barrier outlet drop
- stream outlet velocity
- passability

Ecological Impact

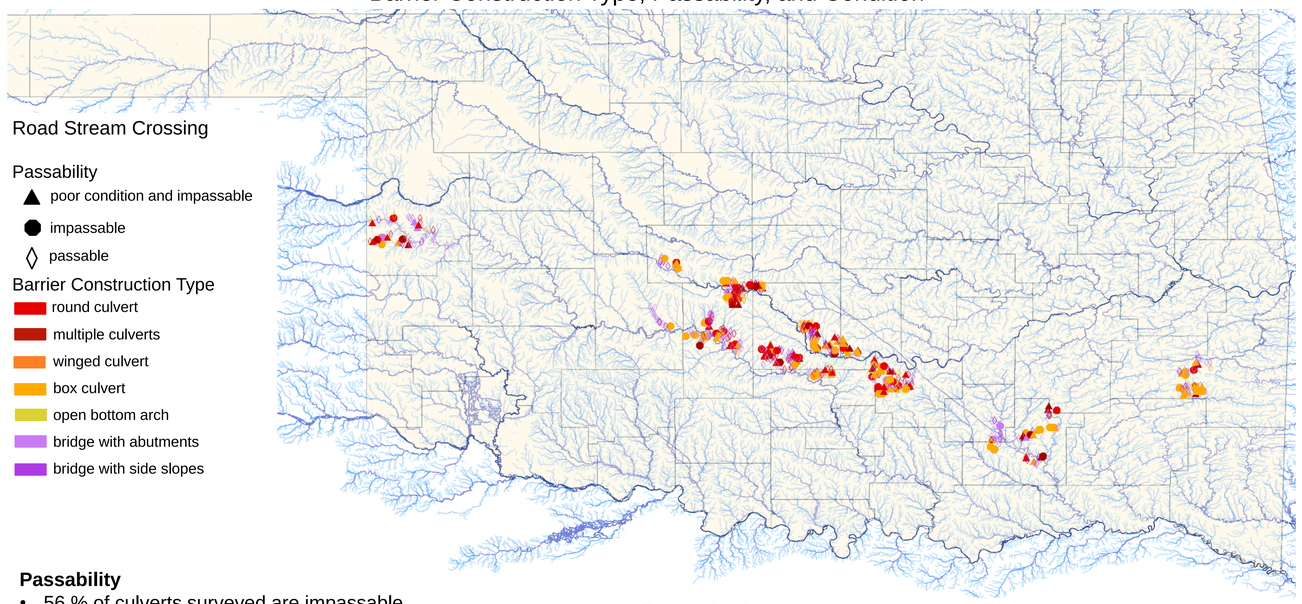
- distance to neighboring barriers
- passability and outlet drop
- stream depth vs. barrier depth

Infrastructure State

- barrier and road condition
- barrier width vs. bankfull width
- traffic density

Results

Barrier Construction Type, Passability, and Condition



Passability

- 56 % of culverts surveyed are impassable
- 57% of box culverts surveyed are impassable
- < 3% of bridges surveyed are impassable

Infrastructure Condition

- 53% of culverts have a low condition rating
- 39% of box culverts have a low condition rating
- 33% of bridges have a low condition rating

Overlap

- 15% of all barriers are both impassable and have a low condition

Figure 1. Map showing the location of 716 road stream crossings surveyed. Locations are separated by barrier construction type using color, and passability by shape. Condition is only shown for barriers that are in poor condition and impassable and indicated by triangles.

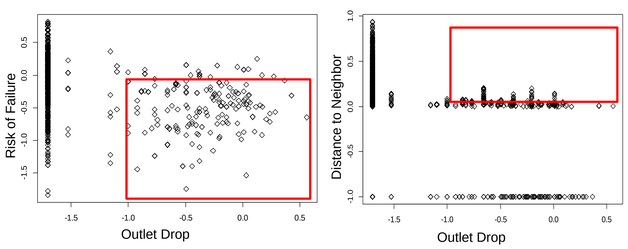


Figure 3. Areas within the red box of this plot are structures that are both impassible to aquatic life and at a high risk of failure

Figure 4. Areas within the red box of this plot are structures that are both impassible to aquatic life and have a neighboring barrier upstream

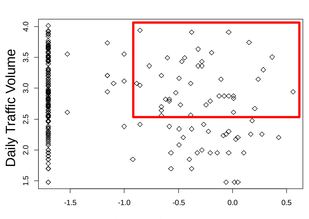


Figure 5. Areas within the red box of this plot are structures that are both impassible to aquatic life and have more than 500 vehicles a day traverse them

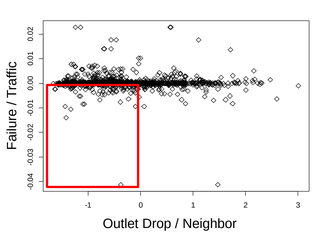


Figure 6. Areas within the red box of this plot are structures that are: impassable to fish, have a neighboring barrier upstream, at a high risk of failure, and have a high traffic volume

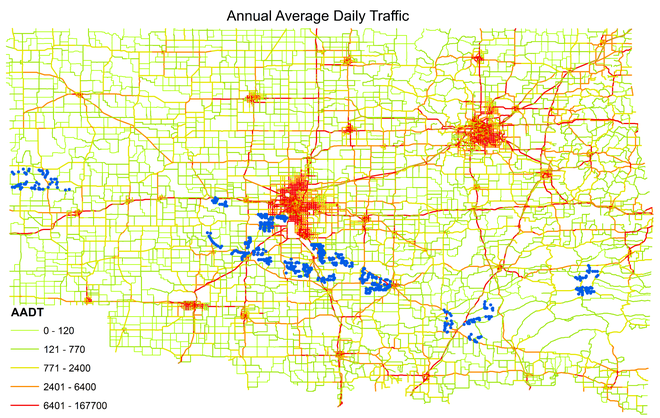


Figure 8. Map showing the average annual average daily traffic for primary roads

Discussion

We find that over 100 of the 716 culverts surveyed (15% of total) are both in poor condition and fragmenting the river network. With an approximated 187,000 road stream crossings in Oklahoma, it can be estimated that there currently are over 28,000 barriers that are in poor condition and unpassable to aquatic life. With so many potential locations in need of restoration it is essential that conservation and road way managers begin to collaborate and prioritize which restoration projects are completed. Collaboration in this manner will allow for maximum amounts of habitat gain and infrastructure repair.

Future Work

Future plans of work include creating indices for rating both a barrier's ecological impact and state as infrastructure. These indices will weigh factors presented here and help to both identify and prioritize locations in need of restoration. Currently we have only identified locations in need of restoration, but it is unfeasible to repair all of these locations. Traffic volume, and the distance to neighboring barriers will be used to help prioritize restoration projects. By identifying and prioritizing restoration projects conservation and road way managers can implement a cost sharing approach. This will allow for maximum amounts of habitat and infrastructure to be restored on a given budget.

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