Assessing the Impact of Anthropogenic Habitat Fragmentation and Area Downsizing on the Environmental Functionality of Marion County Lake and Park.

To: Shawn Hutchinson and the Marion County Park and Lake Officials

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Abstract

Roads and trails have been linked to causing habitat fragmentation and other harmful side effects of ecosystems. With the number of roads increasing globally, it is paramount to study the negative impacts of anthropogenic habitat fragmentation. In this study of Marion County Lake and Park, aerial image analysis of impervious roads in conjunction with *in situ* data collection using a transect survey method were used to identify habitat fragmentation on a local scale. The goal of this study was to identify areas harmed by habitat fragmentation, in order to give recommendations for a lake management plan for Marion County Park. Results and implementation of this research were limited due to COVID-19, however, this research demonstrated the effectiveness of a transect approach to collect various indexes. Further analysis identified 48 different patches ranging from 38m^2 to 145300m^2 and concluded that 16 percent of the land area of Marion County Park and Lake is covered by roads.

Introduction

With a growing population and development occurring globally, the number of roads worldwide are increasing. Roads can cause fragmentation of habitats and detrimental consequences to ecosystems. Developing previously remote land areas and opening them up to land-use changes can cause threats to biodiversity. By some estimates, the length of roads are projected to increase by over sixty percent globally from 2010 to 2050 (Ibisch et al. 2016). Although this phenomenon is usually looked at on a global scale, the effects can be just as damaging at a small-scale such as Marion County Lake and Park. Regardless of increasing scientific evidence of the negative impacts of roads on ecosystems, the current conservation policy frameworks have largely ignored threats of road expansion. Better understanding the impacts of habitat fragmentation due to road development will be a crucial element in protecting biodiversity worldwide.

With outdoor recreational opportunities becoming more accessible and popular, parks especially are designing or altering their sites to accommodate this rise in activity. Largely this means adding in networks of roads and trails to allow access of vehicles and hikers to these places along with the construction of facilities. There are certainly benefits of increasing recreational development. However, the process of adding roads, trails and facilities often comes with a cost. To better analyze the effects of recreation on natural ecosystems, this research examined anthropogenic impacts of Marion County lake by analyzing the physical effects of fragmentation and the potential effects roads would have on the adjacent soil and vegetation in regards to: soil compaction, vegetation richness (soil cover), soil organic carbon, and water retention.

Habitat fragmentation is defined as the process during which a large expanse of habitat is transformed into a number of smaller patches of smaller total area isolated and unlike the original (Fahrig, 2003). The main concerns with this type of degradation is the loss of habitat, which in turn leads to the decline of biodiversity. Ecosystems and wildlife are having to adjust to higher rates of urbanization. However, there are more highways, roads, and trails being implemented in areas that used to be rural. These roads are having detrimental effects on nearby ecosystems. Gravel trails and roads, which is the material used in Marion County Park for side roads and more increases soil organic carbon and can have many other lasting effects on soil properties (Qin et al., 2014). Also, as more houses and development opens up near the park and lake, more conventional roads will be implemented. Conventional roads can increase pH and decrease soil moisture, salinity, and bulk density (Fang et al. 2012). These changes in the soil can cause halophytes (salt loving plants) to only be able to grow far away from roads. As mentioned before, there are some benefits to trails and roads, but there are impactful negatives that can hurt the aesthetic appeal and the overall ecosystem of an area.

Focusing on the park and lake, some of the drawbacks of road construction and amenities are aesthetic deterioration, impact on wildlife/vegetation cover, and possibility of soil/bank erosion. However, there are also some positives that come with these networks of roads. Accessibility to areas in the park and around the lake, increased campsites, picnicking spots, and fishing docks are all features that have to be taken into account. By assessing the costs/benefits of recreational development on habitat fragmentation, more comprehensive management plans can be constructed, including Marion County Park and Lake.

Materials and Methods

Marion County Park and Lake is near the center of Kansas and an hour south of Manhattan, KS (38°18′54″N 96°59′31″W). The park and lake encompasses about 300 acres of land. The lake accounts for a little over half of the 300 acres with depths as large as 40 feet. The park and lake were officially opened to the public in 1940 and now about 275 homes and cottages have been built around the lake. There are also four miles of asphalt roads with many gravel roads (gravel is AB-3 which is crushed limestone) that lead to camping grounds or other parts of the park. The lake functions as a boating, sail boating, swimming, fishing, and scuba diving lake. The park has many areas for camping, bird watching, and picnicking. In 2012, Marion County Park and Lake actually achieved the record for the most people roasting marshmallows simultaneously. Marion Lake and Park consists of 153 acres of waterfront. Construction of the dam was completed in 1937, with the park opening shortly after on May 26th 1940. A majority of the Dam and other facilities were built by the Civilian Conservation Corps (CCC). Part of the significance of Marion County Lake and Park is due to it being listed on the National Register of Historic Places.

Figure 1. Overhead image of people roasting marshmallows at Marion County Park and Lake (Marion County Park and Lake, 2012).

Figure 2. Marion County Park and Lake view (Travel Kansas)

The first step of this project consisted of quantifying the fragmented land patches within the park by labeling a high resolution satellite image with the Matlab (Mathworks, Natick, MA) Image Labeler software. There are 48 patches that were mapped for Marion County Park. The satellite image was obtained from Google Earth and had a size of 4800 $\times$ 2886 pixels. Patches between roads were extracted using Matlab Quantifying changes in patch metrics over time could be a useful indicator of biodiversity changes in fragmented landscapes. Spatial attributes of patches affected by habitat loss and fragmentation over extended time-periods can use methods involving, aerial image acquisition and processing, classification of land cover classes and quantification over land cover loss, quantification of grassland fragmentation, and influence of roads on edge effects of fragmented grassland patches (Niemandt et al, 2016).

Figure 3. Aerial image of Marion County Lake and Park (Google Earth Pro).

In this study, the divisions of patches were then classified into pervious and impervious roads. In this study, pervious roads were designated as roads that are porous and allow for water to penetrate through. These were the smaller gravel roads which branched off from the main blacktop road. The larger paved roads constructed of asphalt were designated as impervious roads. The entire waterbody of Marion Lake was labeled, and finally, docks were labeled and accounted for. This was an important step as it seemed that most of the impervious network of roads lead to areas nearby docks. Labeling this into separate categories gives a better understanding of the number, size, and shape of fragmented areas.

After analyzing the different characteristics of Marion County Park and lake, *in situ* data collection was necessary to determine the direct impacts of impervious roads on different patches. In many studies, transect surveys are sufficient to juxtapose soil characteristics and vegetation cover across patches with rapid change/gradients from the middle of the road to the center of the patch (Bhandari, 2018). Starting at 0m, a sample was collected every 3ft until 15ft distant from the initial sample. After 15ft, samples were collected every 10ft until the final sample at 55ft from the center of the road was collected. At each sampling section, 3 measurements for various functionality indexes were recorded.

Various functionality indexes were measured at each patch including soil compaction, soil temperature, and vegetation cover. In the first site visit, the team was unsuccessful in finding the slope of the patches. However, slope would be an important functionality index to consider. Soil compaction was measured using a penetrometer at varying distances starting at the edge of the patch (closest to the road) and working towards the middle of the patch. In the same fashion, soil temperature was measured using a thermometer, soil moisture using a digital meter, and vegetation cover was measured using pictures along with the *Canopeo* mobile app. The goal of this was to determine how the patch size affected these indexes, and to see if the presence of a road had any effect on the patch itself. Data from these results could then be plotted on a 'X' 'Y' axis graph to show how these indexes change when getting closer to the middle of the patch and further from the road or vice versa. Further description of each component measured is listed below.

Index Components

Vegetation cover: Downward-facing digital images were taken using a self-designed PVC pipe camera stand to quantify the fraction of live green vegetation. A camera was placed on the center of the contraption so that all measurements were the same. It was planned to analyze the images of different transects using the *Canapeo* app, but further analysis was prevented due to COVID-19.

Soil organic carbon/Bulk density: A soil core sampler was used to collect undisturbed soil from three spread out points in the transect. The sampler penetrated the ground a few inches across each sample using a surface soil sampler with a 100 cubic centimeter ring (Eijekkamp, Geisbeek, The Netherlands). Afterwards, soil can be sent to a soil fertility lab to measure soil organic carbon, and bulk density.

Soil compaction: A Humboldt handheld digital soil penetrometer was used to measure 3 observations at 9 different distances of a single patch to measure subsurface soil compaction in

PSI. Penetrometer readings can indicate soil quality and potential issues with runoff/erosion and was measured in kg/c^2.

Soil temperature: Soil temperature was measured 3 times per 9 different points along the transect of the patch using a standard thermometer in units of Celsius.

Soil moisture: A Hydrosense II hand-held soil water reflectometer was used 3 times per 9 different transect points (Campbell Scientific, Logan UT). This raw variable should be converted into volumetric soil water content using a calibration equation, which was not developed for this study.

Patch: 1
Date: 2/29/20

Latitude: N38.32581
Longitude: W96.97919

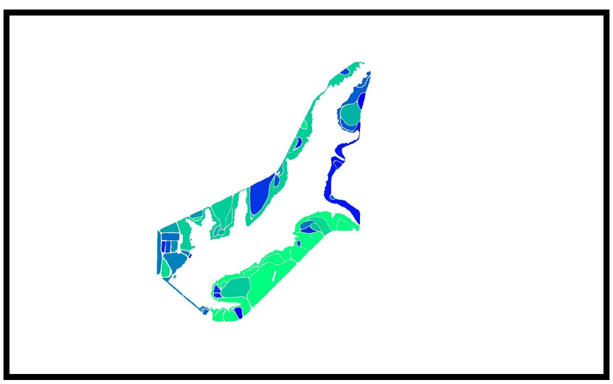
D from road	PR1	PR2	PR3	P1	P2	P3	ST1	ST2	ST3
0	25								
3	25								
6	25								
9	25								
12	7	12	12	1.648	1.619	1.625	4.3	4.3	4.3
15	12	9	7	1.587	1.627	1.632	4.4		
25	7	7	9	1.632	1.483	1.581	3.9	3.8	3.8
35	7	7	8	1.667	1.629	1.649	3.8		
45	7	7	8	1.674	1.656	1.654	4.5	4.5	
55	8	8	6	1.625	1.632	1.65			
Edge	8	8	6	1.702	1.689	1.694			
Tallgrass	8	8	7	1.712	1.706	1.718			
Tall	6	10	8	1.788	1.747	1.741	3.4	3.3	

Figure 4. Initial index recordings from pilot program. PR stands for penetration resistance in kg/cm^2, P for periods in microseconds (soil moisture) and ST stands for soil temperature in degrees C.

Results and Discussion

Due to the COVID-19 pandemic, this project was unable to move past the initial pilot stage and post-survey analysis was limited. It is difficult to predict data trends based off of the limited data collected but if this project is repeated in the future, a transect survey method is an effective way to measure various indexes of different patches at Marion County. Due to environmental conditions, soil properties, and vegetation growth patterns, it is recommended that this data be collected in the late spring or fall. In-depth analysis and classification of patches in Marion County Lake and Park would also be important to identify before field work. An introductory analysis of the park is included in this discussion.

The following maps shown in Figure 4 and 5 indicate the first part of the project which included mapping the park and lake. The first two maps include the entire park boundary with the lake, with different types of land being indicated with different colors. The map coordinates from the NE corner are 38.331580, -96.962092 and 38.312289, -97.003107 in the SW corner. The map area from the North-South distance are 2140 meters, and 3600 meters from the East-West distance, totalling 7,70400 squared meters (7.7 km^2). 48 different patches can be identified from the maps. The smallest patch shown is 38m^2 while the largest patch shown is 145300m^2.



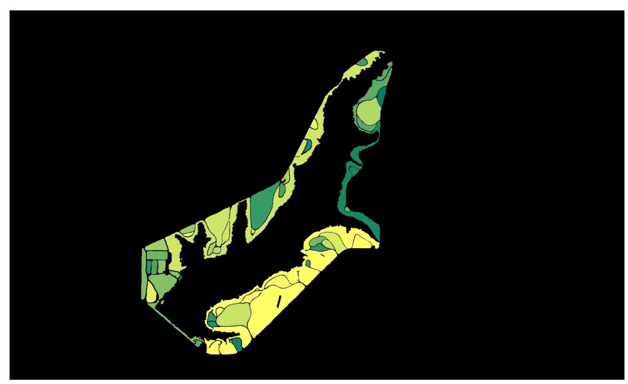


Figure 5. and Figure 6. Labeled Patches of Marion County Park and Lake

The following maps labeled Figure 6 depict areas that are important information for the project to move forward. These maps include: impervious roads, pervious roads, all roads, lake area, buildings, and docks. Important findings from the original image show that the pervious road area is 51,114 and the impervious road area is 38,863. Further analysis showed that 16 percent of the land area of Marion County Park and Lake is covered by roads. Knowing the proportion of roads to total land area is important to consider for future development, and remediation techniques.

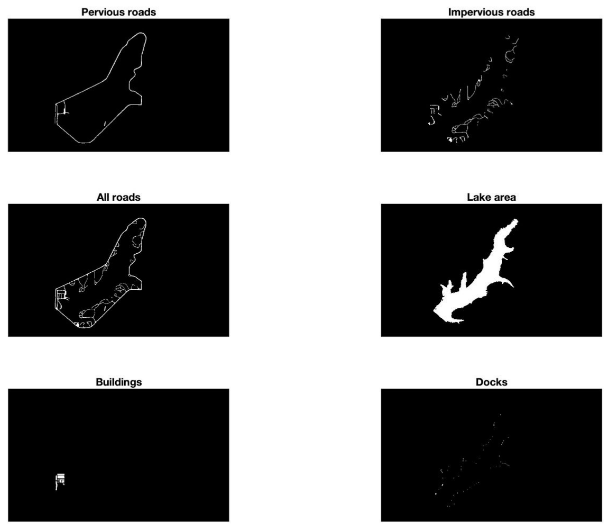


Figure 6. Classified Subplots of Marion County Lake

Although data collection was limited, the transect survey approach to collect data on various patches can be an effective way to measure the impact of habitat fragmentation on soil composition, and vegetation cover. Classification of roads from aerial images is another beneficial way to determine patch sizes before conducting an *in situ* study, and identifying different patch areas to sample. In the future, these methods can be used as a template to move forward in the investigation of habitat fragmentation caused by roads at Marion County Lake and Park.

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