Marion County Lake: Assessing the effects of changing climate and land cover

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Introduction

Marion County Lake was completed in 1937 by the Civilian Conservation Corps. The primary purpose of the lake, then and now, is for recreation. Recreation at Marion County Lake includes fishing, swimming, and watersports. In 2002, Marion County Lake was listed on the registrar of National Register of Historic Places (NRHP).[1]

The officials at Marion County Lake seek to establish a management strategy for Marion County Lake and its surrounding watershed. The primary use of Marion County Lake is recreation based. With that in mind, this work will seek to establish the foundation of a lake management plan to be written for managing the lake for the purpose of maintaining recreation capabilities. To be discussed are the principles of lake management plans, the potential effects climate change will have on Marion County Lake and what management strategies need to be employed, and the effects that changes in land cover will have on the lake - all in terms of the recreation potential of the lake.

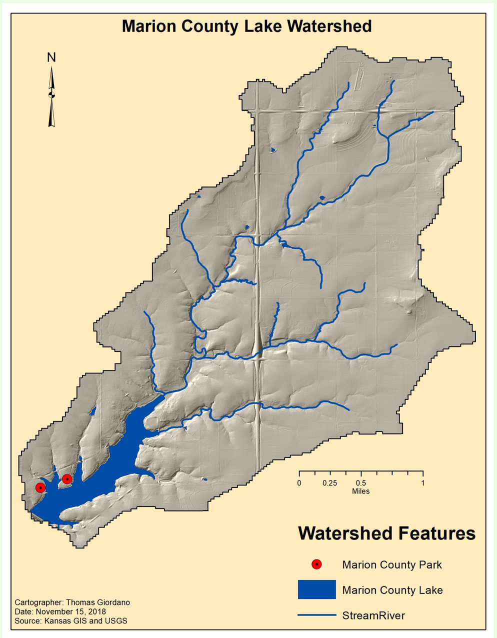

Figure 1. Map of watershed including Marion County Lake

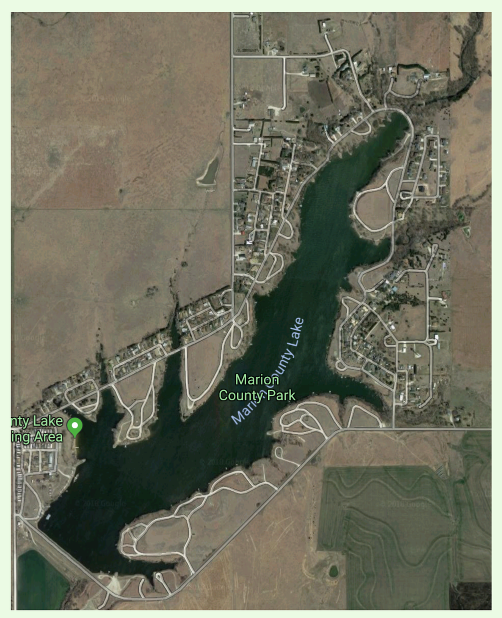

Figure 2. Google Earth imagery of Marion County Lake

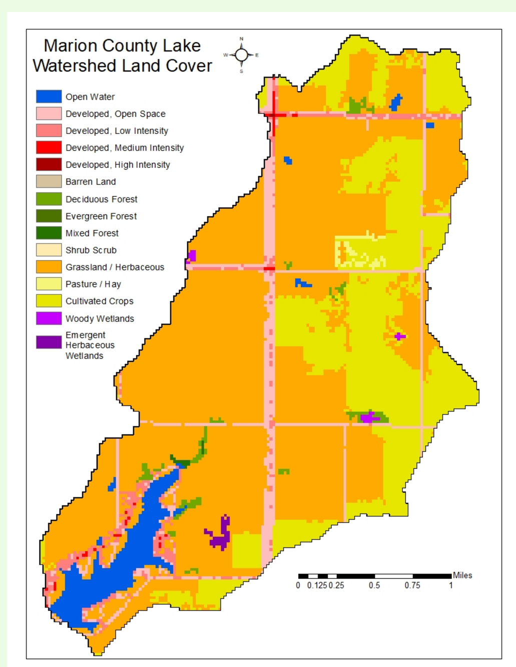

Figure 3. Map of Land Cover of Marion County Lake

Research Objective

Managing Marion County Lake for the volume of water in the lake and the quality of the lake water will be of highest importance. Changes in both climate and land cover are the focus of this report. A 35-year review of daily temperatures and precipitation volumes taken from NOAA at Marion County Lake will be studied to assess historic climate trends at Marion County Lake. Additionally, a climate model using PRISM data will be generated to show a 30-year review of trends of climate change across the United States and more specifically in Marion County. The effects of land cover change will also be assessed in this body of work. Runoff calculations will be performed to determine how changes in land cover will affect the volume of runoff into Marion County Lake, and, subsequently, the lake water volume and water quality. These data pools will be analyzed to offer management strategies for maintaining lake water volumes and lake water quality.

References

1. National Park Service. (n.d.). National Register of Historic Places. Retrieved November 4, 2018, from https://www.nps.gov/subjects/nationalregister/index.htm
2. *Urban hydrology for small watersheds*. (1986). Washington, D.C.: U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division.

Climate Modeling

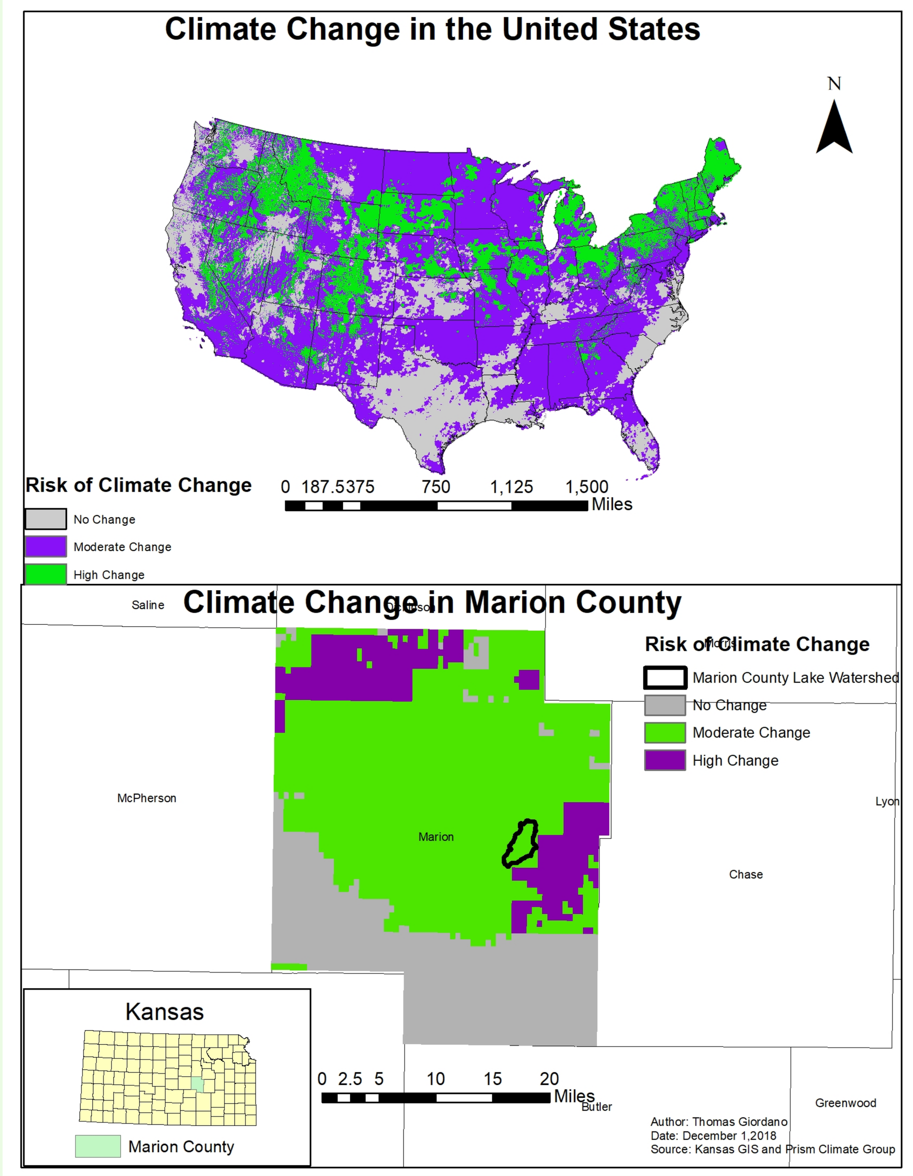

Figure 4. Climate change model of US and Marion County, KS

Over the last 30-year climate normal, precipitation and temperature averages were taken within a raster calculation in GIS. A true/false raster calculator was used on both precipitation and temperature data in order to determine the risk of climate change across the United States. For temperature, if the 2017 average held a value greater than 99% of the climate normal average temperature, a true response was generated. For precipitation, if the 2017 average held a value less than 90% of the average precipitation from the climate normal, a true response was generated. These responses were combined to determine *No Risk*, *Moderate Risk,* and *High Risk* regions.

ArcGIS Model for Climate Change

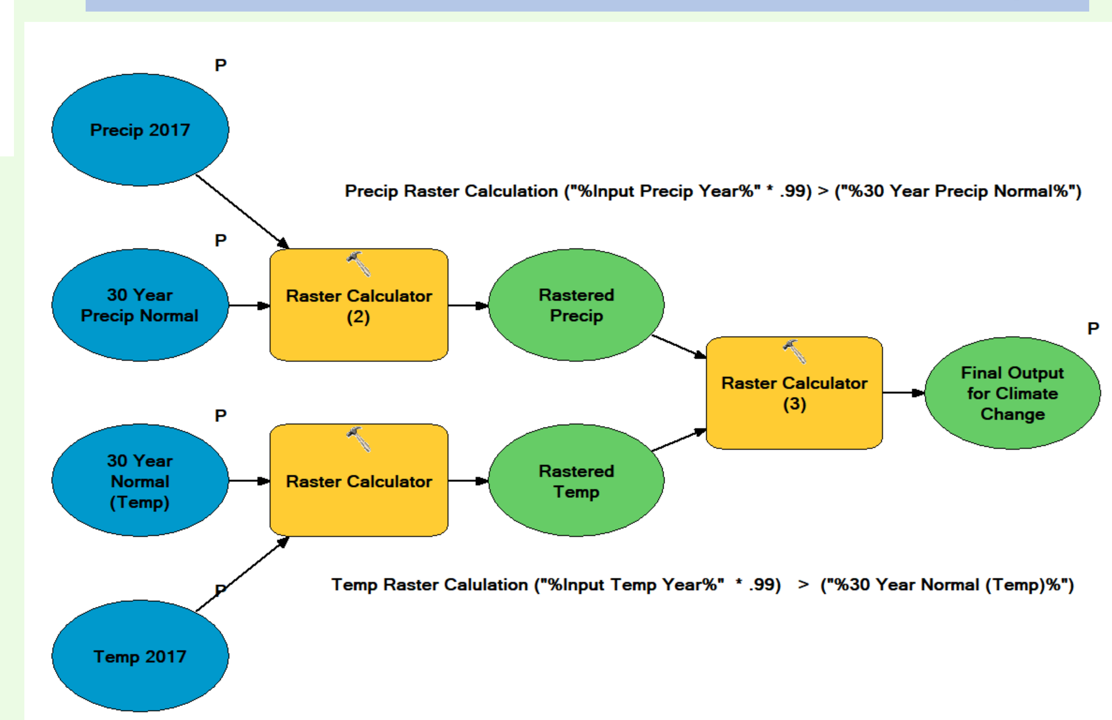

Figure 5. Raster Calculation of raster temperature and raster precipitation obtained from PRISM and Kansas GIS.

NOAA Climate Data 1981-2017

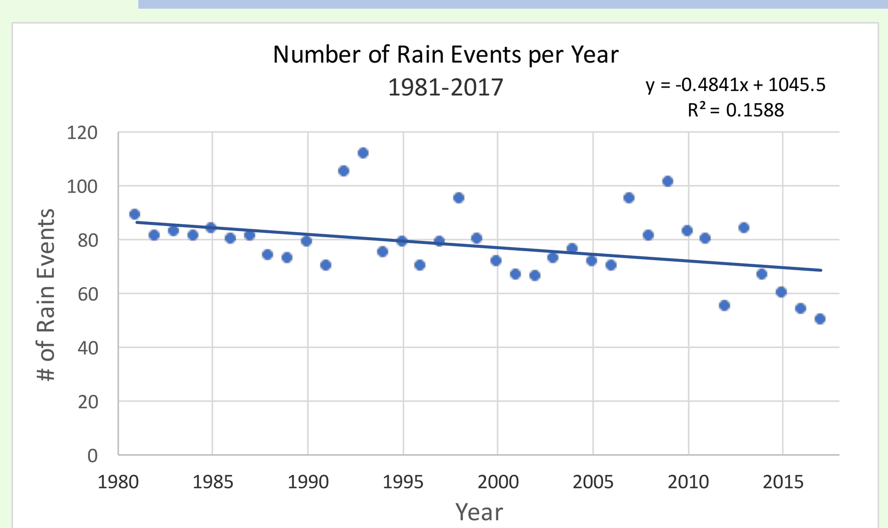

Figure 6. Graph of the Number of Rain Events per Year from 1981-2017. There is an observed decrease in the quantity of rain events per year from 1981-2017.

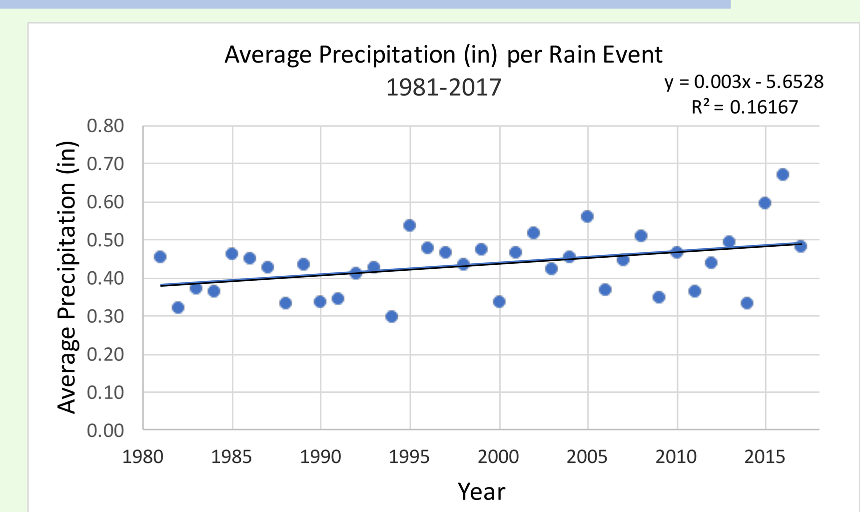

Figure 7. Graph of the Depth of Precipitation per Rain Event from 1981-2017. There is an observed increase in the depth of water per rain event from 1981-2017.

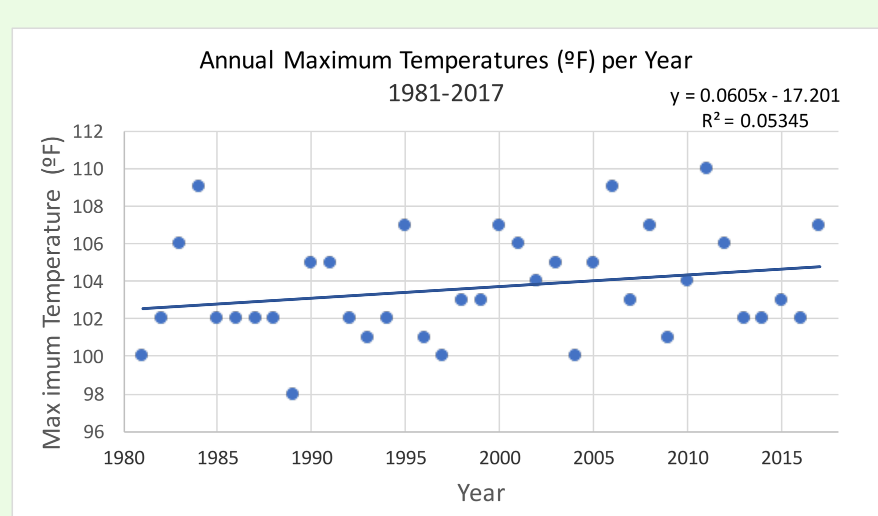

Figure 8. Graph of yearly maximum temperature from 1981-2017. There is an observed increase in the annual maximum temperature.

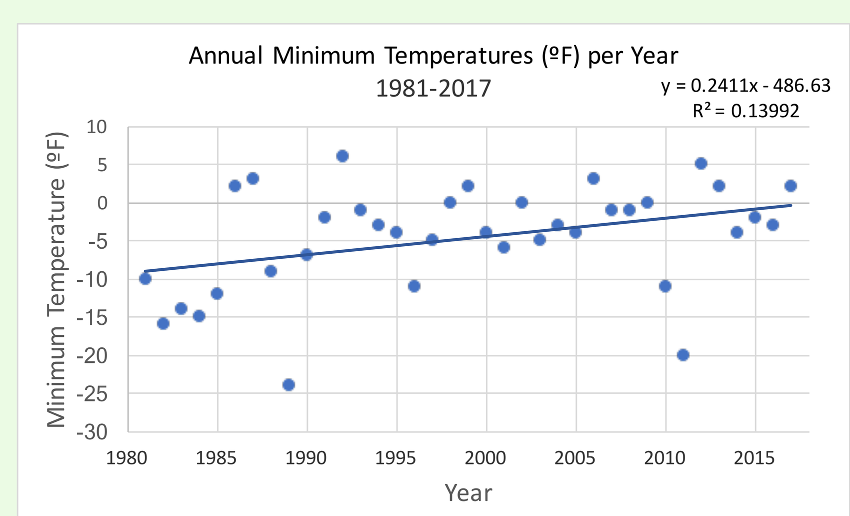

Figure 9. Graph of yearly minimum temperature from 1981-2017. There is an observed increase in the annual minimum temperature.

Runoff Modeling

The runoff models were made using the "curve number" or CN method found in the *Urban Hydrology for Small Watershed* document by the USDA. The major factors that determine the curve number or CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected).

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad S = \frac{1000}{CN} - 10$$

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and

Equation 1. CN Method for calculating runoff.[2]

Land Cover Type	"S"	"Q"	Runoff amount (acre feet)
All Pasture	2.14	0.67	223
Current	1.65	0.84	281
All Developed	0.77	1.3	437

Table 1. Runoff calculations made for differing land covers assuming P = 2 inches.

24hr rain events with projected climate change	"P "	"Q"	Runoff amount (acre feet)
1yr event	3.79	2.34	784
5yr	5.5	3.92	1312
10yr	6.5	4.87	1630
25yr	8.27	6.57	2201
50yr	9.6	7.87	2635
100yr	11.2	9.43	3160
200yr	12.9	11.11	3721
500yr	15.3	13.48	4515
1000yr	17.2	15.36	5146

Table 2. Rain events and their calculated runoff potential assuming current land cover.

Results

Climate Change Results

The model generated in ArcGIS using precipitation and temperature data obtained from PRISM and Kansas GIS shows that Marion County Lake is experiencing moderate impacts of climate change. The NOAA Data Analysis shows trends in both precipitation and temperature indicating climate change. Annual maximum and minimum temperatures are increasing as shown in Figure 8 and 9, respectively. The number of rain events is decreasing while the average depth of precipitation per rain event is increasing as shown in Figure 6 and 7 respectively.

Land Cover Change Runoff Calculation Results

The CN calculation clearly shows that land cover has an effect on the runoff generated for a given area. As shown in Table 1, increasing imperviousness of the land cover causes greater runoff. As rain events become more extreme and 100yr or more significant rain events become more prevalent, it can be expected to see larger volumes of runoff impacting Marion County Lake.