The Des Plaines Rivers' Flooding Problem

Anna Madison Burns

9/26/2020

Why is the Des Plaines River flooding so frequently?

Water flowing freely across Oak Spring Road has become a common sight in Libertyville; after rain, it has become normal to expect the Des Plaines River to have flooded the bridge underpasses along the River Trail, rendering them unusable for weeks. Even worse, in the past years there have been several major flooding events that have impacted homes and businesses across Libertyville as the lakes and rivers are unable to accomodate the excess percipitation. This is a cause for concern for anyone who lives and works in Libertyville – will my home or business be in danger of flooding the next time it rains? Will the Des Plaines River flooding its banks become a common occurence?

One method for answering this question is to look at the peak flow rate trends of the Des Plaines River over time; that is, how fast the river was flowing (a proxy for volume of water). By analyzing this data over a long period of time − between 1967 and 2019 − it becomes clear that there has been a significant increase in how much water moves through the river during peak annual flow events, or the time each year when the river is flowing fastest. This indicates that the volume of water present when the Des Plaines watershed flows fastest has become more extreme over the past fifty years.

This paper examines the increasing streamflow volume of the Des Plaines River during peak flow events between 1967 and 2019, which indicates the watershed region's vulnerability to extreme rainfall events which could have serious impacts on human health and the economy. The increased levels of stream flow reflect both modern changes in permeable surfaces and historic changes in soil composition due to agriculture industry. Furthermore, although there is no evidence to suggest an increase in precipitation over the period studied, predictions for the impact of climate change on the region through the 21st century suggest that that these factors will increasingly impact peak stream flow levels.

A brief ecological and social history of northern Illinois

Northern Illinois is a prairie-forest glaciated landscape with a historically high-organic-content loess soil that has been eroded by extensive industrial agriculture over the past 150 years to a clay-dense soil B-horizon (Knox). The region is populated largely by towns with populations under 30,000 who work both in local industry and in commuting to Chicago or Milwaukee. Agriculture is also common in the area, with large fields of corn and soy as well as smaller produce farms. Calculated for the 1981-2010 climate averages, the Antioch Illinois Weather Service Station reports that the mean January temperature is 21.9 F, with an average of 28.5 days below 32 degrees and 5.5 days below 0 degrees (without accounting for windchill). In contrast, the average July temperature is 73.5 F, with an average of 3.5 days above 90 F. The annual mean precipitation for the region is 36.7 inches (the majority of which tends to fall in the summer months), with an annual mean snowfall of 42.7 inches.

How will northern Illinois be impacted by climate change?

Although global warming will cause an overall increase in global temperatures, specific regions will be impacted in a myriad of different ways. One of the most significant ways that climate change will impact northern Illinois is with shifts in precipitation. Frankson and Kunkel (2017) found that there has already been a state-wide increase in the number and severity of extreme precipitation events. Additionally, Cherkauer and Sinha (2010) discuss how the bulk of annual precipitation is likely going to shift from the summer to the spring. Further, that rain will likely be condensed into extreme precipitation events, or periods when there is heavy rainfall over a short period of time.

These shifts in percipitation trends caused by climate change will compound problems that have already been caused by historic land use changes. Knox (2001) describes how the original organically-rich loess soil has largely been eroded to a clay-dense soil due to early agricultural practices. This clay-heavy soil is less permeable, so less water can soak into it and more is forced to run off into the rivers and lakes. The result of this is that the entire watershed is less resilient, because the already overburdened rivers have to take on the water that the soil no longer can. A primary result of this will be an increase in high stream flow days of up to 22-31%, indicating that more water will enter the watersheds rather than being absorbed by the soil (Cherkauer and Sinha, 2014).

However, soil erosion from land use changes will be the least of our worries in the years to come. Although land use changes have likely driven historic changes in the amount of water entering rivers and lakes, in the future the primary driver for these issues will likely be climate change. This shift is detailed in Frans et. al (2013), who conducted a hydrologic model study of the Upper Mississippi River Valley (including northern Illinois). His team determiend that in a modern application, upwards of 90 percent of changes in water runoff in the region were due to climate change-driven factors even in areas that experienced land use change. This is not to suggest that soil erosion has not impacted water runoff in the past century, only that the changes to the soil which cause these changes have already taken place – the clay-filled soil B-horizon has already been exposed, but we are only just beginning to experience the impact of climate change.

What does this mean for northern Illinois communities?

The increase in stream flow rates during peak flow events over the past sixty years suggests that Lake County communities along the Des Plaines River indicates that the watershed is highly impacted by extreme rainfall events. This information tells us that the Des Plaines River lacks resilience, or the ability to remain stable through environmental changes. This could have serius impacts on the populations of Lake County which fall along the River, including Libertyville.

One of the primary ways that the Des Plaines River's lack of resilience could impact Lake County populations is by overwhelming combiend stormwater-sewage systems, which are common in the Great Lakes Region (Patz, 2014). If the volume of water exceeds the holding capacity of the Des Plaines River watershed and causes flooding, in many areas this excess water is handled by stormwater systems that are combined with sewage systems. When these in turn are overwhelmed, combined water and sewage flood out of these systems, increasing instances of waterborne illnesses due to sewage contamination. A further impact could be increased flooding events when the Des Plaines River is overwhelmed by the volume of water, like those that have been occuring annually in Libertyville, causing significant damage to homes and properties. Both increased instances water-borne illnesses and property damage would most heavily impact the vulernable populations in Lake County, as the costs of repairing a home or recieving medical aid for illness are often very high.

How will I be impacted?

If any of this information concerns you, or leads you to fear for your health, home, or business – you are a climate activist! Even if you have never considered yourself to be one before, climate activism doesn't necessarily mean going vegan or putting solar panels on your house. If you are worried about the impacts that a shifting climate will have on your life, and wonder what you can do to stop or lessen those impacts, you are now a climate activist. As a climate activist, it will be necessary to understand the ways that climate change could impact you. Seeing the data of environmental change yourself can help to dispell any of the healthy skepticism you may have (after all, I haven't shown any proof for my claims yet!). If you don't necessarily believe me yet, that is all right. Read on to see for yourself the data that supports my claim of increased water volume in the Des Plaines River watershed during its fastest annual flows.

Data Analysis

Unfortunately, Libertyville does not have robust historical precipitation data; however, our neighbors in Antioch kept a comprehensive account of daily weather measurements between 1901 and 2008. This data is a useful proxy for understanding precipitation trends in Libertyville, because Antioch is similar both geographically and climactically. I obtained data on precipitation levels from the National Oceanic and Atmospheric Administration (NOAA)'s Climate Data Online database, which is free to access for the public and contains historic records of local weather.

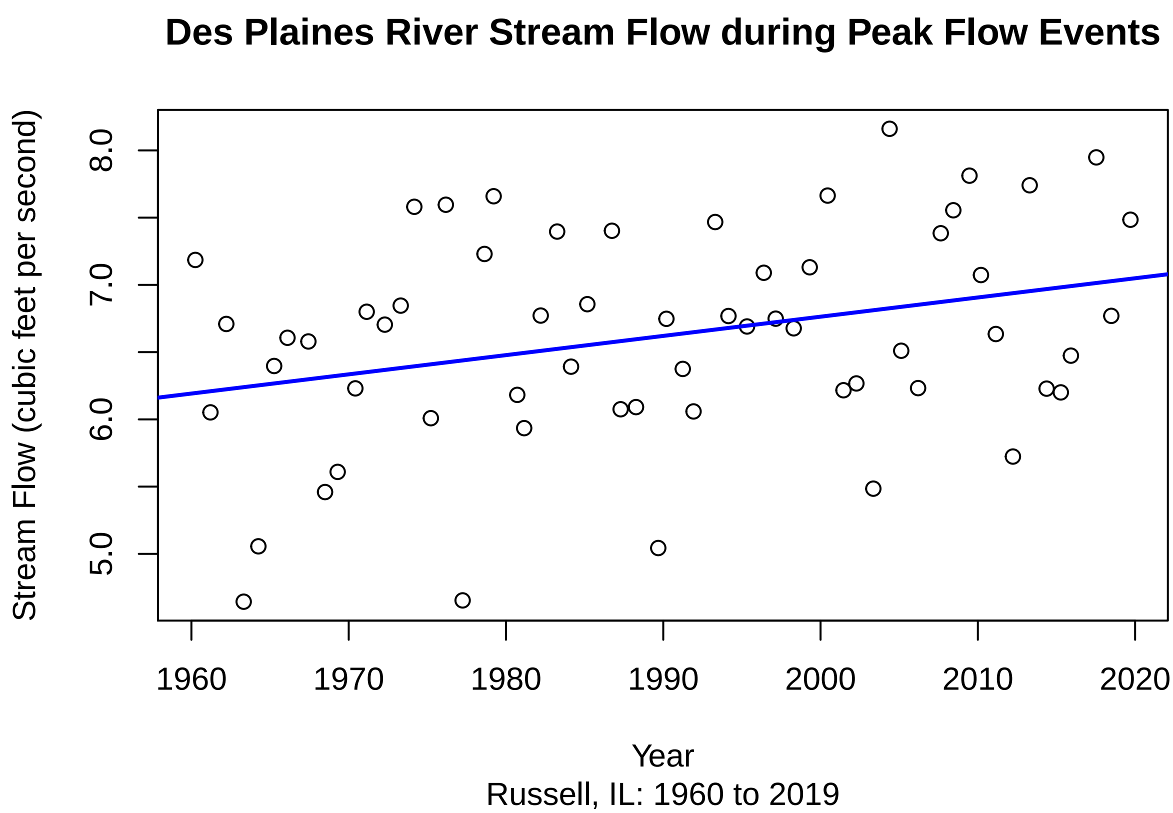
To analyze this data, I compiled the aggregate sums of monthly precipitation for each month between 1901 and 2008. Taking the sum of precipitation levels is useful because averages are skewed by the high number of days without precipitation in seasons where the most rain tends to fall in a few days of the month. Total precipitation within the month paints a better picture of how much rain is actually falling. Notably, the Antioch weather station did not record any weather data between 1922 and 1941, which could impact the reliability of any trends in the data; however, becaues of the length of the temperature record, this gap is comfortably accounted for by the remaining data. I then used a linear model with 5% confidence, meaning that there has to be less than a one-twentieth chance of the model falsely finding correlation in order to determine that there is a linear trend. The null hypothesis was that there is no significant correlation between levels of precipitation and time. My model revealed that there were extremely low levels of correlation between aggregate monthly precipitation and time, which is documented in Table 1. Because I used a confidence level of 5%, the p-value (or the likelihood that the results in the data could occur if my null hypothesis was true and there was no correlation between precipitation and time) would have to be less than 0.05 for the data to be sufficiently 'weird' enough to signify a trend. As you can see in Table 1, the only month that comes close to a p-value of 0.05 is November, but even that month's data is not quite odd enough to detect a trend. Therefore, my null hypothesis that there is no significant trend between precipitation amounts and time in Antioch, IL stands.

Month	Slope	P	R-Sq
January	-0.0286	0.754	0.001
February	0.0108	0.8872	0
March	-0.1121	0.358	0.01
April	0.0301	0.8318	0.001
May	-0.0416	0.8024	0.001
June	0.2584	0.1491	0.025
July	0.0785	0.6443	0.003
August	0.3523	0.0565	0.042
September	-0.1826	0.4162	0.008
October	-0.0296	0.8485	0
November	0.2177	0.0587	0.042
December	0.0918	0.3863	0.009

Table 1. Antioch, IL Monthly Precipitation Trends (1901 to 2008)

In contrast, the U.S. Geological Survey's National Water Information System Des Plaines River metering station, where the flow and the height of the river is measured in Russell, IL (approximately ten miles from Antioch) displays significant trends in streamflow levels during peak flow events from 1960 to 2019. This data is collected in coordination of Illinois Department of Natural Resources' Office of Water Resources, near the Illinois-Wisconsin border and the Sterling Lake system. The river narrows significantly a few miles past Russell in the Wisconsin portion of the watershed, but is at a representative width for the Lake County Des Plaines River watershed by the time it reaches the meter station in Russell, IL. This therefore rules out the problem that the river is narrower in this section than downstream in Libertyville, causing a faster water flow.

Next, data regarding streamflow levels during peak flow events on the Des Plaines River were obtained from the U.S. Geological Survey's site at Russell, IL, located approximately ten miles from Antioch. This data contains the streamflow (cubic feet per second) and discharge levels (feet) during the peak annual streamflow events for every year between 1960 and 2019. The streamflow levels was plotted against time, and a linear regression model was applied to the data. Once again, this linear regression operated at a 5% confidence level, with the null hypothesis that streamflow during peak flow events had not changed over time. A BoxCox graph revealed that the data would benefit from a logarithmic adjustment to correct for variation in the data, and this transformation was applied. The best fit line and plotted data is included in Graph 1.



The linear regression had a p-value of 0.016, meaning that the null hypothesis that there was no correlation between peak streamflow levels and time could be comfortably rejected. There is evidence to suggest that streamflow levels during peak flow events have increased between 1960 and 2019. Although the correlation is low with an adjusted R-squared of 0.1 (meaning that approximately 10 percent of the variation in peak annual stream flow levels can be explained by the variation in the date), because natural phenomenon have so many conflicting variables this level of correlation is satisfactory. Although the data fails the independence assumption for linear modeling (because the datapoints fall on sequential dates), once a logarithmic transformation was applied the data was sufficiently homoskedastic, normal, and linear for the model to still be used.

Skeptic claims: How can we know it's climate change?

Skeptics may question the validity of this assertion on two grounds: that northern Illinois is not expected to see an immediate increase in precipitation levels, and that precipitation levels have not been shown to increase in the region over the past century in spite of rising global temperatures. However, this data does not describe overall levels in precipitation, but rather extreme precipitation events. Cherkauer and Sinha (2010) describe that while precipitation levels may not increase immediately in northern Illinois, the bulk of the rainfall will likely shift from the summer to the spring. Furthermore, this rainfall is more likely to be condensed into extreme precipitation events, which will have more of a damaging imapct on the Des Plaines watershed than rain events over a long period of time would.

Conclusions

These results have a significant impact on the Des Plaines Watershed, demonstrating the vulnerability of the system to extreme precipitation events. As discussed in Cherkauer and Sinha (2010), increase in extreme precipitation events is one of the greatest impacts of climate change on Illinois. The sensitivity of the Des Plaines River Watershed to these events will leave Lake County communities vulnerable to flooding as the 21st century continues.

This data directly reflects Cherkauer and Sinha's analysis that peak stream flow events will become more severe across the Upper Mississippi River Valley. Although this is partially a reflection of the land use change described by Knox (2001), it is likely further impacted by global climate change as detailed in Frans et al. (2013).
This data suggests that Lake County communities along the Des Plaines River could be highly impacted by the sensitivity of the watershed to extreme precipitation events. Outdated infrastructure, including combined stormwater-sewage systems, could be overwhelmed by increased water levels, increasing instances of waterborne illnesses (Patz, 2014). Additionally, agriculture could be negatively impacted by extreme rainfall events as crops are damaged by precipitation, or because water availability will be lower during the summer as precipitation falls more heavily in the spring (Hatfield 2014). This implicates severe human health and economic impacts of climate change on the northern Illinois region. Some of these impacts can be mitigated by updating infrastructure and informing citizens about protecting their homes from flooding. However, to fully stem the impacts of climate change on northern Illinois, a transformation of the economy's reliance on fossil fuels will be necessary in order to stem the worst effects of global climate change on northern Illinois' most vulnerable citizens.

Some of these impacts can be mitigated by updating infrastructure and informing citizens about protecting their homes from flooding. However, to fully stem the impacts of climate change on northern Illinois, a transformation of the economy's reliance on fossil fuels will be necessary in order to stem the worst effects of global climate change on northern Illinois' most vulnerable citizens.

Works Cited

Angel, J. (2020). "Official 1981-2010 Climate Normals." Illinois State Water Survey. Accessed 25 September, 2020 from https://www.isws.illinois.edu/statecli/newnormals/normals.USC00110203.txt.

Cherkauer, K.A. & Sinha, T. (2010). "Hydrologic impacts of projected future climate change in the Lake Michigan region." Journal of Great Lakes Research, 36, pp. 33-50. DOI: 10.1016/j.jglr.2009.11.012.

Frankson, R., K. Kunkel, S. Champion, B. Stewart, D. Easterling, B. Hall, and J. R. Angel. (2017). "Illinois State Climate Summary." NOAA Technical Report NESDIS 149-IL (4).

Frans, C., et al. (2013). "Are climactic or land cover changes the dominant cause of runoff trends in the Upper Mississippi River Basin?" Geophysical Research Letters, 40, pp. 1104-1110. DOI: 10.1002/grl.50262.

Hatfield, J.L. (2014). “Agriculture in the Midwest.” In J.A. Winkler, et al. (Eds.), Climate change in the Midwest: A synthesis report for the National Climate Assessment, pp. 188- 196. Island Press.

Knox, J.C. (2001). “Agricultural influence on landscape sensitivity in the Upper Mississippi River Valley.” Catena, 42(2-4), pp. 193-224. DOI: 10.1016/S0341-8162(00)00138-7.

Patz, J. (2014). “Health.” In J.A. Winkler, et al. (Eds.), Climate change in the Midwest: A synthesis report for the National Climate Assessment, pp. 188-196. Island Press.