The Implications of Droughts on Greater New York's Water Supply

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Abstract

While droughts have not been a frequent issue for the New York area throughout its history, there have been significant droughts that have caused severe stress on the water systems in the area. For example, in the 1960s a drought that lasted about 4-5 years, affected water supply, recreation, agriculture, and other aspects in Greater New York (NYC, parts of New Jersey, part of Connecticut, etc.). The lack of rains during droughts can create many complications for Greater New York's dams, which, based on their design, must be at a specific level to prevent deficits, spills (over the dam) or issues with the water quality. For this project, major aspects of droughts and their relation to Greater New York's water supply were studied. In addition, we wish to create a True Drought Index (TDI) in order to measure the full capacity of historic and future droughts, while also considering the changing supply and demand for water.

Objectives and Purpose

- Create a true drought index that considers the changes of water supply and demand.
- Determine the approximate storage requirements for each county that will allow them to plan for a state of drought in terms of water supply.

The importance of this project has to do with the importance of water. With water being such an essential resource used by the millions everyday, it is important to be able to manage it and be able to meet the

Background

In order to create a sufficient drought index, we considered all variables for water supply and demand for the Greater New York (GNY) area. The supply comes into the reservoirs through the fraction of rainfall that falls in the county.
That is defined as

S = α* Rainfall, where α adjusts rainfall to the amount that actually ends up in the reservoir.

Demand is the domestic and industrial needs for GNY, which is also variable. The key thing here is that the deficit can become large when we compare water supply to demand during drought, because little rainfall creates low supply. As such, we want to examine the deficit on these days when demand is higher than usual. The following equation is used to calculate the deficit:
Def = D-S
where D is Demand, S is Supply, and Def is Deficit

This is used to calculate:
CD (t) = max(0, def(t-1) + def(t)),

Where CD is Cumulative Deficit, max removes all negative values [or surpluses,] and everything is a function of t the number of days. Hence, CD is the added sum of the deficit of each of the 9125 days examined for each county.

We also recorded a value known as storage, which is simply the maximum value calculated for CD in the span of the 24 years examined for each of the 30 counties. In short, storage is one of the more important values in the experiment, given that it represents the most severe "drought level" of the region.

While domestic and industrial demand is easy to obtain, agricultural demand had to be estimated based on soil type

Methods

To begin data collection, we compiled supply and ET_0 information from the NOAA National Climatic Data Center, demand data from the United States Geological Survey, and the information regarding agricultural data was obtained from the National Agricultural Statistics Service. From there, we used programming in MATLAB to calculate our cumulative deficit based on the algorithms we developed.

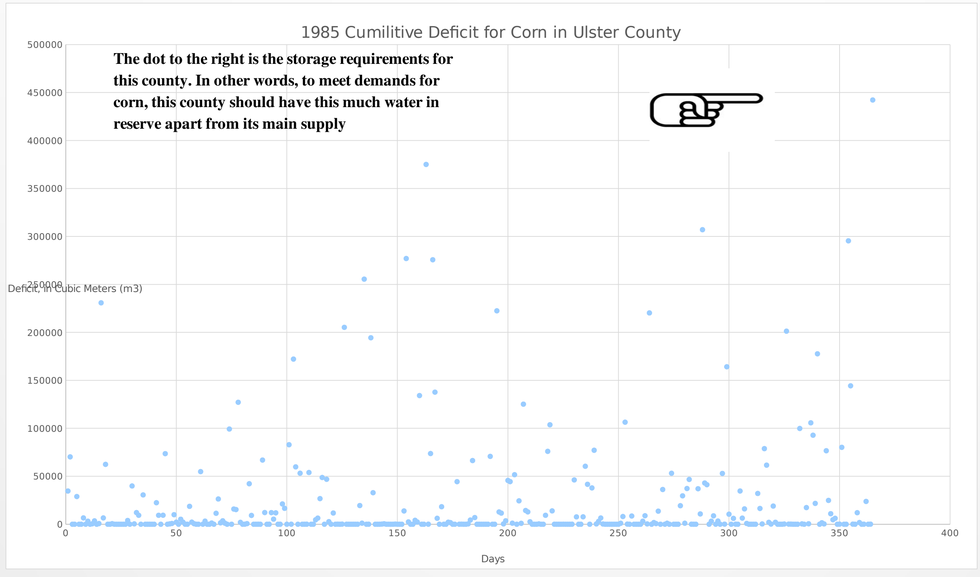

Figure 1 Shows how storage requirements are obtained through Cumulative Deficit.

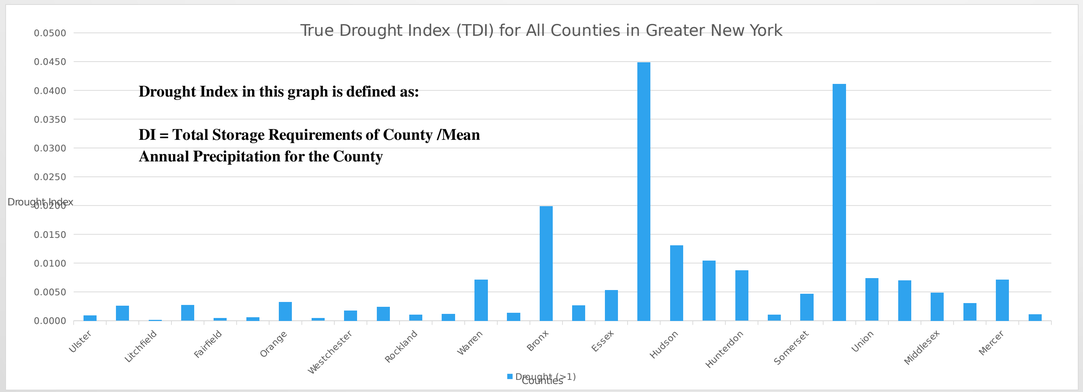

Figure 2 Drought Index that considers supply and demand of water for the specified counties to determine if the county is undergoing a drought. Formula is shown on graph.

Discussion

When we calculated the storage levels for the past 24 years in relation to the supply of each county, we find that not a single county experienced a deficit, which means no county experienced a "drought." This may give the impression that there is no problem. However, since the 1960s drought, the Northeastern part of the United States has experienced above average rainfall. This would naturally explain the lack of deficit since we are getting an abundance of rainfall. That said, one must consider how this data would be if rainfall

Conclusions and Potential Future Experiments

While none of the recorded days had any droughts according to our True Drought Index, we can deduce that this is most likely due to the pluvial, or wet period, Greater New York is experiencing.

In addition, 1960s drought data was not used in this experiment because of the lack of reliable data on demands prior to 1985.

However, in the future, the 1960s drought will be examined with simulated demand scenarios.

The next step from this experiment then is to study the years around recorded droughts, if data is available, in order to get a sense of what may come in the future for GNY.

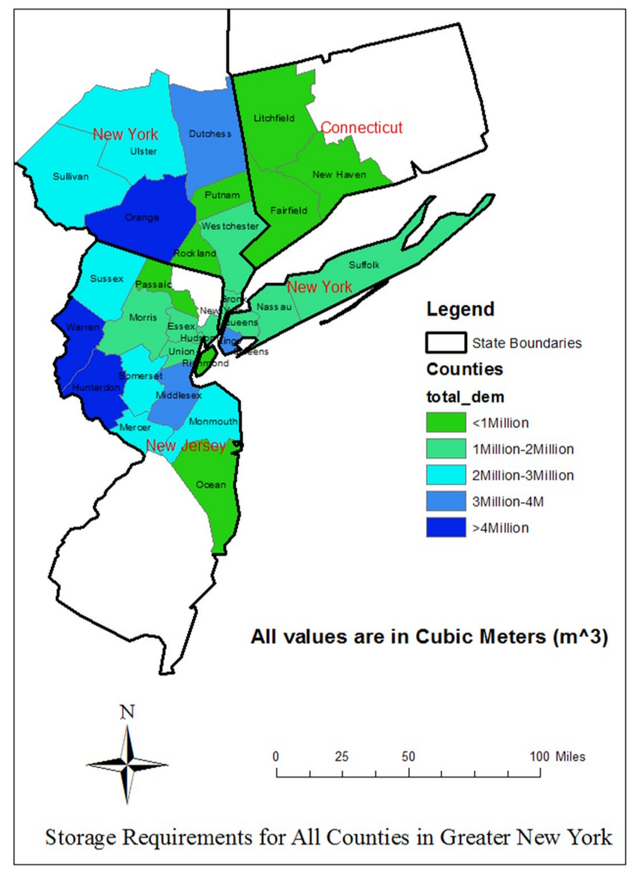

Figure 3 displays the storage requirements for all thirty counties in Greater New York in the recorded time frame of 1985-2009.

Acknowledgements/Affiliations

1. City College Academy of the Arts
2.CUNY CREST
3.The City College of New York

I would like to thank my mentors for leading me through the whole project.

I would also like to thank the CREST-HIRES program for allowing me the opportunity to participate in their program.

This research was supported by NOAA CREST (NOAA CREST–
Cooperative Agreement No: NA11SEC4810004) and funded by The
Pinkerton Foundation.

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