A Preliminary Analysis of Water Demand and Management in Metropolitan North Carolina

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Background

- Domestic consumption is a major impetus for freshwater withdrawals in urban settings of North Carolina (*Fig. 1*) and elsewhere.
- Rapid urban growth has co-occurred with several major droughts in recent history, compelling water managers to emphasize water conservation.
- But, cities vary in their adaptive capacity through water conservation practices, as shown in this poster.

Research Question

- How effective has water management been at reducing per capita demands in North Carolina, and how and why have reductions in water use rates varied by municipality?

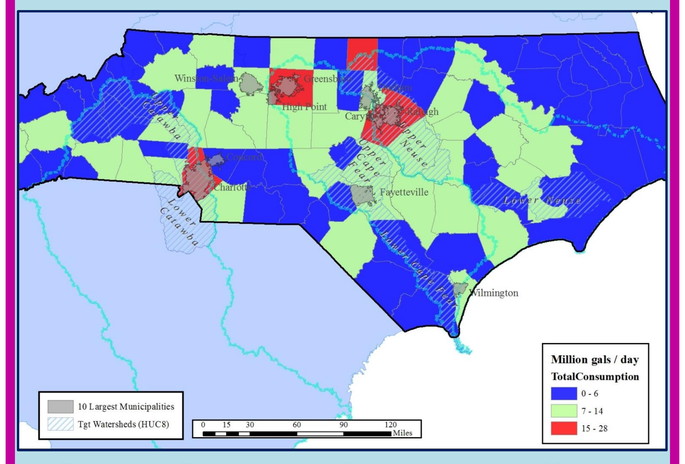

Figure 1. Freshwater Consumption in North Carolina (1985–1995) and Major Urban Areas.

Data Collection

- 3 main data sources were employed:
  1) U.S. Geological Survey National Water Information System data for 5-year, county-level withdrawal trends.
  2) State Climate Office of NC for monthly Palmer Drought Severity Indices (PDSI).
  3) Municipal water data for monthly estimates of water extracted for distribution to select NC cities.

Municipalities have responded to drought differently over the past several decades, with some consuming more water during drought and others adjusting their water use in accordance with supplies.

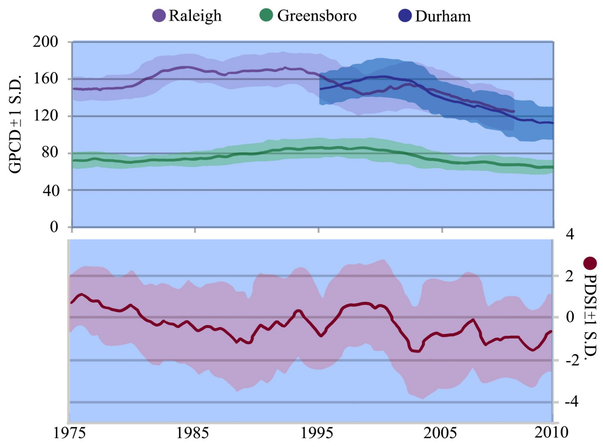

Figure 2. 5-year rolling mean of drought (PDSI) and water use (GPCD) for 3 major municipalities in North Carolina.

Temporal Patterns

- Municipalities vary in the magnitude of water use and in their response to drought (*Fig. 2*)
- While Raleigh appears to exhibit *Amenity Preservation* (i.e. consuming more water to compensate for drought), Greensboro and Durham display varying degrees of *Water Stewardship* by generally decreasing use in response to a drier climate.
- Durham's water policy changes during this period (*Fig. 3*) provide an opportune case for testing the effect of different conservation strategies on water use.

Focusing on Durham, we employed an Autoregressive Integrated Moving Average (ARIMA) time-series model to better understand the effect of two, top-down measures: *Water-use Mandates* during drought periods and a permanent switch in *Water Pricing Structures*. The model estimated that some 21 billion gallons were saved through these two conservation measures.

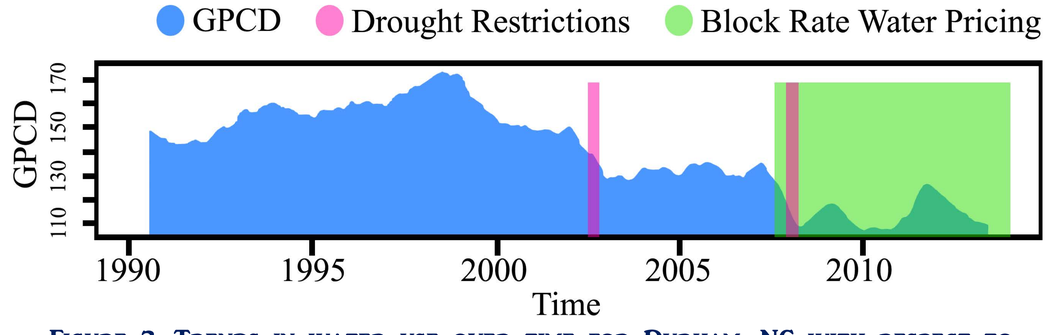

Figure 3. Trends in water use over time for Durham, NC with respect to regulatory and pricing measures (removed of seasonal and random patterns).

Model Forecasts and Water Savings

- In the case of Durham, we split the dataset into 2 parts: 1) before reduction efforts of 2002, when the first Stage IV Drought Restriction was enforced, and 2) all times beyond, including subsequent drought measures and the transition from an uniform residential water use pricing structure to an increasing block rate.
- We fit an ARIMA model to the baseline (pre-conservation) conditions, which accounts for both the general trends and any seasonal patterns.

Model Forecasts and Water Savings

- By using the pre-intervention dynamics as a baseline, we projected water use under "business-as-usual" and contrasted it with actual water consumption (*Fig. 4*).
- The difference between water conserved through policy and business as usual is 1.7 billion gallons/year (range = 0.12–3.7 billion/year).

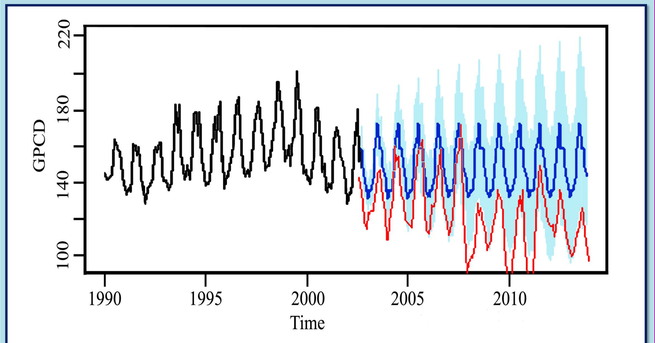

Figure 4. Baseline water use (**black**) fitted with a predictive model of business-as-usual (**blue**) and 95% confidence intervals (light blue), versus actual water use (**red**) for Durham, NC.

Summary

- Water managers in NC have responded to drought in a variety of ways. In the most striking case, Durham is estimated to have conserved billions of gallons. Whereas, Raleigh has maintained high water uses during persistent drought (perhaps related to amenities such as lawn irrigation).
- Yet, considerable uncertainty exists, both currently and under future scenarios subject to climate change.

Next Steps

- The analysis of water demands will be coupled with qualitative interviews with NC water managers, in order to help explain trends in water use rates and the effectiveness of conservation strategies.
- Additionally, Phoenix-area municipalities will be compared to those in NC.

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