Use of the Basin Development Factor to Urban Watershed Response

Theodore G. Cleveland

Shiva Sunder

David Thompson

Acknowledgements

- W.H. Asquith, M.S. Roussel, USGS-Austin; S. Fitzgerald, HCFCD; D. Barrett, F. Liscum, D. Schwartz, S. Johnson (RGMiller, PBS&J, NWS, LJA)
- Texas Department of Transportation, Harris County Flood Control District.

Background

- Needed to explain hydrologic responses to answer:
  - How have responses changed with urbanization over time (in a coastal low-slope area)?
  - How will responses change as urbanization proceeds?
- Want to use the answers to understand how to implement drainage policy, etc.

Background

- Assumptions:
  - Response of a watershed is controlled in large part by its topography, storage properties, and loss (or runoff generation) properties.
  - Observe that topography is relatively unchanged in urban watersheds (we are not moving mountains in our study area) but hydrologic response certainly changes.
  - Response change is some proportion to changes in storage, runoff generation, and conveyance efficiency to the outlet.

Background

- Prior Work:
  - Various work in Houston and in broader Texas area demonstrated that a large fraction of variability is explained by topography, but a distinction between undeveloped and developed was used (binary distinction).
  - A basin-development-factor extends the classification by more categories, possible that such further refinement could improve estimates.

Background

- Basin Development Factor (BDF)
  - The BDF (Sauer et al., 1983) is a metric thought to be associated with runoff transport efficiency of the drainage systems in a watershed.
  - The BDF indirectly addresses the storage and transport components of a watershed’s runoff signal.
  - BDF is a categorical variable, whose value is assigned based on the prevalence of certain drainage conditions that result from urbanization of a watershed.

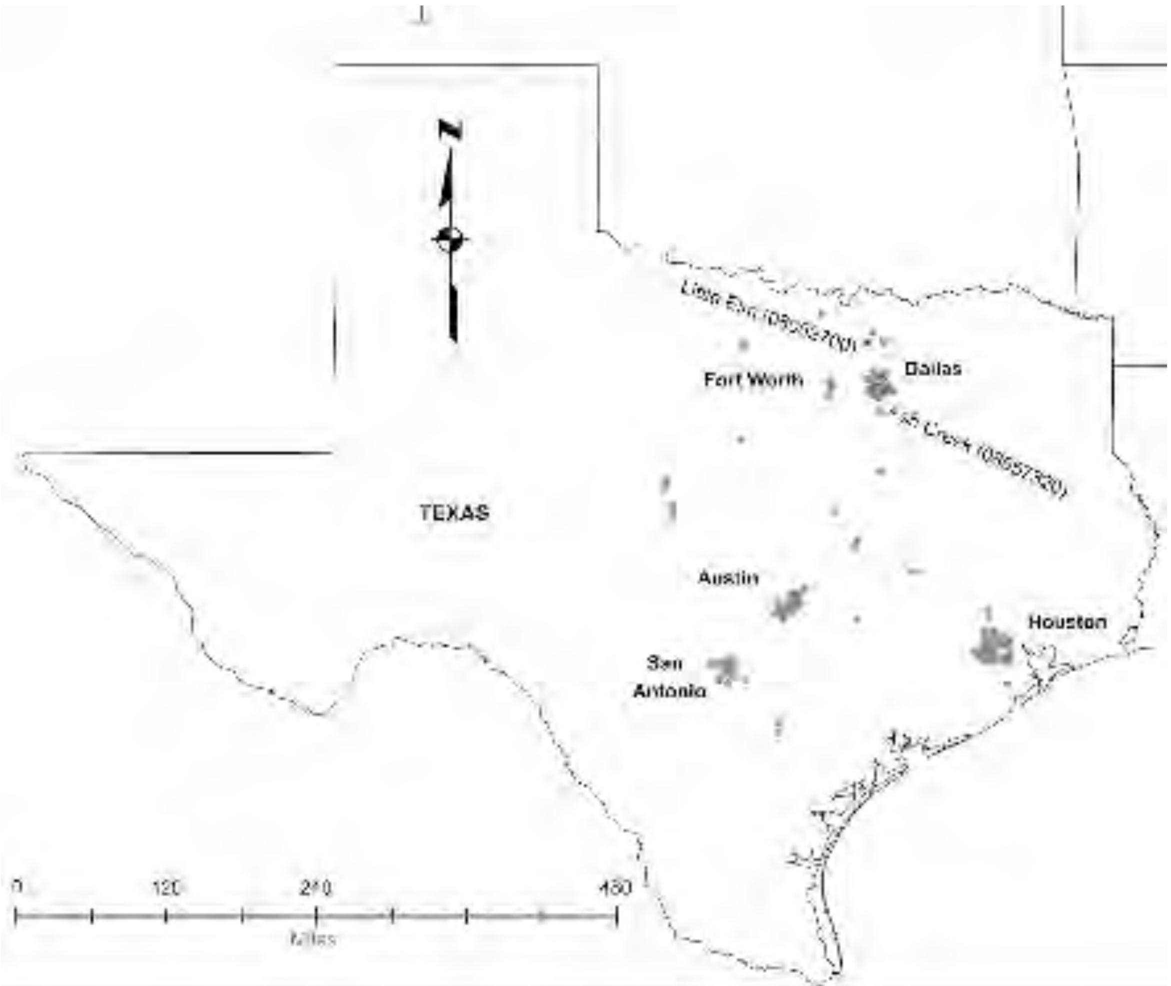
Basin Development Factor

- Basin Development Factor (BDF)
- Scoring based upon presence of
  - (1) Channel Improvements: straightening, deepening, clearing and enlarging.
  - (2) Channel linings
  - (3) Storm drains or storm sewers:
  - (4) Curbs and gutters:
- Value from 0-12. Most analysts produce same scores (+/- 1) when using the same imagery.

What We Did

- Determined present-day BDF for 133 watersheds in Texas with paired rainfall-runoff observations. (historical BDF for a subset was also available)
- Prior analysis of the rainfall-runoff data produced peak discharge factors (Qp), and characteristic times (Tp) – these values were segregated by BDF to examine if a useful relationship exists.
- Conjecture:
  - BDF -> small, Qp -> small, Tp -> large.
  - BDF -> large, Qp -> large, Tp ->small.

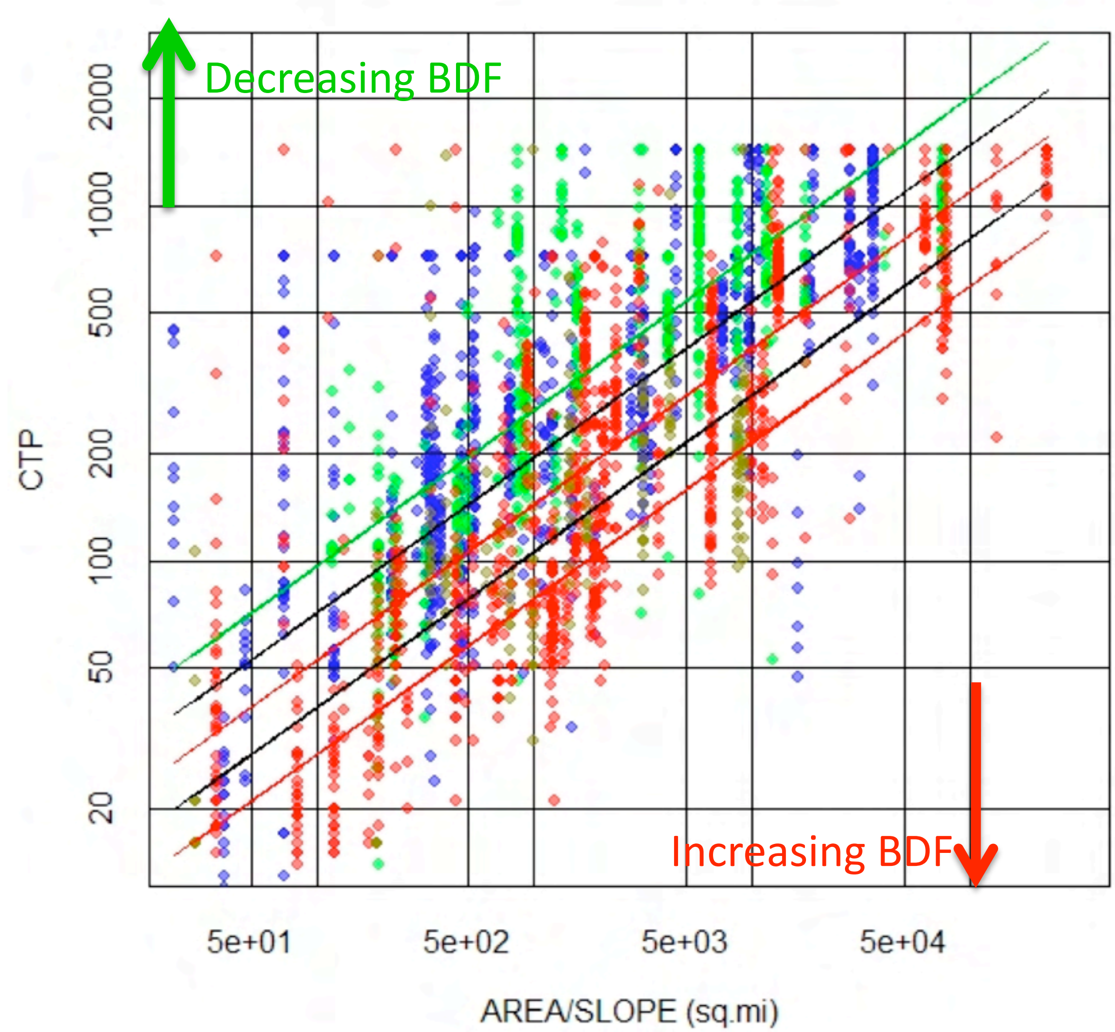
Study Area



- 130+ Texas watersheds.
- 3000+ storms.

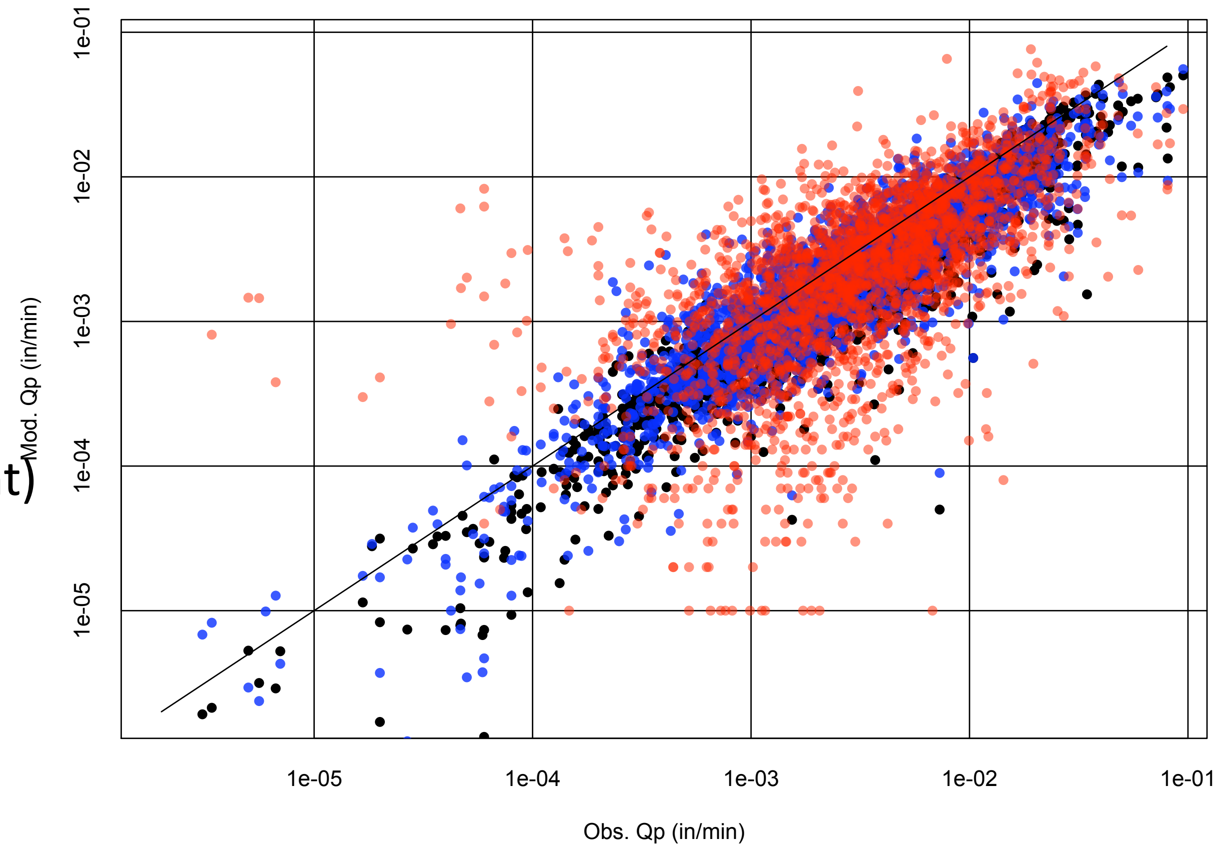
What We Learned

- Considerable variability
- Evidence in the plot supporting the conjecture.
  - More than binary distinction, but not huge demarcations.



What We Learned

- Model and observed responses.
  - Black= storm optimized.
  - Blue = terrain model (binary considerations of development)
  - Red = BDF result.
- Increased variability.



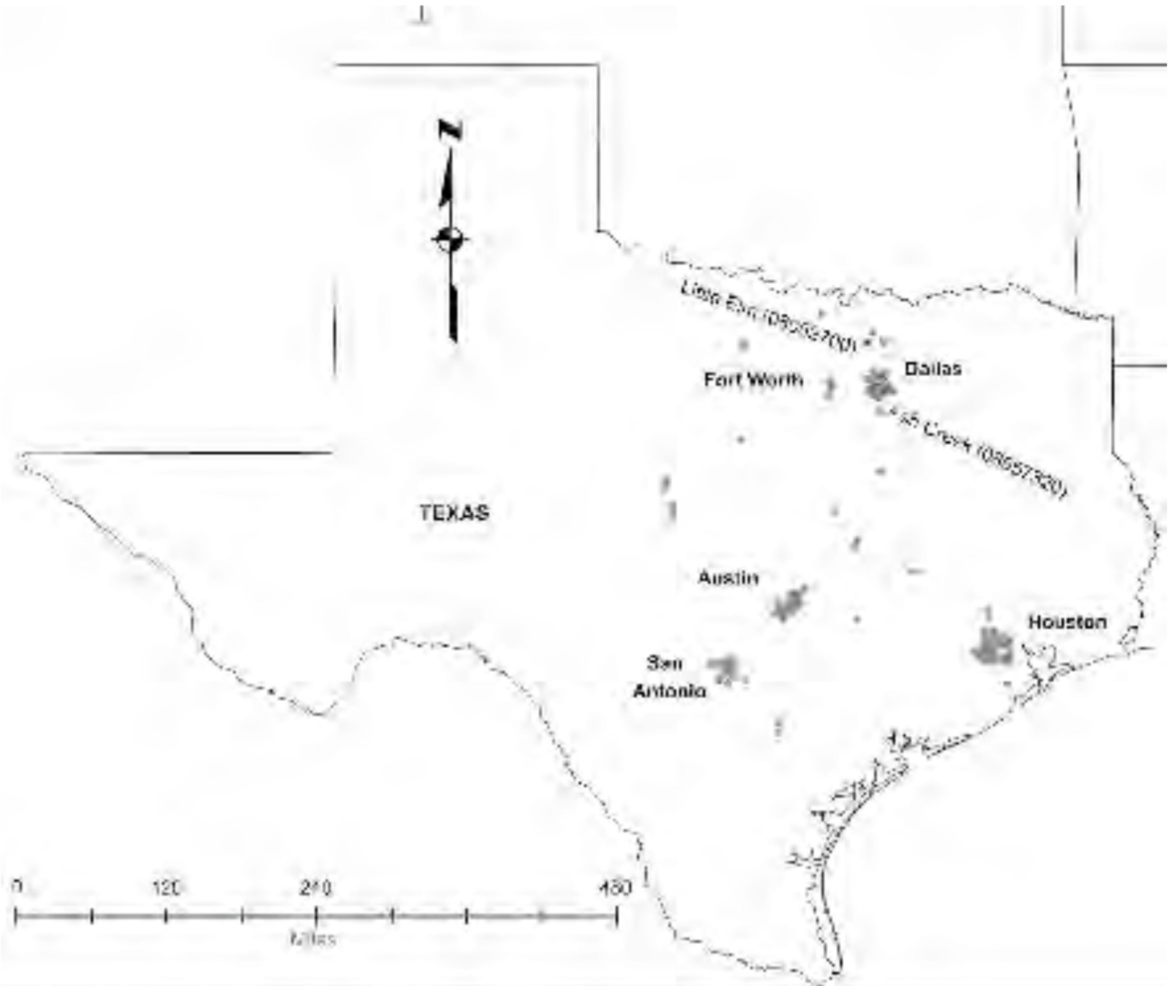
What We Learned

- Inclusion of BDF as an explanatory variable did not increase prediction performance as compared to binary classification of developed/undeveloped.
- If zero-discharge cases are censored (not shown), there is support of the conjecture that BDF explains a portion of response.

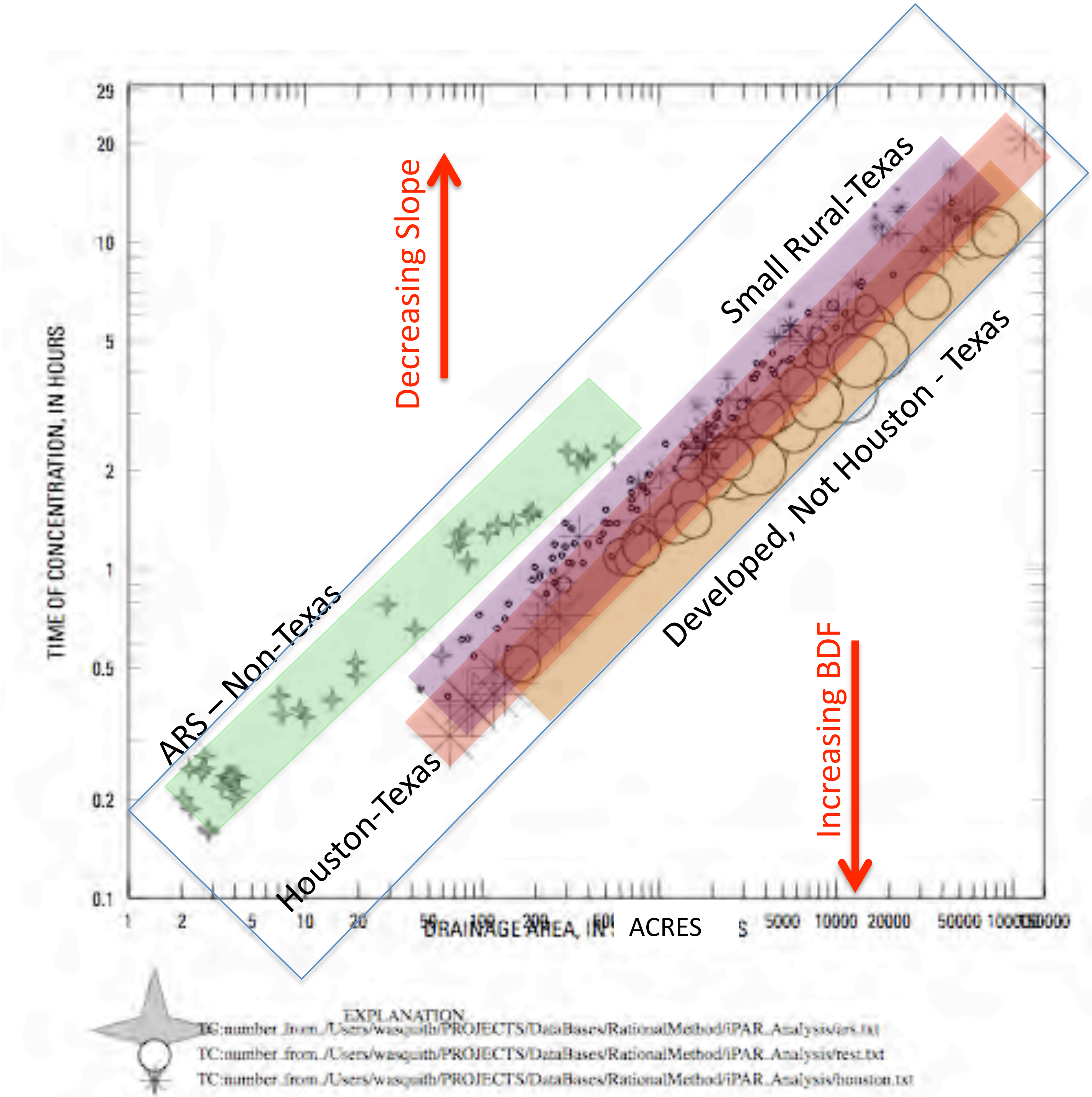
Recent Efforts

- Added ARS paired datasets from 30+ watersheds around the USA; re-analyzed entire database.
- Have 4 “groups”:
  - ARS Not-Texas
  - Small Rural – Texas
  - Urban – Texas (not Houston)
  - Houston.

Study Area



- 130+ Texas watersheds.
- ARS Research Watersheds from:
  - Arkansas
  - Georgia
  - Indiana
  - Iowa
  - Nebraska
  - Ohio
  - Virginia



TIME OF CONCENTRATION, IN HOURS
DRAINAGE AREA, IN ACRES
ARS – Non-Texas
Houston-Texas
Small Rural-Texas
Developed, Not Houston - Texas
Decreasing Slope
Increasing BDF
EXPLANATION
TC:number.from./Users/wasquith/PROJECTS/DataBases/RationalMethod/iPAR.Analysis/ars.txt
TC:number.from./Users/wasquith/PROJECTS/DataBases/RationalMethod/iPAR.Analysis/rest.txt
TC:number.from./Users/wasquith/PROJECTS/DataBases/RationalMethod/iPAR.Analysis/houston.txt

Summary

- BDF applied as part of broader study of response metrics. Exhibits some utility when zero-discharge cases are censored.
- BDF increase correlated with characteristic time decrease (anticipated result).
- Slope (as an explanatory variable) plays a confounding role.

Where we are heading

- Continued to explore the concept --- seems to have value within a geographic region.
- BDF 0-3 is associated with larger characteristic time, BDF 9-12 is associated with smaller characteristic time.
- In the intermediate range of the categorical variable, there is ambiguity.