Trends in Baseflow Metrics in New Jersey Streams and Correlation with Urbanization

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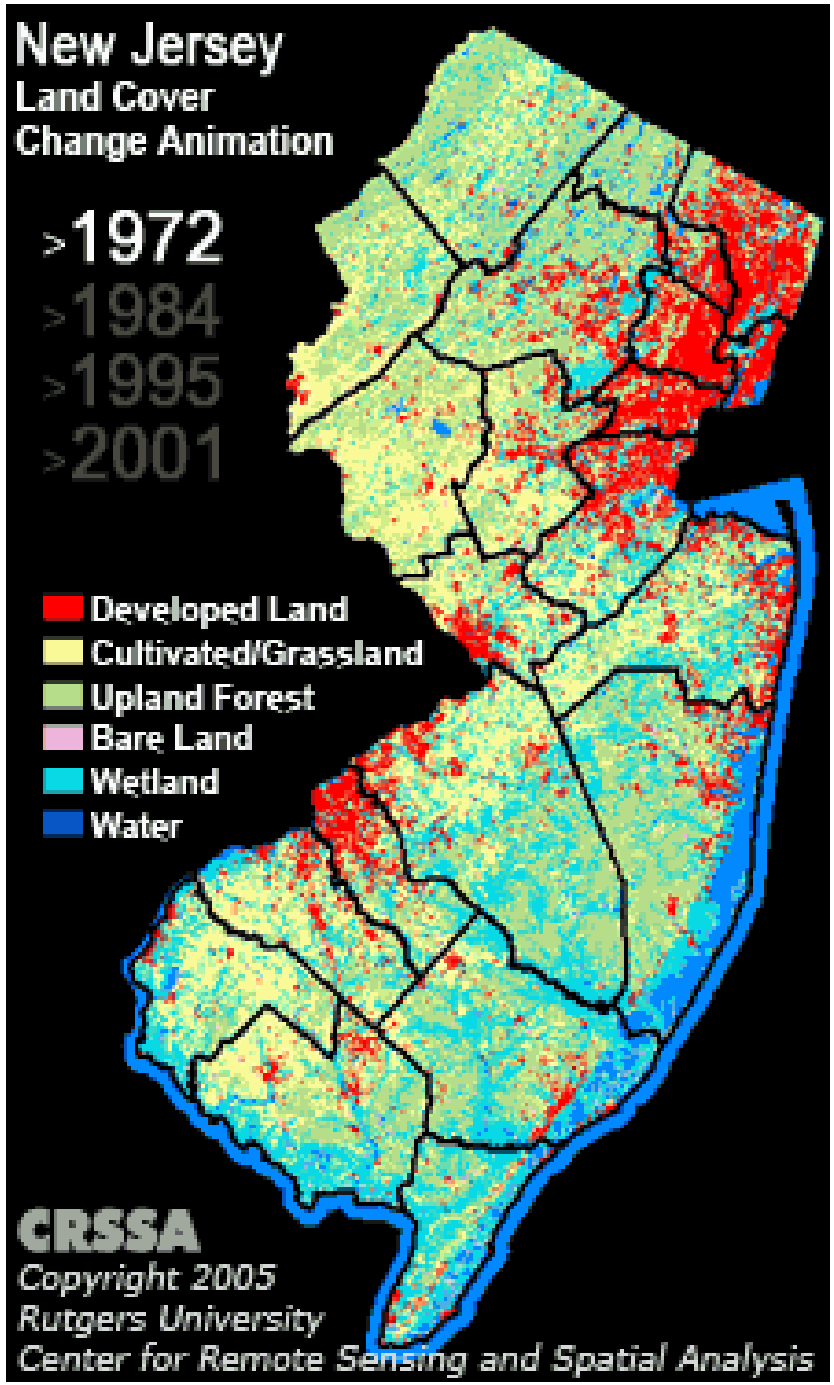
Motivation

- Much of NJ depends on surface water for potable waters
- Droughts are common; perhaps to become more common and/or severe
- Streams and reservoirs rely on baseflow during drought
- Historically rural, water-supply watersheds are urbanizing
- Urbanization reduces infiltration, theoretically reducing baseflow
- Urbanization could therefore pose an important threat to surface water supply (and stream ecology)
- But, several confounders to the theoretical relationship


New Jersey
Land Cover
Change Animation
>1972
>1984
>1995
>2001
Developed Land
Cultivated/Grassland
Upland Forest
Bare Land
Wetland
Water
CRSSA
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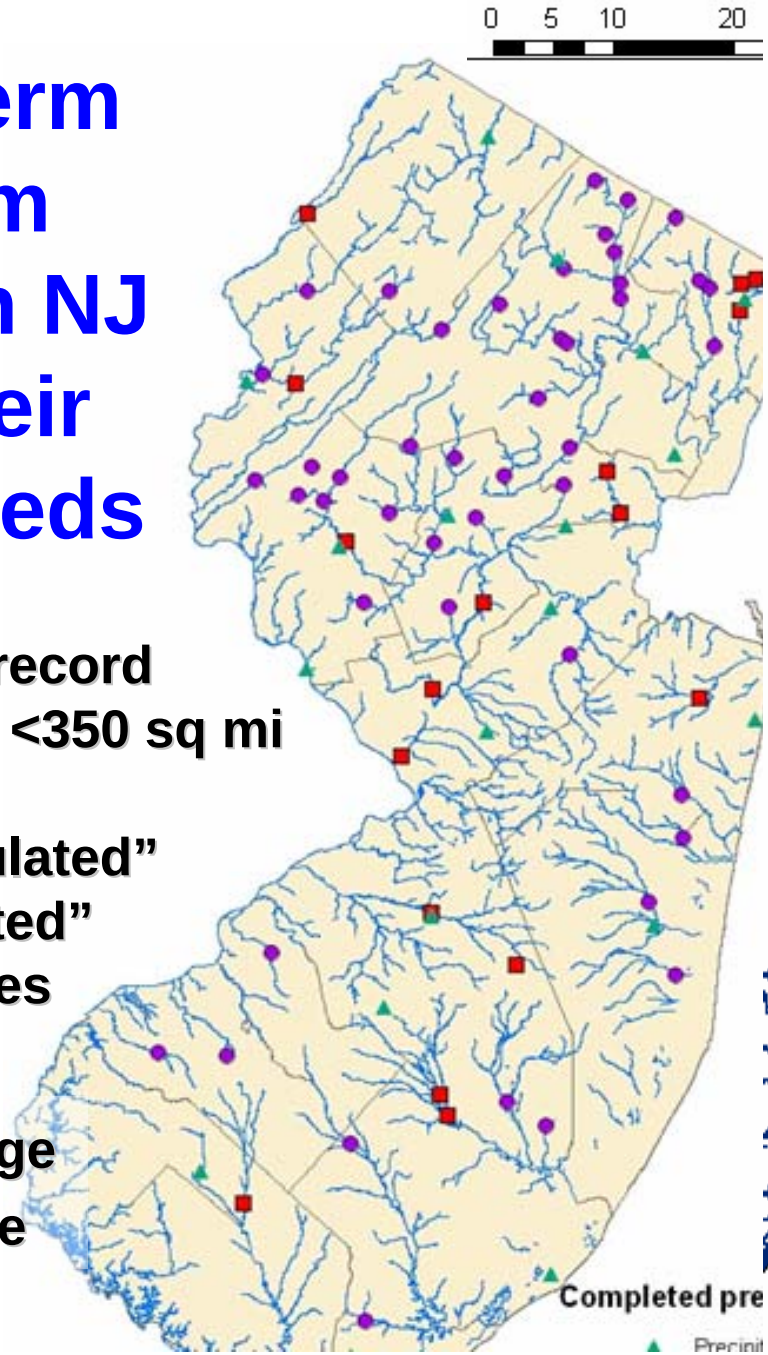
Is the theoretical relationship borne out by historical data?

- daily average flow measured by USGS stream gages
- separate stream flow into base flow and storm flow (WHAT–web implementation of the Eckhardt digital)
- aggregate annually;
- investigate different metrics: daily baseflow normalized by
  - watershed area (BF, cm)
  - annual precipitation (BF/P)
  - total flow (BF/TF, aka baseflow index)
- include minimum annual daily flow (MADF) as possible surrogate for baseflow
- analyze for baseflow trends using Mann-Kendall test
- estimate historic imperviousness by correlation with population
- analyze for correlation with imperviousness

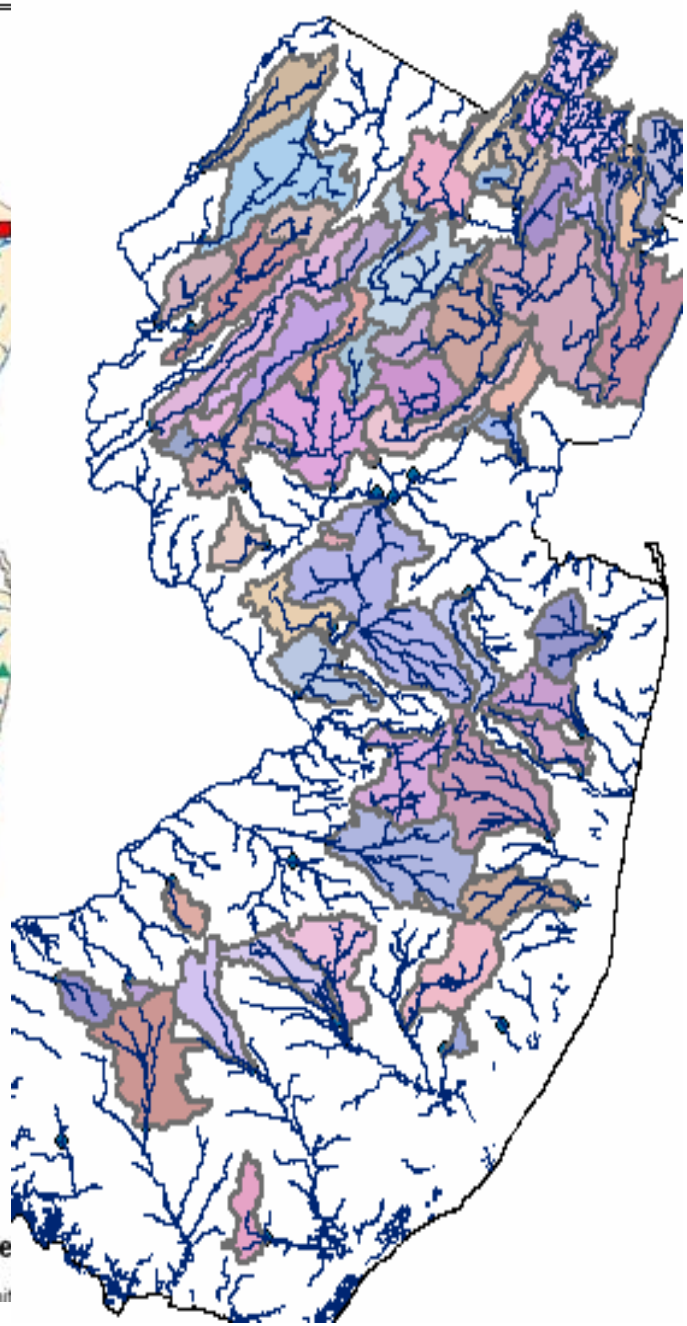
Long-term stream gages in NJ and their watersheds

- > 25 years of record
- drainage area <350 sq mi
- 53 gages
  - 29 “unregulated”
  - 24 “regulated”
- 19 precip gages



Precip. gauge

Stream gage



Percentage of gages with decreasing and increasing trend
(at the 95% confidence interval)

	Unregulated gages n=29		Regulated gages n=24	
Metric	%Dec	%Inc	%Dec	%Inc
BF	7	21	25	8
BF/P	24	21	17	8
BF/TF	14	17	38	13
MADF	14	21	12	36

- **Good news: at unregulated gages, not a dominant decreasing trend in any metric**
- **At regulated gages, decreasing trends outnumber increasing (except MADF). Why? Increasing withdrawals? Increasing evaporation?**

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-Normalizing by P (precip) tripled incidence of decreasing trends at unregulated gages; but did not change incidence of increasing trends

-Sizeable difference in results among metrics

Is inherent variability of metric a factor in detecting trends?

Coefficient of variation (mean/std dev) is a normalized measure of variability

Metric	CV	Percentage of gages at which a trend was detected
BF/TF	.07	40
BF/P	.23	36
BF	.30	30
MADF	.45	41

-BF/TF is a more “stable” variable; more powerful at detecting trends

-MADF had high CV, but the most trends

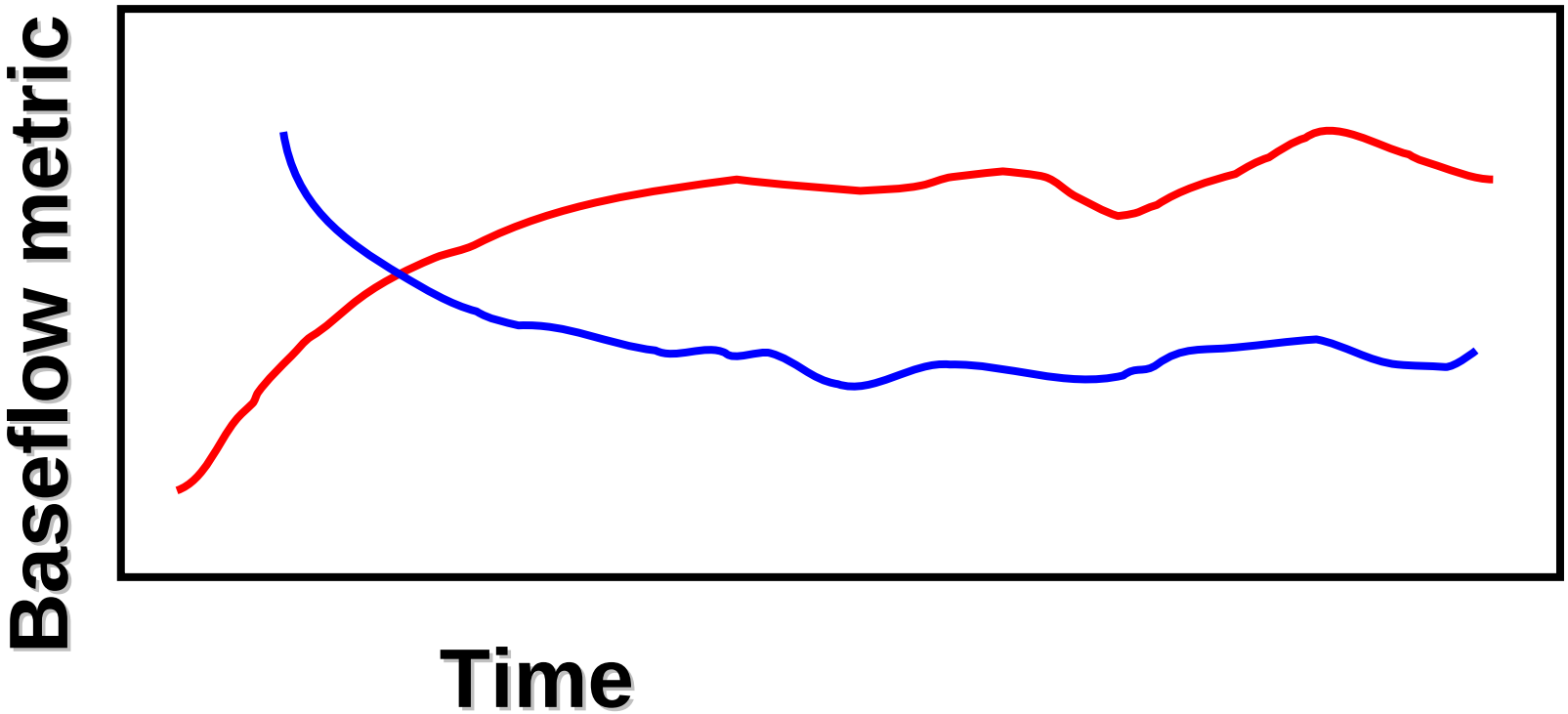
Percent occurrence of a "Consistency Error" for paired metrics for same (unregulated) gage

(error = trend detected in the row metric for a gage, but no trend was detected in the column metric for the same gage)

	MDAF	BF	BF/TF	BF/P
MADF	*****	21%	24%	14%
BF	21%	*****	17%	3%
BF/TF	24%	21%	*****	17%
BF/P	28%	21%	28%	*****

- **Sizeable inconsistency rates – need to be careful in choosing metric.**
- **MADF not a great surrogate.**

If the “trend” looked like this, it might confound trend detection



- Investigate each 10-year block for trend
- Compare with results over entire record

Not much of a problem …

Percent of cases in which no trend was detected in the entire record, but trend was detected in a 10 year period

BF	10%
BF/P	12%
BF/TF	2%
MADF	19%

Left To Do

- develop population density – impervious correlation using current data
- develop population density timeseries using census data
- develop imperviousness timeseries by correlation with population
- within a single basin, are annual baseflow metrics correlated with imperviousness?

Left To Do (2)

- segregate by geology/soils
- segregate by watershed size
- look at other flow measures as surrogate of baseflow, eg, annual median daily flow
- monthly (rather than annual) analysis
- investigate why baseflow is decreasing at so many regulated gages
- using impervious timeseries, investigate trends in flooding

Thank you

Questions, Comments, Suggestions?