

Supporting information for

Assessment of regional variation in stream flow responses to urbanization and the persistence of physiography

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There are 5 pages of supporting information including additional information on the study site, data sources and data reduction methods, as well as 5 tables.

1. Study Location.

Table SI-1. Description of study gradient climates, topography, and soils.

City	City Code	Number of Watersheds	Range of Watershed Areas (km ²)	Mean Annual Precip (cm)	Mean Annual Temp (°C)	Mean Soil Permeability (cm/hr)	Mean Watershed Slope (%)	Mean Dam Storage (MI/km ²)	Glacial History (Yes/No)	Ecoregion (Level II)
Atlanta, GA	ATL	9	66 - 191	136	15	4	4	22.2	N	Piedmont
Baltimore, MD	BES	15	0.5 - 159	117	13	5	4	4.2	N	Northern Piedmont & SE Plains
Boston, MA	BOS	12	11 - 173	121	9	17	3	37.0	Y	Northeastern Coastal Zone
Detroit, MI	DET	6	46 - 186	81	9	9	2	0.0	Y	S. Michigan Drift Plains
Portland, OR	PDX	10	2 - 137	195	11	5	14	20.0	Y	Willamette Valley & Cascades
Phoenix, AZ	PHX	5	170 - 425	46	19	9	5	0.9	N	Sonoran Desert & Arizona Mnts
Pittsburgh, PA	PIT	6	15 - 191	102	11	5	10	5.4	N	Western Allegheny Plateau
Raleigh, NC	RAL	7	3 - 197	119	15	3	3	16.1	N	Piedmont
St. Paul, MN	STP	6	3 - 73	81	7	16	1	0.0	Y	North Central Hardwood Forests

Notes: Mean values are calculated across the watersheds composing each city's gradient.

2. Methods Discussion of Datasets and Compilation.

Numerous national datasets were used to quantify physiographic and land-cover characteristics for each watershed. Most of these data were obtained from the Geospatial Attributes of Gages for Evaluating Streamflow, version II (GAGES II) published by the USGS Falcone (2011), http://water.usgs.gov/GIS/metadata/usgswrd/XML/gagesII_Sept2011.xml.

GAGES II includes geospatial data for USGS-gaged watersheds, such as watershed boundaries, stream lines, and several hundred watershed characteristics compiled from national data sources. Watershed characteristics include environmental features (e.g., climate, geology, soils, and topography) and anthropogenic influences (e.g., land cover, population density, and road density). The GAGES II database was used to identify a watershed-specific value for each physiographic and land-cover characteristic.

To determine general physiographic characteristics for each city, watershed-specific values were averaged among all the watersheds composing each city's urbanization gradient. These value were used to provide an estimate of average climate, soil, and topographic characteristics in each city. City-wide averages are reported in Table 1. Due to strong covariance between watershed slope and rural land use in Phoenix, we opted to use the mean watershed slope of the urban Phoenix watershed (slope = 5%) instead of the gradient average (slope = 16%), which was inflated by covariance.

In addition, we estimated mean watershed slope and soil permeability for watersheds in glaciated and non-glaciated terrains by taking the average of watershed-specific values for watersheds in glaciated terrains (n = 34 watersheds) and non-glaciated terrains (n = 42 watersheds).

Table SI-2. Descriptions and data sources for physiographic characteristics.

Physiographic Characteristics	Description	Compiled Data Source
Mean annual precipitation	Mean annual precipitation from 1950-2000 obtained from 4-km PRISM data.	GAGES II (Falcone 2011)
Mean annual temperature	Mean annual temperature from 1950-2000 obtained from 4-km PRISM data.	GAGES II (Falcone 2011)
Mean soil permeability	Mean surface soil permeability obtained from STATSGO data aggregated by Wolock (1997) at 1 km ² resolution.	GAGES II (Falcone 2011)
Mean watershed slope	Mean watershed slope derived from 100 m resolution National Elevation Dataset.	GAGES II (Falcone 2011)
Lake density	Number of water bodies (lakes, ponds, and reservoirs) per km ² obtained from the USGS National Hydrography Dataset Hi-Resolution (1:24k).	GAGES II (Falcone 2011)
Dam storage	Watershed dam storage measured as megaliters of total storage per sq km. Data based on an enhanced version of 2009 National Inventory of Dams.	GAGES II (Falcone 2011)

Table SI-3. Descriptions and data sources for land cover characteristics.

Land Cover Characteristics	Description	Compiled Data Source
Road density	Kilometers of road per km ² obtained from U.S. Census Bureau TIGER line files from the year 2000.	GAGES II (Falcone 2011)
Population density	Persons per km ² obtained from U.S. Census block data from the year 2000.	GAGES II (Falcone 2011)
Developed land cover	Percent of the watershed considered developed from the 2006 National Land Cover Dataset. Developed land sum the areas covered by classes 21, 22, 23, and 24.	GAGES II (Falcone 2011)
Impervious cover	Percent of the watershed covered by impervious surfaces from the 2006 National Land Cover Dataset with a resolution of 30 m.	GAGES II (Falcone 2011)
Sewage infrastructure	Area-weighted Census block groups were used to estimate the proportion of households with septic and sewer service in each watershed.	U.S. Census Bureau Population and Housing Survey from 1990

Table SI-4. Descriptions and data sources for hydrologic metrics. Values were calculated on an annual basis for each water year between 2000 and 2012 (i.e., Oct 1, 2000 to Sept 30, 2001) and then averaged across the time period to provide one overall value for each metric for each watershed.

Hydrologic Metrics	Description
High-flow frequency	Number of annual flows events that exceed the 75th percentile flow. Days in the same pulse event were counted as one distinct event. Values represent the total number of high flow event each water year.
High-flow duration	Calculated as the total number of days of each high-flow event. Values represent the annual average high-flow duration.
Normalized 1-day maximum flow	Annual average 1-day maximum flow divided by the watershed area in km ² .
Baseflow index	7-day minimum flow for each water year divided by mean annual flow for each water year.

3. Results

Table SI-5. Values for impervious expansion calculated using equation 1 and flashiness response and flashiness baseline calculated using equation 2. R^2 indicates the goodness of fit between the parameter and road density.

City	Impervious Expansion (X_{ic})	R^2	Flashiness Response (F_R)	Flashiness Baseline (F_B)	R^2
All	3.7	0.83*	1.9	10.3	0.48*
ATL	4.1	0.72*	3.7	6.0	0.81*
BES	3.2	0.75*	2.6	13.4	0.89*
BOS	6.3	0.98*	1.4	7.7	0.44*
DET	5.4	0.94*	2.4	5.5	0.94*
PDX [†]	3.3	0.86*	1.4	6.4	0.77*
PHX	1.3	0.96*	0.5	3.7	0.60
PIT	2.5	0.72*	1.7	15.3	0.77*
RAL	4.8	0.89*	3.2	11.0	0.78*
STP	2.6	0.60*	2.2	-5.1	0.81*

*Significant at $p < 0.05$

† Flashiness response and baseline exclude sites with precipitation $> 160\text{cm}$