Supporting Information

Other Temperature Trends in Streams and Rivers

We identified other examples of temperature trends reported for other streams and rivers located in different areas of the world. The objective was to identify other similar studies for comparative purposes. Our strategy involved searching the ISI Web of Science online database (http://isiknowledge.com/) for historical temperature trends in streams and rivers. Methods of measurement and statistical analyses across data sets sometimes differed, but typically involved long-term temperature records following sample withdrawal by thermometers (at least during the early 20th Century). There was a bias in our search with more published studies of trends from streams and rivers in North America and Europe. Some important historical records may have been omitted that were not cited on the ISI Web of Science. Other examples of published trends of long-term water temperature data sets ranged from 20-89 years; increasing temperature trends were typically in the same range and magnitude for different streams and rivers of the world as compared to those reported in the present study. Despite well-known increasing effects of urbanization and climate change on the temperature of the Earth's surface, there have been surprisingly few published historical temperature trends from streams and rivers in the United States, compared to other streams and rivers in the world.

Streams and Rivers	Geographic Location	Record of Observation	Rate of Increase (°C/year)	Literature Reference
	North America			
Hudson River	New York, U.S.A.	1920-1990	0.012	Ashizawa and Cole (1994)
Streams in Minnesota	Minnesota, U.S.A.	1977-2002	0.11	Johnson and Stefan (2006)
Miramachi River	New Brunswick, Canada	1970-1999	0.03	Swansburg et al. (2004)
	Europe			
Llyn Brianne	United Kingdom	1981-2005	0.058-0.071	Durance and Omerod (2007)
River Itchen	United Kingdom	1980-2006	0.104 (winter) 0.050 (summer)	Durance and Omerod (2008)
River Loire	France	1976-2003	0.056-0.074 (spring and summer)	Moatar and Gailhard (2006)
25 Streams/Rivers in Switzerland	Switzerland	1978-2002	0.004 – 0.046	Hari et al. (2006)
Gail River Traun River Danube River Danube River Inn River Lieser River	Federaun, Austria Wels, Austria Linz, Austria Ybbs, Austria Schärding, Austria Spittal, Austria	1901-1990 1901-1990 1901-1990 1901-1990 1901-1990 1901-1990	0.00526 0.01404 0.00893 0.01111 0.00601 0.00968	Webb and Nobilis (1995)
Iron Mill Stream River Pulham River Exeter	Devon, United Kingdom Devon, United Kingdom Devon, United Kingdom	1977-1990 1977-1990 1977-1990	0.073 0.029 0.050	Webb and Walling (1992)
	Asia			
Ara River System	Tokyo, Japan	1978-1998	0.11 - 0.21 (winter and spring)	Kinouchi et al. (2007)
Lena River Outlet During June	Siberia, Russia	1950-1992	~ 0.02	Yang et al. (2005)

Supporting Information Table 1. Examples of other long-term water temperature trends reported for streams and rivers. Both linear regression analysis (e.g. Ashizawa and Cole 1994, Durance and Ormerod 2007) and nonparametric statistical approaches (e.g. Webb and Walling 1992, Webb and Nobilis 1995) have typically been used to analyze long-term trends.

Methods: Sites for Long-term Temperature Trends in Streams and Rivers

We obtained long-term daily and monthly temperature data for 40 stream and rivers sites in the U.S. The data consisted of a variety of historical sources including records collected by researchers associated with the Hubbard Brook Ecosystem Study and University of Maryland Chesapeake Biological Laboratory. Archived records were analyzed from the Poughkeepsie Water Treatment Facility (Poughkeepsie, New York), Dalecarlia Water Treatement Plant (Washington D.C.), and Baltimore Department of Public Works (Baltimore, Maryland). Records were also analyzed from the long-term historic water quality data collected by the U.S. Geological Survey. The richest data sets were from the Delaware River, which included 6 long-term sites that ranged from upstream rural areas in New York to downstream urbanizing areas in Pennsylvania, New Jersey, and Delaware. Data sets from this study are biased towards larger streams and rivers draining the eastern U.S. Surrounding land uses where temperature was measured were quite diverse and were not consistent across all sites. Long-term monitoring of temperature at some study sites has been described previously in publications (e.g. Ritchie and Genys 1975, Likens and Bormann 1985, Ashizawa and Cole 1994, Jaworski et al. 2007)

The long-term records contain several imperfections that should be noted. Mercury thermometers were used where as present day technology also includes electronic digital thermometers and computer data loggers at some stream and river sites. In addition, sampling locations may have shifted during the period of 24-100 years when measurements were made at some sites. The sampling intensity and frequency varied for different sites (e.g. daily data were available for many sites whereas only monthly data

were available for some sites). There were some gaps in the records for some sites where temperature measurements were not reported, although there were surprisingly many consistent records. Overall, the consistencies, length, and quality of long-term records from the diverse historical sources (academic researchers, drinking water treatment plants, and U.S. Geological Survey) would be very difficult to find elsewhere. In addition, these records represent a rare and valuable resource of empirical data based on long-term monitoring that indicate the effects of human accelerated environmental change on different streams and rivers in the U.S.

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Northeastern U.S.						
Hubbard Brook Experimental Forest (Watershed 3)	Woodstock, New Hampshire	1965-2006	43°57’17.54”	71°43’22.14”	0.424 km^2	**Location:** Hubbard Brook Experimental Forest **Operated By:** U. S. Forest Service **Instrumentation:** Calibrated Thermometers and Thermistor-type thermometers **Remarks:** All temperatures were measured at the collection site immediately upstream of the gauging weir (Buso et al. 2000). Temperature measurements were made with calibrated thermometers placed directly in the stream. Since January 18, 1994, thermistor-type thermometers, calibrated against NBS-calibrated thermometers, were used.
Hudson River	Poughkeepsie, New York	1908-2006	41°43'25.81"	73°56'10.66"	30,406 km^2 (Wall et al. 2008)	**Location:** Hudson River at Poughkeepsie **Operated By:** Poughkeepsie Water Treatment Facility **Instrumentation:** Calibrated thermometers **Remarks:** Drinking Water Supply. All water samples were collected from intake pipes located 4 meters below the low tide mark and measurements were made immediately upon sample withdrawal (Ashizawa and Cole 1994). Water collection methods varied somewhat over the 98 year period, but all temperature measurements at PWTF were made with calibrated thermometers soon after water withdrawal.
Delaware River	Harvard, New York	1979-2007	42°01'28.5"	75°07'09.4"	1,186.2 km^2	**Location:** On right bank 243.84 m downstream from Baxter Brook, and 335.28 m downstream from Harvard Road bridge at Harvard. **Operated By:** This station is operated in cooperation with the NYS Department of Environmental Conservation**.** Record for this site is maintained by the USGS New York Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** Subsequent to September 1954, entire flow from 960.9 km^2 of drainage area controlled by Pepacton Reservoir and part of flow diverted for New York City municipal supply. Remainder of flow (except for conservation releases and spill) impounded for release during periods of low flow in the lower Delaware River Basin

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Delaware River	Hale Eddy, New York	1986-2007	42°00'11"	75°23'02"	1,541.0 km^2	**Location:** On left bank at downstream side of bridge on County Highway 56 in Hale Eddy, and 14.48 km upstream from confluence of East and West Branches near Hancock. **Operated By:** This station is operated in cooperation with the New York City Department of Environmental Protection and NYS Department of Environmental Conservation. Record for this site is maintained by the USGS New York Water Science Center. **Instrumentation:** Water-stage recorder. **Remarks:** Subsequent to October 1963, entire flow from 1175.9 km^2 drainage area controlled by Cannonsville Reservoir. Part of flow diverted for New York City municipal supply. Remainder of flow (except for conservation releases and spill) impounded for release during periods of low flow in the lower Delaware River basin
Delaware River	Callicoon, New York	1976-2007	41°45'24"	75°03'28"	4,713.8 km^2	**Location:** On right bank 0.8 km downstream from Callicoon Creek, 0.8 km downstream from Interstate Bridge 7, and 1.29 km southeast of Callicoon. **Operated By:** This station is operated in cooperation with the New York City Department of Environmental Protection and NYS Department of Environmental Conservation. Record for this site is maintained by the USGS New York Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** Subsequent to September 1954, entire flow from 960.9 km^2 of drainage area controlled by Pepacton Reservoir, and subsequent to October 1963, entire flow from 1175.9 km^2 of drainage area controlled by Cannonsville Reservoir.
Delaware River above Lackawaxen River	Barryville, New York	1976-2007	41°30'32"	74°59'10"	5,231.8 km^2	**Location:** On left bank 2.57 km upstream from Lackawaxen River, and 7.4 km northwest of Barryville. **Operated By:** This station is operated in cooperation with the National Weather Service, the New York City Department of Environmental Protection, and U.S. Geological Survey. Record for this site is maintained by the USGS New York Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** Subsequent to September 1954, entire flow from 960.9 km^2 of drainage area controlled by Pepacton Reservoir, and subsequent to October 1963, entire flow from 1175.9 $km^2$of drainage area controlled by Cannonsville Reservoir.

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Delaware River at Ben Franklin Bridge	Philadelphia, Pennsylvania	1965-2007	39°57'14"	75°08'16"	20,701.8 km^2	**Location:** On right bank at river end of pier 12, 45.72 m upstream from Ben Franklin bridge, and at Philadelphia. **Operated By:** Funding for the operation of this station is provided by the Delaware River Basin Commission and the U.S. Geological Survey. This station managed by the Exton Field Office. **Instrumentation:** Water-quality monitor interfaced with a data collection platform. **Remarks:** Data collection discontinued during winter months.
Delaware River	Chester, Pennsylvania	1965-2007	39°50'33"	75°21'28"	26,676.9 km^2	**Location:** In the pumping house of Kimberly-Clark Paper Company at Chester. **Operated By:** Funding for the operation of this station is provided by the Delaware River Basin Commission and the U.S. Geological Survey. This station managed by the Exton Field Office. **Instrumentation:** Water-quality monitor since December 1961. Probes interfaced with a data collection platform since the 1986 water year. **Remarks:** Prior to April 1981 sampling site located at auxiliary tidal-gaging station at the end of Reynolds Aluminum Company pier, 0.8 km downstream from Chester Creek in Chester (latitude 39°50'12", longitude 75°22'00"). Data collection discontinued during winter months. Other interruptions in the record were due to malfunctions of the instrumentation.
Delaware River	Reed Island Jetty, Delaware	1970-2007	39°30'03"	75°34'07"	29,007.9 km^2	**Location:** On dock on streamward side of jetty about 0.6 km downstream from Reedy Island near Port Penn. **Instrumentation:** Water-quality monitor since February 1970. Probes interfaced with a data collection platform since the 1986 water year. Probes placed in situ since July 1998. **Operated By:** Funding for the operation of this station is provided by the Delaware River Basin Commission and the U.S. Geological Survey. This station managed by the Exton Field Office.
Brandywine Creek	Chadds Ford, Pennsylvania	1972-2007	39°52'11"	75°35'37"	743.3 km^2	**Location:** On left bank 8.2 m upstream from Penn Central Railroad bridge at Chadds Ford, 45.72 m upstream from Harvey Run, and 365.76 m downstream from highway bridge on U.S. Highway 1. **Instrumentation:** Water-stage recorder. **Operated By:** Funding for the operation of this station is provided by the Pennsylvania Department of Environmental Protection, Chester County, and the U.S. Geological Survey. **Remarks:** Data collection discontinued during winter months since the 1981 water year

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Pohopoco Creek	Parryville, Pennsylvania	1969-2004	40°50'44"	75°38'46"	249.7 km^2	**Location:** On right bank 0.16 km upstream from Sawmill Run, 0.64 km downstream from Beltzville Dam, 2.09 km upstream from Bull Run, and 3.7 km northeast of Parryville. **Operated By:** Funding for the operation of this station is provided by the U.S. Army Corps of Engineers, the Pennsylvania Department of Environmental Protection, and the U.S. Geological Survey. **Instrumentation:** Water-stage recorder and concrete control.
Pohopoco Creek	Kresgeville, Pennsylvania	1969-2003	40°53'51"	75°30'10"	129.2 km^2	**Location:** On right bank 6.1 m downstream from bridge on U.S. Highway 209 at Kresgeville, 0.32 km downstream from Middle Creek, and 20.92 km northeast of Lehighton. **Operated By:** Funding for the operation of this station is provided by the U.S. Army Corps of Engineers, the Pennsylvania Department of Environmental Protection, and the U.S. Geological Survey. **Instrumentation:** Water-stage recorder.
Gunpowder River at Pretty Boy Reservoir	Near Baltimore, Maryland	1983-2006	39°38’52.34”	76°45’19.26”	122.9 km^2	**Location**: Pretty Boy Reservoir at Beckleysville Road Bridge **Operated By:** Baltimore City Department of Public Works **Instrumentation:** Thermometer **Remarks:** Drinking Water Supply for Baltimore, Maryland
Patapsco River at Liberty Reservoir	Near Baltimore, Maryland	1983-2006	39°26’56.60”	76°52’40.35”	233.2 km^2	**Location:** Liberty Reservoir at Nicodemus/Deer Park Bridge **Operated By:** Baltimore City Department of Public Works **Instrumentation:** Thermometer **Remarks:** Drinking Water Supply for Baltimore, Maryland
Potomac River	Washington, D.C.	1923-2004	~ 38° 56'	~ 77° 07'	~29,785 km^2	**Location:** Dalecarlia Water Treatment Plant **Operated By:** Washington D.C. Water and Sewer Authority **Instrumentation:** Thermometer **Remarks:** Drinking Water Supply, Near Potomac River at Chain Bridge
Patuxent River	Solomons, Maryland	1938-2006	76°27’12.92”	38°19’1.05”	2,352 km^2 (Voinov et al. 2007)	**Location:** Site was located at the mouth of the Patuxent River at the Chesapeake Biological Laboratory research pier. **Operated By:** Chesapeake Biological Laboratory **Instrumentation:** Thermometer **Remarks:** Mesohaline salinity levels, mostly sand bottom with little to no vegetation.

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Southeastern U.S.						
Jackson River	Hot Springs, Virginia	1979-2003	37°56'54"	79°56'58"	893.5 km^2	**Location:** Jackson River at Hot Springs, Virginia **Operated By:** Record for this site is maintained by the USGS Virginia Water Science Center **Instrumentation:** **Remarks:** Datum of gage is 426.7 m above sea level
Hyco Creek	Leasburg, North Carolina	1988-2007	36°23'52"	79°11'48"	118.9 km^2	**Location:** Hyco Creek at Leasburg, North Carolina **Operated By:** Record for this site is maintained by the USGS North Carolina Water Science Center **Instrumentation:** **Remarks:** Datum of gage is 121.9 m above sea level
Reedy Creek	Vineland, Florida	1978-2007	28°19'57"	81°34'48"	1,255.1 km^2	**Location:** 30.5 m downstream of bridge on U.S. Highway 192, about 4.02 km upstream from bridge on Interstate Highway 4, 10.46 km southwest of Vineland, and 45.06 km upstream from mouth. **Operated By:** This gage is monitored by USGS in cooperation with the Reedy Creek Improvement District. **Instrumentation:** Water-stage recorder, water-quality monitor, and data-collection platform.
Coosa River	Stateline, Alabama and Georgia	1977-2007	34°12'06"	85°26'51"	11,297.3 km^2	**Operated By:** The USGS operation and maintenance of this real-time stream gage is funded in cooperation with the Alabama Department of Economic and Community Affairs (ADECA), and Alabama Power, under FERC licensing regulations. The USGS operation and maintenance of the real-time water-quality monitor is funded in cooperation with the Georgia Department of Natural Resources, Environmental Protection Division. **Remarks:** Datum of gage is 169.2 m above sea level
Conasauga River	Tilton, Georgia	1976-2006	34°40'00"	84°55'42"	1,779.3 km^2	**Operated By:** The USGS operation and maintenance of this real-time stream gage is funded in cooperation with the U.S. Army Corps of Engineers, Mobile District. **Instrumentation:** Gage **Remarks:** Datum of gage is 189.7 m above sea level

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Midwestern U.S.						
White River	Centerton, Indiana	1976-2007	39°29'51"	86°24'02"	6,329.9 km^2	**Operated By:** Record for this site is maintained by the USGS Indiana Water Science Center. This gauging station is maintained in cooperation with The U.S. Army Corps of Engineers - Louisville District and The Ohio River Valley Water Sanitation Commision **Instrumentation:** Gage **Remarks:** Datum of gage is 181.5 m above sea level
Skunk River	Augusta, Iowa	1976-2007	40°45'13"	91°16'37.0"	11,168.0 km^2	**Operated By:** Record for this site is maintained by the USGS Iowa Water Science Center. Station operated in cooperation with Iowa DNR Geological Survey Bureau and the National Weather Service. **Instrumentation:** **Remarks:** Datum of gage is 158.9 m above sea level
Des Moines River	Saylorville, Iowa	1962-2004	41°40'50"	93°40'05"	15,128.1 km^2	**Operated By:** Record for this site is maintained by the USGS Iowa Water Science Center. Station operated in cooperation with U.S. Army Corps of Engineers - Rock Island District. **Instrumentation:** **Remarks:** Datum of gage is 240 m above sea level
Western U.S.						
Arkansas River	Pueblo, Colorado	1987-2007	38°16'18"	104°43'03"	12,095.2 km^2	**Operated By:** This station managed by the Pueblo Southeast Colorado Office. Record for this site is maintained by the USGS Colorado Water Science Center. **Instrumentation:** **Remarks:** Datum of gage is 1,444.8 m above sea level
Colorado River	Cisco, Utah	1950-2004	38°48'38"	109°17'34"	62,418.7 km^2	**Operated By:** Station operated by the U.S. Geological Survey as part of the National Streamflow Information Program in cooperation with the U.S. Bureau of Reclamation. Record for this site is maintained by the USGS Utah Water Science Center. **Instrumentation:** **Remarks:** Datum of gage is 1,246.6 m feet above sea level
Dolores River	Cisco, Utah	1950-2003	38°47'50"	109°11'40"	11,862.1 km^2	**Location:** On left bank 0.32 km downstream from Line Canyon, 14.65 km upstream from mouth, 21.73 km downstream from Colorado-Utah State line, and 22.37 km southeast of Cisco. **Operated By:** Station operated by the U.S. Geological Survey as part of the National Streamflow Information Program in cooperation with the U.S. Bureau of Reclamation. Record for this site is maintained by the USGS Utah Water Science Center. **Instrumentation:** Water-stage recorder.
Flathead River	Columbia Falls, Montana	1979-2007	48°21'43"	114°11'02"	11,561.7 km^2	**Operated By:** Record for this site is maintained by the USGS Montana Water Science Center. Station operated in cooperation with the Montana Department of Fish, Wildlife and Parks, Montana Department of Natural Resources and Conservation, PPL Montana, and the U.S. Bureau of Reclamation **Remarks:** Datum of gage is 907.6 m above sea level

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
Madison River	McAllister, Montana	1978-2007	45°29'25"	111°38'00"	5,661.7 km^2	**Operated By:** Station operated in cooperation with the Montana Department of Fish, Wildlife and Parks and PPL Montana. Record for this site is maintained by the USGS Montana Water Science Center. **Remarks:** Datum of gage is 1.429.2 m above sea level
Missouri River	Toston, Montana	1978-2007	46°08'46"	111°25'11"	37,992.5 km^2	**Operated By:** Record for this site is maintained by the USGS Montana Water Science Center. Station in cooperation with Montana Department of Fish Wildlife and Parks and the Montana Department of Natural Resources and Conservation. **Instrumentation:** Gage **Remarks:** Datum of gage is 1,190.5 m above sea level
Fir Creek	Brightwood, Oregon	1978-2007	45°28'49"	122°01'28"	14.1 km^2	**Location:** On right bank, 10.3 km north of Brightwood and 0.97 km above Bull Run Reservoir Number One. **Operated By:** Station operated in cooperation with Portland Water Bureau. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder. **Remarks:** Records provisional. No regulation or diversion upstream from station.
North Santiam River	Niagara, Oregon	1979-2007	44°45'10"	122°17'50"	1,173.3 km^2	**Location:** On left bank 0.16 km downstream from Little Sardine Creek, 1.29 km downstream from Big Cliff Dam, 3.38 km east of Niagara, and at kilometer 92.22. **Operated By:** Station operated in cooperation with the U.S. Army Corps of Engineers and the city of Salem. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder. **Remarks:** Flow regulated since 1953 by Detroit Lake and Big Cliff Reservoir.
Rogue River	McLeod, Oregon	1979-2007	42°39'20"	122°42'50"	2,429.4 km^2	**Location:** On left bank at Obstinate J Ranch, 2.09 km downstream from Big Butte Creek, 2.57 km southwest of McLeod, and at kilometer 247.84. **Operated By:** Station operated in cooperation with the U.S. Army Corps of Engineers. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** Flow regulated since February 1977 by Lost Creek Lake. Diversions for irrigation upstream from station; most of low flow of Big Butte Creek is diverted near Butte Falls.
Bull Run River	Multinomah Falls, Oregon	1978-2007	45°29'50"	122°00'50"	124.1 km^2	**Location:** In Mount Hood National Forest, on right bank 1.93 km upstream from North Fork, 11.27 km southeast of Multnomah Falls, and at kilometer 23.82. **Operated By:** Station operated in cooperation with Portland Water Bureau. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** Regulation at times since 1915 by Bull Run Lake, usable capacity, 15,134,910.03 m^3.

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
North Fork Bull Run River	Multinomah Falls, Oregon	1979-2007	45°29'40"	122°02'05"	21.5 km^2	**Location:** Mount Hood National Forest, on left bank 11.27 km southeast of Multnomah Falls and at mouth. **Operated By:** Station operated in cooperation with Portland Water Bureau. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder. Site located 1.5 m upstream from bridge, on left bank wing wall. **Remarks:** Regulation at times since 1958 by North Fork Reservoir, capacity, about 1,270,493.67 m^3.
South Fork Rull Run River	Multinomah Falls, Oregon	1979-2007	45°26'38"	122°06'20"	39.9 km^2	**Location:** In Mount Hood National Forest, on right bank 9.98 km northeast of Bull Run, and at kilometer 0.97. **Operated By:** Station operated in cooperation with Portland Water Bureau. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** No regulation or diversion upstream from station.
Rogue River at Dodge Bridge	Eagle Point, Oregon	1979-2007	42°31'30"	122°50'30"	3,146.8 km^2	**Location:** On right bank 15.2 m upstream from Dodge Bridge, 1.13 km downstream from Reese Creek, 6.92 km northwest of Eagle Point, and at kilometer 223.06. **Operated By:** Station operated in cooperation with the U.S. Army Corps of Engineers. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder. **Remarks:** Flow regulated since February 1977 by Lost Creek Lake. Diversions for irrigation upstream from station; most of low flow of Big Butte Creek is diverted near Butte Falls.
Blue River	Blue River, Oregon	1979-2007	44°09'45"	122°19'55"	227.1 km^2	**Location:** On right bank 0.48 km upstream from Simmonds Creek, 1.13 km north of town of Blue River, 1.29 km downstream from Blue River Dam, and at kilometer 1.45. **Operated By:** Station operated in cooperation with the U.S. Army Corps of Engineers. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder. **Remarks:** Flow regulated since October 1968 by Blue River Lake. No diversion upstream from station. Discharge not adjusted for storage or release from Blue River Lake as losses from reservoir at times exceed natural flow.

Stream and River	Geographic Location	Record of Observation	Latitude	Longitude	Drainage Area	Site Remarks
South Santiam River	Foster, Oregon	1979-2007	44°24'45"	122°41'15"	1,442.6 km^2	**Location:** On left bank 0.97 km downstream from Wiley Creek and at kilometer 59.55. **Operated By:** Station operated in cooperation with the U.S. Army Corps of Engineers. Record for this site is maintained by the USGS Oregon Water Science Center. **Instrumentation:** Water-stage recorder. **Remarks:** Flow regulated since October 1966 by Green Peter Lake and since December 1966 by Foster Lake. No diversion upstream from station.
Tuolumne River	Lagrange, California	1971-2007	37°39'59"	120°26'28"	3,983.4 km^2	**Location:** On left bank, 0.8 km downstream from La Grange Dam, and 1.77 km east of La Grange. **Operated By:** This station managed by the Sacramento Field Office. Record for this site is maintained by the USGS California Water Science Center. **Instrumentation:** Water-stage recorder and crest-stage gage. **Remarks:** Flow diverted into Modesto Canal and Turlock Canal at La Grange Dam. Flow regulated by Don Pedro Powerplant, Don Pedro Reservoir, 7.2 km upstream, Hetch Hetchy Reservoir, Cherry Lake, and Lake Eleanor. Tuolumne Canal diverts water from the Stanislaus River Basin into the Tuolumne River Basin for power, irrigation, and domestic supply in the vicinity of Sonora, upstream from station. Diversion through Hetch Hetchy Aqueduct to San Francisco began Oct. 19, 1934.

Supporting Information Table 2. Site characteristics and sampling locations for long-term temperature records in streams and rivers. Site information was obtained from U.S. Geological Survey for U.S. Geological Survey sites. Other information was provided from literature sources or investigators conducting research at specific sites. Watershed area may represent an approximate estimate for some long-term sampling sites.

Methods: Analysis of Temperature Trends in Streams and Rivers

For each stream and river, the mean temperature over an annual period was computed. Daily data were averaged to calculate monthly means and these monthly means were then averaged to obtain annual means. Years with incomplete data for more than 3 months were omitted from the analysis. The annual mean was then plotted against time for each site to check for any anomalies or obvious steps in the data that would indicate differences due to forms of measurement at study sites. We analyzed long-term temperature trends using both simple linear regression and nonparametric Mann-Kendall test for trends and Sen's slope estimates for all sites (Supporting Information Table 2). Simple linear regression was performed using the SAS statistical software package and Mann-Kendall trend test was performed using the MAKESENS statistical software provided by the Finnish Meteorological Institute (Salmi et al. 2002). The significance of the simple linear regression analysis was typically similar to the Mann-Kendall trend test, but differed in only a few cases (6 out of 40 analyses); 5 of these cases showed significant trend results using Mann-Kendall. The data may have violated normality assumptions and general assumptions of simple linear regression, which would decrease power relative to that of the Mann-Kendall test. The Mann-Kendall statistic may not be powerful to detect trends with small sample sizes for some records, however. Both methods also have the independence assumption which is commonly violated in hydrologic time series. Previous work analyzing water temperature trends has widely used both linear regression and Mann-Kendall trend analysis approaches (e.g. Webb and Walling 1992, Ashizawa and Cole 1994, Hari et al. 2006, Durance and Omerod 2007).

Stream and River	Geographic Location	Record of Observation	N	Test Z		Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
Northeastern U.S.															
Hubbard Brook-Watershed 3	Woodstock, New Hampshire	1966-2006	41	-0.66		-0.008	-0.029	0.017	-0.025	0.012	6.69	7.08	6.19	7.00	6.28
Hubbard Brook-Watershed 6	Woodstock, New Hampshire	1966-2006	41	-0.55		-0.004	-0.021	0.019	-0.019	0.013	6.66	6.94	6.17	6.92	6.32
Hudson River	Poughkeepsie, New York	1908-2006	88	3.51	***	0.010	0.002	0.017	0.004	0.015	11.93	12.34	11.59	12.22	11.72
Delaware River	Harvard, New York	1979-2007	29	0.39		0.007	-0.044	0.067	-0.031	0.049	8.90	9.77	7.95	9.43	8.35
Delaware River	Hale Eddy, New York	1986-2007	22	1.47		0.043	-0.033	0.119	-0.011	0.101	7.49	8.27	6.74	7.99	6.93
Delaware River	Callicoon, New York	1976-2007	29	2.31	*	0.024	-0.011	0.056	0.005	0.047	10.08	10.57	9.42	10.42	9.67
Delaware River above Lackawaxen River	Barryville, New York	1976-2007	30	1.96	*	0.029	-0.010	0.064	-0.001	0.056	10.87	11.47	10.10	11.27	10.24
Delaware River at Ben Franklin Bridge	Philadelphia, Pennsylvania	1965-2007	40	3.09	**	0.058	0.011	0.103	0.025	0.092	15.33	16.11	13.81	15.77	14.25
Delaware River	Chester, Pennsylvania	1965-2007	40	3.69	***	0.077	0.027	0.115	0.038	0.105	14.94	16.47	14.39	16.13	14.58
Delaware River	Reed Island Jetty, Delaware	1972-2007	36	1.02		0.015	-0.023	0.045	-0.011	0.036	14.41	15.21	13.81	14.97	14.01
Brandywine Creek	Chadds Ford, Pennsylvania	1972-2007	36	2.90	**	0.063	0.019	0.112	0.036	0.098	13.40	14.47	12.84	14.02	12.97
Pohopoco Creek	Perryville, Pennsylvania	1969-2004	34	-1.01		-0.014	-0.050	0.018	-0.038	0.008	9.93	10.60	9.18	10.41	9.33
Pohopoco Creek	Kresgeville, Pennsylvania	1969-2003	34	0.27		0.003	-0.026	0.037	-0.020	0.029	9.93	1.41	9.50	10.26	9.63
Gunpowder River at Pretty Boy Reservoir	Near Baltimore, Maryland	1983-2007	23	2.75	**	0.075	0.012	0.127	0.038	0.104	14.08	14.88	13.25	14.50	13.65
Patapsco River at Liberty Reservoir	Near Baltimore, Maryland	1983-2007	25	-1.19		-0.031	-0.100	0.054	-0.079	0.024	16.32	16.87	15.27	16.71	15.54
Potomac River	Washington, DC	1923-2004	76	6.41	***	0.050	0.034	0.066	0.039	0.061	13.35	13.98	12.91	13.85	13.00
Patuxent River	Solomons, MD	1938-2006	69	5.02	***	0.022	0.011	0.031	0.014	0.028	14.47	14.76	14.17	14.66	14.28

Stream and River	Geographic Location	Record of Observation	N	Test Z	Significance	Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
Southeastern U.S.															
Jackson River	Hot Springs, Virginia	1979-2003	25	-3.25	**	-0.096	-0.140	-0.028	-0.126	-0.053	12.79	13.37	11.71	13.27	12.22
Hyco Creek	Leasburg, North Carolina	1988-2007	17	1.03		0.043	-0.074	0.129	-0.052	0.091	13.94	15.63	13.15	15.29	13.48
Reedy Creek	Vineland, Florida	1978-2007	30	3.21	**	0.043	0.008	0.073	0.016	0.061	20.91	21.43	20.45	21.29	20.52
Coosa River	Stateline, Alabama and Georgia	1977-2007	30	1.28		0.027	-0.032	0.104	-0.021	0.079	18.45	19.21	17.37	19.01	17.79
Conasauga River	Tilton, Georgia	1976-2006	31	1.56		0.020	-0.013	0.053	-0.006	0.042	16.63	16.95	16.07	16.88	16.27
Midwestern U.S.															
White River	Centerton, Indiana	1976-2007	24	-0.07		-0.003	-0.127	0.150	-0.091	0.101	15.33	16.86	12.37	16.45	13.42
Skunk River	Augusta, Iowa	1976-2007	32	1.77	+	0.039	-0.019	0.093	-0.005	0.083	13.56	14.16	12.54	13.97	12.76
Des Moine River	Saylorville, Iowa	1962-2004	43	2.22	*	0.032	-0.004	0.059	0.002	0.050	12.26	13.05	11.67	13.00	11.84
Western U.S.															
Arkansas River	Pueblo, Colorado	1988-2007	20	3.02	**	0.040	0.006	0.066	0.016	0.057	10.79	11.11	10.51	10.99	10.64
Colorado River	Cisco, Utah	1950-2003	54	4.43	***	0.033	0.016	0.052	0.019	0.047	11.23	11.64	10.56	11.53	10.73
Dolores River	Cisco, Utah	1950-2003	49	0.78		0.007	-0.018	0.032	-0.011	0.026	12.24	12.82	11.38	12.57	11.59
Flathead River	Columbia Falls, Montana	1979-2007	29	3.62	***	0.045	0.014	0.079	0.024	0.069	6.18	6.64	5.62	6.54	5.77
Madison River	McAllister, Montana	1978-2007	29	2.53	*	0.027	-0.001	0.067	0.006	0.055	8.60	9.02	7.83	8.94	7.99
Missouri River	Toston, Montana	1978-2007	29	2.68	**	0.034	0.001	0.068	0.007	0.055	8.94	9.40	8.34	9.26	8.55
Fir Creek	Brightwood, Oregon	1978-2007	30	2.46	*	0.021	-0.001	0.043	0.004	0.036	6.73	7.06	6.40	6.99	6.45
North Santiam River	Niagara, Oregon	1979-2007	27	2.25	*	0.017	-0.005	0.041	0.002	0.035	7.56	7.98	7.29	7.78	7.36
Rogue River	McLeod, Oregon	1979-2007	29	3.70	***	0.028	0.012	0.044	0.017	0.040	7.96	8.15	7.68	8.07	7.72
Bull Run River	Multinomah Falls, Oregon	1978-2007	30	2.07	*	0.019	-0.006	0.046	0.001	0.038	7.19	7.59	6.82	7.51	6.94
North Fork Bull Run River	Multinomah Falls, Oregon	1979-2007	29	1.14		0.010	-0.016	0.035	-0.009	0.029	6.78	7.14	6.40	7.07	6.54
South Fork Bull Run River	Multinomah Falls, Oregon	1979-2007	29	2.19	*	0.017	-0.004	0.043	0.002	0.033	7.53	7.84	7.24	7.77	7.30
Rogue River at Dodge Bridge	Eagle Point, Oregon	1979-2007	28	2.51	*	0.027	-0.004	0.052	0.004	0.046	8.62	9.03	8.21	8.97	8.33
Blue River	Blue River, OR	1979-2007	27	-2.42	*	-0.036	-0.080	0.001	-0.070	-0.010	8.94	9.59	8.38	9.42	8.57

Stream and River	Geographic Location	Record of Observation	N	Test Z		Q	Qmin99	Qmax99	Qmin95	Qmax95	B	Bmin99	Bmax99	Bmin95	Bmax95
South Santiam River	Foster, Oregon	1979-2007	24	-0.22		-0.002	-0.038	0.035	-0.029	0.028	9.47	10.03	9.17	9.86	9.23
Tuolumne River	Lagrange, California	1973-2007	35	-1.33		-0.021	-0.052	0.015	-0.047	0.005	11.50	12.34	10.68	12.18	10.86

*** if trend at α = 0.001 level of significance * if trend at α = 0.05 level of significance
** if trend at α = 0.01 level of significance + if trend at α = 0.1 level of significance

Test Z: The absolute value of Z is compared to the standard normal cumulative distribution to define if there is a trend or not at the selected level α of significance. A positive (negative) value of Z indicates an upward (downward) trend.

Sen's slope estimate Q: the Sen's estimator for the true slope of linear trend
Qmin99: the lower limit of the 99 % confidence interval of Q (α= 0.1)
Qmax99: the upper limit of the 99 % confidence interval of Q (α= 0.1)
Qmin95: the lower limit of the 95 % confidence interval of Q (α= 0.05)
Qmax95: the upper limit of the 95 % confidence interval of Q (α= 0.05)

B: estimate of the constant B in equation f(year)=Q*(year-firstYear)+B for a linear trend, the y-intercept
Bmin99: estimate of the constant Bmin99 in equation f(year)=Qmin99*(year-firstYear)+Bmin99 for 99% confidence level of linear trend
Bmax99: estimate of the constant Bmax99 in equation f(year)=Qmax99*(year-firstYear)+Bmax99 for 99% confidence level of linear trend
Bmin95: estimate of the constant Bmin95 in equation f(year)=Qmin95*(year-firstYear)+Bmin95 for 95% confidence level of a linear trend
Bmax95: estimate of the constant Bmax95 in equation f(year)=Qmax95*(year-firstYear)+Bmax95 for 95% confidence level of a linear trend

Supporting Information Table 3. Summary statistics for Mann-Kendall Rank time-series analyses. Each time series is considered independent of the others. No correction was put on the p values to keep the overall type I error <= 0.05

Urban Heat Island Effects and Temperature

Many stream and river sites in urban areas of the mid-Atlantic U.S. showed the most rapid historical increases in temperature (e.g. the Delaware River, the Potomac River, Patapsco River, and Brandywine Creek). The Patuxent River site showed a statistically significant long-term increase in temperature, but it was lower than the other sites. The Patuxent River site is fully tidal and occurs as part of a shallow (<2 m) mesohaline portion of the Chesapeake Bay. The general attributes of shallow temperate estuaries should reflect efficient atmospheric forcing, and indeed during the 1960-2007 period, annual air and seawater temperatures showed tight coupling (r=0.61). Interestingly, levels of increase observed in the Patuxent River series were similar to those of surface air temperature (SATs) reconstructed at US and global scales: about 0.2 C per decade during past three decades (Hansen et al. 2001; http://data.giss.nasa.gov/gistemp/2005/).

In order to provide an example of interactive factors of land use change and urban "heat island" effects, continuous temperature data from August 2004 are also presented from streams draining the well-defined land use gradient at the Baltimore Ecosystem Study Long-term Ecological Research (LTER) site funded by the U.S. National Science Foundation in Baltimore, Maryland, U.S.A. Data represented continuous monitoring of stream temperature by data loggers at different stream locations within the greater metropolitan area of Baltimore, Maryland, U.S.A. Long-term monitoring of stream temperature has been conducted at the Baltimore (LTER) site in forest, suburban, and urban streams that spans a land-use gradient from the densely urban Baltimore City to rapidly urbanizing fringing areas in surrounding Baltimore County (Pouyat et al. 2007).

There were increases in water temperatures in suburban and urban streams that coincide with well-documented increases in air temperature in these geographic areas due to "urban heat island" effects (e.g. Brazel et al. 2000, Pouyat et al. 2007). In addition, there were periodic "surges" in stream temperatures due to runoff from warmed impervious surfaces during hot summer months, possibly due to heating effects of black pavement on storm runoff.

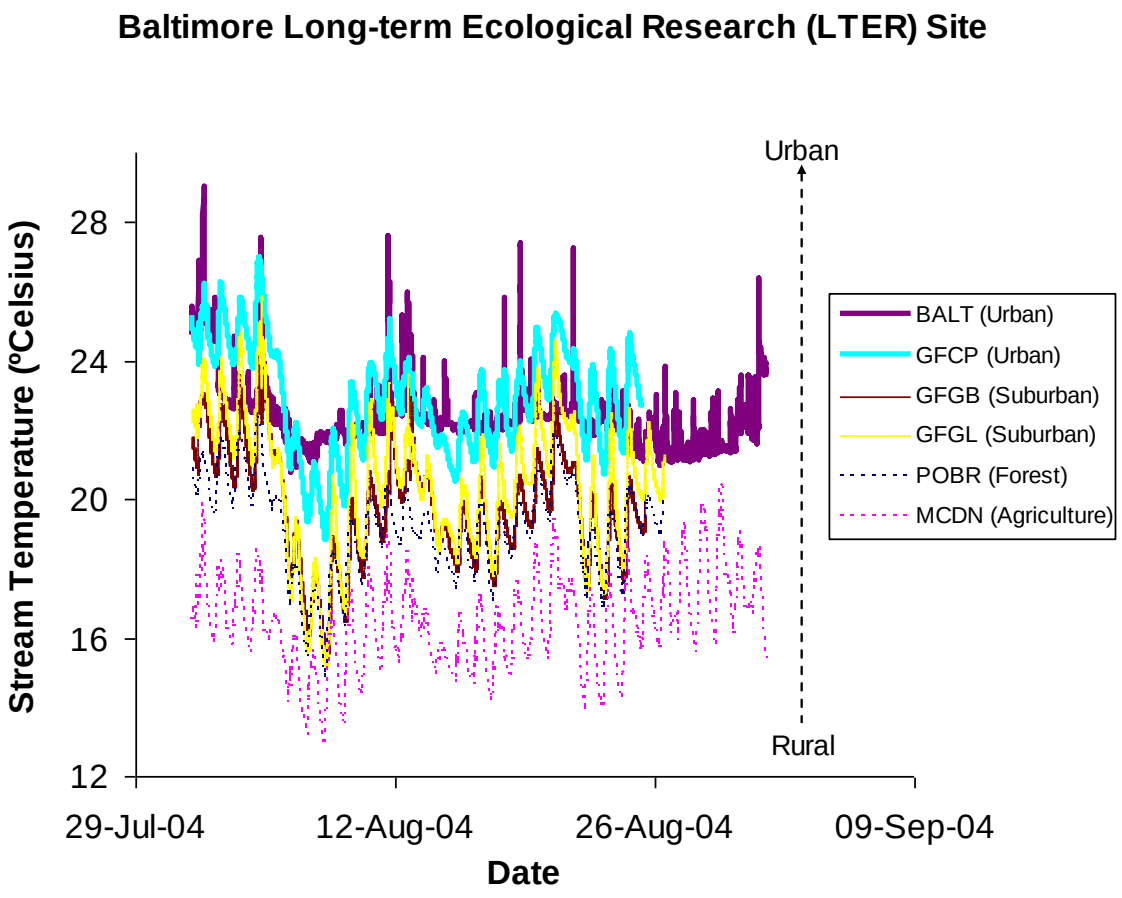

Figure 2. Patterns in continuous water temperature in streams draining watersheds of the Baltimore Long-term Ecological Research (LTER) site in Baltimore, Maryland, U.S.A. Sites represent a well-defined land use gradient from the urban core of Baltimore City, Maryland to rapidly developing rural fringes of Baltimore County, Maryland.

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