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CITY PARKS FORUM
BRIEFING PAPERS

# How cities use parks for…

# Climate Change Management


## Executive Summary

The urban heat island effect, and its mostly negative consequences of modified temperature, wind, precipitation, and air quality patterns, is the primary instigator of local climate change. Continued urbanization of the global population will only hasten further change. The increasing impact of urban heat islands on local climates may eventually translate to more widespread climate change, possibly global, if left unchecked.

Parks are the first and best line of defense against these changes. Urban parks cool and clean the air, improve and modify local wind circulations, and better regulate precipitation patterns. Well-vegetated parks, in a variety of forms and sizes, mitigate the impact of the urban heat island and minimize local climate change. Reduced impact of the urban heat island may prolong or even prevent more widespread global climate change as cities continue to increase in both size and number.


### Key Point #1

Parks moderate artificially higher temperatures from the urban heat island effect through shading and evapotranspiration.

### Key Point #2

Parks enhance local wind patterns in cities through the park breeze (cooler air over parks replaces warmer air in adjacent city neighborhoods).

### Key Point #3

Parks mitigate local precipitation anomalies amplified by the urban heat island effect.

### Key Point #4

Parks sequester carbon and other pollutants trapped by the urban heat island that may otherwise alter local and global atmospheric composition.


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# Climate Change Management

**KEY POINT #1:**

*Parks moderate artificially higher temperatures from the urban heat island effect through shading and evapotranspiration.*

According to the U.S. Environmental Protection Agency (EPA), heat islands are of growing concern for millions of Americans living in and around cities (www.epa.gov/heatisland/). The urban heat island effect is a positive temperature anomaly that occurs over urban areas relative to surrounding non-urban areas. The air over cities becomes warmer due to excessive concentrations of paved surface, reflective surface (both ground and buildings), and population (Ahrens 2006). The heat island effect may generate urban temperatures 2 to 10 degrees F (1 to 6 degrees C) higher than non-urban areas.

Elevated temperatures can impact communities by increasing peak energy demand, air conditioning costs, air pollution levels, and heat-related illness and mortality. Hotter air over cities can also influence local wind and precipitation patterns.

Fortunately, increasing vegetation in cities by creating or expanding parks and open space networks reduces the higher temperature effects of urban heat islands. Urban parks and greenspace counter the effect by cooling the air through both shading and evapotranspiration (evaporation from the leafy parts of plants).

Through EPA's Urban Heat Island Pilot Project (1998-2003), several U.S. cities, such as **Chicago** and **Salt Lake City**, devised approaches to increase greenspace and tree cover in their communities to mitigate their local climate (www.epa.gov/heatisland/pilot/).

Since 1996, Chicago Public Schools has collaborated with the Chicago Park District and the Public Building Commission to create 70 new campus parks around public schools. These parks are designed to provide students and the community with landscaping, recreational opportunity, and cooling potential (egov.cityofchicago.org; www.museumsandpublicschools.org/Partners/cps.html).

One of Salt Lake City's most significant projects has been a three-acre Alpine meadow on the roof of the new conference center, a 1.5 million-square-foot building that occupies a full city block. A waterfall cascades down the front of the building, and a long-submerged creek now runs along its length on North Temple Street. The rooftop meadow is a re-creation of the wild landscape of Utah mountains, and it features 21 types of Utah grasses and 300 varieties of native wildflowers. The meadow demonstrates how buildable space can mitigate urban heat (the Church of Jesus Christ of Latter-day Saints; www.lds.org/).

**KEY POINT #2:**

*Parks enhance local wind patterns in cities through the park breeze (cooler air over parks replaces warmer air in adjacent city neighborhoods).*

Wind is another important, perhaps lesser known, outcome of the urban heat island effect. Urban areas warm up much faster and tend to reach higher temperatures during the daytime than surrounding non-urban areas (Ahrens 2006). Because warmer air is lighter and less dense than cooler air, it rises and causes lower atmospheric pressure over urban areas. As it rises, warm urban air spreads out and cools, becomes heavier, and sinks over non-urban areas, creating higher atmospheric pressure. The pressure difference between urban and non-urban areas generates winds that blow from non-urban high pressure toward urban low pressure. The return of cool non-urban air to replace warm, rising urban air completes the urban breeze cycle (Spronken-Smith and Oke 1999).

Parks may act as microscale "non-urban areas" within a city and thus create an even smaller circulation known as the "park breeze." The daytime cooling that occurs due to evapotranspiration of park vegetation and the evening cooling that occurs because vegetative cover does not retain heat as well as pavement and buildings creates a "park cool island (PCI) effect" (Spronken-Smith and Oke 1999). The difference in temperature between park interiors (especially larger parks) and the surrounding city creates an atmospheric pressure difference similar to that found between non-urban and urban areas. This pressure difference creates a breeze from park interiors to city neighborhoods, modifying the urban heat island.

In the past few years, New York State has invested the lion's share of its money for **New York City** parks in two large waterfront parks that may enhance the urban breeze and park breeze circulations within the city. The state has committed half of the $300 million cost of building the Hudson River Park (150 acres land/400 acres open water) with annual appropriations of around $15 million to $20 million (www.fohrp.org/fohrp.php?screen=park). Gov. George Pataki and Mayor Michael Bloomberg recently signed a memorandum of understanding in which the state pledged $85 million and the city $65 million toward the creation of the Brooklyn Bridge Park (85 acres) (www.brooklynbridgepark.org/).

### KEY POINT #3:

## *Parks mitigate local precipitation anomalies amplified by the urban heat island effect.*

In addition to impacts on temperature and wind, the urban heat island affects local precipitation patterns. Both relatively warmer air and higher concentrations of particulates over cities can cause more frequent precipitation events (Ahrens 2006).

Human-made modifications of the natural environment affect the thermal stratification of the atmosphere above a city as well as the local heat balance and hydrologic cycle (www.atmosphere.mpg.de/enid/3rm.html). The urban heat island effect causes the warmer air (including its higher concentrations of moisture and pollutants) to rise more readily than cooler air over non-urban areas (Oke 1987). Consequently, moisture and pollutants are transported into higher levels of the urban atmosphere. Thus, the urban heat island creates a warmer, moister atmosphere over the city. Once lifted, the air will cool and, if enough moisture is available, clouds and precipitation may form. The increased number of cloud condensation nuclei (CCN) and ice forming nuclei (IN) from urban pollution further enhances urban precipitation.

Qing Lu Lin and Robert Bornstein, meteorologists from San Jose State University, used data from meteorological stations set up during the 1996 Summer Olympics and discovered that the urban heat island in Atlanta created frequent thunderstorms (svs.gsfc.nasa.gov/stories/Landsat/atlanta_heat_ background.html). Using the National Weather Service's ground-based meter to collect data (the same instrument used to forecast weather for Olympic athletic events), Lin and Bornstein found that five of nine days of precipitation over Atlanta were caused by the urban heat island effect (Lin and Bornstein 2000).

Increased thunderstorm frequency over cities has mixed blessings. On one hand, precipitation cleans the atmosphere of pollutants and cools the air over a city. However, the increased precipitation over an area of mostly impervious cover can cause greater likelihood of urban flooding. More rain over urban areas can strain already taxed urban stormwater management systems.

Urban parks reduce the precipitation anomalies of the urban heat island by cooling the air above cities and removing particulates that could potentially become condensation nuclei. Urban parks also provide the cooling effect of additional rainfall without the detrimental impact of stormwater flooding. By providing more parks, cities could better manage precipitation pattern changes.

### KEY POINT #4:

## *Parks sequester carbon and other pollutants trapped by the urban heat island that may otherwise alter local and global atmospheric composition.*

Cities are key contributors to both low-level atmospheric pollution and broader climate change through greenhouse gases such as carbon dioxide. Both results could potentially have a negative impact on urban populations. Urban air pollution from vehicles is particularly harmful, resulting in respiratory problems, acid rain, and reduction in the amount of solar radiation that can reach the earth's surface. Fortunately, research shows vegetation can act as a pollutant sink.

High levels of carbon dioxide ($CO_2$) and other gases trap heat from the Earth in the atmosphere and prohibit it from releasing heat into space, a phenomenon known as the "greenhouse effect." Trees remove (sequester) $CO_2$ from the atmosphere during photosynthesis and return oxygen back to the atmosphere as a byproduct. Trees therefore act as a carbon sink and oxygen source (www.coloradotrees.org).

Project EverGreen has supported studies showing that within one year an acre of trees can absorb enough carbon dioxide to equal the amount produced by driving a car 11,000 miles (Virginia Cooperative Extension, www.ext.vt.edu). At the same time, trees and turf in a park also return significant amounts of oxygen to the atmosphere. A turf area of only 50 square feet produces enough oxygen to meet the needs of a family of four (www.projectevergreen.com).

In addition to carbon, studies have also shown how effectively trees remove other pollutants. A 212,000-acre urban park tree cover removed 48 pounds of particulates, 9 pounds of nitrogen dioxide, 6 pounds of sulfur dioxide, 2 pounds carbon monoxide, and 100 pounds of carbon daily (Coder 1996). The U.S. Forest Service calculates that over a 50-year lifetime one tree generates $31,250 worth of oxygen and provides $62,000 worth of air pollution control (www.coloradotrees.org/). Yet another study found trees in New York City removed an estimated 1,821 metric tons of air pollution in 1994 (Nowak 1995).

Increasing the amount and size of well-vegetated parks can help reduce the amount of pollutants in the atmosphere. In addition to the obvious health benefits for humans, the pollutant-reducing capabilities of vegetation also bode well for climate change management, particularly with respect to the greenhouse effect.

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## City Parks Forum Briefing Papers

This is a special issue in a series of briefing papers on how cities can use parks to address urban challenges. We hope the information here helps you to create great urban parks in your city.

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***Photo of St. Paul, Minnesota, by Bruce Challgren.***