Urban Cooling

or How Local Heat Islands Can Help in the Battle Against Global Climate Change

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Summary/Abstract:

Climate Change (CC) is a momentous global challenge that is abstract, large and remote, making it difficult to motivate most people to act on it with any sense of urgency. In many climate zones, the Urban Heat Island (UHI) is a more immediate, local and palpable challenge, with a 5 to 10 year horizon, rather than the 50 to 100 year horizon for CC. Fortunately, strategies to address the Urban Heat Island Effect are almost identical to addressing global CC. Equally fortunate is the fact that strategies to *mitigate* and to *adapt* to UHI are also nearly identical to each other. These two confluences mean that UHI can be invoked as an effective motivator and mobilizer of behavioral and physical change in many climate zones in the U.S. and other parts of the world. Because adaptation prompts more immediate and direct interventions that tend to have quicker and more tangible results, it is typically more satisfying to humans than the slower-to-bear-fruit mitigation practices and policy-making. The paper discusses the magnitude of the local and global climate problem, ways to motivate people to change their behavior, and why addressing UHI is both timely and necessary. Indeed, it can be argued that in cities waste heat and land use changes are playing a more significant role in local warming than greenhouse gases (GHGs). The essay then describes three urban cooling strategies and tactics, *albedo enhancement, sensible heat reduction,* and *cool micro-climates.* It also acknowledges that UHI can bring unnecessary attention to increasingly uncomfortable air temperatures in cities, and thereby diminish their appeal and can encourage urban residents to migrate to suburban and rural areas, where their life styles will be more wasteful, energy-consumptive and carbon-intensive. Changes in land and building surfaces, as well as reduction of waste heat are among the most effective and direct options to counter CC in the foreseeable future.

> ***"****The vessel we are now aboard is not merely the biggest of all time; it is the only one left. The future of everything we have accomplished…will depend on the wisdom of our actions over the next few years. Like all creatures, humans have made their way in the world so far by trial and error; unlike other creatures, we have a presence so colossal that error is a luxury we can no longer afford. The world has grown too small to forgive us any big mistakes."*
>
> Ronald Wright, *A Short History of Progress*

> *"Most people don't think about global temperatures but local ones…Extremes also have a profound impact on people: a heat wave in 2003 caused about 70,000 premature deaths in Europe. Focusing on links between climate change and the local weather thus makes sense in both science and public understanding."*
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> "Is it global warming or just the weather?" *The Economist,* May 9-15, 2015

I. THE MAGNITUDE OF THE PROBLEM

There is ever-mounting evidence that Climate Change and its cascading impacts will prove to be not only the greatest challenge facing our global civilization, but also one of the greatest crises ever to face humanity. It's *qualitatively* different from war, crime, corruption and poverty, which are chronic problems that we have been with humans since our beginnings. (So has CC, but it has not been as disruptive as now). We humans have had almost perfect climatic and ecological conditions to survive and prosper during the long and tranquil "summer" of the past 10,000 years of the Holocene Age. We have come "to take a gentle climate for granted; civilization has never experienced anything else."[1] Benign conditions for the last 400 generations have allowed us to develop farming and cities – we're not sure which came first – and very complex societies. Indeed, we have taken great advantage of the favorable conditions, "using everything that climate provides…(and) the climate of the last few thousand years is about as good as it gets."[2]

Contemporary climate science begs a profound question - is this long halcyon summer ending, and are we in for the first major climate shock and disruption in ten millennia? Is climate, the big alpha driver of human history, starting to reach tipping points that will dramatically change the atmosphere and oceans on earth? If so, we know the planet itself will do well; it has been through far bigger changes, but will our species continue to grow in number and dominion? Will our newly emerging Anthropocene Age, with humans altering the atmospheric, geologic, hydrologic, biospheric systems and cycles, be a brief footnote after the Holocene?

Are we victims of our own success as a species, and will our combustion of fossil fuels do us in? Will the endless little gasoline bangs in hundreds of millions internal combustion engines around the world combine to effectively disable us in a giant, super-slow-motion explosion?
Rather than reform, will we and our leaders – as civilizations have classically done in previous terminal crises - double down and intensify production, deplete resources, borrow more from the future to pay present bills, binge recklessly on taller, more monumental buildings and more ambitious, spectacular extravaganzas in all human endeavors?

As Stewart Brand writes in *Whole Earth Discipline*, "If we fail to stabilize climate, our civilization will either be gone or unrecognizable."[3] The problem is, of course, how can we mortals wrap our minds and arms around such an unwieldy, complex, amorphous and seemingly slow-moving challenge. People are hard-wired to deal with more

[1] Stewart Brand, *Whole Earth Discipline,* Penguin Books, 2009, p.15
[2] Richard Alley, *The Two Mile Ice Machine: Ice Cores, Abrupt Climate Change, and Our Future,* Princeton University Press, 2000, p.192
[3] Brand, *Whole Earth Discipline,* p.20

pressing problems, especially ones with palpable and personal immediacy. We need to find and develop ways to motivate homo sapiens to be climate smart and climate ready.

II. SOME THOUGHTS ON HUMAN MOTIVATION

> *"The 'ought to' reason is used to frame most of the sustainability solutions... You ought to recycle. You ought to drive less. You ought to adjust your thermostat... 'Ought to' sounds like a good reason for someone else to do something, but not a good reason for me to do something…That leaves us with the 'want to' reason… People want to do something because they love to do it or because they're convinced it will benefit them in some way… Rather than avoiding pain like you do with a 'have to' reason, you're doing something because of the pleasure or other benefit it brings."*
>
> Steve Mouzon, *Original Green,* 7/31/09

Much has been written on what makes people change the way they think and act. There seem to be three basic human motivators of behavior and its modification – pleasure, fear and guilt. Sometimes called carrots, sticks and hot potatoes, each of the three motivators needs to be briefly parsed. Pleasure includes a particularly wide range of feelings, from enjoyment and satisfaction, delight, amusement to comfort, beauty, fun, novelty and love. Fear focuses on worry about dire consequences of our thoughts and actions, from angst, anxiety and awe to distress, nightmare and panic. And guilt is a complex emotion that includes remorse, self-blame and disgrace that sometimes begets repentance and reform.

There are other, less dramatic emotions and feelings that move us to act: safety, comfort, health and security, both physical and psychological. These tend to be at the wide base of Maslow's Pyramid, with higher issues of social conformity, respect and self-actualization also motivators, if less frequent and instinctual. And there are the perennial pocket book issues, which seem to be true of most consumers, both rich and poor, when it comes to their own money - regardless of whether they are for fiscal restraint of heavy spending at the national level. Indeed, self-interest, not self-sacrifice, is what often induces behavioral change. The right economic policies and incentives can push and pull us as individuals to allow self-interest to be in the best collective interest of society and the earth.

Arguably, love is the most powerful motivator. As Steve Mouzon points out,[4] pleasure and beauty delight and satisfy us, while love and compassion *move* people to act. So, it could be argued that love of self, family, friends, community, country and nature are the most potent motivators. We also know competition, status-seeking and peer pressure, as well as the fear and guilt dimensions of feelings described above, can and do make us act. And nothing lubricates reform better than shared fun and humor, including the ability to laugh at ourselves.

[4] Steve Mouzon, *Original Green,* website/blog 7/31/09

We also know there are different social and political persuasions with different reasons and modes for dealing with the threats of CC. As Andres Duany[5] has classified Americans, we are divided into a half dozen cohorts: the Ethicists, who are moralists and activists who want to proactively save the environment; the Trendsetters, who will prominently live greener lives if it isn't too onerous; the Opportunists, who are pragmatic and entrepreneurial about the business opportunities that CC opens up and offers; the Survivalists, who are pessimistic enough to circle the wagons for family and friends and even retreat to armed, survivalist compounds; the Apathetics, who are ignorant, skeptical or indifferent, but will come along if and when climate gets too hot; last, there are the Denialists, who simply refuse to admit there's a problem and who believe CC is a hoax. Each group or type is subject to common human norms and genetics, and will be motivated by the same universal emotions and feelings to change, if in different ways and at different times.

There are many motivators offered by problems around the world - from urban air pollution and congestion to health problems and infrastructure failure - to deal with sea level rise and stormwater flooding, etc. The particular cocktail of concerns will vary from climate to climate, culture to culture, and economy to economy. For many places, especially those in hot and in temperate climates, UHI will raise temperature to levels of discomfort sooner than CC, making trouble sooner in populous places. Because hotter temperatures impact not just poor and marginal urban areas but all areas of the city, and because heat waves kill more people than all other natural disasters, UHI's impact will be widely felt.

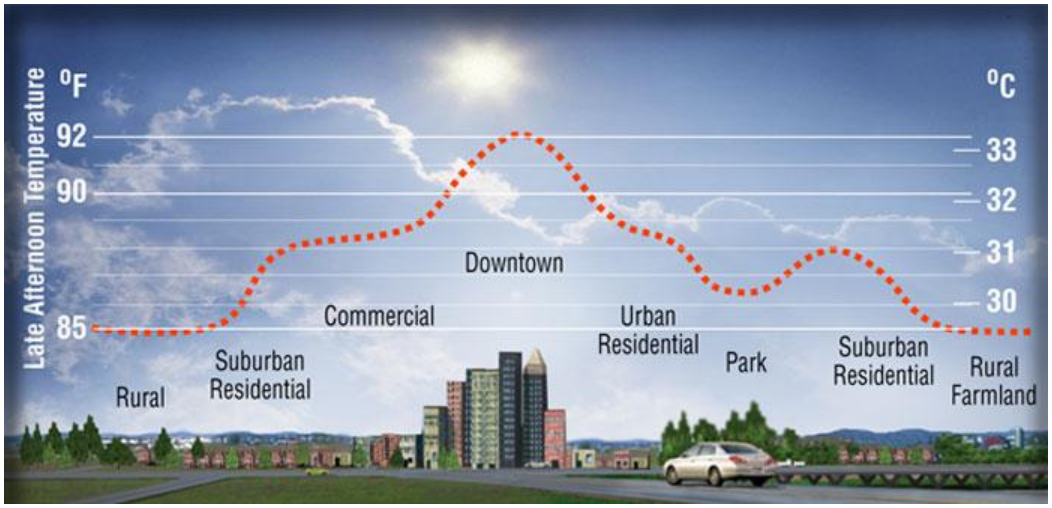
In any case and whatever the motivator, climatologists tell us we have no time to waste.

III. WHAT IS THE URBAN HEAT ISLAND?

UHI or UHIE are easily conflated and confused with global CC. There is considerable overlap, but also consequential difference. CC is very widely agreed by the scientific community to be the result of changes in the composition of the earth's atmosphere, which in turn triggers collateral changes in the lithosphere, hydrosphere and biosphere, not to mention impacts on human civilization. In essence the increase in Greenhouse Gases (GHGs), most notably CO2, in the earth's atmospheric layer causes it to trap more of the heat radiating out from the earth's surface. GHGs are opaque to this longer wave radiation, but transparent to the shorter wave radiation from the sun. So there is a slow overall increase in average land and ocean temperatures. There are local variations, including cooling temperatures and growing glaciers in some places, but the overall trend is hotter, especially in the polar regions, but the overall trend is becoming clearer and clearer. (There seems to be unanimous agreement in the scientific community about *how* GHGs interact to increase the earth's temperature, but 3-5% of scientists believe there may be other causes and doubt whether humans are the sole or primary cause of CC.)

[5] Andres Duany, lecture, U. of Michigan, April, 2013, and in *Agrarian Urbanism,* Prince'sFdn, 2011, pp. 66-68 (later retitled *Garden Cities)*

Unlike CC, which is a global phenomenon, UHI is a local phenomenon. The increase in local temperatures is *not* from GHGs trapping heat in the atmosphere, but from a local increase in *sensible heat*. This heat is from two sources: hot gases emitted from tailpipes and chimneys, and sensible heat from dark surfaces - blackish rooftops, streets and parking lots - that have been heated by the sun to temperatures hotter than the surrounding air and surfaces. Both heat sources raise the average urban temperature higher than the surrounding suburbs and rural countryside or wilderness, which have fewer tailpipes, chimneys and dark surfaces per acre. The rural to urban temperature gradient can be 5 to 7 or more degrees F, with heat waves that may double this delta between city center(s) and countryside.



Brian Stone, the G.I.T. Professor of Urban Planning and UHI expert, has written that cities like Atlanta have experienced more climate change from local UHI than from global CC.[6] He suggests that hotter temperatures amplified by UHI will make outdoor activities for more than a few hours per day too uncomfortable for most people. Indeed, heat waves in most large American cities are trending hotter and more frequent, with the increasing need for "cool centers" that are open to people whose homes are dangerously hot. These air-conditioned sanctuaries (with back-up generators) are typically in institutional buildings open to the public, where citizens can find relief, including extended stays if necessary. Annual deaths from heat waves are increasing,[7] and more of these centers will be needed to cope with hotter and longer episodes. According to the *New York Times* (6/6/15) "The August 2003 heat wave in western Europe led to about 45,000 deaths. The July-August 2010 heat wave in western Russia killed about 54,000 people…from 1981 to 2010, the average American experienced about four dangerously humid days, with wet-bulb temperatures exceeding 80 degrees. By 2030, that level is expected to more than double, to about 10 days per summer." Cities in hot, humid tropical zones will be especially hard hit with the sickly and deadly combination of high temperatures and high humidity.

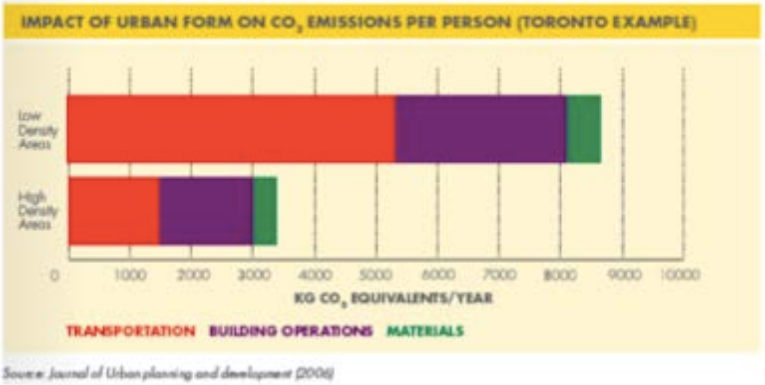
[6] Brian Stone, *The City and the Coming Climate,* 2012, pp. 93-95
[7] *Ibid,* p. 1-15

IV. WHY URBAN HEAT ISLANDS ARE PARADOXICALLY TIMELY AND HELPFUL

> *"…large cities in the U.S. (tend) to be warming at more than twice the rate of the planet as a whole as a result of the loss of naturally vegetated land covers…global estimates of climate change are likely to underestimate rates of warming in the very places where most of the global population now resides: cities."*
>
> Prof. Brian Stone, Urban Climate Lab, G.I.T.

UHI is both an opportunity and a burden for cities. As noted, ways to mitigate and adapt to local UHI are complementary to ways to address global CC. But as a 5-10 year rather than a 50-100 year challenge, it can more effectively and more immediately motivate people to modify their behavior, with more manageable, concrete steps and quicker feedback. Because its negative impacts require quick attention, UHI also tends to privilege adaptation above mitigation. And adaptation feels more proactive, direct and satisfying than mitigating longer term and more uncertain CC impacts. And because UHI can threaten human health, it is a particularly personal stimulant for quick action. On the other hand, it can be argued that it gives cities a bad name for being hotter than suburbia and the countryside, at precisely the time that more people are moving to urban places. Indeed, if severe enough, UHI could dampen even reverse migration to cities.

Why is it desirable for more people to live in cities? Compared to their suburban and rural counterparts, urban residents have smaller energy, carbon and ecological footprints, which is the equivalent area needed to provide the resources they consume and to absorb their wastes. (Urbanites walk, bike and use transit more often than auto-dependent suburbanites and ruralites, and their more compact, party-wall/multi-floor housing take less energy to mechanically heat and cool.) This environmental paradox is especially pronounced in America, where suburban lifestyles are exceptionally consumptive and waste-producing. So, sound practices and policies that induce and incent migration to the city is a positive step toward reducing CC. On the other hand, if cities are known to be hotter in the hot season(s), it's a disincentive to live there, even an incentive to move out of the city. Therefore, it's wise to address UHI - for both perceived and real reasons. And happily, while urban cooling strategies are being implemented, global CC is simultaneously addressed (with less politically partisan hullabaloo).

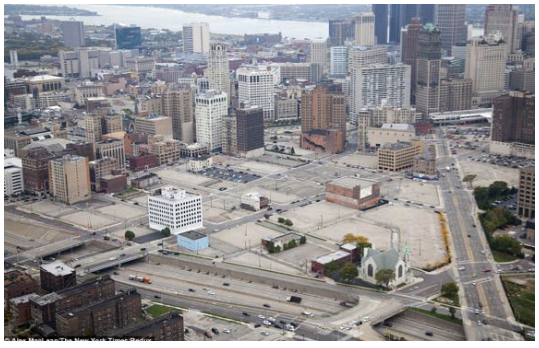


Source: Journal of Urban planning and development (2006)

V. WHAT ARE UHI MITIGATION AND ADAPTATION STRATEGIES

There are three ways to mitigate and adapt to UHI in order to achieve urban cooling. The first is *albedo enhancement.* Albedo is measured by the Solar Reflectivity Index (SRI), which indicates the percentage of solar radiation that is bounced back through the earth's atmosphere into outer space before it heats up any mass or air. It's a significant metric because any solar energy that hits light colored surfaces is reflected back into space *before* it makes the photo-thermal conversion, that is, before it changes from short wave to longer wave infrared radiant heat, which in turn would be trapped by the earth's atmosphere. The solar energy enters and immediately leaves our planet without heating it up, passing directly through the atmosphere and its GHGs. Accordingly, white and light colored horizontal surfaces with a high SRI – primarily roofs and pavement– increase the urban albedo, and reduce the ambient air temperature. Converting half a city's rooftops to green roofs, it is estimated that temperatures can be diminished by up to 3.5 degrees F.[8] (Green roofs offer a lot of environmental benefits… However a recent study suggests that roofs painted white might actually be more effective at fighting climate change. The study compared three types of roofs – green, black and white – and came to the conclusion that white roofs have great economic benefits, and they are also three times more effective than the other two at fighting climate change.)[9]

Obviously, the infrastructure for motorized vehicles is a fat target for albedo enhancement. The paved street and road surfaces tend to be dark colored asphalt, which absorbs the solar radiation and heats the air temperature about them. The surface area devoted to vehicles in motion is immense, as is the paved parking areas for vehicles at rest. In some cities, the combination - call it "motorized space" - is a very high percentage of the land area. Both areas can be literally lightened up with paint, made all the more timely by recent technical and cost breakthroughs in durable pavement coatings (which could be applied by volunteer/guerilla labor in a Tactical Urbanist initiative).



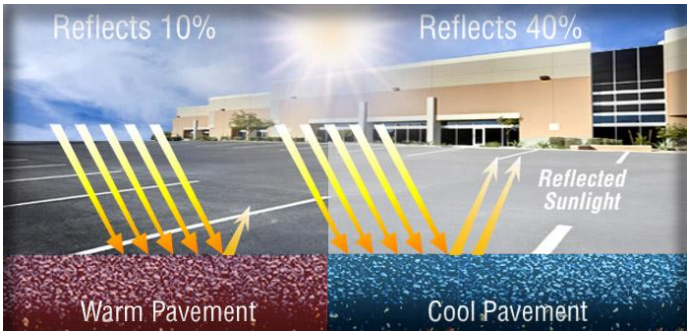
In the case of downtown Detroit, remarkably the motorized space is approximately 60%.

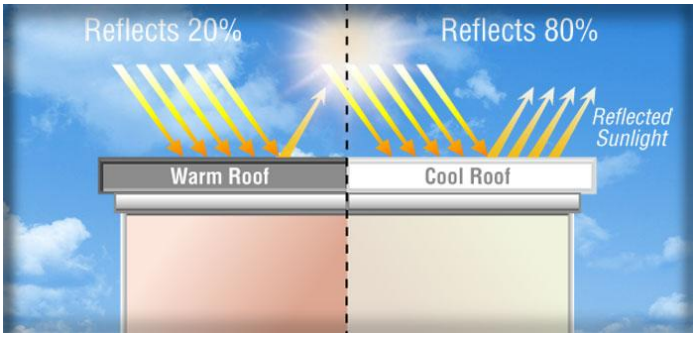
[8] *Ibid,* p. 107
[9] Sproule et al., "Economic comparison of white, green, and black flat roofs in the United States," *Energy and Buildings,* Vol 71, March 2014, pp. 20–27

In cities that have been visited by less decline, the percentage is lower, but still surprisingly high.

In this well-known photo of downtown Houston – one that purportedly embarrassed the City into building a number of public venues and arenas in the area – the paved area is roughly 50%.

More reflective surfaces, especially horizontal ones like roofs and pavement, are very effective ways to bounce back solar radiation before it heats up the surface and nearby air.





Princeton University students painting a roof white in New York City.

The second strategy is *sensible heat reduction,* that is, to reduce the local production and release of sensible heat into the urban environment, in the form of hot air and other gases. This means decreasing the combustion of hydrocarbon fuels in both motor vehicles, power plants and industrial processes. The most significant of these anthropogenic sources of UHI are vehicle traffic. Good walkable, bikable, transit oriented urbanism is an effective way to reduce tailpipe emissions of heat. All the well-known arguments for greater *accessibility* and less *mobility* are directly germane. Cities with mixed use development on smaller bocks and close-grained jobs-housing balance are all the more justified. And vehicles and building HVAC systems that not only burn less fossil fuel, but also emit lower temperature fumes can play a positive role. Last, utilizing lower tech cooling and dehumidification devices to reduce the voluminous hot air pumped into the air shed by air conditioning systems - a fast-growing problem as the Developing World is increasingly able to afford these energy-intensive mechanical systems.

The third strategy is creating *cool micro-climates* within the city. This cooling is achieved primarily with plant materials, especially shade trees, the great natural multi-taskers of the environment. Trees along streets, roads and in parking lots constitute a large and particularly effective part of the urban tree canopy. The list of the environmental contributions of vegetation is long: trees provide cool shade, evapo-transpiration that cools and moistens the air, carbon sequestration, particulate pollution filtration, soil retention, water retention, animal habitat, nuts, fruits, flowers and fragrance, while absorbing sound, shaping/softening public space and bestowing beauty and biophilic presence. Every culture seems to relish trees and the dappled light they filter (probably because humans are believed to have originally evolved under the canopy at the forest edge, overlooking the savannah of east Africa). Urban street trees often grow larger, with bigger canopy spread, because they have less competition from other trees. Accordingly, a healthy urban specimen can have many times the cooling capacity of a forest tree. Green “living walls” and green roofs also have cooling benefits, but are less cost-effective and require more maintenance than trees. In hot, arid climates, water fountains and pools can also cool the air by evaporation, as can “swamp coolers” that do not discharge sensible heat or use as much electricity as air conditioning.

The three main UHI reduction strategies:

1. Albedo Enhancement (lighter-colored roofs and pavement)

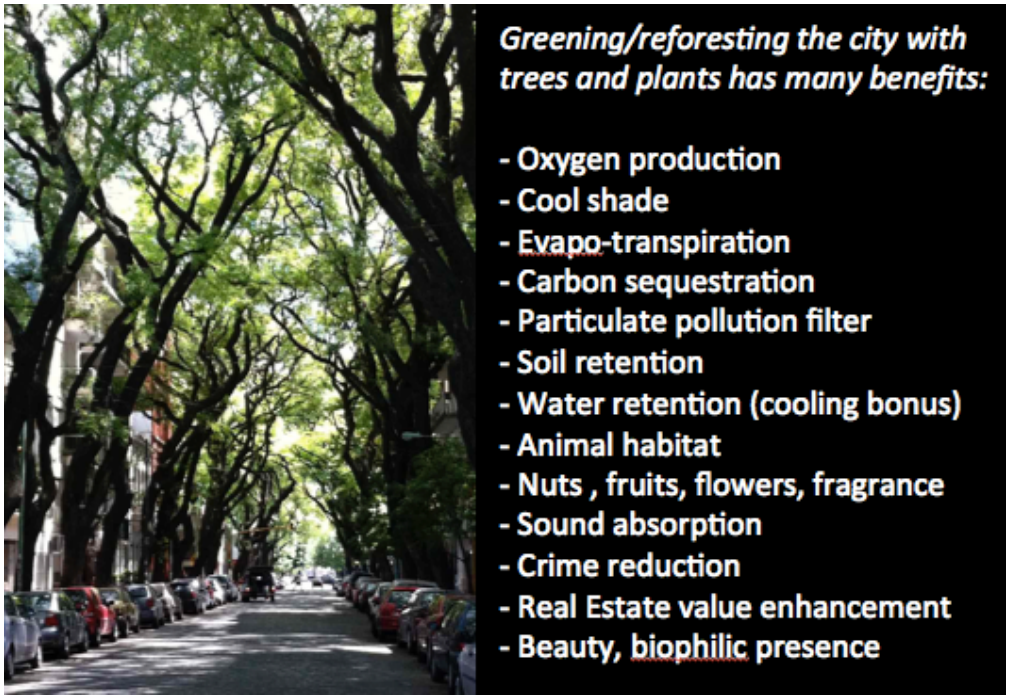
2. Sensible Heat Reduction (hot gases from tailpipes and chimneys)

3. Cool Micro-climates (trees and vegetation to shade, filter, cool the air, etc., while providing scale, beauty and other amenities)

Trees are also known to increase real estate values, especially along tree-lined streets. They've even been shown to decrease crime.[10] Trees and other vegetation can also decrease mental fatigue, improve worker attitudes on the job, and reduce stress as well as feelings of anger, depression, or anxiety.[11] There are a few negative externalities of trees, such as increased water demand, maintenance costs, allergies and resistance from some residents who don't want trees in front of their homes. And vegetation that provides cover for criminals is also an obvious downside.

Many cities have lost their forest cover – Atlanta has lost half its tree cover in the last quarter century, while Seattle lost a third - but studies have shown that recouping Atlanta's original tree cover could lower air temperatures by more than 12 degrees F on the hottest days and diminish heat waves even more.[12] According to the U.S. Conference of Mayors, at least 135 cities have tree inventory, planting and maintenance programs, and almost half of them have adopted tree canopy goals.[13] For instance, Washington, D.C., has incorporated a citywide 40 percent tree canopy goal. To achieve this goal by 2032, the city must increase its canopy cover from the existing 35 percent by planting 8,600 trees per year. Seattle plans to increase its tree canopy from 18 to 30% in 30 years.[14] Many of the trees are being planted along streets, roads, sidewalks and biking/walking paths. Melbourne, Australia, where they're not just planting trees but what they call an "urban forest" to deal with increasing temperatures plans to double the forest canopy from around 22% to around 40% over the next 20 years. In city that is 4-7degrees C hotter than its green suburbs, their research indicates that that will actually cool the city by four degrees.[15] Urban trees are part of a larger global reforestation effort, one that is arguably about *recarbonizing* the environment, while we try to *decarbonize* our lives.

[10] Austin Troy, Morgan Grove, Jarlath O'Neil-Dunne **,** *Landscape and Urban Planning* 106, 2012, pp. 262–270
[11] Bell JF, Wilson JS, Liu GC. Neighborhood greenness and 2-year changes in body mass index of children and youth. Am J Prev Med. 2008; 35, pp. 547–553.
[12] Brian Stone, *The City and the Coming Climate,* 2012, p. 99-104
[13] "Protecting and Developing the Urban Tree Canopy," U.S. Conference of Mayors, 2008, p.8
[14] Emily Oaksford, *APA Sustaining Places*, website/blog, 3/18/15, citing source in footnote 9
[15] Hayley Birch, "Where is the world's hottest city," *The Guardian,* 7/22/15



All three of these Lean strategies are proven antidotes to global CC, on top of their urban cooling benefits. Importantly, they directly adapt to CC by tempering increasing global air temperatures, while quietly and indirectly helping with mitigating these increases. They are achievable, easily understandable strategies that lend themselves to distributed, democratic action at the local scale. The bottom-up, low-tech nature of albedo enhancement, which can be as easy as applying white paint to rooftops, is consistent with both Tactical and Lean Urbanism. Planting street trees and other vegetation along sidewalks and in median strips can be done with volunteer labor, and is consistent with Tactical, Lean and New Urbanism. Reducing tailpipe and chimney heat can be achieved by both low- and high-tech techniques, with the most effective and Leanest strategy being the negatrip – simply walking and biking more, and driving less in compact, location-efficient, mixed-use, transit-served neighborhoods, which is consistent with New Urbanism. Part of the transit mix can be AVs, if and only if, they are shared vehicles. (Better yet is AVT – Automated Vehicle Transit – which allows AVs to share space in BRT lanes, thereby avoiding both street congestion and the need for more advanced AV systems, with all their thorny technology and legal issues. BRT buses can also be AVs.)

There are outstanding technical questions. The direct and indirect relationships between UHI and CC are not fully clear. The role of water vapor in the air and subsequent formation of clouds in and around cities is complex and not fully understood yet. (Cloud cover increases albedo, and rainfall cools urban surfaces, complicating the factors that determine air temperature.) Nor has how much air temperature can be lowered by these three strategies been accurately or widely measured. Also, there may be other techniques that emerge that may be as or more effective. More research is needed, as well as more media attention, which has been light to date.

And there are open, unresolved geo-political issues. It's not clear in what climate zones UHI will mobilize action, and in what cities and cultures other issues will be more salient. (In Asia, air and water pollution are much more visible incentives; extreme weather events, like Superstorm Sandy, can be local game changers.) Cities with cool summers in areas like the Pacific Northwest may well not rally to this strategy, and need to find other motivators. UHI was conspicuously missing in the Kyoto Protocol, which focused on GHG mitigation. With no international or national mandate or framework, there was and there remains no incentive to invest in *global* mitigation, and less incentive to invest in *local* urban heat management. Any successor agreement needs to include UHI in its calculus.

While Urban Cooling does address global CC, it's a local, accessible, appreciable way to make to *adapt* to it, while obliquely *mitigating* it. Albedo enhancement and reforestation "are the single most effective option available to cities to counteract the very real threats of CC during the next half century…none is more effective and less energy-intensive than planting trees."[16] And, unlike infrastructure, which begins to degrade and lose value the moment it is installed, a tree increases in value and size for decades after it's been planted. Commbining tree planting with avoided deforestation and agroforestry (where shade trees are interspersed with crops) makes for "*adaptive mitigation*," which is a more potent and effective way to synergistically address UHI and CC. UHI mitigation will be both more effective and more appealing in cities in hot, humid climate zones, where increasing summer temperatures will continue to make outdoor activity more uncomfortable and in some cases prohibitively inhospitable and unhealthy. "Simulations in the NASA-funded research suggest that the number of 'high heat stress' days in Houston will more than double by mid-century, researchers said. In some areas, the number could triple, they said."[17] A long list of American cities – Baltimore, Birmingham (AL), Charleston (SC), Charlotte, Denver, Memphis, Nashville, Richmond, St. Louis, and Washington (DC) are estimated to see 5 to 9 times as many heat stress days (either above 90 or 100 degrees, depending on geographic location/climate zone) by 2050 and 18 to 33 as many by 2100.[18]

Because urban cooling emphasizes adaptation over mitigation, it appeals to the human proclivity to short term thinking and immediate action. Its concrete initiatives provide a sense of progress in the shifting uncertainties of the ongoing change and unfurling disruption of the earth's weather and climate. And yet, albedo enhancement, reduction in GHG emissions, and cool micro-climates frontally address global CC at the same time, even if those benefits may take a decade or more to manifest themselves. Last, urban cooling is essential if cities, with their multiple smaller footprints per capita, are to attract more residents and to keep their existing populations from migrating to the cooler suburbs and countryside, a move that would in the end aggravate CC and make both cities and hinterland even hotter. Urban cooling is in so many ways on the right side of many ledgers, and it can happily inform and shape many urban strategies and initiatives.

[16] Brian Stone, *The City and the Coming Climate,* 2012, p. 99
[17] Carol Christian, *Houston Chronicle,* "Houston's high heat stress days could double by midcentury," 6/10/15
[18] *Ibid*