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## 'Heat Island' Tokyo Is in Global Warming's Vanguard

By JAMES BROOKE

**T**OKYO, Aug. 12 — With the temperature 96 degrees in the shade, veterans of this concrete jungle braced themselves recently as they opened a door to an apartment building roof. But instead of confronting a wall of dry heat, they felt their faces cooled by moist air, carrying a light scent of soil and fresh grass.

Tile by tile, workers were laying a new form of ultralight and ultracheap roof garden. With a low-maintenance variety of grass growing in four inches of vermiculite, a mineral substance often used in gardening, this carpet of cooling green weighed only 16 pounds per square foot.

"If a roof is rated to take people, which most are, it can easily take a roof garden," Takaharu Yoshioka, environmental director of Greenwich Garden, a landscape design company, said stepping onto the emerald lawn. "Last year we did only 50 roof gardens. So far this year we have already had 200 orders."

The realization that Tokyo is becoming a vast "heat island" is behind the boom in roof gardens. Here, centuries of gradual climate change are telescoping into decades.

"Over the last century, Tokyo temperatures have increased five times as fast as global warming," said Takehiro Mikami, a professor of climatology at Tokyo Metropolitan University. While the world's average mean temperature has increased by one degree Fahrenheit since 1900, Tokyo's has increased by 5.2 degrees.

The findings parallel recent research by NASA scientists using satellites to monitor Mexico City, Atlanta and dozens of other growing metropolises around the world. They found that cities tend to have temperatures far warmer than the surrounding landscape, in many cases up to 10 degrees warmer. Often the heat changes the weather itself, causing more storms downwind of cities, the scientists found.

This month, during a two-week heat wave, Tokyo salarymen staggered down noonday sidewalks, their black suit jackets folded over their forearms. Women sprouted parasols to ward off the unrelenting sun. Heat stroke felled 16

members of a high school soccer team.

For the Northern Hemisphere, the first half of this year was the warmest in 143 years, Britain's Meteorological Office announced on Aug. 1.

In Tokyo the most dramatic temperature changes have taken place when people notice it the least.

From midnight to 5 a.m., average Tokyo temperatures have risen by 7.2 degrees over the last century. In Tokyo, a seaport in a traditionally temperate zone, weather experts define a "tropical night" as a night when thermometers never drop below 77 degrees Fahrenheit.

"A century ago the number of tropical nights was zero to five in a summer," said Professor Mikami. "Now the number of such nights reaches 30 or 40. By 2010 it will increase to 50 or 60."

With this summer's heat, Tokyo and a northern suburb have received 18 smog alerts, one-third more than normal. Chiba, an eastern suburb, has received two smog warnings, more dangerous than an alert, the first such warnings in 17 years.

Though it is of little concern to city dwellers battling August heat, winters are also milder, with night temperatures rarely dipping below freezing. Snow is increasingly rare. None fell here last winter.

While scientists worry about climate change on a global scale, it is evident in Tokyo today.

"Leaves used to start turning their colors in the end of November," said Shinsuke Hagiwara, chief researcher of National Institute for Nature Study. "Now they only start in mid-December."

This spring, cherry blossoms came so early that when Prime Minister Junichiro Koizumi held the government's annual cherry blossom viewing party in April, there were no blossoms left.

A type of mosquito carrying dengue fever, usually found in warmer places, has expanded its range to 60 miles north of Tokyo in the last three years, said Mutsuo Kobayashi, a medical entomologist.

Palm trees and wild parakeets are increasingly common.

"Subtropical plants are taking the place of temperate plants here," Mr. Hagiwara said. Referring to his institute's botanical reserve, he said palm trees "started growing naturally in the forest in the mid-1950's."

Compressing centuries of ecological change into decades could have disastrous consequences. "If something unexpected would occur, like a sudden cold year," Mr. Hagiwara said, "the newcomers would easily die out."

Reflecting rising concern, the phrase "heat island" has entered Japanese vocabulary. City officials are wrestling with the concept of thermal pollution.

Increasingly, modern Tokyo is viewed as a huge, multifaceted radiator. During the day the sun's heat is absorbed by acres of black asphalt, by car bodies, by black rooftops and by buildings made of concrete rather than the older, cooler materials of wood and brick. At night these surfaces discharge heat, preventing the city from cooling.

At the same time, new earthquake mitigation techniques are allowing Tokyo to go vertical, with new high-rise buildings blocking cooling sea breezes. As temperatures rise, residents respond by simply twisting the dials on now universal air conditioners, expelling even more hot air into the atmosphere.

Under one \$330 million mitigation plan unveiled last month, a four-mile-long pipe, six feet in diameter, would circulate cold seawater below Tokyo, flushing heated water into the bay. Environmentalists worry, though, about the impact of raising some bay water temperatures by as much as 10 degrees.

Local human activity makes Tokyo appear as a big red blotch on thermal satellite images. In contrast, global warming generally appears to be caused by the release of heat-trapping gases that are a consequence of industrialization and that are enveloping the planet.

Tokyo has another major handicap: greenery occupies only 14 percent of central Tokyo, less than New York, London or Berlin. Plants play a crucial role in cleaning air and in cooling temperatures, absorbing carbon dioxide from the atmosphere.

While new parks in a densely packed city like Tokyo would cost hundreds of billions of dollars, one city survey calculated that 11.5 square miles of rooftops could be converted into gardens.

Last year a city law mandated that all new medium-size buildings, those on plots over one-quarter acre, dedicate at least 20 percent of the roof to a garden. A variety of tax breaks are being put into effect to encourage roof gardens.

Increasingly, roof gardens are planted for prestige and aesthetics.

In April the Imperial Hotel, a venerable downtown landmark, opened a 5,700-square-foot expanse of lawn atop its 17-story main building.

Illuminated at night by solar-powered lights, the midair swatch of green is visible from the hotel's adjacent tower. Today, workers clamber over the roof of the Tokyo Metropolitan Assembly Hall, building a \$500,000, nearly one-quarter-acre roof garden that is to open this fall.

In typical Japanese fashion, the new idea has provoked a herdlike response.

"You are journalist No. 78 to visit our garden," Kazuyoshi Kojima, director of greenery promotion for Tokyo's Shibuya ward, said at a showcase roof garden he opened 14 months ago. A mix of sample gardens mounted by landscaping companies, the plots ranged from ornamental gardens with tall bushes to low-budget, typhoon-proof plots of grass.

"More building owners should construct gardens like this," said Miwako Koyama, who stopped by the garden with a friend after their women's group's luncheon meeting. "It is really good."

Sharing a parasol, Yoshie Kunimi agreed: "So beautiful. It would be nice if we could have one like this on the rooftop of our house. But we have to think of drainage, planters, winds, money."

Architects traditionally have resisted roof gardens. Their weight necessitated structural reinforcement. Their water and plant roots inevitably seemed to percolate into the structures.

Now architects say that new technology and materials solve the weight and water problems. In fact, they contend that a living grass covering actually protects roofs from sun damage and cracking and that grass roofs save money the year round by cutting heating and cooling costs.

"Last winter we didn't use any heat at all," Mr. Kojima said of the four-story municipal office building under his 3,500-square-foot garden. Before the building had a roof garden, he said, air conditioning had to be turned on more frequently.

With Tokyo's summer temperatures bound to continue upward, city officials say they want to make roof gardens as common for the buildings here as stairways.