New York Energy Smart
EMEP
Environmental Monitoring, Evaluation, & Protection

New York State Energy Research
and Development Authority

Environmental Monitoring, Evaluation,
and Protection Program

NYSERDA
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PROJECT UPDATE

May 2007

New York City Regional Heat Island Initiative: Mitigating New York City's Heat Island with Urban Forestry, Living Roofs, and Light Surfaces

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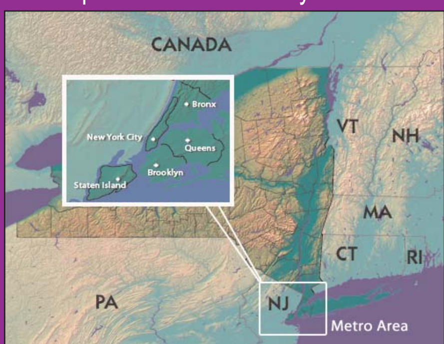
Project Location

Metropolitan New York City



Project Cofunders

US Forest Service

NYS Department of Environmental Conservation

NYC Department Environmental Protection

Contact Information

For more information on this project see:

http://www.nyserda.org/programs/environment/emep

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Keywords

- Climate change
- Electricity demand reduction
- Evapotranspiration
- Light surfaces
- Urban forestation
- Urban heat island

PROJECT FOCUS

This project analyzed New York City's mesoclimate and "heat island" dynamics by modeling its urban morphology, surface cover, and meteorology. Researchers tested various scenarios for mitigating the heat island effect in order to analyze their potential for reducing surface and near-surface air temperatures enough to impact energy consumption and, in particular, on-peak electricity demand. The mitigation strategies were compared in terms of their effectiveness and cost-effectiveness, both citywide and in particular case-study areas.

CONTEXT

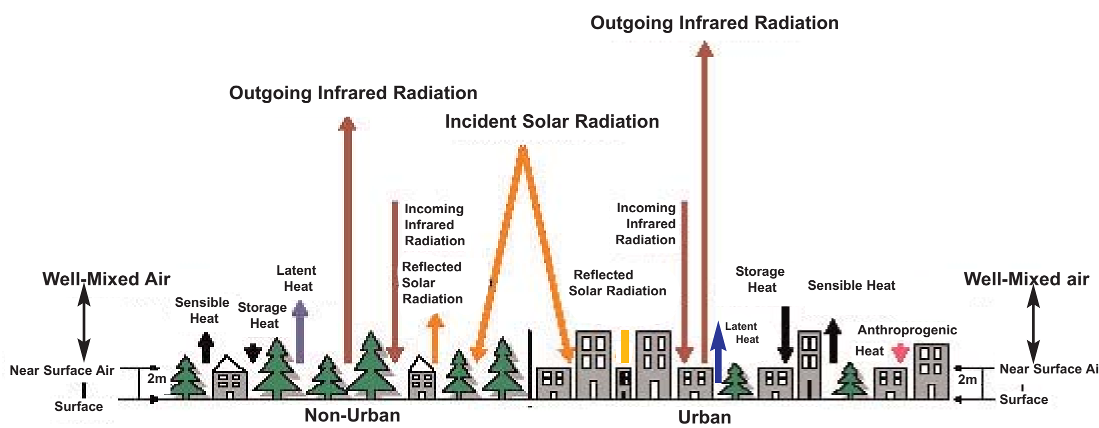
New York City, like other large cities, is warmer than surrounding areas due to the urban heat island effect (UHIE). This phenomenon occurs when naturally vegetated surfaces are replaced with impervious surfaces that absorb, retain, and reradiate more solar energy than do grass and trees. The rate at which energy is absorbed and reradiated depends on the physical properties of different surface types, their configuration within the urban fabric, regional meteorology, localized microclimate, and the addition of anthropogenic heat into the urban atmosphere.

Currently, New York City's summertime temperatures average 7.2ºF (4ºC) warmer than surrounding suburban and rural areas. A recent study (Laurie Kerr & Daniel Yao, 2004) determined that for each degree Fahrenheit of temperature increase during the summer, the City consumes an average of 3,300 MWh more energy per day for cooling. Given an average cooling season of 150 days, the annual energy savings for each degree of UHIE reduction would be roughly 495 million KWh. While this analysis points to significant financial implications for the City, it nevertheless understates the overall value of heat island mitigation, because substantial additional savings would result from expected improvements in public health and environmental protection.

Several heat island mitigation strategies have been proposed, including urban forestry, living roofs, and light-colored surfaces. Each of these strategies, or a combination of them, could be implemented citywide or at the community level within New York City.

METHODOLOGY

The project established seven case-study areas for which temperature data were obtained during three heat waves in the summer of 2002. A remote-sensing and geographic information system (GIS) data library was developed to characterize the numerous dimensions of New York City's heat island, including land surface, urban morphology, and urban function information, as well as base map layers including streets, hydrology, open space, block groups, and land cover.



Credit: Cynthia Rosenzweig

Diagram illustrating a typical non-urban energy balance as compared to a typical urban energy balance. Longer arrows denote a greater heat flux (e.g latent heat flux is larger in non-urban areas than in urban areas; sensible heat flux is larger in urban areas than in non-urban areas).

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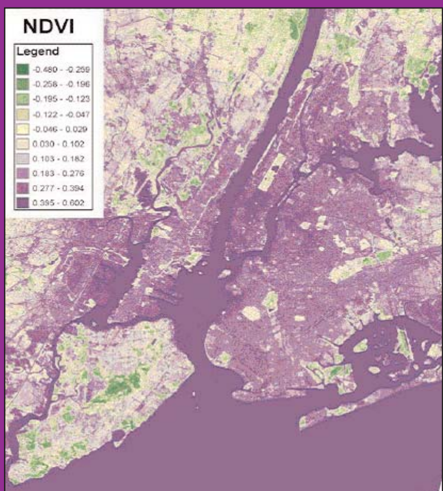

Credit: Cynthia Rosenzweig
Normalized difference vegetation index (NDVI) derived from September 8, 2002 Landsat image. NDVI is an alternative measure of vegetation amount and condition. It is associated with vegetation canopy characteristics such as biomass, leaf area index and percentage of vegetation cover. NDVI units are non-dimensional, a fraction with a potential range between -1 and 1.

Project Status

- Initiated 2004
- Completed 2006

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Public Service Commission
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Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSERDA's key efforts, the Environmental Monitoring, Evaluation Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor-owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

A regression analysis was performed for surface temperatures on a range of environmental variables to determine the extent to which surface temperature depends on environmental factors.

To test the mitigation scenarios, a state-of-the-art, three-dimensional, non-hydrostatic regional climate model (Penn State/NCAR MM5) was used. Model performance was evaluated by comparing hourly near-surface air temperatures simulated by the MM5 model to weather station data.

Potential cooling within each case study area was investigated by applying a set of nine mitigation scenarios to model-derived temperatures for impervious surfaces, grass, and trees. The goal was to highlight relative differences between the various mitigation strategies. Scenarios were tested at intensities of 100%, 50%, and 10% redevelopment of the available area in which the scenario could be implemented. The relationship between intensity of redevelopment and cooling potential was assumed to be linear; thus, 100% redevelopment has twice the cooling potential of 50% redevelopment.

Potential reductions in near-surface air temperature may be underestimated, as the effect of shading is not represented by the regional climate model and atmospheric mixing tends to dampen the effect of land-surface cover changes.

PROJECT FINDINGS

- Mitigation strategies can significantly reduce surface temperatures in New York City, leading to a reduction of near-surface air temperatures. Vegetation has a greater impact on surface temperature, and therefore on heat island potential, than urban geometry or surface reflectance (albedo).
- In most of the case-study areas, street tree planting offers the greatest cooling potential per unit area redeveloped, followed by living roofs and light surfaces. However, light surfaces offer the greatest absolute temperature reductions, because 64% of New York City's surface area could be lightened, whereas only 17% of the City's surface area could be planted with new street trees.
- Planting street trees has greater cooling potential than planting open-space trees, because the temperature differential between trees and impervious surfaces is greater than that between trees and grass. Also, the cooling effect of open-space trees tends to be localized. For example, surface cooling around the 850 acre Central Park tends to be limited to 200 feet (61 meters) from the Park's borders. Outside the 5 acre Bryant Park, cooling is limited to 50 feet (15 meters).
- Mitigation strategies should be chosen to reflect neighborhood conditions. For example, in most case-study areas, curbside planting is the individual strategy with the greatest cooling potential. However, in Midtown Manhattan, which has the greatest available rooftop space, living roofs could have a greater impact.
- Cooling New York City's urban heat island could improve public health by reducing heat stress and temperature-dependent pollutants like ground-level ozone, as well as the City's contribution to greenhouse gas emissions. The reduced demand for energy could lower the cost of air conditioning for both residential and commercial customers.

PROJECT IMPLICATIONS

Through extensive data collection, modeling, and statistical analysis, this study has provided insight into the dynamics of New York City's heat island effect, showing the strengths and weaknesses of various mitigation scenarios and indicating directions both for urban policy and future research. The study reveals that urban forestry, living roofs, and high-albedo surfaces can significantly cool the City's urban heat island, but it also underscores that the choice of which strategy to employ should reflect local conditions at the neighborhood level. These findings are intended to provide New York with useful information both in pursuing the goal of energy conservation and in improving the urban environment and human health.

Credit: Cynthia Rosenzweig
Fordham Bronx case study area, street view