EPA Urban Heat Island Pilot Project
City Profile: Sacramento (Archived Page)

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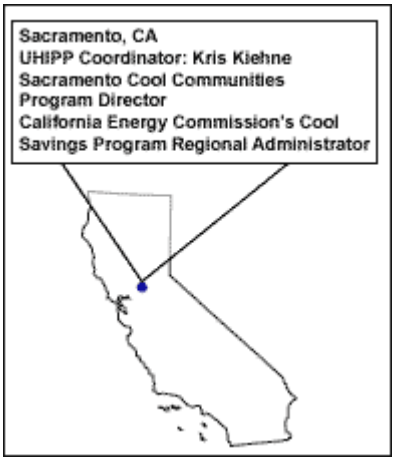


Sacramento is located in California's central valley against the Sierra foothills. The city has a population of approximately 400,000 people and covers over 96 square miles. The Sacramento Metropolitan Statistical Area includes about 1.8 million people in a six-county area and covers approximately 984 square miles.

Sacramento's Heat Island

In July 1998, the National Aeronautics and Space Administration (NASA) took flyover photographs of Sacramento using Advanced Thermal and Land Applications Sensor aircraft data. These flyover shots represent a typical view of the city (left) and a thermal readout of metropolitan hot spots (right).

The images are visible (left) and thermal infrared (right). The white areas, mostly rooftops, are about 140°F (60°C) and the dark areas, primarily vegetative areas or water, are approximately 85-96°F (29-36°C). The hottest spots are buildings, seen as white rectangles of various sizes.

Aerial view of Sacramento (courtesy of NASA-Marshall Space Flight Center- Global Hydrology and Climate Center).

Sacramento's rail yard is the orange area east of the Sacramento River, which flows from top to bottom. In the thermal image, red and yellow areas indicate "hot spots" and generally correspond with urban development, while blue and green areas are cool and generally correspond to the natural environment. (These images have not been calibrated. Absolute temperatures will change after calibration, but the relative temperature differences between surface types will not.)

Before determining how heat island reduction strategies impact an area, researchers need to evaluate existing surface characteristics. Aerial photos are useful for estimating the

proportions of vegetative, roofed, and paved surface cover relative to the total urban surface in a city. Having this urban fabric information can help researchers simulate the meteorological and air quality impacts of heat island reduction strategies.

Surface cover data also help scientists determine an area's heat island. The Department of Energy's Lawrence Berkeley National Laboratory (LBNL) modeled Sacramento's near surface heat island, which represents near ground air temperatures as opposed to surface temperatures measured by thermal images.

LBNL conducted this modeling over a large area, several times larger than the city center. They found that topography greatly influences Sacramento's heat island with the eastern area being consistently cooler due to the higher elevations of the Sierra foothills. LBNL simulations indicate that after 12:00 p.m., the temperature distribution in the Sacramento area becomes a strong function of elevation. From noon until 5:00 p.m., Sacramento's simulated heat island, which represents air temperatures near the ground, is approximately 0.9-1.8°F (0.5-1°C).

Sacramento's Climate

Sacramento's climate is characterized by mild year-round temperatures. Summers are dry with little humidity and an abundance of sunshine. Winter months can be cool and often rainy. The highest temperatures occur throughout July and August and can average around 88°F (31°C). The coldest days are usually in January when the temperature can drop to an average low of 38°F (3°C). Average monthly temperatures for Sacramento range from 53.5°F (12°C) in January to 88°F (31°C) in July.

Sacramento receives an average annual rainfall of about 18 inches per year and has an average relative humidity in June of 78% in the morning and 32% in the afternoon. Based on 1961-1990 National Climatic Data Center data, Sacramento has, on average, 1,237 cooling degree days and 1,869 heating degree days.

Local climate data, such as cooling and heating degree days, can help researchers estimate the potential energy savings and air quality impacts of implementing heat island reduction strategies. For example, areas with long, sunny, hot summers and high cooling degree day values, generally can achieve substantial energy savings.

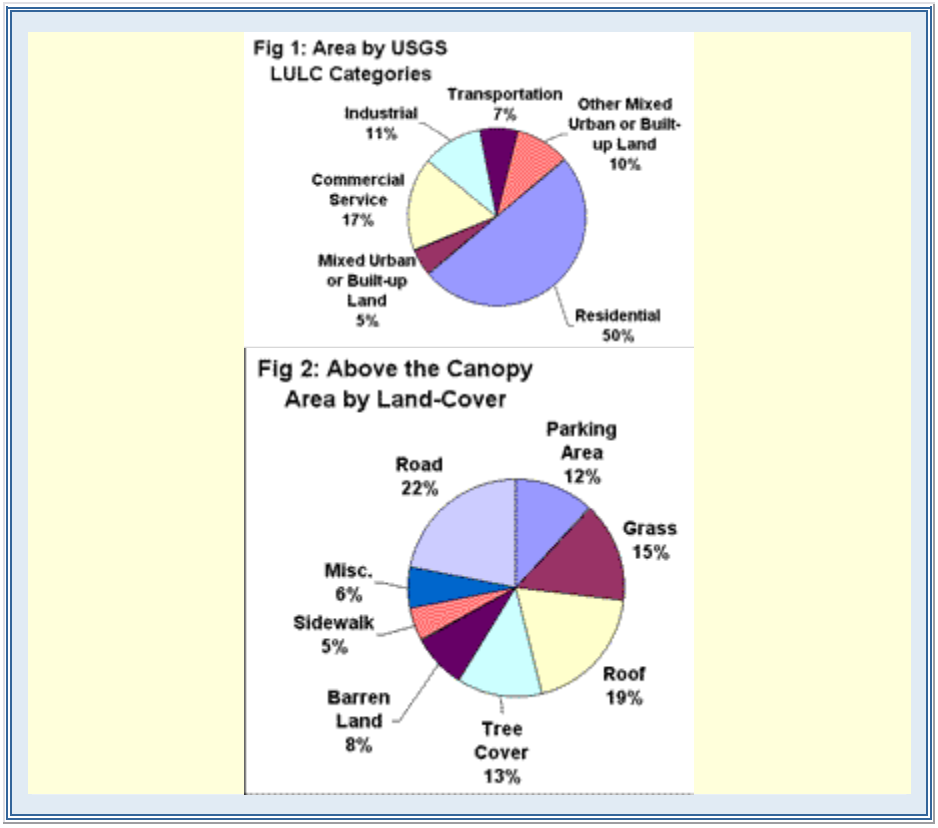
Information on an area's local climate also can help communities focus on heat island reduction activities that best suit their region. For example, cities with predominantly dry climates may achieve greater benefits from increasing vegetation than would cities in humid climates. Dry-climate cities more effectively capture the cooling benefits of evapotranspiration

– or evaporation of water from leaves. However, dry-climate cities also need to consider the availability and cost of water to maintain vegetation.

Sacramento's Urban Fabric

In 1999, the Department of Energy's Lawrence Berkeley National Laboratory (LBNL) conducted an urban fabric analysis to determine the proportions of vegetative, roofed, and paved surface cover relative to the total urban surface in the city. LBNL used digital aerial photos covering 25 square miles of Sacramento, which represented a variety of neighborhoods (e.g., industrial, commercial, residential).

LBNL used the aerial photos to characterize the area fraction of various surface types (e.g., roofs, sidewalks) and vegetative cover. LBNL then used United States Geological Survey land use/landcover (LULC) data to extrapolate detailed surface characteristic findings to the entire Sacramento Metropolitan Statistical Area.



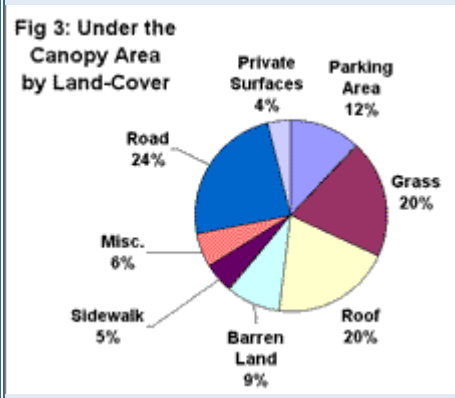


Figure 1 shows the classification and relative proportions of land use in the Salt Lake City metropolitan area based on USGS LULC data.

Figures 2 and 3 provide an above the canopy and under the canopy view of the Salt Lake City MSA's developed area. These figures provide an overall average urban fabric breakdown. Within each land-use category (e.g., residential, commercial, industrial) the surface type percentages vary greatly. For example, tree cover ranged from 2.0% in industrial areas to 20.5% in residential areas.

Source: Characterizing the Fabric of the Urban Environment: A Case Study of Sacramento, California; Hashem Akbari, L. Shea Rose, and Haider Taha, Lawrence Berkeley National Lab, December 2000.

LBNL concluded that although Sacramento is a fairly green city, the potential for additional urban vegetation is large. Considering that trees potentially can shade 20% of the roof area, 20% of roads, 50% of sidewalks, and 30% of parking areas, Sacramento could increase additional tree cover by approximately 15%.

LBNL also found that with 56% of Sacramento's surfaces being impermeable (roofs and pavement), the metropolitan area has a large potential for solar reflectance– or albedo–modification, starting with the impermeable surfaces.

Sacramento's Energy Savings Analysis

Sacramento has a May through September cooling season. Most residential buildings are one story and commercial buildings are low-rises. Air conditioning saturation in the Sacramento Metropolitan Statistical Area (MSA) is high with a total air conditioned roof area in 1998 of 648 million (M)ft² residential, 37 Mft² office, and 50 Mft² retail.

Modeling Methodology

The Department of Energy's Lawrence Berkeley National Laboratory (LBNL) analyzed the energy savings potential (direct and indirect effects) of heat island reduction measures on cooling energy use in Sacramento. Determining direct energy impacts involved modeling the

effects from placing eight mature deciduous shade trees around residential buildings, eight shade trees around office buildings, and four shade trees around commercial buildings to provide 10% summertime (April - October) transmittance and 90% transmittance for the remainder of the year.

In addition, determining direct impacts involved modeling the effects from increasing solar reflectance– or albedo– on residential and commercial roofs from 0.2 to 0.5 and 0.6, respectively, using an infrared emittance of 0.9, to calculate savings. (Emittance is the percentage of energy a material can radiate away in the form of heat.) This modeling was performed using DOE-2 building energy software, which is an advanced computer program that simulates hourly building energy use.

LBNL modeled the indirect impacts by analyzing the ambient cooling from the placement of four or eight shade trees per building and from the reduced rooftop temperatures due to the albedo changes discussed above. LBNL captured these indirect effects by using the Colorado State Urban Meteorological Model (CSUMM). The CSUMM outputs were used to modify the typical meteorological year 2 data, which were fed into the DOE-2 building energy model.

Modeling Results

LBNL calculated the following annual results for the total Sacramento MSA:

- $26M energy savings in 1997 dollars ($46M in annual electricity savings less a 43% natural gas deficit);
- 486 megawatts peak power avoided (84% from residential, 7% from office, and 9% from retail); and 92,000 tons of carbon emissions reduced.

Sacramento's Air Quality

Ground-level ozone is one of Sacramento's biggest air quality problems. Sacramento has been classified as a severe nonattainment area for ozone. California must reduce the region's emissions of ozone-forming chemicals by 3% per year through 2005, or until the one-hour standard is achieved and maintainable over a 10-year period.

The Sacramento region has determined that 70% of their ground-level ozone pollution comes from vehicles. The area has been focusing on reductions of nitrogen oxide (NO_x), which is an ozone precursor. Heat island reduction measures potentially can lessen volatile organic compounds, which are precursors to ground-level ozone and NO_x emissions.

Modeling Methodology

In 1999-2000, the Department of Energy's Lawrence Berkeley National Laboratory (LBNL) used the Colorado State Urban Meteorological Model (CSUMM) and the Urban Airshed Model (UAM-IV) to estimate the impacts of heat island reduction activities in Sacramento on the area's local meteorology and ozone air quality.

LBNL used a modeling domain of 20,592 km² or 8,043 square miles – several times larger than the Metropolitan Statistical Area.

LBNL determined that the solar reflectance– or albedo– in the Sacramento modeling domain is relatively uniform due to the expanse of agricultural land. Albedo ranged from 0.08 in a few areas (e.g., lakes and the San Francisco Bay) to 0.22. Most of the urban area had an albedo of 0.14-0.16 and the surrounding area had an albedo of 0.18. LBNL found vegetation in Sacramento to be quite high with over 80% of the domain having a vegetative cover higher than 0.40.

LBNL simulated heat island reduction measures by increasing the solar reflectance and vegetative cover inputs into the meteorological model, CSUMM. LBNL increased solar reflectance levels and vegetative cover in the city center area by approximately 0.11 and 0.14, respectively.

Modeling Results

Using a July 11-13, 1990 modeling period, LBNL found decreases of ground-level ozone up to 10 parts per billion (ppb) and temperature reductions up to 2.9°F (1.6°C). LBNL's modeling resulted in ozone increases as well as decreases. Within the entire modeling domain, there were net ozone decreases, in general.

The simulated temperature decrease that was correlated with the 10 ppb decrease in ground-level ozone was 2.2°F (1.2°C). Compared to Baton Rouge and Salt Lake City, Sacramento experienced the largest simulated reductions in ground-level ozone, possibly due to the fact that Sacramento covers a large geographic area allowing for cumulative impacts from heat island reduction measures.

Sacramento's Heat Island Reduction Activities

Currently, state and local leaders are working to reduce the imapct of heat islands. EPA's Sacramento Urban Heat Island Pilot Project (UHIPP) Coordinator has been leading a Sacramento Cool Community Program (SCCP) through the Sacramento Tree Foundation (STF). Sacramento has launched several demonstration projects, including installing reflective and

green roofs, planting shade trees, and showcasing cool pavements – all in an effort to educate the community about urban heat islands and strategies to reduce them.

Sacramento Cool Community Program

SCCP has established five working subcommittees to advance heat island mitigation policies:

- The Trees & Vegetation Subcommittee has developed new maintenance guidelines for the Sacramento parking lot shading ordinance, is looking for partners to retrofit existing parking lots, and is planning a parking lot conference.
- The Cool Roofing Subcommittee is promoting the development of residential cool roofing products by compiling a list of cool roofing products and suppliers, and is creating a database of existing Sacramento area cool roofs. SCCP's Program Director is also a Regional Administrator for the California Energy Commission's Cool Savings Program. This cool roof incentive program, funded by peak load reduction legislation, is geared towards commercial and industrial building owners and managers.
- The Cool Pavement Subcommittee has developed a list of cool pavement products, is seeking partners for additional cool parking lot demonstration projects, and will stimulate research into pavement life versus temperature. To date, the subcommittee has implemented a cool paving demonstration at Bannister Park in Fair Oaks.
- The Air Quality Impacts Subcommittee has reviewed air quality modeling by the Department of Energy's Lawrence Berkeley National Laboratory and is providing input to the State Implementation Plan for ozone air quality attainment.
- The Outreach & Education Subcommittee has developed outreach materials, and continues to hold meetings with local planning agencies and commissions, to plan educational workshops for teachers and faculty managers at schools, and to influence the design and environmental review procedures in the Sacramento area.

Since 1990, the Sacramento Municipal Utility District (SMUD) in collaboration with STF has been operating Sacramento Shade, the nation's largest shade tree program. As of January 2004, over 312,000 trees had been planted. The program promotes tree planting to shade homes, schools, and public buildings directly with the main goal of reducing air conditioning needs.

Sacramento Parking Lot Shading Ordinance

This ordinance requires developers of new parking lots to plan to cover 50% of the lot with shade trees within 15 years.