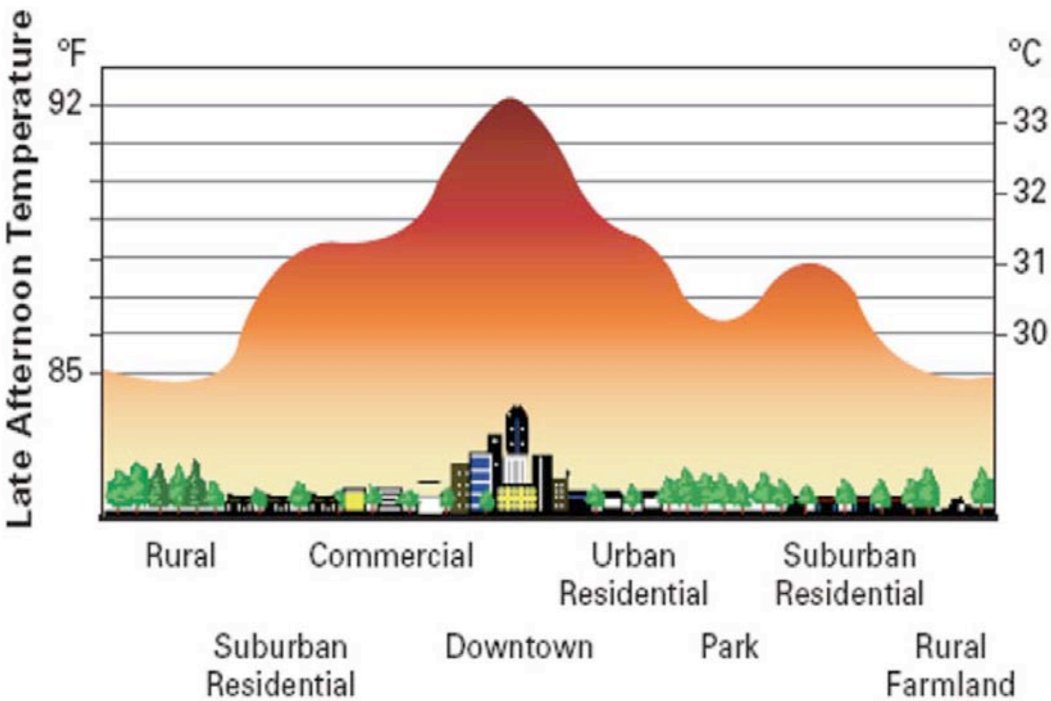
Summary Report
Urban Heat Island Effect



City of Las Vegas
Office of Sustainability
April 2010

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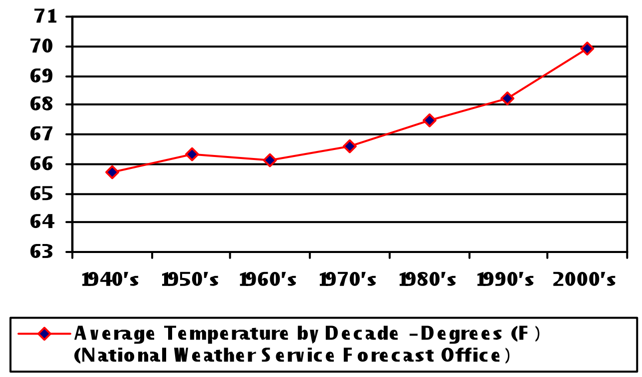
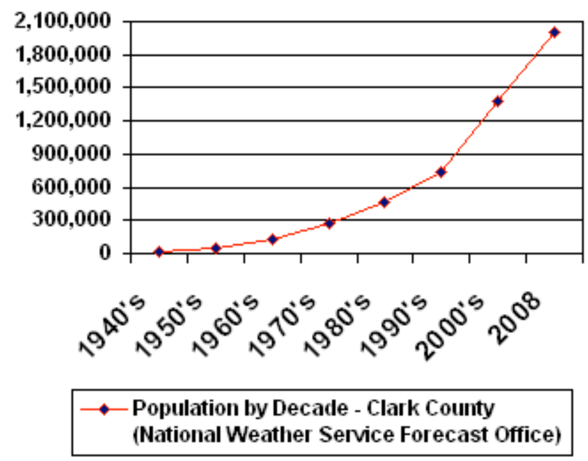
Summary Report – Urban Heat Island Effect

Preface

This report discusses issues and policies related to the urban heat island (UHI). Topics covered include the effects of urbanization on average temperature and strategies to mitigate temperature increases. Cool paving and roofing materials along with an expansion of the city's urban forest are proven methods to help mitigate the urban heat island effect.

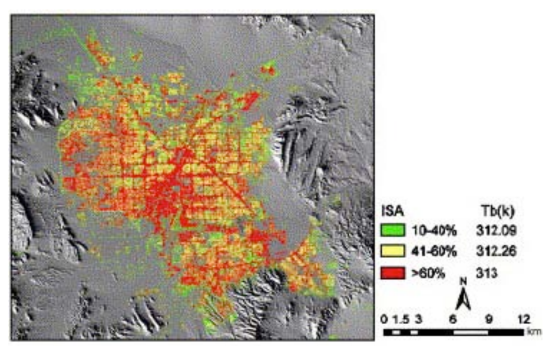
Background





Temperatures in the city of Las Vegas are expected to be hot, as the city is located in the Mojave Desert with summertime temperatures reaching 100 – 120^{o}F. As the city continues to expand, the natural desert landscape is being replaced with hard or impervious surfaces (highways, streets, parking lots, sidewalks and buildings) that absorb the sun's rays (heat). The absorbed heat is radiated back into the air causing the air temperature of urban environments to climb even higher and remain hotter for longer periods of time.

The average temperature (measured at McCarran Airport[1]) has risen four degrees in just four decades (1970's – 2000's). The largest temperature increase corresponds to the largest increase in population, with over one million people relocating to the Las Vegas Valley during the same timeframe. As the population increased so did the demand for new infrastructure (roads & highways) and structures (residential & commercial). These new impervious surfaces absorb and radiate heat, resulting in an increase in the average temperature.



This 2002 Landsat satellite image summarizes temperature differences in three impervious surface area (ISA) categories. The surface area rating is based upon anthropogenic density, or man-made materials as opposed to natural occurring landscape. The researchers[2] averaged the temperatures to reflect a more general temperature distribution pattern. The thermal

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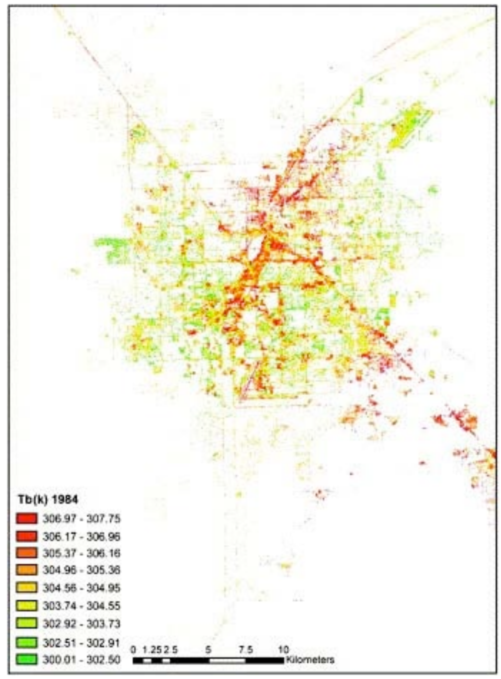
[1] Temperature and Population data from: National Weather Service Forecast Office - Las Vegas Climate Book
www.wrh.noaa.gov/vef/climate/figure6.php
[2] Landsat images have been reproduced from: George Xian & Mike Crane, Remote **Sensing of Environment** Volume 104, Issue 2, 30 September 2006, Pages 147-156 Thermal Remote Sensing of Urban Areas (with permission from the authors.)

gradient transitions from the center to the edge of the Las Vegas Valley, moving from hot (high-density urban > 60% ISA) to warm (urban 41 – 60% ISA) to cool (non-urban 10 – 40% ISA). Some non-urban areas have a higher temperature reading than urban areas, but lower than the high-density urban area. In general, urban land use and land cover (LULC) creates a daytime cooling effect in low- to medium-density urban areas (from new landscape and vegetation) and an urban heat island in high-density areas (higher percentage hardscape).

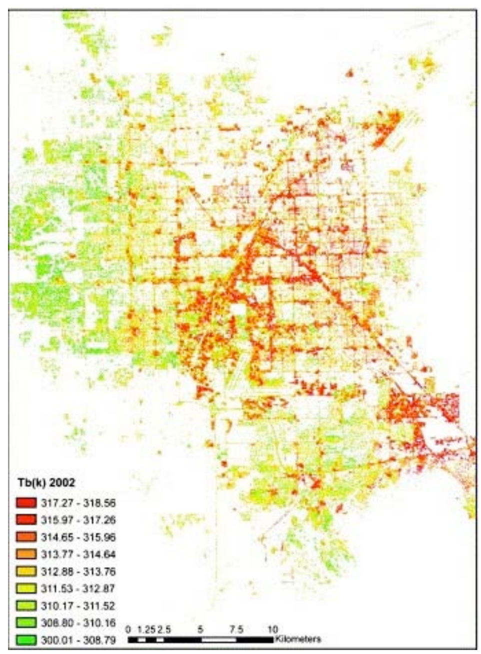
Landsat Images[3]

The Landsat images on the right depict the impervious surface area in the Las Vegas Valley in 1984 & 2002, using temperature. Temperature is divided into intervals of 10 degrees, with red reflecting the hottest surface temperatures. The '10 percent or greater' imperviousness category (green) was approximately 112 mi^2 in 1984 and doubled to 239 mi^2 in 2002. The doubling of the '10 percent or greater' category demonstrates the affect new impervious surfaces are having on the urban temperature.



1984 Landsat Image – Las Vegas Valley
From: Remote Sensing of Environment

Structures in the vicinity of the Las Vegas "Strip" and the downtown (red diagonal area in center of images) are primarily tall commercial buildings (hotels and entertainment gaming facilities) that reduce airflow (wind blocks) and are surrounded by impervious surfaces (parking lots, roads and highways) These large structures attract thousands of visitors (vehicles) that use air conditioners (cars/buildings), and produce additional heat. These high-density urban areas display similar thermal characteristics in 1984 and 2002.



2002 Landsat Image – Las Vegas Valley
From: Remote Sensing of Environment

New development areas on the western side of Las Vegas did not show strong "hot" characteristics (2002) despite having large areas of high-density ISAs. Newer construction materials and larger quantities of vegetation and landscaping may explain the "cooler" phenomenon. Ground observation[4] documented that prior to the 1990's most residential housing in Las Vegas was constructed using asphalt roof shingles (darker materials absorb more heat). The majority of newer residential and commercial structures have been built with stucco exteriors and clay/fiber-cement tile

[3] Landsat images have been reproduced from: George Xian & Mike Crane, **Remote Sensing of Environment** Volume 104, Issue 2, 30 September 2006, Pages 147-156 Thermal Remote Sensing of Urban Areas (with permission from the authors.)

[4] Ground observations and finding by researchers: George Xian & Mike Crane.

roofs (materials that absorb less heat). These newer building materials help to mitigate the urban heat island by absorbing less and reflecting more of the sun rays (heat) into the atmosphere, helping to explain the cooler temperatures.

Impacts of Urban Heat Island

The Environmental Protection Agency (EPA) has found that urban heat island is a growing concern for millions of Americans living in and around cities. Urban and suburban temperatures are hotter (see table on right) than nearby rural areas (by 2 to 10°F or 1 to 6°C). Increasing energy demands are impacting communities as consumers pay higher energy bills and air pollution increases. Over the past two decades many cities have experienced an increase in the incidents of illnesses and mortalities caused by heat.

Ten Hottest Months and Years - Las Vegas Valley
Source: Clark County Department of Air Quality & Environmental Management

Avg. Monthly Temp.	Month	Avg. Yearly Temp.	Year
95.4	Jul-07	71.1	2007
95.3	Jul-05	70.1	2005
94.8	Jul-03	70.1	2003
94.6	Jul-05	69.8	2006
93.5	Jul-02	69.7	2000
93.4	Jul-59	69.6	2001
93.4	Jul-69	69.4	2004
93.2	Jul-97	69.4	1996
93.1	Jul-72	69.2	1981
93.0	Jul-04	69.0	1995

The Role of the City of Las Vegas

The city recognizes the impact the urban heat island is having on our community and will continue to examine mitigation strategies through updates of the Las Vegas Municipal Code and the 2020 Master Plan. These updates will encourage the use the newest building materials and strategies that help to mitigate the urban heat island, when feasible. Cool paving, cool roofing and urban forestry are three such strategies and are discussed in the following sections.

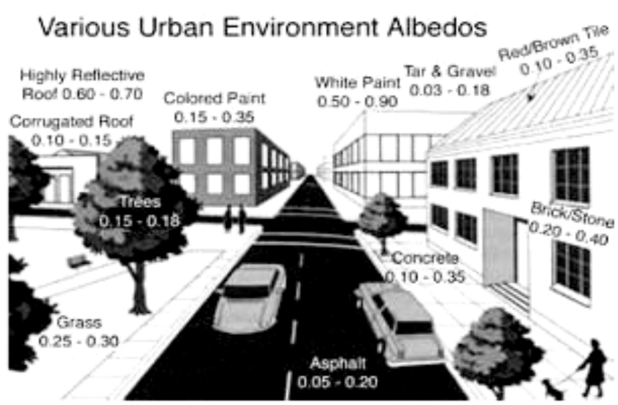
Cool Paving

Introduction

Replacing the desert environment with large areas of impervious materials (pavement) and little vegetation exacerbates the urban heat island effect. One approach to mitigate the UHI effect is the use of alternative or cool paving materials. Cool paving materials absorb less heat than traditional impervious materials resulting in lower UHI impacts on the community.

Albedo Ratings

All surfaces have albedo ratings (see graphic on right).[5] The albedo of an object is the extent to which it diffusely reflects light. The range for albedo is 90 percent for fresh snow (high reflectivity) to about four percent for charcoal (low reflectivity) one of the darkest substances. When seen from a distance the ocean surface has a low albedo; while desert areas have some of the highest albedos among landforms.[6]



[5] Cool Houston Plan (p. 5) Report Editors: David Hitchcock, HARC & Valerie Cook, HARC

[6] Definition and examples of Albedo were found on the following website: http://en.wikipedia.org/wiki/Albedo

The albedo rating of materials is very important. A lower albedo rating means an object has less solar reflectance which equates to a greater potential for heat absorption. To combat the urban heat island, materials with higher albedo ratings should be used, when possible. The effectiveness of cool paving technology is based on geology, the intensity of development and the area climate.

Cool Paving Types

There are three types of cool pavements: cement concrete, asphalt concrete and porous paving. The picture on the right shows different applications for paving materials at a demonstration project at Bartley Hall, Villanova University.[7] Standard concrete (typical) is followed by interlocking pavers (middle), and finally porous concrete (cool pavement). The picture helps to demonstrate one of the benefits of porous concrete – water absorption. Notice the lack of glare on the porous section (absorption) while the standard concrete and pavers look wet or slick.

The following table categorizes alternative paving materials into three categories (cement concrete, asphalt concrete and porous paving). The typical use, solar reflectance and lifecycle are identified, but it is important to note that as new technologies are developed, higher solar reflectance and lifecycles are expected. Currently, not all paving technologies can be used in high-traffic areas. The solar reflectance of "cool asphalt, white aggregate and light colors" was estimated, because no definitive results were available.

Cool Paving Technology	Uses	Solar Reflectance	Lifecycle
Cement Concrete			
Cool concrete	New construction	New 35-45% Old: 25-35%	15-35 years
White topping	New / resurfacing		10-15 years
Porous concrete	New construction	30-40%	15-20 years
Concrete pavers	New construction (not for heavy traffic)	30%	10-15 years
Asphalt concrete			
Cool asphalt White aggregate	New construction	10-15%	7-10 years
Cool asphalt White aggregate or Light colors	Resurfacing / Maint. Chip seal Asphalt emulsion Surface coating	Estimated… 20% 15% (asphalt & surface)	 5-7 years 3-5 years 3-7 years
Open graded asphalt	New construction	10%	7-10 years
Porous Paving			
Porous paving	New construction	Same as grass plus cooling effect from water	15 years

Adapted from L. Gartland, Cool Alternative Paving Materials and Techniques, http://www.energy.ca.gov/coolcommunity/strategy/coolpave.html

Cool Paving Benefits

Reduced Air Temperatures

Cool pavements have a higher albedo rating than most impervious pavements, which results in less heat absorption during daylight hours and cooler air temperatures during the night.

Improved Stormwater Management

The ability to slow and filter stormwater is a great asset in desert southwest and especially southern Nevada, which is prone to destructive flash flooding. Porous pavements allow water to percolate and infiltrate the ground more effectively than non-porous pavements, improving

[7] Cahill Associates Environmental Consultants http://www.thcahill.com/images/pconcrete2.jpg

stormwater management. The EPA and the Nevada Department of Environmental Protection (NDEP) requires municipalities to address non-stormwater discharges under the Clean Water Act and the National Pollutant Discharge Elimination System (NPDES). Cool pavements are one step toward conformance with Federal statutes and management directives.

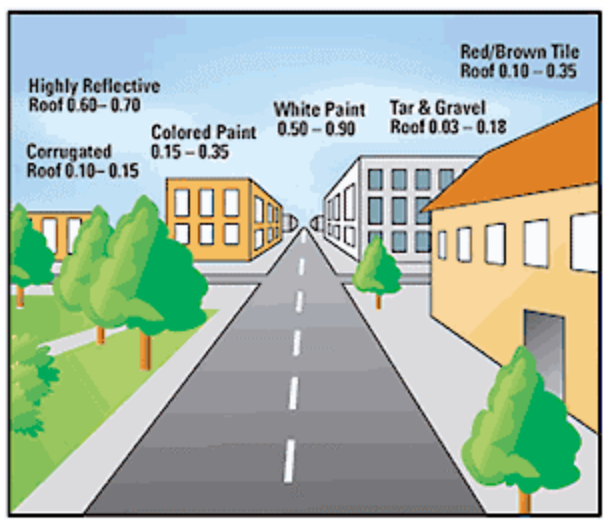
Enhanced Nighttime Illumination
Cool pavements reflect artificial lighting during the night (street and head lights) improving overall visibility while using less lighting (saving energy). Adding alternative pavements to parks, trails and other areas would improve visibility by as much as 30% (based on the albedo of the pavement and the lighting sources used).[8] White or light colors are the best for reflecting light.

Superior Durability
Porous pavements benefit from the cooling effect of evaporation, which means hot pavements will cool quicker and suffer from less heat gain over their lifecycle. Reducing this stress will effectively prolong the life of projects that use alternative pavements by reducing the amount of expansion and contraction that weakens pavements over time.

Cool Roofing

Introduction
Research by the EPA and the Department of Energy (DOE) has found 90% of the roofs in the United States are dark colored. Traditional building materials with low surface reflectivity results in roof temperatures of 150 to 190°F (66 to 88°C), and contribute to the urban heat island. One solution is to use "cool roofing" materials that offer higher levels of reflectance and emittance than traditional building materials, keeping temperatures cooler during summer and reducing the urban heat island effect.[9]

Emissivity Measurement
As with cool pavements, the albedo rating for cool roofing materials depends on the product. For instance, the rating for white paint (superior reflectance) is higher than red/brown tile (more heat absorption). To gauge the effectiveness of roofing materials another measure is emphasized: emissivity. The amount of heat that is released from a surface (see lower diagram on right.) is called emissivity.[10] To measure emissivity a scale of 0 – 1 is used with zero meaning no heat is being released (surface is hot) and one indicates the surface releases absorbed heat (cool surface). In warm and sunny climates highly emissive roofing products can help reduce the cooling load



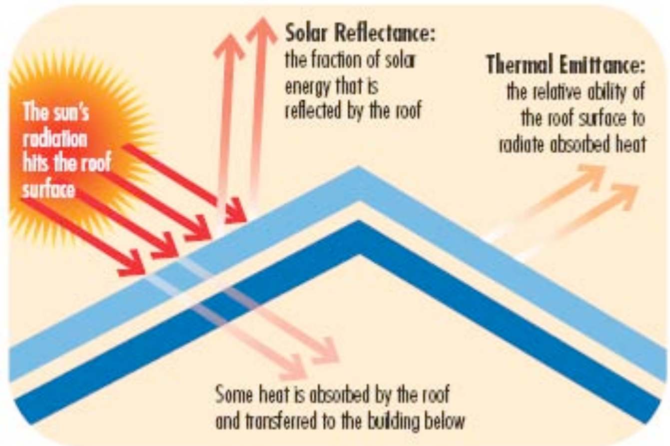
[8] Cool Houston Plan – Improved Nighttime Illumination Pg. 30 http://files.harc.edu/Projects/CoolHouston/CoolHoustonPlan.pdf

[9] EPA Cool Roofs webpage http://www.epa.gov/heatisland/strategies/coolroofs.html
[10] Solar Reflectance – Thermal Emittance table is from: Cool Roofs Rating Council www.coolroofs.org/images/radiativeprops.png

on the building.

ENERGY STAR® Roof Product Program

Since Americans spend about $40 billion annually to air condition buildings (one-sixth of all electricity generated in this country) a program has been created to rate and classify cool roofing materials.



The Roof Product Program has cool roofing specifications for both low-sloped and sloped roofs (low-sloped roofs must have an average initial albedo of at least 0.65, and sloped roofs must have an average initial albedo of 0.25 or more.) The benefits to selecting ENERGY STAR® roofing materials are:

- ENERGY STAR® qualified roof products reflect more of the sun's rays. This can lower roof surface temperature by up to 100°F, decreasing the amount of heat transferred into a building; and
- ENERGY STAR® qualified roof products can help reduce the amount of air conditioning needed in buildings, and can reduce peak cooling demand by 10–15 percent.[11]

[11] ENERGY STAR Reflective Roof Products http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products

Cool Roofing Technologies & Types

Liquid Coating[12]

Prefabricated membrane[13]

Metal Panel[14]

Green/Garden Roof System[15]

White Tile Roof[16]

Cool Roofing Technology	Uses	Solar Reflectance	Emissivity	Lifecycle
Liquid Applied Coatings				
White	Coating	75 – 80%	.87	5 – 10 years
Colors	Coating	25 – 65%	.87	5 – 10 years
Aluminum-asphalt	Coating	50%	.40	5 – 10 years
Prefabricated Membranes				
Single-ply (White)	New Construction Re-roofing	75 – 80%	.80	8 – 15 years
Modified bitumen Metal-foil/white	New Construction Re-roofing	25% 85%	.80	15 – 20 years
Metal Panel Roof Systems				
Metal Panel System (white)	New Construction Re-roofing	50%	.60	15 – 25 years
Green/Garden Roof System				
Green Roof System	New Construction Re-roofing	N/A	N/A	15 – 25 years
Specialty Products Systems				
Clay tiles (white)	New Construction	40%	.85	20 – 30 years
Concrete tiles (white)	New Construction	40%	.85	20 years
Metallic tile (white)	New Construction	40%	.65	20 years

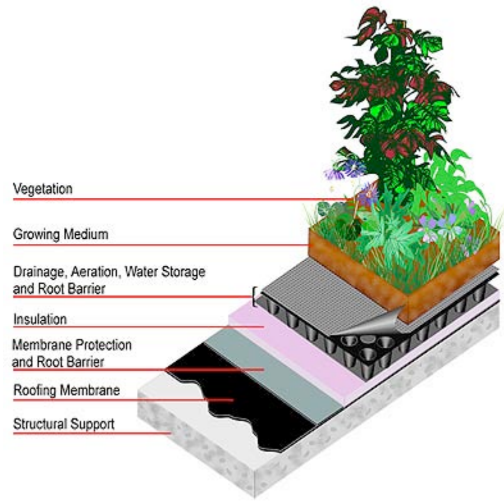
** Data is from the Department of Energy Website – Product List dated 01-07-2008.
http://www.energystar.gov/ia/products/prod_lists/roofs_prod_list.pdf

[12] Liquid Coating picture from: http://www.makercoating.com/images/roofinglarge.jpg
[13] Prefabricated Membrane picture from: http://www.interbuild.com/ExhibitorLibrary/1042/thumb_Mechanical_Fix_1.JPG
[14] Metal Panel (solar shield) roof: http://solarshieldroofing.com/Portals/21/solarshield4-(2).jpg
[15] Green/Garden Roof – taken by staff – C2 Lofts, Las Vegas Nevada.
[16] Florida Solar Energy Center picture: http://www.fsec.ucf.edu/en/publications/html/FSEC-CR-1220-00-es/images/WStile.jpg

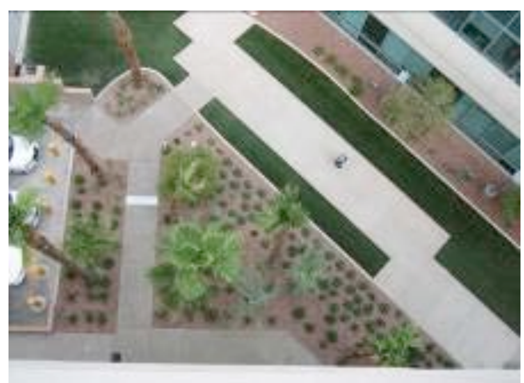
While thermal emittance is not a qualifying criterion for the ENERGY STAR® label, a rating of 80% or more further reduces heat transfer to the indoors. For more information about products and ratings for cool roof products please visit the *Cool Roofs Rating Council,* which was created in 1998 to develop accurate and credible methods for evaluating and labeling the solar reflectance and thermal emittance (radiative properties) of roofing products and to disseminate the information to all interested parties. http://www.coolroofs.org/

Green Roofs

A green roof consists of vegetation and soil or a growing medium planted on the rooftop or top of a structure (normally buildings and homes). Green roofs provide a pleasant place to spend time, particularly in urban environments; process carbon dioxide (CO_2) in the atmosphere and produce oxygen; provide food through gardens and help insulate structures so they don't use as much energy to heat or cool.[17]



On hot summer days, the surface temperature of a vegetated rooftop can be cooler than the air temperature, whereas the surface of a traditional rooftop can be up to 90°F (50°C) warmer. Additional layers, such as a root barrier and drainage and irrigation systems may also be included (see diagram of layers on right).[18] In Europe, green roofs are widely used for stormwater management, as well as their aesthetic benefits.



The Molasky Corporate Building is the first commercial office buildings in Las Vegas to incorporate a rooftop garden. Although a rooftop garden doesn't provide the same benefits, when compared to a green roof, it is a better option in Las Vegas because of the desert environment. The vegetation is located on the 7th story of the building, just above the parking structure as shown in the pictures above.[19]

[17] Riley, Trish. The Complete Idiot's Guide to Green Living: Earth-saving solutions for every part of your life. Penguin Group, 2007.

[18] This diagram was posted on Usemenow.com as, "Here is the City of Chicago's Guide to Rooftop Gardening and Penn State Center for Green Roof Research. http://www.usemenow.com/web-log/archives/2005/02/rooftop_housing.html

[19] Illustration and picture of Molasky Corporate Building provided to city of Las Vegas by: Pamela Puppel, Burch Design Group. January 2008.

Cool Roofing Benefits

- **Energy**
  1. Reduced peak power demand
  2. Insulation from extreme temperatures, keeping the building interior cool in the summer

- **Quality of Life**
  1. Cooler temperatures around building (evapotranspiration – green roofs)
  2. Reduce noise transfer from the outdoors
  3. Offer an attractive alternative to traditional roofs
  4. Addresses growing concerns about urban quality of life
  5. Improve human health and public safety

- **Monetary**
  1. Extended roof life cycle (protect underlying roof material by eliminating exposure to the sun's ultraviolet (UV) radiation and temperature fluctuations)
  2. Improved efficiency of HVAC equipment over long-term
  3. Energy saving for owners/tenants

- **Environmental**
  1. Provides on-site treatment and reduction of non-stormwater pollutants
  2. (Green roof) absorb air pollution, collect airborne particulates, and store carbon
  3. (Green roof) serves as living environment that provides habitats for birds and small animals

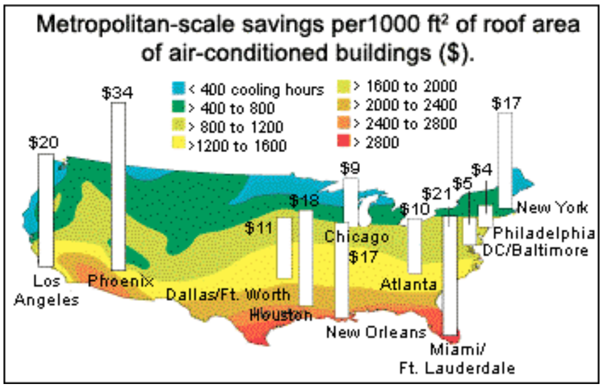
What Is the Energy Savings Potential of a Cool Roof?
An estimate of cool roof energy savings can be determined by considering the following factors:[20]

- Air conditioning: cool roofs can reduce summertime energy use in air conditioned buildings. In buildings without air conditioning, cool roofs can improve comfort by reducing top-floor temperatures
- Roof insulation: cool roofs save more energy when installed on buildings with low roof insulation
- Attic radiant barrier: these structures reduce the energy saving potential of cool roofs (picture right, by trapping heat[21]
- Attic ventilation: buildings with low attic ventilation see a greater benefit from a reflective roof
- Local climate: **cooling energy savings are typically greatest in areas with long, sunny, hot summers**

Radiant Barrier - Attic

[20] EPA's Urban Heat Island http://www.epa.gov/heatisland/strategies/coolroofs.html
[21] BTU Busters http://www.btubusters.com/04RADIANT-BARRIER-PRODUCT.html

The EPA monitored several buildings in California and Florida and demonstrated that cool roofs save residents and building owners 20-70% in annual cooling energy use. These products reduce heat transfer to the indoors thus lowering air conditioning costs. The chart below shows the estimated saving based on square footage in several climates across the United States:

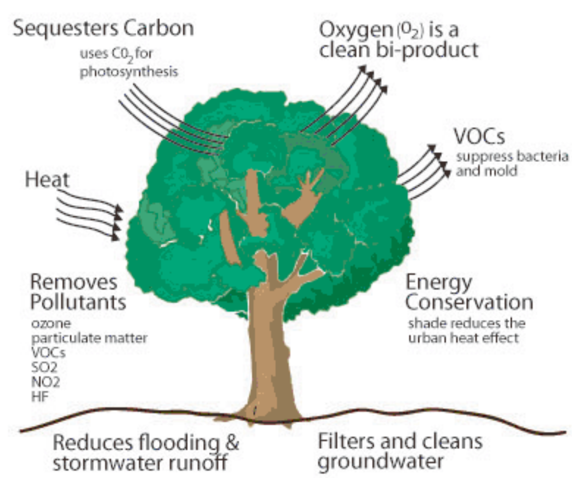


To calculate the savings for your own home using the ENERGY STAR Roofing Comparison Calculator, visit the following website: http://roofcalc.cadmusdev.com/. This calculator will assist you in determining if a cool roof will provide additional savings for your home or business.

Cool Trees

Introduction

As the population continues to grow in the city of Las Vegas and the entire region, it is important to balance growth with sustainable development that ensures the quality of life continues to improve for the community. Offsetting the effects of urban heat island is one of the many benefits an urban forest provides for a community.[22]



Trees increase the community aesthetics and offer greater livability, while providing cost effective ecosystem services, such as storm water interception and air pollution reduction. As part of the city's "green infrastructure," tree-lined streets encourage pedestrian activity, and when planted strategically enhance our public safety. Urban forests provide habitats for wildlife while enhancing the quality of life for residents and visitors.[23]

[22] Combination of 2020 Master Plan (p.36) and Cool Houston Plan (p.38)

[23] Tree graphic is a reproduction based on an original graphic in the Cool Houston Report. http://www.harc.edu/Projects/CoolHouston/About/Plan

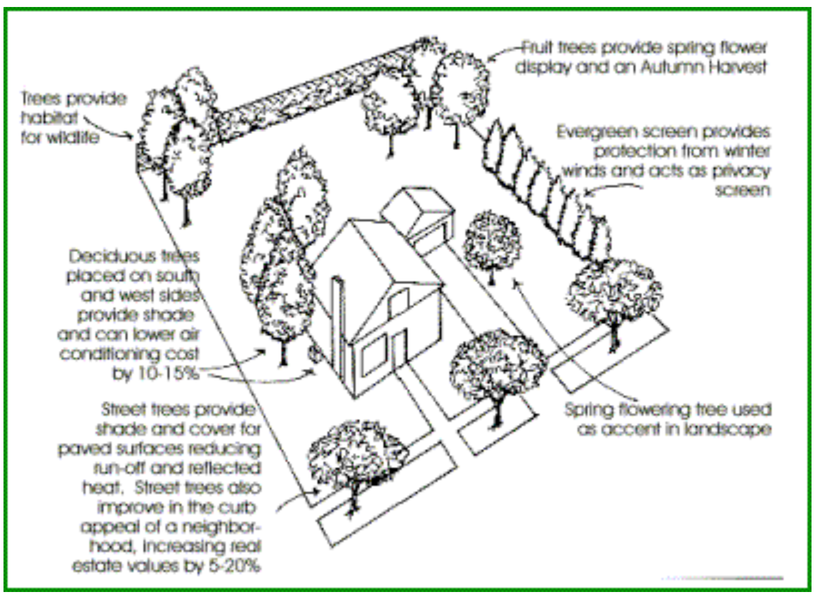
Background

Urban forests reduce air and surface temperatures (UHI) in a number of ways:

- Shading maximizes energy savings for homes, businesses and automobiles. Rays from the sun can quickly heat a structure, parking lot or automobile, but shading from a well-placed tree can reduce solar heat gain by as much as 40 percent
- The process in which tree absorb water into their roots and emit it from their leaves is called evapotranspiration, which cools air temperatures by 2 – 9^0 F
- Trees reduce conductive heat loss by blocking and reducing winds, which slows the exchange of heated or cooled air in homes and businesses

The city of Las Vegas governs 84,563 acres with an approximately canopy coverage of nine percent (7,665 acres)[24]. Canopy coverage varies in different parts of the community as shown in these pictures of East and West Las Vegas[25] which can be explained by land use categories, age of developments and the commitment by local citizens to preserve and maintain landscaping.

Urban Forestry Benefits



http://www.marinreleaf.org/benefits_trees_diagram.gif

[24] GIS analysis using SNWA Data – for 2006.
[25] Pictures of Las Vegas community were taken by city employees in 2006 and December 2007.

Trees Improve Air Quality
Urban trees provide air quality benefits in four main ways:

1. Trees absorb gaseous pollutants (e.g., ozone, nitrogen oxides, and sulfur dioxide) through leaf surfaces.
2. Trees intercept particulate matter (e.g., dust, ash, pollen, and smoke).
3. Trees release oxygen through photosynthesis.
4. Trees transpire water and shade surfaces, which lower local air temperatures, and contribute to reducing ozone levels.

An American Forest's study of the Colorado Front Range area found that the existing six percent tree canopy cover annually removed 1,080 tons of air pollutants, a process valued at $5.3 million. The city of Las Vegas has a nine percent tree canopy, but an inventory of the city's existing trees needs to be completed before the city can capture the benefits.

Trees in Davis, Calif. parking lots reduced asphalt temperatures by as much as 36° F, car interior temperatures by over 47° F, and air temperatures by 1° - 3° F. By shading asphalt surfaces and parked vehicles, the trees reduced hydrocarbon emissions from gasoline that evaporates out of leaky fuel tanks and worn hoses. These evaporative emissions are a component of smog, and parked vehicles are one source.

Trees Save Energy
Trees modify the climate and conserve building energy use in three principal ways:

- Shade from trees reduces the need for air conditioning in buildings and makes air temperatures outside cooler.

- Trees transpire – water absorbed by plants evaporates into the atmosphere from leaf surfaces, resulting in cooler air temperatures.

- Trees block winds and slow wind speed, reducing cold outside air from entering into buildings. This prevents heat loss and lessens the need for heating.

A computer simulation of annual cooling savings for an energy efficient home in Tucson, Arizona indicated that the typical household with air conditioning spent about $400 each year for cooling and $50 for heating. Shade and lower temperatures from three 25-ft tall trees, two on the west side of the house and one on the east, was estimated to save $100 each year for cooling, a 25% reduction.

Windbreaks reduce wind speed and resulting air infiltration by up to 50%, translating into potential annual heating savings of 10-12%.

Trees Reduce Atmospheric Carbon Dioxide
Urban forests can reduce atmospheric carbon dioxide in two ways:

- Trees sequester carbon dioxide as woody and foliar biomass.

- Trees near buildings reduce the demand for heating and air conditioning, thereby reducing emissions associated with electric power production.

Sacramento, California's 6 million trees remove approximately 335,000 tons of atmospheric carbon dioxide annually, with an implied value of $3.3 million.[26]

Trees Reduce Stormwater Runoff
A healthy urban forest can reduce the amount of runoff and pollutant loading in receiving waters in four ways:

- Leaf and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.

- Root growth and soil fauna and root decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.

- Tree canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces.

- Transpiration through tree leaves reduces soil moisture, increasing the soil's capacity to store rainfall.

A typical, medium-sized tree in coastal southern California was estimated to intercept 2,380 gallons of rainfall annually.

In the Colorado Front Range, existing canopy cover (6%) was estimated to reduce runoff by 52.9 million ft3, valued at $3.2 million annually.[27]

Trees Provide Aesthetic, Social, Economic and Health Benefits
One of the most frequently cited reasons that people plant trees is for beautification, but there are a lot of other good reasons to have trees in our cities.

- Trees provide shade.

- Trees add color, texture, line, and form to the landscape and soften the hard geometry that dominates built environments.

[26] In the above example, avoided power plant emissions (83,300 tons) accounted for 32% of the amount reduced.

[27] Cleaner Air, Tree by Tree - A Best Management Practices Guide for Urban Trees in Southern Nevada

- Landscaping, especially with trees, can significantly increase property values. Example: A value of $15,000 (9% of property value) was determined in a U.S. Tax Court case for the loss of a large black oak on a property valued at $164,500.

- Research on hospitalized patients with views of nature and time spent outdoors has shown that they need less medication, sleep better, and have a better outlook than patients without connections to nature.

- Research on the aesthetic quality of residential trees has shown that street trees are the single strongest positive influence on scenic quality.

- Recent research has also shown, trees can contribute to reduced levels of domestic violence, as well as foster safer and more sociable neighborhood environments.

- Research has shown that shoppers in well-landscaped business districts are willing to pay more for parking and up to 12% more for goods and services.

- In a Chicago study, trees were shown to reduce crime. Apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees. Buildings with medium amounts of greenery had 42% fewer crimes.[28]

An important distinction to draw from this report is that no one solution will reduce the urban heat island effect in a community. Implementing new technologies in combination with urban forestry will help reduce the UHI impacts. Development is necessary, especially with a growing population in the United States and in Southern Nevada. The city of Las Vegas is working to reduce the urban heat island effect by:

- Adopting an Urban Forestry Initiative (May 7, 2008).

- Researching and identifying new technologies that can be implemented in the Mojave Desert to reduce the Urban Heat Island Effect.

- Educating the residents of Las Vegas on actions they can take to help reduce the Urban Heat Island Effect.

[28] * This information is from USDA Forest Service Publication NA-IN-02-04.