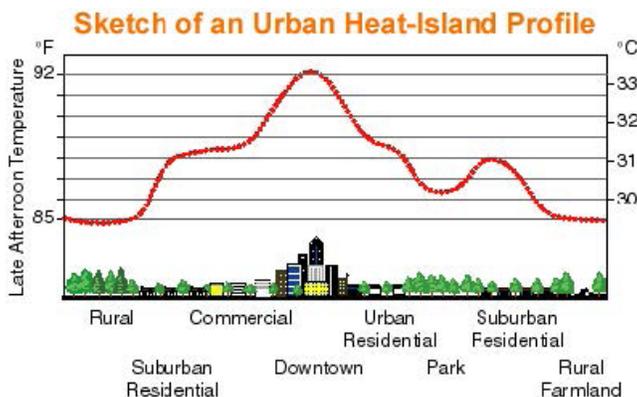


# INVISIBLE STRUCTURES VS. HEAT ISLAND IMPACTS



## Potential Benefits with Invisible Structures' Products vs The Heat Island Effect

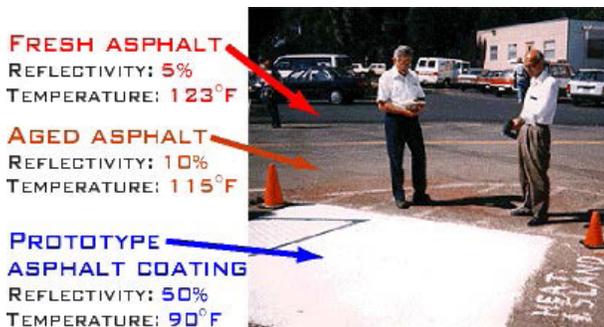
The information provided in the paragraphs below, can be found at the web address: <http://eande.lbl.gov/HeatIsland/>. It offers a brief overview of the potential benefits associated with the use of Invisible Structures, Inc. products. Please note that inclusion here does not imply endorsement by the Heat Island Group. The intention of this document is solely to showcase the principles governing the use of our products. For detailed product information, kindly visit our website at: <http://invisiblestructures.com/>.



### HIGH TEMPERATURES

As many city residents can tell you, cities can be very hot places during the summer. On warm summer days, the air in a city can be 6-8°F hotter than its surrounding areas. Scientists call these cities "Urban Heat Islands." What causes this to happen?

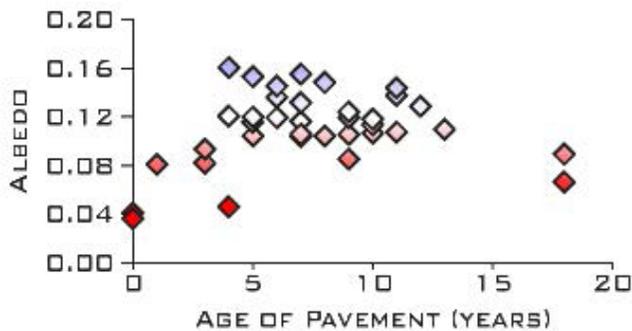
There are fewer trees, shrubs, and other plants to shade buildings, intercept solar radiation, and cool the air by "evapotranspiration." Buildings and pavement made of dark materials absorb the sun's rays instead of reflecting them away, causing the temperature of the surfaces and the air around them to rise. These higher temperatures contribute to a trend of increasing temperatures. Link: [Cool Pavements](#)



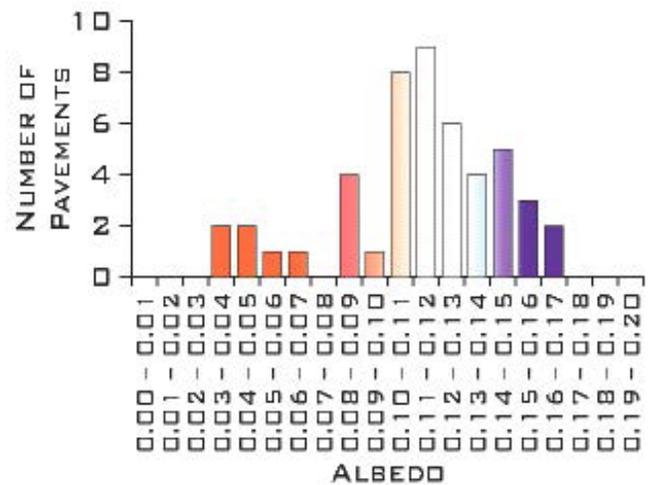
### COOL PAVEMENTS

Dark materials absorb more heat from the sun--as anyone who has worn a black t-shirt on a sunny day knows. Black surfaces in the sun can become up to 70°F (40°C) hotter than the most reflective white surfaces. Roads and parking lots are frequently paved with black asphalt concrete (commonly called "asphalt") and other dark materials that absorb most of the sunlight that falls upon them. The energy of the sunlight is converted into thermal energy and pavements get hot, heating the air around them and contributing greatly to the heat island effect. [Grasspave2 offers live grass vegetation cover, while Gravelpave2 offers light colored stone fill for greater reflectivity.]

We measured the albedos of various asphalt concrete pavements. The most recently paved surfaces have an albedo of about 0.04, because the asphalt (bitumin) coats the aggregate. (A typical asphalt concrete pavement is about 85% by volume of mineral aggregate and 15% asphalt.) Within 5 years the albedos increase to a mean value of 0.12 because the asphalt wears away, revealing some of the aggregate.



Over time, the albedo of asphalt concrete approaches 0.12



Over time, the average albedo of asphalt concrete is about 0.12

The data of the graph above is plotted as a histogram. The average albedo is about 0.12. The maximum does not exceed 0.16. Note that a specific pavement's albedo would depend on the kind of aggregate used and the history (e.g. sunlight, soiling, [maintenance], traffic) of the pavement.

[Grass has an effective albedo of 0.4, including a reflectance of 0.25 + 0.15 "effective reflectance" to account for evapotranspiration of well-watered grass. This number should transfer to a Grasspave2 pavement surface.]

## COOL ROOFS

Dark materials absorb more heat from the sun--as anyone who has worn a black t-shirt on a sunny day knows. Black surfaces in the sun can become up to 70°F (40°C) hotter than the most reflective white surfaces. If those dark surfaces are roofs, some of the heat collected by the roof is transferred inside.

Staying comfortable in under a dark shingle roof often means more air conditioning and higher utility bills. These roofs also heat the air around them, contributing to the heat island effect. Conversely, cool roofs can reduce the heat island effect and save energy. In a study funded by the U.S. EPA, the Heat Island Group carried out a detailed analysis of energy-saving potentials of light-colored roofs in 11 U.S. metropolitan areas. About ten residential and commercial building prototypes in each area were simulated. We considered both the savings in cooling and penalties in heating. We estimated saving potentials of about \$175 million per year for the 11 cities. Extrapolated national energy savings were about \$750 million per year. Link: [Ways to Save Energy](#)

The Heat Island Group has monitored buildings in Sacramento with lightly colored, more reflective roofs. We found that these buildings used up to 40% less energy for cooling than buildings with darker roofs. The Florida Solar Energy Center performed a similar study, also showing up to 40% cooling energy savings. [Cool Roofs can also include Vegetated roofs, such as those that would use Grasspave2 (flat surfaces) or Slopetame2 (sloped surfaces), with all the same benefits offered by vegetated surfaces.]

## VEGETATION

On warm summer days, the air in a city can be 6-8°F hotter than its surrounding areas. What causes this to happen? One reason is that there are fewer trees, shrubs, and other plants to shade buildings, intercept solar radiation, and cool the air by "evapotranspiration." Link: [Evapotranspiration](#)

Planting trees and bushes can thus help reduce urban temperatures as well as make cities greener. By providing shade and reducing urban temperatures, vegetation can save energy. Link: [Ways to Save Energy](#)

Planting trees haphazardly throughout a city isn't the best way to achieve their benefits. The Heat Island Group promotes the proper planting and maintenance of urban trees. Link: [Planting Trees Properly](#)

## EVAPOTRANSPIRATION

Evapotranspiration occurs when plants secrete or "transpire" water through pores in their leaves--in a way, plants sweat like people do. The water draws heat as it evaporates, cooling the air in the process. A single mature, properly watered tree with a crown of 30 feet can "evapotranspire" up to 40 gallons of water in a day. This is the equivalent of removing all the heat produced in four hours by a small electric space heater, or the power necessary to light one hundred 100W light bulbs.

## WAYS TO SAVE ENERGY

Measures that mitigate the heat island effect can save energy directly and indirectly.

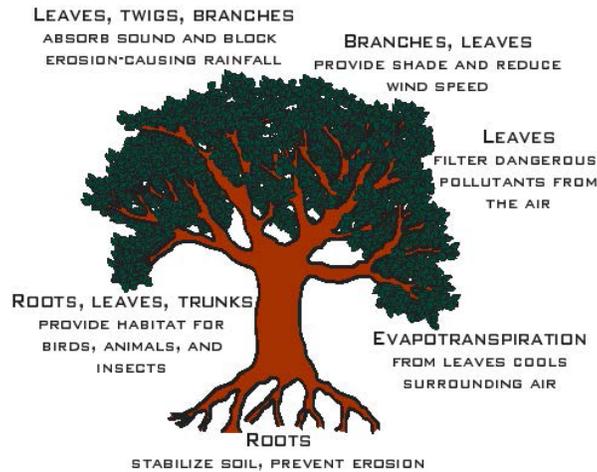
Direct effects include:

Cool Roofs are roofs that would reflect solar radiation. This would reduce the heat conducting into buildings and directly reduce air-conditioning use. [Use of vegetated roofs has additional benefits of lower reflected heat, air and water cleansing by vegetation, and protection of the underlying roof system.] Vegetation shading the walls and windows of buildings would also directly reduces air-conditioning use.

Indirect effects include:

Cool Roofs and Cool Pavements in a neighborhood would alter the surface energy balance. The result would be a lower ambient temperature, which, in turn, would further reduce the air-conditioning energy use as well as the likelihood of smog. Link: [Air Quality](#)

[Cool pavements include both Grasspave2 (vegetation) and Gravelpave2 (light colored stone fill) which are equally capable to support full growth of tree root systems below the pavement structures.] 2 of 5



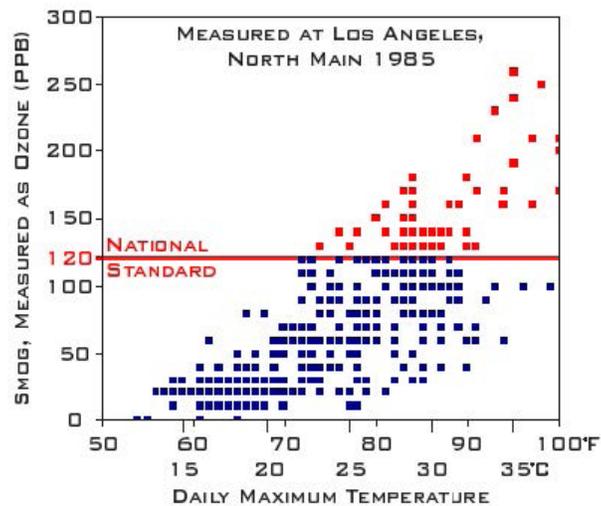
## PLANTING TREES PROPERLY

The Heat Island Group staff has been working with American Forests in the Cool Communities Program to promote proper planting and maintenance of urban trees.

Trees, shrubs, and other plants shade buildings, intercept solar radiation, and cool the air by “evapotranspiration.” Planting programs can help reduce urban temperatures and make cities greener. Within ten to fifteen years--the time it takes a tree to grow to a useful size--trees placed in strategic locations can reduce heating and cooling costs by an average of 10-20%. Over their lifetimes, trees can be much less expensive than air conditioners and the energy needed to run them. Link: [Evapotranspiration](#)

Correct selection and location of trees is important to achieve the best results. Two proven methods maximize benefits:

1. Deciduous trees shading the south and west sides of a building block the summer sun. For a home monitored in Sacramento, California, Heat Island Group researchers found that this reduced cooling energy use by as much as 30%. Trees, bushes, or vines should also shade your air conditioner, which works more efficiently when kept cool. Also, evergreen trees and bushes to the northwest can protect buildings from cold winter winds.
2. Trees grouped together create a refreshing park or oasis in a city and also cool nearby neighborhoods. Grouped trees can protect each other from the sun and wind, making them more likely to grow to maturity and live longer. [Tree groupings added within Grasspave2 and Gravelpave2 porous pavements will shade vehicles and ground surfaces while also adding evapotranspiration benefits to old or new parking areas.]



## AIR QUALITY

Urban heat islands are not only uncomfortably hot, they are also smoggier.

Smog is created by photochemical reactions of pollutants in the air. These reactions are more likely to occur and intensify at higher temperatures. In Los Angeles, for example, for every degree Fahrenheit the temperature rises above 70°F, the incidence of smog increases by 3%.

Higher ambient temperatures in heat islands also increase air conditioning energy use. As power plants burn more fossil fuels, they increase both pollution levels and energy costs.

The impact of these pollution levels is seen in smog. The formation of smog is highly sensitive to temperatures - the higher the temperature, the higher the formation and, hence, the concentration of smog. In Los Angeles at temperatures below 70°F, the concentration of smog (measured as ozone) is below the national standard. At temperatures of about 95°F all days are smoggy. Cooling the city by about 5°F would have a dramatic impact on smog Concentration. Link to: [High Temperatures](#)

The following paragraphs originate at the Web address: <<http://www.turfgrassod.org/trc/environment.html>>, and offer a quick summary of the issues related to potential benefits for the use of Invisible Structures, Inc.'s grass porous paving and vegetated roofs. Inclusion here does not indicate any endorsement of these uses by the Turf Producers International. The purpose of this Paper is to illustrate the principles guiding the use of our products only.

## **OUR PRECIOUS PLANET**

Being A True Environmentalist Begins Right Under Our Feet

Turfgrass -- Functional, Recreational & Aesthetic  
The earth has been good to us, but we haven't always been good to it.

While industry and technology have provided jobs and goods to make life easier, the effect on the environment has been substantial.

But we can help restore this precious earth with something as simple as turfgrass -- the earth's living skin.

The U.S. Congress has acknowledged these positive benefits to our environment. "Turfgrass sod in urban areas and communities can aid in the reduction of carbon dioxide emissions, mitigating the heat island effect, reducing energy consumption and contributing to efforts to reduce global warming trends."

Scientific research has documented the many benefits of turfgrass to our environment. Our turfgrass lawns, parks and open areas:

- Provide a natural, comfortable, and safe setting for fun and games.
- Release oxygen and cool the air.
- Control pollution and reduce soil erosion.
- Purify and replenish our water supply.

[Reinforced grass porous pavements will also provide these functions, in addition to providing a rate of infiltration in the range of 1200 to 35 inches per hour, depending upon base course materials and compaction.]

## **OUR ENVIRONMENT**

The satisfaction of creating beauty within the landscape can be rewarding for you and the environment. With turfgrass sod, the rewards are practically immediate.

[Unlike the need to wait for 10-15 years for new trees to mature]

## **POLLUTION CONTROL**

Today's improved turfgrass varieties are very effective in reducing pollution.

- Turfgrass traps and removes dust and dirt from the air.
- 2,500 square feet of lawn absorb carbon dioxide from the atmosphere, and release enough oxygen for a family of four to breathe.

## **NATURE'S AIR CONDITIONER**

Another benefit that everyone enjoys, usually without notice, is turfgrass' tremendous cooling effect.

- On a hot summer day, lawns will be 30 degrees cooler than asphalt and 14 degrees cooler than bare soil.
- The front lawns of eight houses have the cooling effect of about 70 tons of air conditioning. That's amazing when the average home has an air conditioner with just a three or four ton capacity.
- The cooling effect of irrigated turf reduces the amount of fuel that must be burned to provide the electricity, which powers the air conditioners.
- Watered when the grass plant needs it, turfgrass will very efficiently and effectively use almost every drop.

## **A NATURAL FILTER**

Runoff water in urban areas carries many pollutants.

- Turfgrass acts as a natural filter, reducing pollution by purifying the water passing through its root zone.

[Data providing quantification formulas is very rare, but historical use of Grasspave2 porous pavement has demonstrated long term success and performance as a bio-filter inlet surface – especially valuable for treatment of "first flush" pollutants from hard pavement surfaces.]

## **SOIL EROSION**

The clean gentle strength of turfgrass is the most cost-effective method for controlling wind and water erosion.

- A healthy sodded lawn absorbs rainfall six times more effectively than a wheat field and four times better than a hay field.
- A sodded lawn will absorb greater amounts of rain than a seeded lawn - even after three years of growth.

[Grasspave2 surfaces are capable of infiltrating from 1.5 to 3.0 inches of rain before any surface runoff begins (over clay soils), with these quantities increasing as subsoil porosity increases.]

## **FUN & GAMES**

The soft resilient surface of turfgrass is the safest and least expensive place to play.

- For backyard ball games or the Super Bowl, athletes of all sizes prefer the green cushion of turfgrass.
- Turfgrass is the only place for putting, picnics or just plain relaxing.

[Please refer to use of our Draincore2 product by our Sports Turf Drainage Licensee at: <http://www.geoturf-sports.com/>.]

## OUR MENTAL HEALTH

Turfgrass quietly adds to the beauty of our lives and even our mental and physical health.

- Doctors have shown that people recover faster in a hospital when given a landscape view, rather than seeing only the walls of adjoining buildings.

## TURFGRASS

... a continuing source of oxygen and cool air.  
... a cleansing answer to our environment.  
... a source of beauty and comfort.

With the benefits of turfgrass working their wonders for us, we will be able to share a beautiful and healthy planet with our future generations.

Copyright 1998-99 Turfgrass Producers International

## OTHER PRODUCTS

In addition to all of the surface treatment options presented above to reduce the Heat Island Effects of traditional urban development, Invisible Structures' products also include Draincore2 for subsurface collection/conveyance of filtered water, and Rainstore3 for subsurface storage of filtered stormwater. This stored water can be infiltrated directly into subsoils, or stored for harvesting and reuse in the landscape or buildings - reducing energy required to treat and convey community water for such uses.

