Greener Years for Goodyear

URBAN HEAT ISLAND MITIGATION

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Background:
The City of Goodyear, Arizona is only 10% built out, placing the city in a position to decide what its future will look like. The developed areas replace vegetation with concrete, asphalt, and other heat-absorbing, low albedo materials, resulting in the urban heat island effect. The UHI effect is a phenomena of higher temperatures within urban areas as compared to rural areas, mainly due to large amounts of heat retentive materials used in construction and often accompanied with a reduction of vegetation in urban areas. It has been shown that UHI effect has caused air temperatures to be 3.6-9°F (2-5°C) warmer than temperatures in the surrounding rural areas. Mitigation techniques rely on minimizing the amount of heat absorbed into the urban system, and maximizing the speed at which the urban system sheds its heat.

Goals:
Determine typical land coverage in built-out sections of Goodyear
Research UHI mitigation techniques for recommendation for the City of Goodyear

Methods:

- Data organization and calculations for changed land cover temperature impact
- Goodyear land coverage data
- Literature review to determine land cover impacts on temperature and mitigation methods

Acknowledgment
This material is based upon work supported by the National Science Foundation under Grant No. SES-1462086, DMUU: DCDC III: Transformational Solutions for Urban Water Sustainability Transitions in the Colorado River Basin. Any opinions, findings and conclusions or recommendation expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF).

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Results
Across all of the selected areas, shown to the right, the average pavement area is 27%, with a high of 57% coverage. The average roof area is 19%, and average canopy cover is 6%. Areas 4 and 7 have the highest canopy coverage, even though they have a high concentration of parking lots. In total, Goodyear has 1.4-2% tree cover.

From roof and pavement cover, nearly half of the measured area has the potential for its albedo, or reflectivity, to be raised. With an average pavement cover of 27%, over one quarter of the selected areas' albedo can be raised to over 50%. Increase of 10% in urban albedo is associated with a decrease in temperature of .54– .97°F (.11-.54°C).

Area	Paved Area % Coverage	Roof Area % Coverage	Canopy Cover % Coverage
1	17%	21%	2%
2	21%	20%	5%
3	20%	12%	1%
4	23%	13%	10%
5	28%	19%	2%
6	23%	23%	2%
7	29%	23%	20%
8	57%	18%	7%
Average	27%	19%	6%

Figure 1: Area coverage for paved area, roof area, and tree canopy cover in study areas.

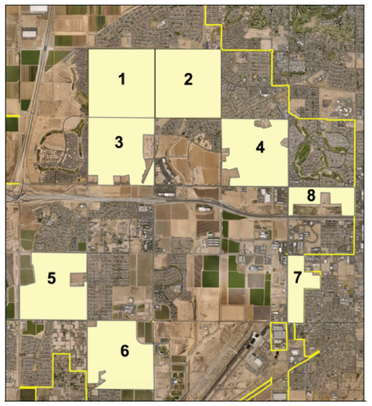
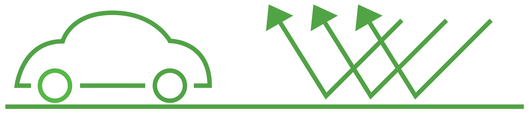


Figure 2: Location of study areas within Goodyear

UHI Mitigation Solutions:



Cool Pavement

Both academic research and commercial products demonstrate that pavement reflectivity can be increased to reflect over 50% of incident Infrared Radiation. White or slag cement concrete can have albedos of 70% and 60%. Slag cement is produced with byproducts from the production of iron, increasing the albedo of the concrete. Raising the albedo of the pavements within Goodyear from 10% to 35% can result in a 1°F decrease in temperature.

Cool Roofs

Roof surfaces account for 19% of the total urban surfaces in the selected areas. With high albedo materials or coating, rooftop albedo can be increased to nearly 80%. Cool Roofs reduce cooling loads in buildings, minimizing operation costs. Cool roofs are most effective in cities such as Goodyear with year-round warm climates.

Canopy Cover

A 10% increase in tree cover is associated with a 1.8°F (1°C) decrease in temperature. In one year, the trees in the 8 selected areas' energy savings of 587 MWh is worth $46,960. Mostly shaded parking lots are demonstrated to have an ambient temperature of 3°F (1.7°C) cooler than unshaded lots.

Conclusion:
Covering the City of Goodyear's pavements with solar reflective coatings or opting for slag cement concrete to replace asphalt, and painting or coating rooftops white will effectively mitigate the UHI effect in Goodyear. Increasing the canopy cover of Goodyear will also reduce temperatures in the city, while also providing additional services such as pollution sequestration, stormwater capture, and increased community value. Of the measured areas in this study, 46% can have albedos raised to values higher than 50%, leading to lower urban temperatures.

Future Study:
Studies are needed to determine if it is possible to increase canopy coverage with the limited amount of water that is available. Research the specific return on investment on canopy coverage in Goodyear. A consulting group should be brought in to determine the specific costs of slag cement concrete to gradually replace current asphalt roads, and for use on future paved areas. The group should investigate the costs of coating paved areas, specifically parking lots with low canopy cover.

Recommendations:
The City of Goodyear should change its Engineering Standards to require the use of slag Portland Cement Concrete in all new roads and paved areas due to the cooler surfaces and longevity. As asphalt pavements degrade in the city, pavement should be replaced with slag cement concrete. For all new developments, residential, commercial, or industrial, rooftops should be made from or coated with high albedo materials. Albedo should be 80% in order to gain the full benefits from cool roofs. Trees should offer 15-30% canopy coverage for the City of Goodyear's developed areas. Areas with large amounts of asphalt should have 30-50% of tree cover in order to effectively mitigate the heat gain of the pavement and mitigate the UHI. These trees should be drought tolerant, use minimal amounts of water, but also have a wide canopy. See Goodyear Preliminary Tree plan, or Phoenix Tree Plan for species lists.

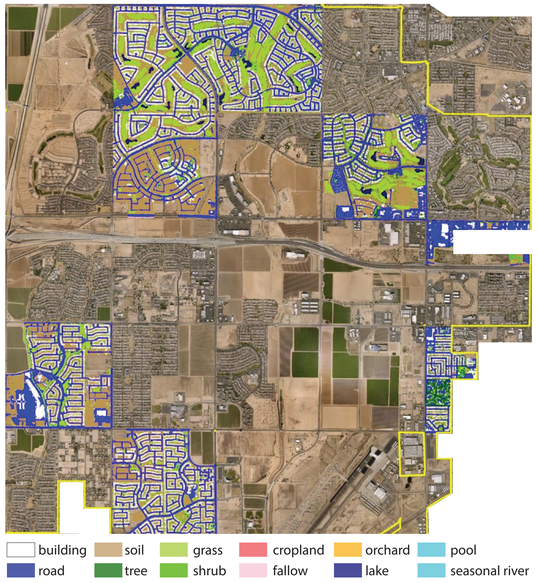


Figure 3: Goodyear with GIS overlay of land coverage