RESILIENCE STRATEGIES FOR EXTREME HEAT

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

Climate change is contributing to more frequent, severe, and longer heat waves during summer months across the United Sates. The number of heatwaves observed in 2011 and 2012 were triple the long-term average, and require planning for economic, health and environmental tolls.[1]

Local and state governments are already deploying resilience strategies to address urban heat islands, prepare for long-term trends of higher temperatures and plan emergency responses for heatwaves. To help local, county, and state officials understand the role of some common strategies in a holistic approach to managing climate risks, this fact sheet considers a comprehensive set of resilience benefits and co-benefits for those strategies. Estimates of costs are included, if available, though actual project costs will depend on local climate projections and other factors. Identification of co-benefits creates more opportunities for financing, additional design objectives and increases the political viability of these resilience actions. The monetization of each benefit summarized in this fact sheet will be most helpful in prioritizing strategies for closer study in your community. This fact sheet also includes tools that town or city officials and planners can use in assessing local project co-benefits.

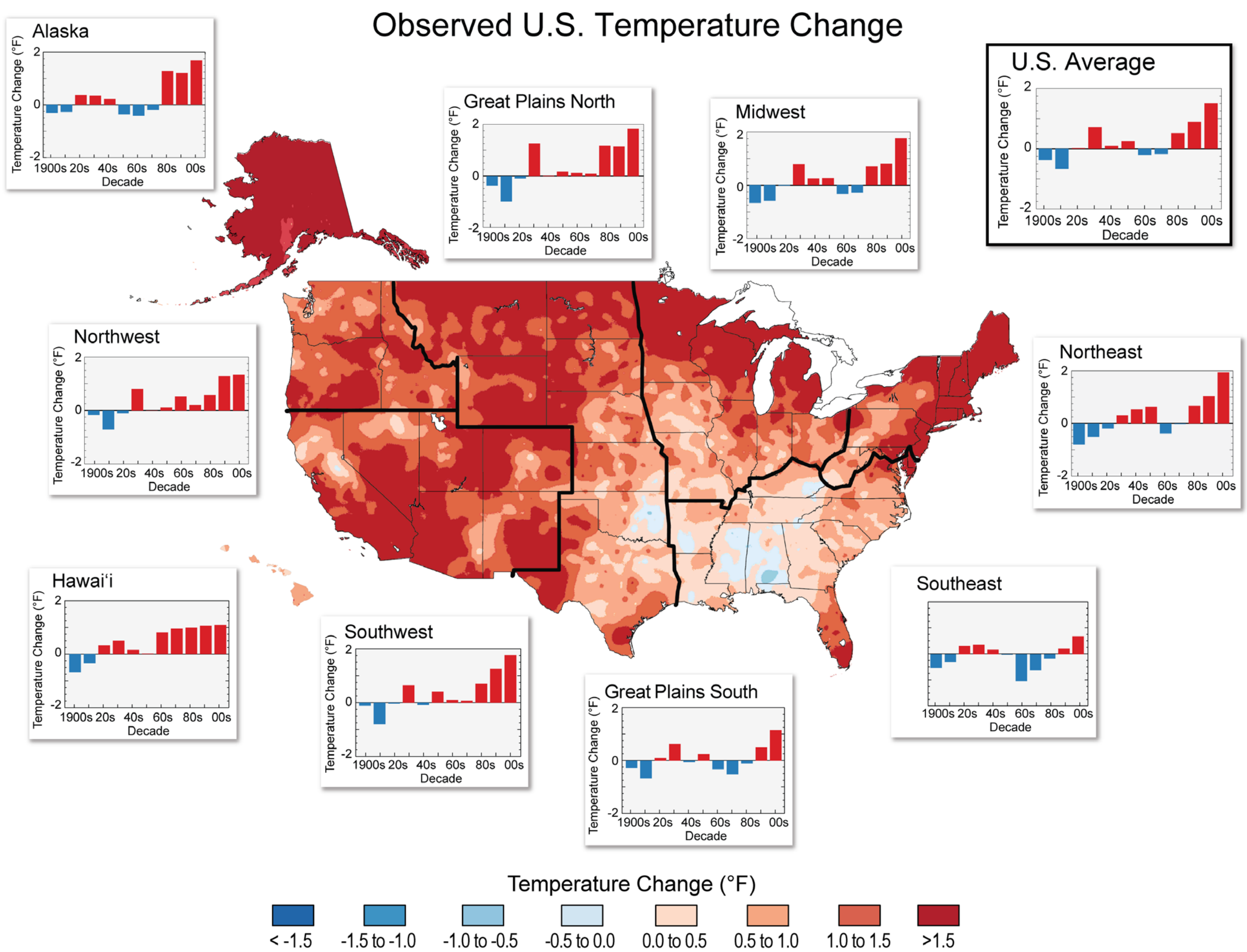
INTRODUCTION: HIGHER TEMPERATURES MEAN GREATER IMPACTS

Extreme heat causes more deaths than any other weather-related hazard—more than hurricanes, tornadoes, or flooding, and an average of more than 65,000 Americans visit emergency rooms each summer for acute heat illness.[2]

Heat will cause economic losses too. The U.S. Environmental Protection Agency (EPA) projects more than 1.8 billion labor hours lost due to extreme heat in 2100, costing more than $170 billion in wages.[3] Higher temperatures contribute to more use of air conditioners and stress on electric grids, resulting in power outages.[4] Electricity demand for cooling increases 1.5–2 percent per 1 degree F increase in air temperature between 68 and 77 degrees.[5] Energy costs to consumers nationwide will increase by 10–22 percent due to increased consumption, costing between $26 and $57 billion by the end of the century,[6] a considerable burden for low-income homes.

The heat is especially burdensome in American cities because of the urban heat island effect. Higher temperatures are amplified because cities' impervious surfaces, like pavement, retain more of the sun's energy while energy usage from heating, ventilation and automobiles produce waste heat. The annual mean air temperature of a city with a population of 1 million or more can be 1.8 to 5.4 degrees warmer than its surroundings, and could be 22 degrees greater at night.[7] While rural areas may not experience as high temperatures as cities, a study in Ohio found that suburban and rural areas were just as vulnerable to heat,[8] and a study comparing heat mortality in Northeastern urban and rural counties found that heat mortality was present in both urban and non-urban counties.[9] To respond to the growing challenges related to extreme heat, communities are implementing strategies that change building design, urban planning, and emergency planning through regulations, incentives, pilot projects, and new climate resilience programs.

FIGURE 1: Observed U.S. Temperature Change



The map shows temperature changes from 1991-2012, compared to the 1901-1960 average (in Alaska and Hawaii, the changes are compared to the 1951-1980 average). The bars on the graph show the average temperature changes by decade for 1901-2012 (relative to the 1901-1960 average) for each region. The far right bar (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region.

Source: NOAA NCDC / CICS-NC

CHOOSING COOL ROOFS TO REDUCE HEAT SENSITIVITY

Cool roofing products are made of highly reflective and emissive materials (often light colored) that can remain 50–60 degrees cooler than traditional materials during peak summer weather.[10] About 60 percent of urban surfaces are covered by roofs or pavement, traditionally made of dark materials with low solar reflectance (5–15 percent) that absorb about 90 percent of the sun's energy,[11] transferring that heat energy to the ground or buildings below.[12] Cool roof materials have higher solar reflectance (more than 65 percent) and transfer less than 35 percent of the energy to the buildings below them.[13] Material options depend on the slope of the roof, but include coatings, asphalt shingles, metal, clay tiles, and concrete tiles[14] and can be implemented on commercial or residential buildings.

COST

When compared with conventional roofs, cool roofs can be the same price, but often are 5–10 cents greater cost per square foot than conventional roofing materials (and 10–20 cents per square foot greater for a built-up roof with cool coating). Some roofing options cost significantly more (up to $1.50 per square foot), but these can result in greater reflectivity and greater benefits.[15] The **Key Tools** section provides links to resources for developing an accurate cost estimate and prediction of related energy savings, and guides to cool roofing materials.

BENEFITS

Reduced Energy Use

Cool roofs transfer less heat to the building below, so less air conditioning is necessary to keep indoor air temperatures comfortable. This becomes particularly valuable during peak electrical demand periods on hot days. Cool roofs can reduce cooling system needs and reduce peak electricity demand by up to 10–40 percent.[16]

The annual energy cost savings for a white roof are estimated nationally as 3.3 cents per square foot.[17] These costs vary based on many factors, including local climate, building characteristics, insulation materials, etc. In many cases, these cost savings allow the cool roofs to pay back their premium over traditional roofs in a few years. In cooler climates with greater heat energy expenditures, cool roofs can potentially increase winter heating costs, requiring a careful cost benefit analysis.[18]

Observed savings for individual buildings include:

- For older buildings in New York City, immediate payback was achieved by upgrading a dark roof with light coating. Replacing a black membrane with white paid for itself in five years.[19]
- In Washington, D.C., the average premium for a cool roof is 76 cents per square foot, while the average, calculated energy savings total $1.34 per square foot.[20]
- A California study showed statewide energy savings of 45 cents per square foot from cool roofs (with estimated cost premiums of up to 20 cents). At this premium, cool roofs were cost effective in all but one of California's climate zones (and in that zone, a cool roof with a cost premium of 18 cents or less per square foot is cost effective).[21]
- A study of a retail store in Austin, Texas, found a negligible premium for cool roofing installation but the building experienced an annual energy savings of 7.2 cents per square foot.[22]
- A study in Philadelphia, showed that homes with cool roofs saved 6.4 percent on energy after switching from traditional roofs.[23]

Improved Public Health

By reducing indoor air temperatures, cool roofs can contribute to lower rates of heat-related illnesses and mortality, especially in homes without air conditioning and in top floors of buildings. For example, the 1995 heat wave in Chicago contributed to more than 700 deaths, most of which occurred in the top floors of buildings with dark roofs. In an un-air-conditioned building, replacing a dark roof with a white roof can cool the top floor of the building 2–3 degrees.[24] Philadelphia added cool roofs and insulation to residential buildings that lack air conditioning,[25] and a study showed that daily maximum indoor air temperatures dropped by 1.3 degrees, and maximum ceiling temperatures dropped by an average of 3.3 degrees. Models of mortality rates and temperature show mortality increasing by 1 percent per 1 degree increase when temperatures are in the 80s, 2 percent per 1 degree increase in the 90s, and 5 percent per 1 degree increase in the high 90s. This shows a reduction of a couple degrees can greatly reduce heat-related mortality.[26]

Estimating the impact of cool roofs on heat-related stress on a community-wide scale is challenging. However, simulations of heat events can be used to evaluate how increasing reflectance across urban surfaces may reduce these risks. One study modeled impacts of surface reflectance on meteorological conditions and compared it to historical heat events, finding that increasing urban surface reflectance between 10–20 percent would decrease heat-related mortality 1–5 percent in Baltimore, 1–21 percent in Los Angeles, and 9–10 percent in New York City. This translates to 32 lives saved in Baltimore over a decade, 22 in Los Angeles and 219 in New York City.[27]

IMPLEMENTATION EXAMPLES

- Dozens of cities and some counties and states have mandatory, incentivized, or city-led cool roof initiatives. The geographic diversity of these programs indicates that cool roofs are a widely applicable strategy.

- **Houston** added mandatory cool roofing provisions in 2016, setting standards for roof solar reflectance for new commercial buildings and alterations to existing commercial buildings in its Commercial Energy Conservation Code.[28]
- A **New York City** initiative called NYC Cool Roofs provides no-cost cool roof installations to non-profits and low-income housing buildings and low-cost installations to certain building owners that still need to cover material costs and agree to share energy data with the city.[29]
- **Philadelphia** passed an ordinance amending the building code to require white coloring or use of highly reflective materials (as identified by Energy Star) on new buildings and additions to buildings.[30]
- **Chicago** Energy Code requires new roofs have a reflectivity of 72 percent or greater and that aging roofs maintain a reflectivity of 50 percent or greater.[31]

INSTALLING COOL PAVEMENTS TO REDUCE HEAT EXPOSURE

Conventional pavements in the United States are made with impervious concrete and asphalt, which can reach peak summertime surface temperatures of 120–150 degrees because of lower solar reflectance (about 5–40 percent).[32] Various types of cool pavement materials have been developed that have higher solar reflectance. Some are also permeable, allowing for more evaporative cooling of pavement surfaces.

While the impacts of cool pavements on air temperature are not well-studied, researchers at Lawrence Berkeley National Laboratory estimated that every 10 percent increase in solar reflectance (across pavement and roofs) could decrease surface temperatures by 7 degrees, and if pavement reflectance throughout a city were increased from 10–35 percent, the air temperature could be reduced by one degree.[33]

COSTS

Cool pavement costs vary by local climate, expected traffic, area being paved, and contractor. The costs range from 10 cents to $10.00 per square foot, with higher cost materials generally having longer service lives. There are also options to coat pavements with cooler surface applications, which can cost between 10 cents and $6.50 per square foot.[34] Cool pavements have not been widely implemented long enough to calculate their benefits per square foot, and doing so is very complicated due to the number of factors addressing temperatures on sidewalks and roads. However cities are implementing the strategy, often on an experimental basis, followed by broader application within their comprehensive set of urban heat island mitigation activities.

BENEFITS

Improved Public Health

Studies on surface reflectivity (of roofs and pavements) in urban settings found potential human health benefits. A 2014 study in Washington, D.C., found that a 10 percent increase in urban surface reflectivity could reduce the number of deaths during heat events by an average of 6 percent.[35] This study is encouraging, but does not isolate the direct influence that pavement installations and cool pavements can play in reducing air temperatures and building energy use.[36]

Reduced Stormwater Runoff

Some cool pavements can also be permeable, allowing air, water, and water vapor into small gaps in the pavement. These pavements address local flooding and urban stormwater issues by allowing water to pass through the voids and into the soil or supporting materials below. Some permeable pavements contain grass, which both absorbs water and is cooler than dark pavement options. Cool, permeable pavements can also reduce the need for other infrastructure such as stormwater drains, bringing down project costs. This may also contribute to public safety because roads with better drainage improve driving conditions. More research is needed in designing pavements that can accomplish these benefits on a larger scale with few tradeoffs.[37]

IMPLEMENTATION EXAMPLES

- **Los Angeles** conducted test applications of a light gray coating called CoolSeal and found up to a 10-degree reduction in pavement temperature. The city is applying the material to a larger neighborhood area to continue testing. The mayor has predicted the city could reduce its urban heat island effect by 3 degrees in the next 20 years, using cool pavements and other measures.[38]

- The **Cool Houston** plan is targeting older parking areas, new streets, and new commercial and residential parking areas for cool paving. The plan emphasizes cool pavement to reduce temperatures and reduce degradation of the pavement due to high temperatures.[39]

INCREASING CANOPY COVER AND VEGETATION TO REDUCE HEAT EXPOSURE

Trees and vegetation can reduce heat by shading buildings, pavement, and other surfaces to prevent solar radiation from reaching surfaces that absorb heat, then transmit it to buildings and surrounding air. A number of studies have quantified the cooling effect of urban vegetation. A study in Phoenix used a microclimate model to measure the impact of trees and cool roofs on air temperatures. The study found that increasing tree canopy cover to 25 percent can reduce temperatures 4.3 degrees, and switching landscaping from xeric (dry) to oasis (adding grass patches to residential backyards) can reduce average neighborhood temperatures 0.4–0.5 degrees.[40] A Philadelphia study attributed a 0.9 degree air temperature reduction during the nighttime hours on the warmest summer day of 2008 to urban trees.[41]

COSTS

A study of five cities (Berkeley, California; Bismarck, North Dakota; Cheyenne, Wyoming; Fort Collins, Colorado; and Glendale, Arizona) showed that the cities spend \$13–\$65 annually per tree, but experienced benefits of \$31–\$89 per tree. For every dollar invested in management, the returns ranged from \$1.37–\$3.09 per tree, per year, for the five cities (when considering stormwater runoff, energy savings, air quality and aesthetic benefits).[42]

BENEFITS

Reduced Energy Use

Urban forests can decrease energy costs to consumers and across cities. A Chicago study found that increasing tree cover by 10 percent could lower total heating and cooling energy use by 5–10 percent annually (\$50–\$90 per dwelling unit). The avoided cooling costs come from the heat reduction noted above, while the reduced heating costs come from blocking winter winds once the trees matured (a benefit that cool roofs and cool pavements do not provide).[43]

The U.S. Forest Service conducted an analysis of Philadelphia's urban forest, which has an estimated 2.9 million trees and a tree canopy that covers 20 percent of the city. Using the i-Tree Eco model (see **Key Tools**) the study found that Philadelphia's urban forest reduces annual residential energy costs by \$6.9 million each year and provided an estimated compensatory value for Philadelphia's trees of \$1.7 billion.[44] In an i-Tree analysis of Washington, D.C., energy costs to residential buildings are decreased \$700,000 annually by the city's trees.[45]

Trees can conserve energy and reduce energy bills in suburban and rural areas as well. Trees planted on the east, west and northwest sides of the home can provide shade in the summer and warmth and windbreaks in the winter. Shade trees planted over patios, driveways and air-conditioning units can reduce home temperatures and energy costs. Tree-shaded neighborhoods can be up to 6 degrees cooler than treeless areas and a landscape planned for shade can reduce home air conditioning costs by between 15 and 50 percent.[46]

Improved Public Health

A study estimating the potential health impacts of urban heat island mitigation strategies in Washington, D.C., found that increasing vegetative cover by 10 percent could reduce deaths during heat events by an average of 7 percent compared to past events, saving approximately 20 lives per decade.[47]

Improved Air Quality

The U.S. Forest Service's Philadelphia study estimated that the city's trees store about 702,000 tons of carbon or 2.6 million tons of CO_2, a value of \$93.4 million. Each year Philadelphia's trees remove about 27,000 tons of carbon or 99,000 tons CO_2 (a value of \$3.6 million per year) and remove 513 tons of air pollution (an estimated \$19 million per year).[48] The Washington, D.C, study estimated that the city's trees store 649,000 tons of carbon, and each year remove 26,700 tons of carbon (with an associated value of \$1.9 million per year), and about 619 tons of air pollution (a value of $26 million per year).[49]

Reduced Stormwater Runoff

Trees and vegetation can improve water retention and reduce runoff in storms. In New York City, trees intercept more than 890 million gallons of rainfall each year (at a benefit of over $35 million).[50] A tree with a 25-foot diameter canopy and associated soil can manage one inch of rainfall from 2,400 ft^2 of impervious surface.[51]

Social Benefits

The presence of street trees has been linked to psychological and health benefits. A study in Toronto found that people who live in areas with more trees on the streets have a better health perception.[52] Also, studies around the country have found that up to a certain percent canopy coverage, trees increase property values. In Minnesota, a 2010 study found that a 10 percent increase in tree cover near a home increased home sales prices by an average of $1371 (adding an average 0.5 percent value to a home).[53] A 2015 study in Florida found that property value increased by $1585 per tree.[54]

IMPLEMENTATION EXAMPLES

- **Louisville, Kentucky,** set a goal of achieving 45 percent tree canopy, and the urban forest currently saves more than $5 million of energy costs for consumers annually.[55]
- **Baltimore's** Disaster Preparedness and Planning Project, an all hazards plan, recommends increasing green spaces in vacant lots, building on the city's goal of increasing urban tree canopy to 40 percent by 2037.[56]
- **Indiana's** Department of Natural Resources undertook a study in 2010 of all the environmental services and economic benefits the state's urban tree canopy provides. It found:
  - $9.7 million in energy savings
  - $24.1 million in managed stormwater
  - $2.8 million in improved air quality
  - $1.1 million in sequestered carbon dioxide
  - an estimated $41 million per year from aesthetic and social benefits.[57]

RAISING AWARENESS AND PREPARING FOR EXTREME HEAT

Communities and states are preparing for rising temperatures and extreme heat through emergency planning. Before heat waves occur, city and state emergency management and health services should consider heat vulnerability in their community with special attention on the most vulnerable to heat stress: older adults, infants and children, people with chronic conditions, low-income residents, and outdoor workers.[58] Additionally, those without access to air conditioning are among the most vulnerable during extreme heat events. A compounding vulnerability is that power outages (caused by energy demand or storms) can further limit access to air conditioning.

Specific activities communities can complete to begin preparing for extreme heat include:

- Identifying a heat threshold at which a heat emergency is declared. The way heat affects health differs across the country. Areas where heat is more persistent during the summer or where there is more widespread use of air conditioning may have a higher threshold for experiencing heat stress.[59]
- Determining messaging on heat warnings, safety during heat events, services available, and media channels used to communicate these messages. Consider how to disseminate messages to vulnerable populations, including non-English speakers, and keep in mind that this might require active outreach or checking on vulnerable residents.[60]
- Establish cooling centers in public buildings that remain open so the public can seek relief from the heat, and consider transportation access to and geographic distribution of these centers.
- Understand local, state and partner roles and responsibilities in heat emergencies. Develop a database of facilities and organizations that serve vulnerable populations.[61]

COSTS

Costs vary broadly based on whether emergency heat planning can be integrated in an updated hazard mitigation plan or public health planning. Comprehensive and effective extreme heat event notification and response programs can be developed and implemented at a low cost. Instead of creating a separate heat preparation office or program, cities and states can instead plan for short-term reallocation of existing resources in an extreme heat event.[62] Emergency planning avoids the sometimes high costs of infrastructure investment, but only reduces sensitivity to heat, while the strategies above reduce the heat that people are exposed to.

BENEFITS

Improved Public Health

The benefits of extreme heat planning include reduced hospital visits during heatwaves. A study on Philadelphia's Hot Weather-Health Watch/Warning System found that issuing a warning saved 2.6 lives for each warning day and for three days after the warning ended.[63] A study evaluating the effectiveness of Montreal's Heat Action Plan found that the plan prevented 2–3 deaths on hot days, more than half the deaths attributed primarily to heat.[64]

Improved Awareness of Climate Change Risks and Coordinated Response

The heat planning process can nest into other emergency preparedness or climate resilience activities, and act as a foundation for discussions about climate change impacts to public health and safety. In Philadelphia, a task force comprising public and private organizations serving at-risk individuals, emergency responders or providers of critical infrastructure began developing the Excessive Heat Plan. The Health Department and Southeastern Pennsylvania Red Cross established a telephone hotline for residents with heat-related questions. The plan also taps neighborhood volunteers elected to coordinate neighborhood beautification projects to identify and evaluate the health status of high-risk and hard-to-reach individuals.[65]

IMPLEMENTATION EXAMPLES

- **Arizona** Department of Health Services (ADHS) published the Arizona Climate and Health Adaptation Plan in 2017 to develop interventions and enhance public health preparedness activities related to climate-sensitive hazards.[66] The ADHS also released a Heat Emergency Response Plan in 2014. It assigns tasks to individuals and department branches in a heat event, guides interagency coordination, and provides materials like sample news releases and resources on identifying heat stress to educate the public about the dangers of extreme heat.[67] An assessment of cooling centers in Maricopa County found that the centers offered various services for at least 1,500 individuals daily.[68]
- The **Wisconsin** Climate and Health Program released an *Extreme Heat Toolkit* to support local governments, health departments and citizens in preparing for and responding to heat events. The toolkit acknowledges that Wisconsin does not have a typically warm climate, but in 2012 the state experienced 24 heat-related fatalities, and climate trends analysis indicate extreme heat events will become more likely and longer-lasting. The toolkit includes several guides on heat illness, vulnerable populations, messaging about heat emergencies, and checklists for preparing, anticipating and responding to extreme heat events.[69]

CASE STUDY: LOUISVILLE, KENTUCKY, COMBINES URBAN COOLING STRATEGIES

A 2012 study from the Georgia Institute of Technology found that Louisville was the fastest-warming heat island in the United States.[70] That same year, the city experienced a heat wave, forcing the cancellation of a horse race and widespread damage to infrastructure. Following that record-breaking heat, the city took action on climate change:

- A regional climate and health assessment, the Urban Heat Management Study, was initiated to consider heat management strategies, model the results of managing heat with cool materials, green space, energy efficiency and combined strategies, and conduct a population vulnerability assessment.[71]
- The Louisville Metro Office of Sustainability announced a cool roof rebate program for residents and businesses to apply for a rebate of $1 per square foot of cool roof to incentivize at least 100,000 square feet of new cool roof installations.[72]
- The city has installed cool roofs on eight park

buildings in 2016, nearly 145,000 square feet of cool roofs since 2009 and cool coatings on the top of three parking garages.[73]

- Due to the findings of the assessment study, the city hired a forester[74] and completed an Urban Tree Assessment in 2015 which recommended that the city increase its canopy cover from 37–40 percent and from 8–15 percent in central business district areas.[75]

INSIGHTS

The strategies discussed in this paper offer the primary resilience benefits of reduced temperatures, energy savings and improved public health. These benefits vary greatly between communities and climates, but the **Key Tools** section below provides guidance for estimating costs and benefits in specific locations or projects to choose the right strategy and design.

Analysis of the co-benefits offered by those strategies can help identify no-regrets strategies that provide quantitative benefits like improved property values, reduced flooding damage, or better air quality. Not all benefits are quantitative. Qualitative benefits like social and aesthetic impacts can improve community buy-in, and for some communities can be just as compelling as cost savings or other measured benefits.

Most communities mentioned here are employing multiple strategies, demonstrating that comprehensive heat mitigation planning usually means applying locally

TABLE 1: Costs, Benefits, and Applications of Extreme Heat Resilience Strategies

	ADAPTATION CATEGORY			APPLICATION		BENEFITS								COSTS				
	DECREASE EXPOSURE	DECREASE SENSITIVITY	INCREASE ADAPTIVE CAPACITY	RURAL APPLICATION	URBAN APPLICATION	ENERGY	PUBLIC HEALTH	CARBON CAPTURE	AIR QUALITY	VULNERABLE POPULATIONS	STORMWATER MANAGEMENT	CLIMATE RESILIENCE COORDINATION	SOCIAL BENEFITS	INSTALLATION	MAINTENANCE	CITY COST	INDIVIDUAL	REBATES OFFERED
Cool Roof	●			●	●	●	●		●	●				●	●	▲	▲	▲
Cool Pavement	●				●	●	●			▲	▲			●	▲	▲	▲	▲
Trees	●	●		●	●	●	●	●	●	●	●		●	●	●	▲	▲	▲
Emergency Plan		●	●	●	●		●			●		●			●	●		

The benefits and costs of the strategies overviewed in this fact sheet are summarized above, with dots indicating a benefit that could be expected from one of the four strategies. When weighing different strategies for use in a community, consider the greatest local vulnerabilities and which benefits would address them, then choose strategies that offer these benefits. Be aware of gaps in benefits offered by the strategies prioritized. Yellow triangles indicate benefits and costs that could apply in certain areas, or with specific design choices with that cobenefit in mind. Green circles indicate that these benefits could be expected in most locations, and are often primary benefits or cobenefits associated with the strategy.

optimal strategies to bring down temperatures in specific neighborhoods and buildings. A mix of green infrastructure, careful zoning, and preparedness activities can optimize co-benefits to generate the greatest value as demonstrated by Louisville and communities across the country. **Table 1** shows that each strategy comes with its own sets of benefits and costs. Considering which benefits are most needed in your community, and which combination of strategies may yield them, helps to prioritize local resilience activity.

KEY TOOLS

This fact sheet draws heavily on a few tools and guides that are available to communities and states working to become more resilient to climate impacts.

ASSESSING HEALTH VULNERABILITY TO CLIMATE CHANGE (2014)

This guide from the Centers for Disease Control (CDC) helps local health departments assess local vulnerabilities to health hazards associated with climate change. This targeted climate and health vulnerability assessment can be used to implement public health interventions for those that are the most vulnerable. It provides a conceptual framework on how to define vulnerability, and assess exposure, and includes a case study.

https://www.cdc.gov/climateandhealth/pubs/assessing-healthvulnerabilitytoclimatechange.pdf

COOL ROOFS AND COOL PAVEMENTS TOOLKIT (2012)

Developed by the Global Cool Cities Alliance to help homeowners and city officials transition to cool roofs and pavements, this toolkit includes technical information about design, costs and benefits.

https://www.coolrooftoolkit.org

GUIDELINES FOR SELECTING COOL ROOFS (2010)

The U.S. Department of Energy provides guidance on choosing materials and how to analyze expected costs with potential savings in this publication.

https://energy.gov/sites/prod/files/2013/10/f3/coolroof-guide.pdf

HEAT ISLAND COMPENDIUM (2008)

This EPA resource describes urban heat island causes, impacts, and reduction strategies in depth. The guide includes a chapter of activities that help implement the other strategies on a city-wide level.

https://www.epa.gov/heat-islands/heat-island-compendium

I-TREE

Developed by the U.S. Forest Service, this suite of tools provides urban and rural forestry analysis, including tools to assess benefits. The freely accessible tools aid communities in completing city-, county-, or statewide tree surveys, and in identifying and measuring the services that one tree or a whole urban forest can provide. The suite is updated periodically with newer data and additional benefits to measure. It is also adding a smartphone app.

https://www.itreetools.org

ROOF SAVINGS CALCULATOR

Developed by Oak Ridge and Lawrence Berkley National Laboratories, the Roof Savings Calculator is based on hourly performance, added together for annual savings based on weather data for a select location. The calculator can be used to estimate energy savings for residential and commercial buildings.

http://rsc.ornl.gov

U.S. RESILIENCE TOOLKIT

As an interactive website, this tool allows users to discover climate hazards and develop solutions that reduce climate-risk. It provides a library of tools for individuals and city officials including case studies of how communities, businesses and individuals are documenting vulnerability and taking action (with several related to extreme heat).

https://toolkit.climate.gov

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