Heat Islands

Read each of the articles and answer the following questions.

1 Using Trees and Vegetation to Reduce Heat Islands

- According to the passage, what is one way trees and other plants help reduce heat islands in cities? (Focuses on factual detail - finding the answer directly in the text

- The passage says planting trees around buildings can be helpful. Where on a building would be the most effective place to plant trees for shade? (Focuses on making inferences - using the text to understand an unstated detail)

- Besides reducing heat, what are two other benefits of planting trees and vegetation in cities mentioned in the passage? (Focuses on main ideas - finding important points in the text)

① Using Trees and Vegetation to Reduce Heat Islands

Trees and other plants help cool the environment, making vegetation a simple and effective way to reduce urban heat islands. Trees and vegetation lower surface and air temperatures by providing shade and through evapotranspiration. Shaded surfaces, for example, may be 20–45°F (11–25°C) cooler than the peak temperatures of unshaded materials.

Trees and vegetation are most useful when planted in strategic locations around buildings or to shade pavement in parking lots and on streets. Researchers have found that planting deciduous trees (trees that drop their leaves in the winter) or vines to the west is typically most effective for cooling a building, especially if they shade windows and part of the building's roof.

Benefits and Costs

The use of trees and vegetation in the urban environment brings additional benefits including:

- *Reduced energy use:* Trees and vegetation that directly shade buildings decrease demand for air conditioning.
- *Improved air quality and lower greenhouse gas emissions:* By reducing energy demand, trees and vegetation decrease the production of associated air pollution and greenhouse gas emissions. They also remove air pollutants and store carbon dioxide.
- *Enhanced stormwater management and water quality:* Vegetation reduces runoff and improves water quality by absorbing and filtering rainwater.
- *Reduced pavement maintenance:* Tree shade can slow deterioration of street pavement, decreasing the amount of maintenance needed.
- *Improved quality of life:* Trees and vegetation provide aesthetic value, habitat for many species, and can reduce noise.

The primary costs associated with planting and maintaining trees or other vegetation include purchasing materials, initial planting, and ongoing maintenance activities such as pruning, pest and disease control, and irrigation.

A study of urban forestry programs in five U.S. cities showed a range of expenditures: annual costs ranged from almost $15 per tree in the Desert Southwest region to $65 per tree in Berkeley, California. Pruning was often the greatest expenditure, accounting for roughly 25–40% of total annual costs (approximately $4–$20/tree). Administration and inspection costs were the next largest expenditure, ranging from approximately 8–35% of annual expenditures (about $4–$6/tree). Tree planting, surprisingly, accounted for just 2–15% of total annual urban forestry expenditures (roughly $0.50–$4/tree) in these cities.

Although the benefits of urban forestry can vary considerably by community and tree species, they are almost always higher than the costs. The five-city study discussed above found that, on a per-tree basis, the cities gained benefits ranging from about $1.50–$3.00 for every dollar invested. These cities spent roughly $15–$65 annually per tree, with net annual benefits ranging from approximately $30–$90 per tree.

Heat Islands

Read each of the articles and answer the following questions.

2 Using Green Roofs to Reduce Heat Islands

- Explain one way that green roofs help the environment in the summer.

- How can green roofs help save building owners money?

- According to the passage, explain why green roofs are typically more expensive or less expensive to install than conventional roofs?

② Using Green Roofs to Reduce Heat Islands

A green roof, or rooftop garden, is a vegetative layer grown on a rooftop. Green roofs provide shade and remove heat from the air, reducing temperatures of the roof surface and the surrounding air. On hot summer days, the surface temperature of a green roof can be cooler than the air temperature, whereas the surface of a conventional rooftop can be up to 90°F (50°C) warmer.

Green roofs can be installed on a wide range of buildings, from industrial facilities to private residences. They can be as simple as a 2-inch covering of hardy groundcover or as complex as a fully accessible park complete with trees. Green roofs are becoming popular in the United States, with roughly 8.5 million square feet installed or in progress as of June 2008.

Benefits and Costs

In addition to reducing urban heat islands, the benefits of green roofs include:

- *Reduced energy use:* Green roofs absorb heat and act as insulators for buildings, reducing energy needed to provide cooling and heating.
- *Reduced air pollution and greenhouse gas emissions:* By lowering air conditioning demand, green roofs can decrease the production of associated air pollution and greenhouse gas emissions. Vegetation can also remove air pollutants and greenhouse gas emissions through dry deposition and carbon sequestration and storage.
- *Improved human health and comfort:* Green roofs, by reducing heat transfer through the building roof, can improve indoor comfort and lower heat stress associated with heat waves.
- *Enhanced stormwater management and water quality:* Green roofs can reduce and slow stormwater runoff in the urban environment; they also filter pollutants from rainfall.
- *Improved quality of life:* Green roofs can provide aesthetic value and habitat for many species.

Estimated costs of installing a green roof start at $10 per square foot for simpler extensive roofing, and $25 per square foot for intensive roofs. Annual maintenance costs for either type of roof may range from $0.75–$1.50 per square foot.

While the initial costs of green roofs are higher than those of typical other materials, building owners can help offset the difference through reduced energy and stormwater management costs, and potentially by the longer lifespan of green roofs compared with conventional roofing materials.

Researchers and communities are beginning to perform detailed, full life-cycle analyses to determine the net benefits of green roofs. A University of Michigan study compared the expected costs of conventional roofs with the cost of a 21,000-square-foot (1,950 m^2) green roof and all its benefits, such as stormwater management and improved public health from the absorption of nitrogen oxides. The green roof would cost $464,000 to install versus $335,000 for a conventional roof in 2006 dollars. However, over its lifetime, the green roof would save about $200,000. Nearly two-thirds of these savings would come from reduced energy needs for the building with the green roof.

Heat Islands

Read each of the articles and answer the following questions.

3 Using Cool Roofs to Reduce Heat Islands

- What is the most important feature of a cool roof, and how does it help keep buildings cool?

- According to the passage, what are some benefits of using cool roofs besides reducing heat islands in cities?

- The passage mentions cool roofs might cost a little more than regular roofs. How much more expensive are cool roofs typically, according to the text?

③ Using Cool Roofs to Reduce Heat Islands

A high solar reflectance—or albedo—is the most important characteristic of a cool roof as it helps to reflect sunlight and heat away from a building, reducing roof temperatures. A high thermal emittance also plays a role, particularly in climates that are warm and sunny. Together, these properties help roofs to absorb less heat and stay up to 50–60°F (28–33°C) cooler than conventional materials during peak summer weather.

Building owners and roofing contractors have used cool roofing products for more than 20 years on commercial, industrial, and residential buildings. They may be installed on low-slope roofs (such as the flat or gently sloping roofs typically found on commercial, industrial, and office buildings) or the steep-sloped roofs used in many residences and retail buildings.

Through the ENERGY STAR program, EPA and the Department of Energy (DOE) help consumers and other purchasers identify the most energy-efficient roofing products. Roofing materials with the ENERGY STAR label have met minimum solar reflectance and reliability criteria. Based on 2006 data from more than 150 ENERGY STAR partners, shipments of cool roof products have grown to represent more than 25% of these manufacturers' commercial roof products and roughly 10% of their residential roof products.

Benefits and Costs

Cool roofs provide a number of benefits beyond urban heat island reduction, including:

- *Reduced energy use:* A cool roof transfers less heat to the building below, so the building stays cooler and uses less energy for air conditioning.
- *Reduced air pollution and greenhouse gas emissions:* By lowering energy use, cool roofs decrease the production of associated air pollution and greenhouse gas emissions.
- *Improved human health and comfort:* Cool roofs can reduce air temperatures inside buildings with and without air conditioning, helping to prevent heat-related illnesses and deaths.

Cool roofs deflect some desired heat gain during the winter. In general, though, cool roofs result in net energy savings, especially in areas where electricity prices are high.

Although costs will vary greatly depending on location and local circumstances, cool roof coatings on a low-slope roof might cost $0.75–$1.50 per square foot, while single-ply cool roof membrane costs vary from $1.50–$3.00 per square foot. The cost premium for cool roofs versus conventional roofing materials ranges from zero to 5 or 10 cents per square foot for most products, or from 10–20 cents for a built-up roof with a cool coating used in place of smooth asphalt or aluminum coating.

A California study found that cool roofs provide an average yearly net savings of almost 50 cents per square foot. This number includes the price premium for cool roofing products and increased heating costs in the winter as well as summertime energy savings, savings from downsizing cooling equipment, and reduced labor and material costs over time due to the longer life of cool roofs compared with conventional roofs.

Heat Islands

Read each of the articles and answer the following questions.

4 Using Cool Pavements to Reduce Heat Islands

- What are two ways that cool pavements can help the environment besides lowering temperatures?

- Why is it difficult to compare the cost of cool pavements to regular pavements?

- According to the passage, what is one benefit of cool pavements that might improve safety?

④ Using Cool Pavements to Reduce Heat Islands

Cool pavements currently refers to paving materials that reflect more solar energy, enhance water evaporation, or have been otherwise modified to remain cooler than conventional pavements.

Conventional paving materials can reach peak summertime temperatures of 120–150°F (48–67°C), transferring excess heat to the air above them and heating storm water as it runs off the pavement into local waterways. Due to the large area covered by pavements in urban areas (nearly 30–45% of land cover based on an analysis of four geographically diverse cities), they are an important element to consider in heat island reduction.

Cool pavements can be created with existing paving technologies (such as asphalt and concrete) as well as newer approaches such as the use of coatings or grass paving. Cool pavement technologies are not as advanced as other heat island reduction strategies, and there is no official standard or labeling program to designate cool paving materials. To help address the growing demand for guidance on pavement choices, the Transportation Research Board has formed a subcommittee on Paving Materials and the Urban Climate. The subcommittee's scope includes modeling, design practices, testing, standards development, and planning and policy considerations.

Benefits and Costs

In addition to reducing heat islands, the benefits of cool pavements include:

- *Reduced stormwater runoff and improved water quality:* Permeable pavements can allow stormwater to soak into the pavement and soil, reducing runoff and filtering pollutants. Both permeable and non-permeable cool pavements can also help lower the temperature of runoff, resulting in less thermal shock to aquatic life in the waterways into which stormwater drains.
- *Lower tire noise:* The open pores of permeable pavements can reduce tire noise by two to eight decibels and keep noise levels below 75 decibels, although noise reduction may decline over time.
- *Enhanced safety:* Permeable roadway pavements can improve safety by reducing water spray from moving vehicles and increasing traction through better water drainage.
- *Better nighttime visibility:* Reflective pavements can enhance visibility at night, potentially reducing lighting requirements and saving both money and energy.
- *Improved local comfort*: Cool pavements in parking lots or other areas where people congregate or children play can provide a more comfortable environment.

Comparing the costs of cool pavements with those of conventional paving materials is difficult. The cost of any pavement application varies by region, the contractor, the time of year, materials chosen, accessibility of the site, local availability of materials, underlying soils, size of the project, expected traffic, and the desired life of the pavement.

Communities that want to use cool pavements as part of a heat island reduction program may find it hard to estimate the net costs or benefits based on temperature reduction alone. The greatest overall value may result when multiple benefits, such as improved stormwater management and water quality, are factored into the evaluation of a paving approach.

Heat Islands

Read each of the articles and answer the following questions.

5 Using Green Walls to Reduce Heat Islands

- The passage says green walls can help improve air quality in two ways. What are those two ways?

- The passage talks about green walls and their effect on building temperatures. How much difference can a green wall make in reducing temperature changes on a wall's surface?

- Besides improving air quality, what other benefit do green walls provide according to the passage?

⑤ Using Green Walls to Reduce Heat Islands

The term *green walls* includes all forms of vegetated wall surfaces. However, there are three major system categories that fall under this term: green facades, living walls, and retaining living walls.

Improved Exterior Air Quality

- Green walls reduce air pollution levels by lowering extreme summer temperatures through photosynthesis, trapping particulate matter, and capturing gases.
- The ability of green walls to provide thermal insulation for buildings means less demand on power, and as a result, fewer polluting by-products are released into the air.

Improved Energy Efficiency

- Green walls can reduce the temperature changes at a wall's surface from a range of 10-60°C (50-140°F) to one of 5-30°C (41-86°F)

Improved Indoor Air Quality

- Most North Americans spend 80-90% of their time indoors and as a result, are highly influenced by the effectiveness of interior air circulation systems. It has been estimated that problems associated with poor indoor air quality negatively affect workplace production by $60 billion per year in the United States.

Noise Reduction

- The vegetated surface provided by strategic urban greenery such as green walls and roofs will block high-frequency sounds, and when constructed with a substrate or growing medium support can also block low-frequency noises.
- For over 30 years, plant life has been used this way along freeways, roads, and rail lines in North America and Europe.

Increased Biodiversity

- Green walls can help reduce the loss of biodiversity due to the effects of urbanization, help sustain a variety of plants, pollinators, and invertebrates, and provide habitat and nesting places for various bird species.

Urban Agriculture

- Green walls offer the opportunity for urban agriculture, such as vertical gardens of small fruits, vegetables, and herbs.

Onsite Wastewater Treatment

- Several water-recycling systems can be applied to green walls. These systems pump grey water through a green wall, which then passes through filters, gravel, and marine plants.
- Treated water is then sent to a grey water holding tank for household or irrigation use or released into the public water treatment system. Some of these systems also collect stormwater, which is filtered for household use or irrigation purposes.

Heat Islands

Read each of the articles and answer the following questions.

Smart Growth and Heat Islands

- What are two main things that cities have a lot of, that cause them to be hotter than surrounding areas?

- The passage talks about two different ways to cool down cities. What are they?

- According to the passage, how can planting trees and building parks help a city in more ways than one?

Smart Growth and Heat Islands

While many factors contribute to heat island formation, several characteristics typical of urban areas significantly influence the existence of a heat island. Urban areas commonly have few trees and green spaces and are predominantly made up surfaces that are impervious or covered with buildings, thus leading to extreme temperatures. Roads, parking lots, and

buildings are often constructed of materials that reflect less and absorb more of the sun's energy. In addition, cities are typically designed to be dense and compact, which prevents adequate release of heat. Therefore, because urban design plays a large role in the creation of heat islands, smart growth development strategies provide an opportunity to reduce the heat island effect. When communities also incorporate cooling strategies into smart growth initiatives, they can realize multiple benefits more efficiently than pursuing these issues separately.

Based on the experience of communities around the nation that have used smart growth approaches to create and maintain great neighborhoods, the Smart Growth Network developed a set of ten basic Smart Growth principles, as follows:

- Mix land uses, such as residential, commercial, and recreational uses
- Take advantage of compact building design
- Create a range of housing opportunities and choices
- Create walkable neighborhoods
- Foster distinctive, attractive communities with a strong sense of place
- Preserve open space, farmland, natural beauty, and critical environmental areas
- Strengthen and direct development towards existing communities
- Provide a variety of transportation choices
- Make development decisions predictable, fair, and cost effective
- Encourage community and stakeholder collaboration in development decisions

Heat island cooling strategies can incorporate these smart growth principles. For example, planting trees and vegetation and promoting parks and open space throughout developed areas can simultaneously result in mixed land uses, more attractive communities, and preserved natural beauty. Local heat island initiatives can incorporate community and stakeholder collaboration in decisions on appropriate strategies, which helps to foster a stronger community as a whole.

Conversely, smart growth initiatives can incorporate any or all of the main heat island cooling strategies – trees and vegetation, green roofs, cool roofs, and cool pavements, as illustrated in the following examples. When developing new smart growth areas, local officials and developers can incorporate green and cool roofs into the design of residential and commercial buildings. These roof designs help to lower energy costs and allow continued use of existing buildings. Planting trees and adding green spaces not only reduces temperatures inside and outside buildings, but can also enhance the attractiveness and distinctiveness of a community. Streets, alleys, parking lots, sidewalks, and other surfaces can be constructed using permeable/pervious paving materials, helping to cool a community while also reducing stormwater runoff which can increase its walkability.

By combining smart growth and urban cooling strategies, communities can address heat islands while enhancing the quality and character of their neighborhoods.