

# The Roof is Growing!

A top-down approach to saving the environment

## What's a green roof?

A green roof replaces traditional roofing with a lightweight, living system of soil, compost, and plants. It creates a thin, green skin atop a building that gives a little something back to the world.

## STUDENT WORKBOOK



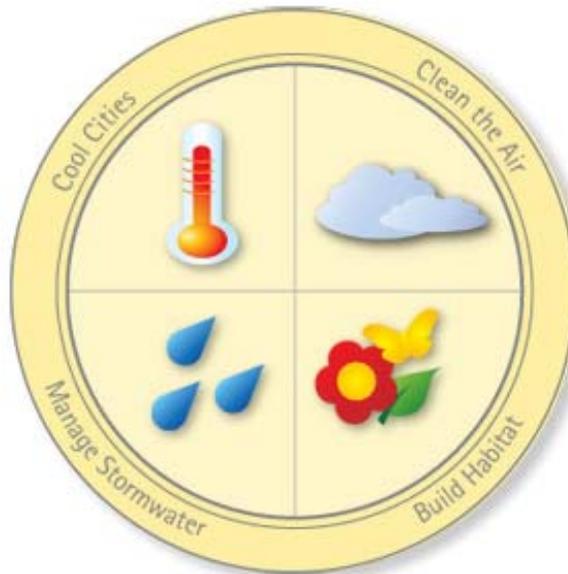
### Discover how green roofs can benefit the environment.

#### Cool Cities

Conserve energy by reducing the temperature on the roof and surrounding areas.

#### Manage Stormwater

Reduce runoff of rain or melting snow into storm sewers.



#### Clean the Air

Slow the growth of carbon dioxide (CO<sub>2</sub>) in the atmosphere.

#### Build Habitat

Create an environment to support insects, birds, and other wildlife.

YOUR NAME: \_\_\_\_\_

YOUR SCHOOL: \_\_\_\_\_



# What is a green roof?

Green roofs are living roofs!

Green roofs cover roof surfaces that are built to keep water out with living, breathing, plant materials that absorb water and let it flow through.

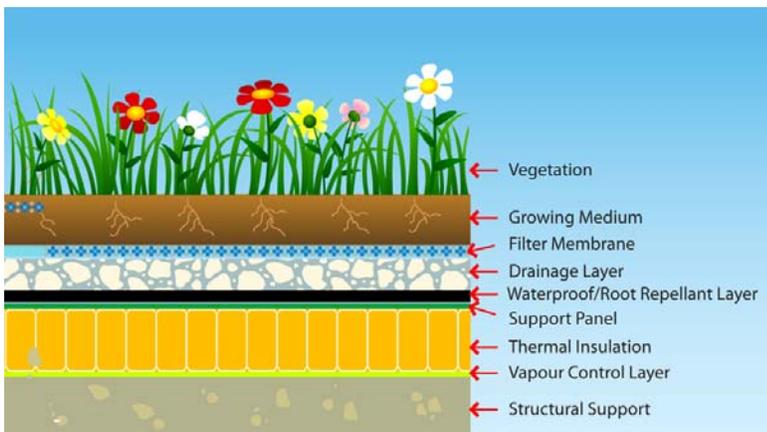
Green roofs are good for people and they are good for the environment. They provide natural spaces for people to enjoy. They help to cool cities in the summer. They reduce stormwater runoff that flows into our watersheds. They help to reduce air pollution. And, they create a place for wildlife in the city.

## How is a green roof constructed?

A green roof is made up of plants, engineered soil, and a drainage layer over a waterproofing membrane. Additional layers, such as a root barrier, and drainage and irrigation systems may also be included.

The soil used on a green roof is called “engineered soil” because it is specially made to be lighter in weight than regular garden soil. It’s a lot like the soil you use for a potted plant.

This illustration shows how a typical green roof is constructed.



## Who creates a green roof?

Landscape architects, along with other professionals, are the people who create green roofs. Green roofs are just one type of project a landscape architect works on. They also create parks, playgrounds, trails and bike paths, and many more sites that people enjoy.

Landscape architects analyze, plan, design, and manage the natural and built environment. They are also problem solvers—they analyze the impact of a proposed project to be sure that it benefits the environment.



*The green roof shown above is on the headquarters of the American Society of Landscape Architects in Washington, DC. It is an intensive and extensive green roof.*

## TWO TYPES OF GREEN ROOFS

### **Extensive green roofs**

*Extensive green roofs are light in weight and fairly inexpensive to construct and maintain. An extensive green roof usually has a thin (2 – 6 inch) layer of lightweight, engineered soil.*

### **Intensive green roofs**

*Intensive green roofs, also called high-profile, are more like a ground-level garden.*

*Their innovative design allows them to hold the weight of more soil. A wider variety of plants can be put on an intensive green roof since the soil is deeper.*

*Landscape architects enhance the quality of our lives by adding beauty to the environment and by working to safeguard the environment.*



# Cool Cities



## Green roofs reduce the urban heat island effect

On a hot day, the temperature in a city's center is up to 10° Fahrenheit warmer than in the surrounding areas.

That's because cities have a lot of dark-colored and paved surfaces.

Dark surfaces absorb the sun's heat. Paved surfaces, like asphalt and concrete, trap the heat.

### What is the urban heat island effect?

Scientists call this temperature increase the *urban heat island effect* because concentrated "islands" of heat form when cities replace natural land cover with pavement, buildings, and roads.

What two factors cause *urban heat islands* to form in a city?

1. \_\_\_\_\_

\_\_\_\_\_

2. \_\_\_\_\_

\_\_\_\_\_

### Plants Help Reduce the Temperature

The plants on a green roof help reduce the temperature in a city.

- They act as a shade barrier.
- They lower air temperature through evapotranspiration.

*Evapotranspiration* is the combination of what two natural processes:

\_\_\_\_\_ + \_\_\_\_\_

Precipitation (rain or snow) waters the plants. Plants release or "transpire" water through pores in their leaves. These pores are called stomata. In a way, plants sweat like people do.

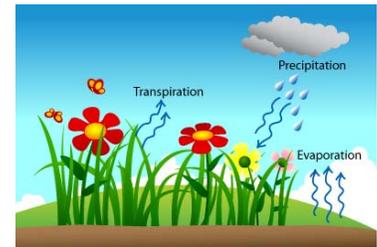
The water on a plant's leaves draws heat as it evaporates. This cools the surrounding air in the process.

### GREEN ROOF FACTS

*The temperature on conventional city rooftops can easily reach 150° to 175°F or higher in the summer.*

*On a hot day, how much lower could the temperature on a green roof be in comparison to a conventional roof?*

\_\_\_\_\_ ° F to \_\_\_\_\_ ° F



# Cool Cities

## Saving energy

During hot summer months, green roofs help reduce a building's cooling costs because they shade the roof surface and prevent the roof from heating up.

When air temperatures are cooler, the need for air conditioning decreases and energy consumption is reduced.

## Taking the temperature

**Fahrenheit** (used in the US) and **Celsius** (used in most other countries) are both ways to measure temperature, just using different numbers. Fill in the blanks below.

Frozen water measures 0° in Celsius, but \_\_\_\_\_° in Fahrenheit

Boiling water measures 100° in Celsius, but \_\_\_\_\_° in Fahrenheit

To convert from one temperature scale to the other, use these formulas:

**°F to °C** — Deduct 32, then multiply by 5, then divide by 9

**°C to °F** — Multiply by 9, then divide by 5, then add 32

## What's your opinion?

- People and the environment would benefit if green roofs were put on some new and existing buildings where you live.

Do you agree or disagree?

Circle your answer and explain your choice.

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## GREEN ROOF FACTS

*It is estimated that a change of 1.8° Fahrenheit (1° Celsius) results in how much of a reduction in cooling demands in a building?*

\_\_\_\_\_ percent

## THINK ABOUT IT

*What areas in your city contribute to the urban heat island effect?*

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*Are there some places that help reduce the effect?*

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# Clean the Air



Green roofs help make the air healthier.

## What's that floating in the air?

You've probably noticed little specks of dust floating around in the air. It's called particulate matter and it is dust and soot so small that it floats in the air. It is an indication of air pollution.

Air pollution is a serious environmental problem in most big cities. Polluted air is bad for our health, and it hurts plants and animals too. It damages buildings and it can even change our weather.

Particulate matter gets into the air when things are burned.

## PARTICULATE MATTER

*Name three ways particulate matter gets into the air?*

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## Greenhouse gases

An environmental problem that happens when we burn certain materials like coal, oil, and natural gases is that we create greenhouse gases.

Why do scientists call these gases "greenhouse gases"?

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*What is the principal greenhouse gas?*

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## Plants filter particulate air pollution

The leaves on plants act like filters capturing particulate matter like dust, soot, and pollen and removing them from the air.

This is good for the people and animals who breathe the air.

And, it's good for the environment because particulate matter in polluted air captures and holds the sun's heat. Clean air holds less heat.

## GREEN ROOF FACTS

*Plants can absorb air pollution.*

*How many pounds of particulate matter would a 20-square-foot green roof absorb?*

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# Clean the Air

## Plants slow the growth of CO<sub>2</sub>

In the process of photosynthesis, plants remove carbon dioxide (CO<sub>2</sub>) from the air and release oxygen. This slows the increase of CO<sub>2</sub> levels in the Earth's atmosphere.

Photosynthesis is the way a plant makes food for itself. Chlorophyll in the "green" part of the leaves captures energy from the sun and this powers the building of food from very simple ingredients—CO<sub>2</sub> and water.

The process of photosynthesis consumes CO<sub>2</sub> and releases oxygen (O<sub>2</sub>).

## Gathering facts and figures

Where do all these facts and figures about green roofs come from?

Tests are run to gather data and then the results are interpreted. This is called scientific inquiry.

What is scientific inquiry?

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## Designing a green roof

Since green roofs require plants that are naturally adapted to the extreme environmental conditions found on rooftops, landscape architects and scientists are conducting research about green roofs in the many different climates found across North America.

Landscape architects need this information to better understand how to design green roofs.

The green roof on the headquarters of the American Society of Landscape Architects (ASLA) has equipment that gathers data on light, temperature, and stormwater runoff.

- The ASLA green roof has been as much as 32° Fahrenheit cooler than the conventional asphalt roofs on the neighboring buildings. Temperature differences are greatest on the hottest days.
- From July 2006 to May 2007, the ASLA green roof retained nearly 75 percent of the total rainfall (29 inches). This kept 27,512.4 gallons of rainwater out of the city storm drains.

## GREEN ROOF FACTS

*How many pounds of CO<sub>2</sub> does a healthy tree consume each year?*

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*The carbon is stored in the tree (wood is about 45 percent carbon) and the oxygen is released back into the atmosphere.*

*If kept in good health and maintained properly, a green roof that measures 10 feet by 10 feet (100 square feet) consumes as much carbon dioxide (CO<sub>2</sub>) per year as a 13-foot tree.*

## WHAT DO LANDSCAPE ARCHITECTS DO?

*You know that landscape architects help to create green roofs. What other kinds of projects do they work on?*

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*Hint: Visit ASLA's Career Discovery website to find out more about what landscape architects do.*



# Build Habitat



Green roofs create an environment to support insects, birds, and other wildlife.

Urban areas are built by and for humans, but animal and plant life have to share the same spaces.

Animals didn't move into our neighborhoods—we moved into theirs. People built roads and buildings in the wetlands, fields, and forests that once only wildlife called home.

Some animals still live in and migrate through cities, but their native habitats have been lost or broken up, and the air and water qualities are worse. That means it can be harder for these animals to survive.

## Green roofs provide habitat for wildlife

Habitat is the environment in which an animal or plant lives or grows. Growing a garden on a roof offers some unique challenges, but the payoff is that we can create habitats that provide food and a place for wildlife to live in or migrate through. These green spaces are called wildlife corridors. And people also get to enjoy the beauty of a natural space.

## Planning a green roof

A green roof is a blend of ecology and engineering. Landscape architects must understand how nature operates in order to create a green roof environment that will sustain life. And, as they design the roof, they work with other professionals to understand the engineering issues.

What are five questions a landscape architect must think about when planning a green roof?

1.

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2.

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3.

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4.

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5.

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*Green roofs like this one on the headquarters of the American Society of Landscape Architects provide green spaces for wildlife.*

## GREEN ROOF FACTS

*Experience with green roofs in Germany show that they can have a life span of 40 – 50 years.*

*What is the typical life span of a conventional roof?*

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# Build Habitat

## Weighing the possibilities

Since a green roof sits on top of the existing roof structure, it's important to calculate how much additional weight the existing roof structure can support. A landscape architect works with a structural engineer to determine that weight.

Using this information, the landscape architect and structural engineer make decisions about a green roof's design. They must be sure that the weight of the soil and plants is less than or equal to the weight the roof structure can support.

## Attracting wildlife

Suppose you were designing a green roof. Which plants would you select to attract wildlife? Choose your favorite plant that attracts each type of animal and note it below.

**Birds:**

**Bees:**

**Butterflies:**

## Going native

Native plants are plants that occur naturally in an area. They provide a food source for wildlife such as nectar, berries, and seeds. Landscape architects know which plants are native in different parts of the country.

## Calculating the cost

Extensive green roofs have thinner and less numbers of layers, so they are lighter and less expensive to construct.

Intensive green roofs are more like a ground-level garden. A wider variety of plant material can be included since the soil depth is greater.

## What's your opinion?

In some cities in the United States, people get incentives such as tax credits when they build green roofs on new and existing buildings.

Why do you think a city government would do that? Do you think it's a good idea?



## GREEN ROOF FACTS

*How much weight can most flat roofs support?*

\_\_\_\_\_ to \_\_\_\_\_  
pounds per square foot

*This means most roof structures can support soil that is how deep?*

\_\_\_\_\_

*Are the plants you chose for your green roof native to the area where you live? If you're not sure, use the internet or other sources to find out.*

*If the plants aren't native to your area, can you find some native plants that will attract wildlife?*

## GREEN ROOF FACTS

### **Conventional roof**

\$ \_\_\_\_\_ to \$ \_\_\_\_\_  
per square foot

### **Extensive green roof**

\$ \_\_\_\_\_ to \$ \_\_\_\_\_  
per square foot

### **Intensive green roof**

\$ \_\_\_\_\_ to \$ \_\_\_\_\_  
per square foot





# Manage Stormwater

Did you ever wonder where all the water goes after a heavy rainstorm?

To keep city streets from flooding, rainwater from storms is transported by large pipes called storm sewers, or storm drains, to natural bodies of water or other areas where it will be absorbed.

Chances are that whatever rain goes into a storm sewer winds up in your local stream and eventually your watershed.

A watershed is the land that catches water from rain then drains it into streams, rivers, lakes, or groundwater.

## Managing stormwater runoff

Stormwater runoff is water that flows over the ground surface to the sewer system. This happens when the ground is too saturated to absorb the water, if rainfall is very heavy, or when rain falls on an impervious surface such as a conventional roof or a parking lot.

What are two reasons why many cities have a problem with stormwater runoff?

1. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

2. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Green roofs are living roofs

They cover conventional roof surfaces, which are built to keep water from getting through by using living, breathing plant materials that absorb the water.

Why is the soil on a green roof called *engineered soil*?

\_\_\_\_\_  
\_\_\_\_\_

## PROTECTING THE WATERSHED

*Planting a green roof is one way to help protect the watershed.*

*Why is it important that we protect the watershed?*

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## THINK ABOUT IT

*Can you name three types of impervious surfaces?*

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

*Hint: An impervious surface is an artificial surface that doesn't allow water to run through it.*



# Manage Stormwater

## Plants and soil absorb rainwater

Plants and soil absorb rainwater and they also slow stormwater runoff in sewers.

Rain falling on the surface of a conventional roof quickly flows off and into a storm sewer. When rain falls on a green roof, much of it is absorbed by the plants and the engineered soil.

A green roof acts like a massive sponge. In the same way that water is delayed from draining when you water a potted plant, a green roof provides a delay mechanism that relieves pressure on a city's storm sewer system.

The amount of rain a green roof absorbs depends on many factors – the depth of the green roof, the plant types, the city, and the season.

## Plants and soil filter rainwater

Rain may contain things that are not good for the environment including elements like nitrogen (N) and phosphorus (P). A green roof's plants and soil filter these elements from the water and prevent them from getting into the watershed.

Why are nitrogen and phosphorus bad for the watershed?

\_\_\_\_\_

Nitrogen and phosphorus aren't good for our watersheds, but they are good for plants.

How do plants use nitrogen?

\_\_\_\_\_

How do plants use phosphorous?

\_\_\_\_\_

## Do you know?

Some steps *you* can take to help protect your watershed are:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_



## GREEN ROOF FACTS

*Generally, what percent of the rain that falls on a green roof is absorbed?*

### Summer

\_\_\_\_\_ % to \_\_\_\_\_ %

### Winter

\_\_\_\_\_ % to \_\_\_\_\_ %

## WHERE IS YOUR LOCAL WATERSHED?

*If you don't know where it is, do some research to find out the location of your watershed.*

\_\_\_\_\_

