KINGSLAND
wildflowers
at BROADWAY STAGES

GREEN ROOF TEACHER'S GUIDE

Grades Pre-K through 5

By Vicki Sando

Aligned with New York State Common Core Standards and
2018 New York City Department of Education PK-8 Science Scope & Sequence

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Front cover photo: James Park/Broadway Stages
Back cover photo: Andrew Maas/NYCA

James Park/Broadway Stages

Kingsland Wildflowers at Broadway Stages Partners

BROADWAY STAGES

NCA NEWTOWN CREEK ALLIANCE

ALIVE STRUCTURES

KINGSLAND wildflowers at BROADWAY STAGES

Kingland Wildflowers at Broadway Stages Location & Transit

520 Kingsland Avenue,
Brooklyn, NY 11222

Closest subway stop:
Greenpoint Avenue G

Closest bus stop: Greenpoint Ave / Kingsland Avenue B24

There is parking on site.

Please note: The green roof has limited accessibility for people with disabilities.

To schedule a private group tour or an educational field trip with your organization or class, contact info@kingslandwildflowers.com.

Andrew Maas/NYCA

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Introduction

Kingsland Wildflowers at Broadway Stages Green Roof & Community Engagement Center is a green oasis located in an industrial area along Newtown Creek in Greenpoint, Brooklyn. Since the first section of green roof was installed in 2016, it has become a crucial component of the community's overall environmental restoration efforts and a vibrant community and educational space.

Among their many benefits, green roofs serve as excellent educational platforms. They facilitate enriched learning about wildlife, ecology, sustainability, and the urban environment for students of all ages and abilities. They offer a hands-on experience of nature, which has been shown to improve psychological and physical health and educational outcomes. Unlike ground-level school gardens, green roofs can provide undisturbed outdoor research opportunities in a unique microclimate and wildlife habitat setting.

The 22,000 acres of green roofs at Kingsland Wildflowers at Broadway Stages were made possible through a grant from the Greenpoint Community Environmental Fund (GCEF) and generous in-kind donations from building owner Broadway Stages, a film and television production company. In order to facilitate use of the roof for outdoor learning, GCEF funded this guide together with science equipment for a green roof teaching lab at Kingsland Wildflowers. The seed for the guide was planted by the NYC Green Roof Researchers Alliance (GRRA), a consortium of over 50 researchers, educators, and policy makers. The GRRA fosters collaboration among green roof experts to study the environmental, social, and educational benefits of green roofs, create a map and database of NYC green roofs, and develop policies to expand green roof installation in the city. NYC Audubon coordinates the GRRA with funding from The New York Community Trust.

Open House New York

Kingsland Wildflowers at Broadway Stages from above.

Niki Jackson/NYCA

Canoes on Newtown Creek.

HISTORY OF NEWTOWN CREEK AND KINGSLAND WILDFLOWERS

The watershed of Newtown Creek was once covered in pristine woodlands in the higher elevations and dense wetlands and marshes in the lower regions, all connected by freshwater streams spilling into larger tributaries that emptied into the tidal East River. Native Americans hunted, gathered, fished, and farmed in the watershed for thousands of years. In the 17th and 18th centuries, the Dutch and then the English discovered and exploited the value of these waterways for agriculture and commerce. By the mid-19th century, the creek had become a major industrial shipping hub, channelized and lined with bulkheads. Oil refineries, chemical plants, copper smelters, and other highly polluting industries proliferated alongside the water, leading to widespread environmental contamination in and around the creek.

Until the 2000s, governmental oversight of these industries was lax, even after the passage of the major federal environmental laws in the 1970s. Over decades, oil refining, storage, and distribution facilities leaked more than 50 million gallons of oil into an estimated 100 acres of soil and groundwater in northeast Greenpoint along the creek. The spill, discovered in 1979, was the second largest oil spill ever recorded in the U.S. Initial remediation efforts by the companies involved were ineffective, and finally, in 2010, the U.S. Environmental Protection Agency declared the area a Superfund site. Newtown Creek continues to be heavily polluted by the annual discharge of more than 1.2 billion gallons of combined sewage and stormwater when wastewater treatment plants are over capacity during rainstorms.

Greenpoint community groups mobilized to get the spill remediated, address the effects of pollution in the creek and neighborhood, and install green infrastructure to reduce stormwater runoff. With funds from the settlement with ExxonMobil over the spill, in 2011 the New York State Attorney General's Office and Department of Environmental Conservation established the Greenpoint Community Environmental Fund (GCEF), with the goal of mitigating water and air pollution and improving the environment and access to green space for Greenpoint residents.

Kingsland Wildflowers at Broadway Stages is among the environmental mitigation efforts funded through GCEF. It includes both extensive and intensive green roofs, including a beautifully landscaped wildflower meadow open to the public for classroom visits and programs. The project was initiated by Marni Majorelle, owner of the green roof landscaping business Alive Structures, together with non-profit organizations and other local businesses. Broadway Stages owners Tony and Gina Argento paid for the necessary structural improvements and donates the ongoing use of the space. Alive Structures designed, built, and continues to maintain the green roofs.

New York City Audubon has managed Kingsland Wildflowers at Broadway Stages as a community education center and wildlife research station beginning in the project's inaugural year of 2016 through the duration of the GCEF grant, working with Newtown Creek Alliance as the educational partner for watershed awareness and community advocacy. With the support of GCEF and community organizations,

programming includes class visits from Greenpoint schools, lectures, art events, volunteer days, and an annual festival. Kingsland Wildflowers is a terrific example of how various stakeholders can partner to find creative solutions for environmental concerns in a community.

THE BENEFITS OF GREEN ROOFS

Perhaps the earliest green roofs were the legendary Hanging Gardens of Babylon, described in Greek and Roman writings. Some researchers believe that the accounts refer to gardens on terraces known to have been built in the ancient city of Ninevah. Throughout history, different peoples built houses of living turf to provide shelter, protect livestock, or hold religious ceremonies. Sod was used in places where wood and stone were scarce, and valued for its insulating properties in harsh climates. Examples include the turf houses of the Vikings and the sod houses of Native Americans, whose techniques were borrowed by homesteaders in the treeless prairies.

Modern green roof technology was developed in Germany in the 1970s. Green roofs have been widely used in Europe for decades, and a number of European cities now require green roofs on most new construction. More recently, the movement to install green roofs has been spreading across North America, with cities such as Toronto, Chicago, and San Francisco taking the lead.

In New York City, there are green roofs on apartment buildings, schools, convention centers, entertainment centers, and government buildings. However, green roofs still cover just a small percentage of rooftop space in the five boroughs that could be harnessed to make a more resilient urban environment. When properly designed and sited, green roofs provide multiple environmental benefits, as detailed below. They soak up stormwater to reduce sewage overflows that pollute the city's waterways, filter air pollution, moderate urban summer heat, reduce energy costs, decrease carbon emissions, and create habitat for wild birds, bats, and pollinators.

Mitigating Stormwater Runoff

Approximately 60 percent of New York City's sewage treatment system combines sewage and stormwater in the same pipes. When the system is at full capacity, which happens during many rainstorms, the mixture of raw sewage and rainwater is released into local waterways in an event called a combined sewer overflow (CSO). Green roofs act like sponges to absorb and slowly release stormwater into roof drainage and sewer systems. This helps prevent the overburdening of wastewater treatment plants and pollution of waterways. Reducing stormwater runoff is especially critical in low-lying areas like Greenpoint, which experiences flooding during significant rainstorms and where as little as one-tenth of an inch of rain over an hour can trigger CSO releases.

Cooling and Cleaning the Air

Because of the prevalence of cement, asphalt, brick, and other surfaces that absorb and radiate heat, temperatures in urban areas are often a few degrees warmer than in suburban and rural areas, a phenomenon known as the urban heat island effect. Vegetation on green roofs retains heat and lowers surface temperatures through evaporation from the soil and transpiration by the plants; it also filters pollutants and improves the surrounding air quality. According to the EPA, green roof temperatures can be 30° to 40°F lower than those of conventional roofs and can reduce city-wide ambient temperatures by up to 5°F. Unlike a black tar or reflective-surface roof, a green roof can also substantially reduce energy costs for a building by insulating the top floor and reducing the need to provide cooling and heating. Lower energy use helps lessen air pollution and greenhouse gas emissions, which is essential for combating climate change.

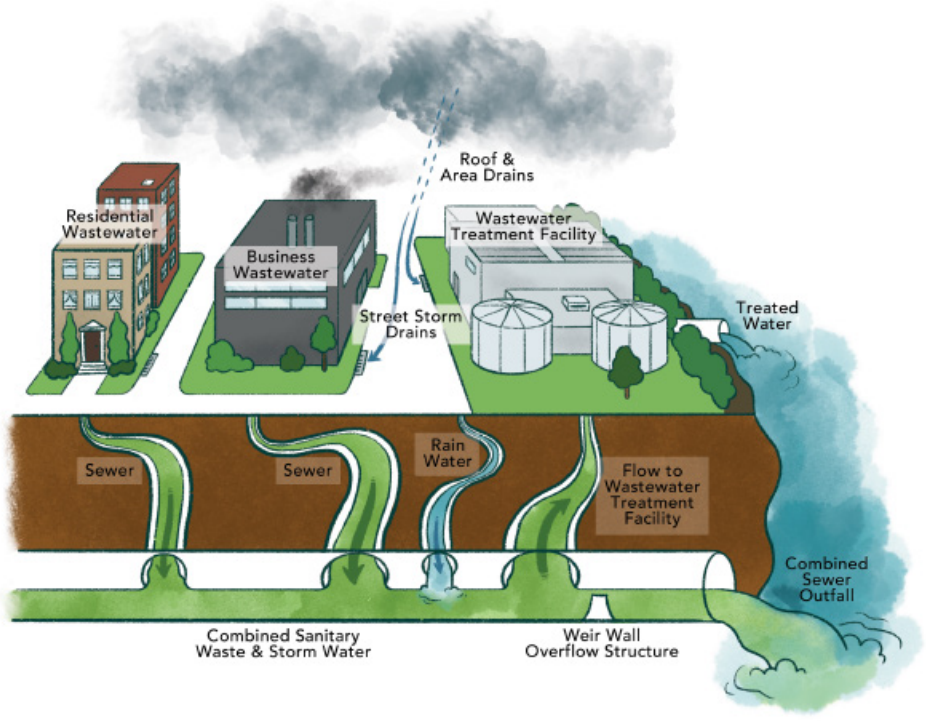
Urban Wildlife Habitat

Green roofs provide places where local and migratory species of insects, birds, and bats can find food, water, shelter, and mates, and raise their young. In urban areas, this is particularly critical because of the large amount of impervious surface, such as concrete and buildings, and lack of green space such as parks and gardens. Green roofs, especially those like Kingsland Wildflowers at Broadway Stages planted with species native to the New York region, provide habitat for local wildlife and help connect a matrix of small and large green spaces in New York City.

To learn more about green roof biodiversity, NYC Audubon scientifically monitors the different green roofs at Kingsland Wildflowers to learn what species they support. Researchers identify birds and bats using visual observation and automatic recording units, and sample for insects by collecting them in traps. Kingsland Wildflowers is a habitat on which some species may live for their entire lives (for example, soil insects), but is a temporary habitat for other species (birds) as they travel between larger green spaces. It also provides stopover habitat for birds and bats as they travel long distances during migration.

Each year, NYC Audubon scientists collect and identify thousands of arthropods (spiders and insects) from more than 13 orders, observe dozens of bird species, and record high bat activity. Insects pollinate, break down plant material, cycle the soil, and provide food for other insects, birds, and bats. Many native bee and butterfly species are present throughout the spring, summer, and fall. Birds identified at Kingsland Wildflowers include Barn Swallow, Red-tailed Hawk, Chimney Swift, House Sparrow, European Starling, Northern Mockingbird, and American Robin. The most abundant bat there is the Eastern Red Bat. The wildlife community continues to develop over time.

Zoe Lehar



New York City's combined sewage system.

BUILDING AND PLANTING GREEN ROOFS

Unlike a container garden, a green roof system is a roof surface predominantly covered with vegetation, a growing medium, and other substrates, all functioning together as a unit. Unlike a black or reflective-surface rooftop, green roof systems are composed of various layers to insulate and protect the underlying roof membrane from root damage, help support plant growth, and release excess water slowly off the roof and into drainage systems.

Structural Considerations

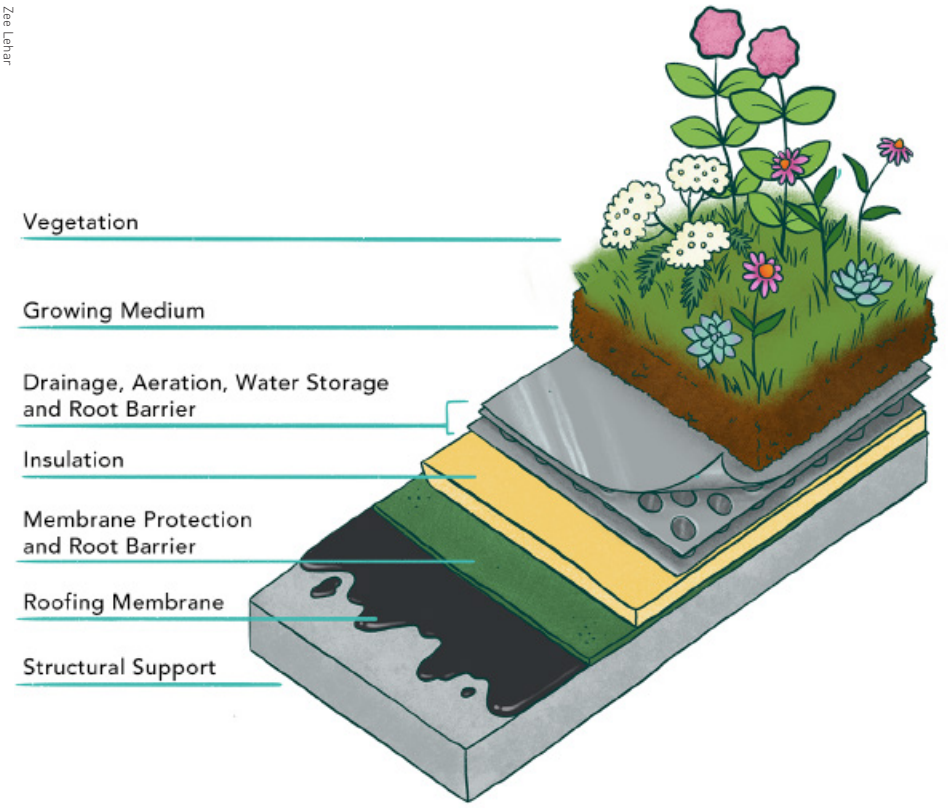
Before adding a green roof to a building, a structural engineer must decide if the framework can bear the additional weight. All structures are either under tension (pulling), compression (pushing), or both forces at the same time. The architectural design of the building and the strength of the materials used in its construction will determine the weight load capacity of its roof. Engineers also consider additional weight factors: "dead load," or static weight, "live load," like people and cars; and "environmental load," or snow, rain, wind, and earthquakes. A structural engineer will analyze the building's current weight-bearing capacity to determine if the roof can support a green roof system or if upgrades are required. The engineer will also assess the condition of the roof membrane, the roof's accessibility, and its electrical and water systems. Consideration of all these factors is imperative so the building can adequately and safely support a green roof.

Types of Green Roofs

Depending on the structural weight load of a building, a green roof can be either "extensive," "semi-intensive," or "intensive." Extensive green roofs have soil depths of six inches or less; plantings are limited to sedums and some low-growing native plants. Semi-intensive green roofs have growing media depth that ranges from 25 percent above or below six inches and can support a mixture of sedums, native plants, grasses, and small shrubs. Intensive green roofs have soil depths greater than six inches and can support larger plants. Kingsland Wildflowers at Broadway Stages has both intensive green roofs, which are open to the public, and extensive ones, which are not.

During the initial construction of Kingsland Wildflowers' intensive green roofs, protective layers of root barrier, drainage conduits, and filter fabric were installed over the roof decks. Irrigation lines were put down and covered with two inches of specialized gravel for drainage. Above those sub-layers, an ultra-light, engineered growing medium of six inches was spread on the surface and planted with native wildflowers. Bluestone pathways meander through wildflower meadows and circle back to the community center gathering area. A beautiful orb water fountain, designed by British artist Allison Armour, makes a powerful focal point. The organic design of Kingsland Wildflowers' green roof provides a striking contrast to the surrounding views of neighboring industries.

Zee Lehar



Green roof layers.

Living Walls

Living walls are another form of green infrastructure. Like green roofs, the walls of plants help reduce and insulate the building temperature and improve air quality. These vertical gardens can be grown on the outside or inside of a building façade or can be free-standing. The plant framework contains a growing medium and often an integrated watering system. Kingsland Wildflowers at Broadway Stages will be installing a vine-based living wall as part of the third-floor green roof expansion, which will be used for research monitoring its value as bird habitat.

Plants for Green Roofs

Rooftops present challenging conditions for growing plants: direct sunlight, extreme temperatures, wind, and precipitation can quickly stress vegetation that is planted in very shallow soil. While regular maintenance can eliminate some of these issues, plants for green roofs are typically selected to withstand harsh environments. Sedums, which are succulents, are frequently used because of the ability of their thick leaves and stems to retain water, their shallow root systems, and their capacity to self-propagate. They come in hundreds of varieties and are ideal for extensive and semi-intensive green roofs. Deeper semi-intensive and intensive green roof systems can support native plants, wild grasses, shrubs, and even trees, though they require more maintenance than simpler extensive green roofs.

The plants used at Kingsland Wildflowers at Broadway Stages are species native to our ecoregion, grown in nurseries in New York State, Pennsylvania, and New Jersey. They have evolved here over thousands of years together with native insects, birds, and other animals as part of a complex ecosystem. Kingsland Wildflowers has over 28 varieties of native herbaceous perennials, including Wild Strawberry (Fragraria virginiana), Nodding Onion (Allium cernuum), Tall Coreopsis (Coreopsis tripteris), Early Goldenrod (Solidago juncea), Orange Milkweed or Butterfly Weed (Asclepias tuberosa), and several native grasses such as Prairie Dropseed (Sporobolus heterolepis) and Little Bluestem (Schizachyrium scoparium). Also planted are native shrubs such as Beach Plum (Prunus maritima). These plants and others were selected to attract birds and other wildlife. For example, milkweed is the host plant for the Monarch Butterfly—currently under consideration for designation as an endangered or threatened species—and also produces silky seed pod fibers that the Baltimore Oriole and American Goldfinch collect for soft nest-lining material.

HOW TO USE THIS GUIDE

The science activities in this guide integrate with New York State Common Core Standards and the NYC Department of Education PK-8 Science Scope & Sequence. It is organized by grade, from pre-K through 5, with activities corresponding to each grade's relevant Scope & Sequence Essential Questions.

Lesson recommendations range from a pre-kindergarten green roof sensory tour to second-grade wildlife corridor mapping activities to fifth-grade green roof model making projects. All learning activities can be scaled up or down and modified to match the student community. Many lessons are adaptable to students with special needs for differentiated instruction. Some of the activities can be conducted on a green roof, while others would be taught in a classroom. The lesson suggestions can also be integrated into curricula for STEM, science, math, English language arts, social studies, environmental studies, and art. Included here are book recommendations and links to formal lesson plans, videos, and other useful information. Accompanying worksheets and other resources are available.

Niki Jackson/NYCA

Kingsland Wildflowers at Broadway Stages.

RESOURCES

NYC GREEN ROOF TOURS

Kingsland Wildflowers at Broadway Stages: www.kingslandwildflowers.com

The High Line: www.thehighline.org/groups/schools/

Jacob K. Javits Convention Center: www.javitscenter.com/sustainability/green-roof-tours/

P.S. 41 Green Roof Environmental Literacy Laboratory: www.ps41.org/apps/pages/index.jsp?uREC_ID=357901&type=d; contact vsando@ps41.org to arrange a class tour of PS 41.

BOOKS

Beth Hanson, *Green Roofs and Rooftop Gardens,* Brooklyn Botanic Garden, 2012

Leslie Day and Mark A. Klingler, *Field Guide to the Natural World of New York City,* Johns Hopkins University Press, 2007

VIDEOS

Greening Brooklyn: Kingsland Wildflowers Green Roof: www.youtube.com/watch?v=ZiTlxkh_V-Q

GREEN ROOF INTRODUCTION

https://thekidshouldseethis.com/post/why-cities-need-more-green-roofs

CyberChase Season 11, "Housewarming Party" & "Housewarming Party: For Real": https://tinyurl.com/yb7jvbzx (Educational animated/live videos on green roofs)

WEBSITES/CURRICULA

www.growtolearn.org/?s=green+roofs (NYC DOE guide to installing green roofs on schools)

www.amplify.com/curriculum/amplifyscience (NYC DOE Science Curriculum)

www.oasisnyc.net/map.aspx (Interactive mapping tool for NYC environmental sites)

www.newtowncreekalliance.org/ (Newtown Creek information and curriculum)

www.nwf.org/Eco-Schools-USA/About/STEM (Green STEM Curriculum)

Pre-Kindergarten

Essential Question 1: How do we use our senses to explore, investigate, and understand the world around us?

1A. My Five Senses

Supplies: magnifying glasses, paper, crayons, colored pencils

A green roof is an ideal place for young children to explore their various senses in a natural setting while high above the ground. Kingsland Wildflowers at Broadway Stages' unique location offers students the opportunity to observe and describe similarities and differences between the green roof and neighboring industry. Using magnifying glasses, students study plants and insects up close to sharpen their observational skills, while the teacher records their impressions. The teacher directs students to close their eyes and asks, "What sounds do we hear on the roof?" and "Are the sounds from nature or man-made?" Back in Kingsland Wildflowers' educational room, students take turns describing their observations of sight, smell, hearing, and touch while the instructor records their findings on the whiteboard. Students document their experiences by drawing what they discovered on the green roof.

Essential Question 2: Where do the people and animals around me live?

2A. Where We Live

Supplies: clipboards, paper, pencils

New York City is diverse not only in the people who live here, but also in the neighborhoods across the five boroughs. Kingsland Wildflowers at Broadway Stages is in an industrial neighborhood that includes a wastewater treatment plant, scrap metal recycling facility, and other processing factories. On the green roof, the teacher asks questions such as, "Why are factories needed in our City?" and "Why is this green roof good to have in the neighborhood?" Students compare and contrast the green roof and the active industrial sites nearby and discuss the connections to pollution of the neighborhood and what's being done to address it. Back in the education center, the teacher records their observations and responses on the whiteboard.

In the school classroom, the teacher follows up the visit by making a class neighborhood book of student drawings and observations from their trip to the green roof.

2B. Animal Habitats

Supplies: magnifying glasses, bird photographs

On the green roof, students hunt for places where birds and arthropods hide—under a rock, in the plants, or inside a birdhouse. The teacher asks why arthropods, such as pill bugs, ants, spiders, and beetles, might find shelter under rocks or hidden in crevices of plants. Students identify partly eaten leaves and other evidence of wildlife habitation. The teacher points out the birdhouses and asks, "Does the size and shape of the birdhouse determine what bird will use it?" By reviewing photographs of birds observed on the green roof, students figure out which birds would use the boxes.

As a follow-up classroom activity, students individually or as group replicate a bird or insect habitat using shoeboxes, clay, pebbles, dried plants, wood chips, or other found objects. A larger classroom "habitat" can be constructed with blocks or cardboard boxes.

Essential Question 3: What does water do?

3A. Water on Different Surfaces

Supplies: a small potted plant, an eyedropper for each student, small cut squares of paper towel, wax paper, construction paper, sponges

How does a green roof absorb water? Students test the absorption properties of different substances by using eye droppers to drip water onto surfaces such as paper towels, wax paper, construction paper, and sponges. The teacher makes a connection between the sponge and a green roof by pouring a small container of water on a sponge and in a dry potted plant. How much water drained out? What happened when the same amount of water is poured on a hard surface?

Essential Question 4: How do plants grow and why are they important?

4A. Green Roof Plants

Supplies: plastic bottles (one per student or group), potting soil, sedum cuttings and/or grass seeds, X-Acto knife or scissors

In the classroom, with adult assistance, students make a miniature green roof using recycled plastic bottles, soil, and plants or seeds. Plastic water bottles are carefully cut by an adult in half with an X-Acto knife or scissors and the top is inverted into the bottom of the bottle. A drainage barrier, such as a piece of muslin fabric, is secured over the mouth with a rubber band. The soil and plant seeds or sedum cuttings are added to the top section. Students observe and record the parts of the plants, measure how fast they grow, and notice water drainage. Grass seeds are ideal for quick propagation. See Resources.

Math Extension: Finding Patterns

Supplies: small cups for collecting items on roof, graphic signs for sorting

With the help of instructors, students gather small pebbles, leaves, stems, flowers, and other items on the green roof. Moving inside, they sort the various objects collected into categories: bigger/smaller, heavier/lighter, flat/round, sharp/smooth, geometric shapes, and color.

Mitch Waxman/NCA

Michelle Maani/Audubon Photography Awards

Andrew Maas/NYCA

Niki Jackson/NYCA

James Park/Broadway Stages

Clockwise from top left: Painted Lady Butterfly. Students testing the solar fountain at Kingsland Wildflowers at Broadway Stages. Swallow house. Bumblebee on Purple Coneflower. Barn Swallow.

Book Recommendations

iKids, *The Five Senses,* Innovative Kids, 2009

Paul Showers and Aliki, *The Listening Walk,* HarperCollins, 1993

Megan Wagner Lloyd and Abigail Halpin, *Finding Wild,* Knopf Books for Young Readers, 2016

Emily Jenkins and Stephanie Graegin, *Water in the Park,* Schwartz & Wade, 2013

Maria Alaina, *Patterns in Nature,* Capstone Press, 2013

Rotraut Susanne Berner, *In the Town All Year 'Round,* Chronicle Books, 2008

Resources: Plastic Bottle Projects

https://balconygardenweb.com/plastic-bottle-vertical-garden-soda-bottle-garden/
www.wikihow.com/Make-a-Mini-Greenhouse
www.instructables.com/id/Plastic-Bottle-Planters/

Kindergarten

Essential Question 1: What do living things need to live and grow, and how might they change their environments to survive?

1A. Observing a Place

Supplies: clipboards, worksheets, pencils, photos for sorting

Thinking like scientists, students take a multisensory scavenger hunt on the green roof to locate and record various living and nonliving things from a checklist worksheet. Back in the education room, students sort magnet-backed photos, which can be placed on a whiteboard, of the things they found on the scavenger hunt. They put them in categories of living and nonliving, then classify the living group into plants, insects, and birds. They evaluate and discuss the needs of each and how they all work together as a system in the natural world. The teacher asks, "How can humans make sure other living things will be able to live and grow?"

1B. Monarch Migration

Supplies: Monarch life cycle cutouts, migration maps, milkweed plants/seeds, magnifying glasses, paper, colored pencils

Kingsland Wildflowers at Broadway Stages' green roof is an important resting spot for Monarch Butterflies during their annual fall migration from Canada to Mexico. Students begin in the education room with a review of the Monarch life cycle, migration patterns, the threats causing its population to dwindle, and its host plant, milkweed. The teacher asks, "What are the needs of a Monarch Butterfly?" and "Why is milkweed important for the Monarch's survival?" Students explore the green roof to identify milkweed plants and look for other evidence that the green roof is a habitat for butterflies. Afterwards in the classroom, they have the opportunity to plant milkweed or propagate seeds.

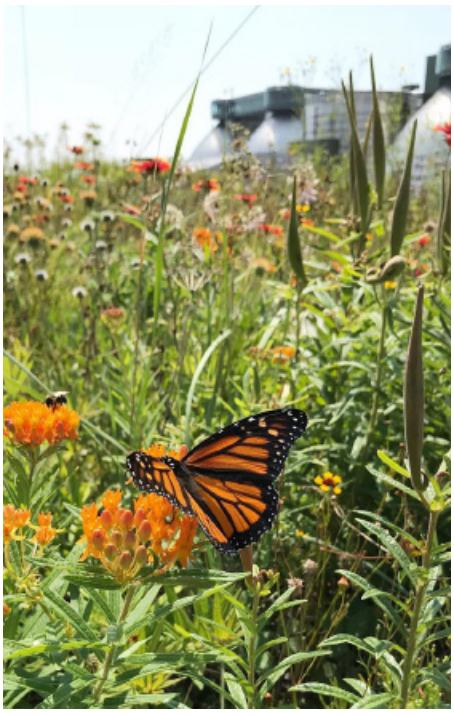
Essential Question 2: How do pushes and pulls influence the way an object moves?

2A. Forces: Tension and Compression

Supplies: string, rubber bands, large paper cups, a piece of cardboard, kitchen sponge, black marker, small plastic or paper cups

Young children learn the fundamentals of physical forces that operate on a green roof. The teacher holds the ends of a piece of string or length of rubber band and has students do the same. When they put their hands together, they demonstrate that the string offers no resistance; when they pull their hands apart, they demonstrate resistance. The teacher explains that the resistance they feel is a force called tension. To demonstrate compression—or forces pushing in—students try to crush a large paper cup with their feet or squeeze it with their hands. Using a permanent marker, the teacher draws a series of lines crosswise on both sides of a kitchen sponge and has students bend the sponge into a U-shape. What happens to the lines on either side of the sponge? Where is the sponge in tension? (On the outside.) Where is the sponge in compression? (On the inside.) The teacher explains that structures such as green roofs are always bending from forces (load), and the columns and beams of the structure resist compression and tension. In the classroom, students make predictions and test different amounts of large paper cups to support a rectangular piece of cardboard (flaps from a large cardboard box are handy for this purpose) that a child will stand on. Where should the cups be placed to distribute the weight (load) of the child? Another way for young children to understand how force, weight (load), and counterweight help structures stand up is to build structures with plastic cups, craft sticks, and small blocks. See Resources for lessons.

Sol Kjok, NOoSPHERE Arts



Monarch Butterfly on the green roof.

Vicki Sando

A construction project to understand how force, weight, and counterweight help structures stand up.

Math Extension: Geometric Shapes

Supplies: clipboards, worksheet of shapes, pencils

Students identify circles, semi-circles, ovals, squares, rectangles, and triangles in plants, on the building structure, and in the surrounding landscape. Back in the classroom, children color, cut out, and glue shapes from a downloadable worksheet to recreate the green roof.

James Park/Broadway Stages

Multisensory scavenger hunt at Kingsland Wildflowers at Broadway Stages.

Book Recommendations

Peter Brown, *The Curious Garden,* Little Brown Books for Young Readers, 2009

Charlotte Guillian and Yuval Zommer, *Street Beneath My Feet,* words & pictures, 2017

Joshua S. Bruner and Sharon Katz Cooper, *When Butterflies Cross the Sky: The Monarch Butterfly Migration,* Picture Window Books, 2016

Kathleen Weidner Zoehfeld, *What's Alive?,* HarperCollins, 1995

Kevin Kurtz, *Living Things and Nonliving Things: A Compare and Contrast Book,* Arbordale Publishing, 2017

Alina A. Dumitrescu, *Shapes in Nature: Learn Geometric Shapes,* independently published, 2016

Andrea Beaty, *Rosie Revere, Engineer,* Harry N. Abrams, 2014

Resources

www.nwf.org/Educational-Resources/Wildlife-Guide/Invertebrates/Monarch-Butterfly (Monarch Butterfly information)

www.monarchs-and-milkweed.com/ (Monarch eggs, larvae, milkweed cuttings and seeds)

www.pbs.org/wgbh/buildingbig/index.html (Lesson plans for engineering projects)

https://littlebinsforlittlehands.com/best-structure-building-activities-kids/(Engineering activities for younger students)

www.k5architecture.org (K-5 architecture curriculum)

Grade 1

Essential Question 1: How do we see objects?

1A. Using Binoculars and Magnifying Glasses

Supplies: binoculars, magnifying glasses, paper, pencils

Students receive instruction on using binoculars and magnifying glasses to observe objects and then demonstrate their ability to focus correctly on various focal points, on the green roof and in the distance. Students explain why binoculars and magnifying glasses are essential tools for studying birds and other wildlife, allowing people to see them from a safe distance or up close. In the education room, students develop their observational skills by drawing plants and other objects they have viewed with magnifying glasses.

1B. Tracking Light on the Green Roof

Supplies: a ball of string

Depending on the time of day, students observe and investigate how light moves across two levels of the green roof by using string to mark the separation between light and shadow. Does the border between light and dark change over a short period? What will happen over a more extended period? Students also test how solar power operates by interacting with the solar fountain on the green roof. What happens when they block the sun over the basin? Does the water still spray or does their shadow cause it not to function?

Essential Question 2: What structures and behaviors help plants and animals survive?

2A. Habitats on the Green Roof

Supplies: magnifying glasses; ball of string; clothes pins; laminated photos of birds, plants, and insects

After a discussion of what kinds of places animals use for food, shelter, and breeding, students investigate how the green roof is a habitat for birds and insects by looking under rocks, walking through the wildflowers, looking for seeds that could be food for birds, and observing available bird nesting places. After the tour, students demonstrate their understanding of how habitats are living systems by making a food web using photos and a ball of string to make connections among the different elements. In the classroom, students show their understanding of habitats by writing an informational booklet, creating a graphic organizer, or building a three-dimensional model showing how green roofs are habitats for birds and insects.

2B. New York City Birds

Supplies: bird photos, bird recordings, paper plates, scissors, metal fasteners, tape, feathers, tissue paper, markers, colored pencils, crayons

Students investigate the different types of birds found on the green roof. With guidance from the instructor, they learn to distinguish species by examining photographs attached to a white board and listening to bird songs and calls. Students learn the difference between songs and calls through a fun exercise in which each student makes up a song or call, and then all of the students' sounds are combined into a class song. Students group photos of birds to identify similarities in their beaks and predict what types of food different species eat based on their beak structures. What kind of beak would a seed-eating bird have? What kinds of beaks would birds that eat insects or small mammals have? Students create replicas of birds using paper plates, craft feathers, tissue paper, and other materials. A classroom engineering challenge for students is to design and construct a bird's nest out of twigs, clay, feathers, string, moss, etc. and try to make it stay on a branch, with a real egg, without falling. See Resources for lesson plans.

Art Extension: Sun Prints

Supplies: sun print paper, plant cuttings, basin of water

Students make sun prints with plants from the green roof, using special paper that captures the plants' silhouettes after being exposed to sunlight and water.

Book Recommendations

DyAnne DiSalvo-Ryan, *City Green,* HarperCollins, 1994

Jeannie Baker, *Home,* Greenwillow Books, 2004

Allison Jay, *Bee & Me,* Candlewick, 2017

Peter Brown, *Mr. Tiger Goes Wild,* Little Brown, 2013

Phyllis Root and G. Bryan Karas, *Anywhere Farm,* Candlewick, 2017

Holly Bang and Penny Chisholm, *Living Sunlight: How Plants Bring the Earth to Life,* Blue Sky Press, 2009

Demi Lyn Noel Frandsen and Iy Capener, *A Bird's Eye View: Atticus Sees New York City,* CreateSpace Independent Publishing Platform, 2018

Carolyn Cinami DeCristofano and Giovana Medeiros, *Running on Sunshine: How Does Solar Energy Work?* HarperCollins, 2018

Resources

www.birdsleuth.org (Bird information and curriculum)

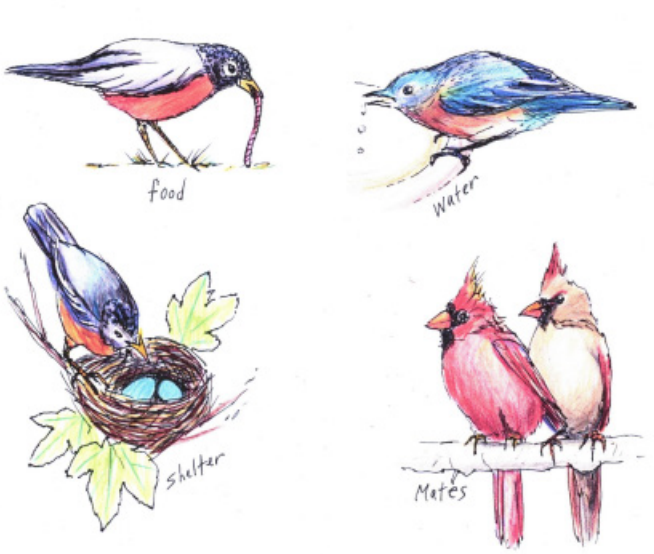
www.pbs.org/parents/crafts-for-kids/sun-prints (Sun prints)

www.enlightensc.org/lesson-plan/1st-grade (Solar lesson plans & resources)

https://educators.brainpop.com/lesson-plan/food-chains-and-food-webs-lesson-plan (Food web lesson plan)

Tina Wong/Greenpoint Eco-Schools

Vicki Sando



Marni Majorelle/Alive Structures

Learning to use binoculars at Kingsland Wildflowers at Broadway Stages. Robin on the green roof railing. Habitat needs.

Grade 2

Essential Question 1. How do the properties of water and other earth materials affect life on Earth?

1A. Green Roof Growing Media

Supplies: green roof growing media, potting soil, sifters, plastic containers, magnifying glasses, worksheets, pencils

Green roof growing medium is an engineered soil used on rooftops because of its superior drainage ability and light weight. Using sifter screens in the Kingsland Wildflowers at Broadway Stages education room, students sift both green roof media and other types of soil to separate the particles and evaluate the composition of each. Students observe the filtered materials using magnifying glasses and classify them on worksheets by particle size, color, and content. How does green roof growing media compare to ground soil found in the surrounding area? Taking samples of growing medium back to the classroom, students make a hypothesis and carry out investigations on seeds germinated in each type of soil.

Essential Question 2: How does water change land?

2A. Green Roof Models

Supplies: roof demonstration models, thermometers, measuring containers for water

Besides providing habitat, green roofs reduce stormwater runoff and reduce a building's temperature. Students investigate and compare how green roofs, black tar roofs, and reflective-surface roofs absorb solar heat and water runoff by testing the set of free-standing roof models at Kingsland Wildflowers at Broadway Stages. They place a thermometer inside each model to compare temperature differences. Students place a container inside each roof model and pour water to compare stormwater runoff differences. Does the green roof hold more water than the black or silver roof? What is the temperature difference between the green, black, and reflective roofs?

In the classroom

Supplies: recycled tissue boxes, scissors, construction paper and glue stick; markers; large craft sticks and hot glue to attach border around rooftop; plastic straw section for drain hole on roof; plastic piece or tray to hold green roof sponge; Mod Podge glue to coat and seal paper box

Students design and construct their own roof models using tissue boxes and other standard supplies to replicate the same tests. Students make predictions on whether their models will achieve the same or similar results as Kingsland Wildflowers at Broadway Stages.

Essential Question 3: How do plants and animals depend on each other?

3A. Bats

Supplies: bat recordings; magnifying glasses; plastic plates and cups; straws; cotton balls; string; paper—regular weight or construction (include several colors, including the color that the target insect is attracted to); assorted building materials such as wire, screen, cardboard, twist ties, foil, masking tape, glue (items that might help students create imaginative insect traps); and corn syrup, soda, and other scents to attract insects.

When dusk brings a halt to most of the industry surrounding Kingsland Wildflowers at Broadway Stages, Eastern Red Bats begin foraging around the green roof for moths and beetles. These solitary night creatures are an essential part of New York City's ecosystem and are the second most diverse group of mammals worldwide. Bat populations have been on a steep decline in recent decades, largely due to white-nose syndrome (WNS). WNS is caused by a fungus that spreads among hibernating bats. It is thought to be one of the worst wildlife diseases in modern history, killing more than six million bats in North America. Green roofs can be helpful for bat conservation because they provide bats in urban areas with a necessary food source. At Kingsland Wildflowers, students listen to research recordings of bats from the green roof. They investigate the green roof looking for evidence of beetles and moths, which are the bats' primary food source. Why are plants important for bats if their diet is insects? Are these plants a food source for moths and beetles? Why are bats critical to an ecosystem? What happens to the ecosystem if bats disappear? Students design and construct simple insect traps to help researchers monitor and record what food sources are available for bats and birds on the green roof.

Back in the classroom, students make paper models of bats, develop an awareness campaign to inform their community about white nose syndrome, build/install bat boxes in the schoolyard, and/or plant a pollinator garden.

Essential Question 4: How do shapes affect the stability of structures?

4A. Structure and Function

Supplies: paper; clear tape; empty cans to roll cylinders; books or other flat objects to test load

Before installing a green roof, an engineer needs to determine how much weight the roof can support. Students observe and discuss how geometric shapes determine the stability of a structure by touring the Kingsland Wildflowers at Broadway Stages building. Using paper and tape, students make three sets each of three-dimensional cylinders, triangles, and bridges. They stack books or other flat objects on different combinations of shapes to see which supports the greatest amount of weight or load before being crushed. Does one particular configuration support more weight than others? When looking at bridges and cranes, which geometric shape do we observe the most? Students investigate how the beams, columns, and floors inside the building support the green roof.

Back in the classroom, students compare the components of the Kingsland Wildflowers at Broadway Stages building to their school building.

Vicki Sando

Jake McIntosh/NYCA

Niki Jackson/NYCA

Vicki Sando

Clockwise from top left: Students can make roof models to test in the classroom. Putting the growing medium on Kingsland Wildflowers at Broadway Stages. Two simple insect traps students can make.

Book Recommendations

Melvin Berger, *Oil Spill!,* HarperCollins, 1994

Thomas Locker, *Where the River Begins,* Puffin Books, 1993

Molly Bang, *Common Ground: The Water, Earth, and Air We Share,* Blue Sky Press, 1997

Peggy Bresnick Kendler, *Our Water Supply,* Newbridge Educational Publications, 2003

Suzanne Slade and Carol Schwartz, *What if There Were No Bees?,* Picture Window Books, 2010

Elizabeth Carney, *National Geographic Readers: Bats,* National Geographic Children's Books, 2010

Scot Ritchie, *Look at That Building! A First Book of Structures,* Kids Can Press, 2011

Resources

www.teachengineering.org/activities/view/insect_trap_activity (STEM lesson plan for insect traps)

https://tryengineering.org (Lesson plans for critical load, waterproof roof and pollution patrol)

www.pbs.org/wgbh/buildingbig/index.html (Lesson plans for engineering projects)

https://littlebinsforlittlehands.com/best-structure-building-activities-kids

Engineering activities for younger students

www.k5architecture.org (K-5 architecture curriculum)

www.youtube.com/watch?v=jUh6R1hs2Tw (Video on creating a classroom green roof model)

http://www.greeneducationfoundation.org/institute/lesson-clearinghouse/553-build_a_green_roof.html (Lesson plan for green roof model)

www.scholastic.com/teachers/search-results/?search=1&filters=&text=bats (Scholastic lesson plans about bats)

www.whitenosesyndrome.org (Information about the efforts to protect bats against white-nose syndrome.)

Grade 3

Essential Question 1: How do environments change over time?

1A. Green Roof Observational Study over Time

Supplies: magnifying glasses, microscopes, paper, colored pencils

Scientific field research depends on observing a location and recording findings over time. Students visit the green roof in three seasons during the school year to investigate and document how it has changed. How have the wildflowers developed from spring to fall? What do students notice about a plant's life cycle during the school year? How many arthropod species can they find in fall, winter, and spring? Are they in different locations depending on the season? Students make visual observations and use hand tools and microscopes for collecting data to describe plants, wildlife, and weather conditions. Students use their evidence to make predictions about what they might observe during their follow-up visits to the green roof. They conclude the study with a research report including graphical displays or models.

1B. Mapping Green Corridors

Supplies: maps of the Greenpoint, Brooklyn, area; a computer or tablet; rulers; paper; colored pencils

Honeybees can travel as far as two to four miles from their hive to forage for food. Students use maps and online mapping tools to analyze and diagram the presence of green roofs, community gardens, parks, school gardens, cemeteries, and other green spaces around Kingsland Wildflowers at Broadway Stages. Using these tools, students determine the distance a bee or bird would need to travel between Kingsland Wildflowers and nearby green spaces to find food, water, or shelter. Which are the closest and farthest green areas that wildlife can reach? Can students identify potential park or green roof space that could shorten the distance wildlife need to reach a habitat? See Resources for mapping tools.

1C. Timeline of Newtown Creek

Supplies: photos of Greenpoint, Brooklyn, area over time

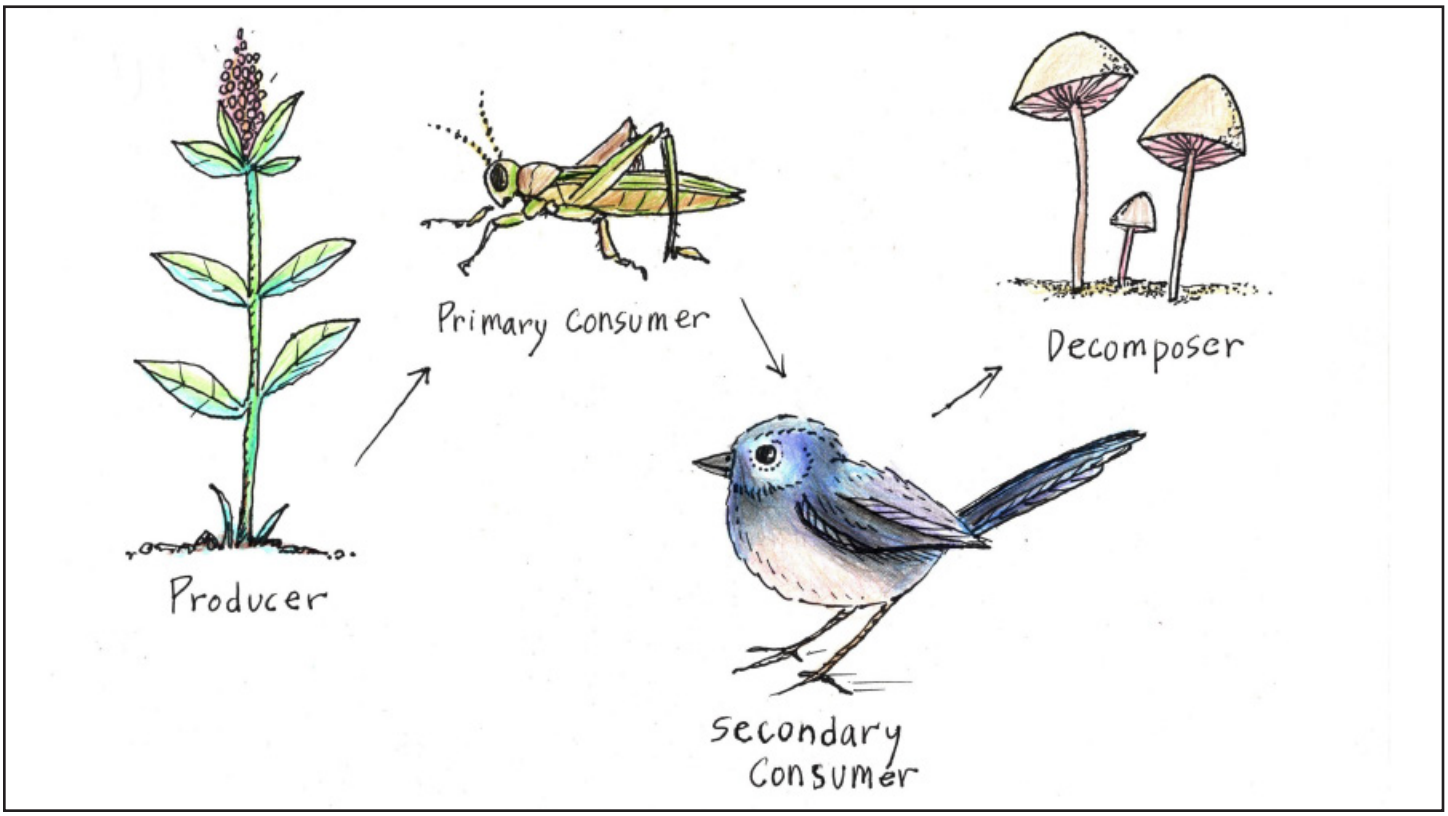
Students research how the area has changed since Native Americans inhabited the area. They map out key dates and events, including the arrival of Europeans, types of industrialization over time, and significant environmental activities, including the construction of Kingsland Wildflowers at Broadway Stages and other community revitalization efforts. Students communicate this information by creating a visual timeline from both historical photos and photos they have taken during their visit to Kingsland Wildflowers and Newtown Creek. See Resources.

Essential Question 2: How do the traits of an organism help it to survive in its environment?

2A. Systems Thinking on the Green Roof

Supplies: clipboards; worksheets; pencils; magnifying glasses; photos of plants, insects, and birds found on the green roof

Vicki Sando



Components of a food web.

A system is described as its components and their interactions. Green roofs are living systems of producers, consumers, and decomposers. Students identify the components of the Kingsland Wildflowers system by locating the different types of organisms on the green roof and using worksheets to categorize them into producers, consumers, and decomposers. How is each species linked together in a food web? What would happen if we eliminated milkweed from the green roof? How would this affect monarch larvae and butterflies? Students use their findings to make a food web map demonstrating their understanding of how living things interact on the green roof.

2B. What Are Invasive Species?

Supplies: photos of native plants, non-native plants, and invasive species; seed samples; plant cuttings; magnifying glasses

What happens when a plant, insect, or animal comes from a different place and displaces native species? A species is considered invasive when its introduction to an ecosystem causes harm to the economy, environment, or human health. In this activity, students will discuss how European Starlings and House Sparrows were introduced into Central Park in 1890 by Shakespeare fans, who wanted to bring all the birds mentioned in his plays to the U.S. Students learn the difference between native and non-native plants (species that are not natural to an area) on the green roof and what makes a plant invasive (not all non-native plants are invasive). How do invasive plants get to the green roof if they weren't planted? Students investigate the green roof and identify invasive plants such as Horseweed (Erigeron canadensis), which produces thousands of tiny seeds that are easily spread over vast distances, and Drooping Brome or cheatgrass (Bromus tectorum), which uses its extensive root system to exploit water and other soil nutrients, along with other non-native species that are not invasive. In the education room, students discuss and debate the merits of removing or controlling invasive species. Should people intervene or let nature take its course?

2C. Making a Biodome

Supplies: plastic bottles or rotisserie chicken plastic containers; soil, plants, seeds, pill bugs, ants, or other small organisms

A biodome is a closed-environment, self-sufficient living system. In the classroom, students design and construct biodome models, using recycled plastic bottles or rotisserie chicken plastic containers, soil, plants, and other living organisms. They observe and record how the dynamics of the closed ecosystem change over time. Students change the location and lighting conditions of the biodome and make predictions about how those changes will affect the living system. See Resources for lesson plans.

Marni Majorelle/Alive Structures

Monarch Butterfly caterpillars on the green roof.

Book Recommendations

Lynne Cherry, *A River Ran Wild,* HMH Books for Young Readers, 2002

Cindy Jenson-Elliot and Carolyn Fisher, *Weeds Find a Way,* Beach Lane Books, 2014

Sneed B. Collard III, *Science Warriors: The Battle Against Invasive Species,* HMH Books for Young Readers, 2008

Janet Schulman and Meilo So, *Pale Male: Citizen Hawk of New York City,* by Knopf Books for Young Readers, 2008

Sneed B. Collard III, *Many Biomes One Earth,* Charlesbridge, 2009

Patricia Lauber and Holly Keller, *Who Eats What? Food Chains and Food Webs,* HarperCollins, 2016

Dr. Seuss, *The Lorax,* Random House Books for Young Readers, 1971

Resources

www.teachengineering.org (Lesson plans for biodomes, engineering)

www.oasisnyc.net/map.aspx (Interactive mapping tool)

www.pbslearningmedia.org/resource/tdc02.sci.life.oate.lp_energyweb/producers- consumers-decomposers (Lesson plans for how organisms are linked together in an ecosystem)

www.nyhistory.org/library/digital-collections (Resources for historic New York City maps, photos, and other materials)

Grade 4

Essential Question 1: How do the structures of plants and animals help them survive in their environment?

1A. How Do Spiders and Other Non-flying Arthropods Get on the Green Roof?

Supplies: photographs of local spiders, crickets, pill bugs, and ants; magnifying glasses

Spiders "balloon" to disperse, which means they let out a strand of silk and let the wind take them off the ground. They then float through the air (sometimes at the height of planes and at considerable distances), their movements determined by wind and pressure changes. Luck determines whether they fall on a city street, in the middle of a lake, or in a park or green roof. Once they land on a green roof, if they can survive the local environmental conditions and there is enough food available, they can live there for generations. Students hunt on the green roof for evidence of spiders and other non-flying arthropods, such as crickets and pill bugs, and explore how these insects' internal and external structures help them survive. How did they get on the green roof if they can't fly? What other means of transportation might have carried them to the green roof? Back in the education room, students discuss possible ways these arthropods arrived on the roof and how they continue to survive and reproduce in a new habitat.

1B. Biomimicry

Supplies: magnifying glasses, microscopes, clipboards, paper, colored pencils

Living organisms have evolved over billions of years to adapt through natural selection. Biomimicry is the imitation of natural patterns and strategies to find solutions to complex human problems. A well-known example is Velcro, an invention inspired by plant burrs. Exploring the green roof, students use hand lenses and microscopes to look for plant and insect structures—such as thorns, seed pods, stems, wings—that can inspire a solution to a design challenge, recording their findings.

Back in the classroom, students construct a three-dimensional model or write a design proposal for their solution.

Essential Question 2: How do we know energy is conserved as it is transferred from one form to another?

2A. Temperature: Green, Black, and Silver Roofs

Supplies: thermometers, plastic bags, twist ties, clipboards, paper, pencils

Students use thermometers and other heat sensors to test the temperatures underneath the green, black, and reflective roof models at Kingsland Wildflowers at Broadway Stages to demonstrate the differences. How does each roof surface absorb the sun's heat? Which roof model has the highest internal temperature and which has the lowest? What are the other pros and cons for each roof surface? In addition, by fastening a clear plastic bag over a plant, students observe transpiration and how plants cool off a green roof surface. If more green roofs were installed on rooftops, how would that affect the urban heat island effect in New York City? Students make connections between different roof surfaces and higher temperatures, recording their observations and discussing strategies for reducing the heat island effect.

STEM Extension: Water Systems

Supplies: binoculars, clipboards, pencils, measuring containers, NYC Department of Environmental Protection water system map

How is the green roof part of the larger water system in the city and community? Students review the water cycle, where New York City gets its water supply, and what happens to wastewater and stormwater. Pointing out the nearby Newtown Creek Wastewater Treatment Plant next door, discuss its vital functions and how it can affect waterways in the Greenpoint community. Students also examine how green roofs help reduce stormwater runoff by slowly releasing excess rainwater, which helps prevent pollution in the waterway. Using roof models at Kingsland Wildflowers, students test the drainage of green roofs compared with black or reflective roofs. Does the green roof retain more stormwater compared to the other roof surfaces? Why is this helpful during a significant rainstorm when the treatment plant is at overcapacity? Would installing more green roofs help urban waterways during heavy rainstorms? Back in their classroom, students build water filtration systems or map the water cycle system in New York City. See Resources.

Book Recommendations

Kay de Silva, *Spiders: Amazing Pictures & Fun Facts on Animals in Nature,* Aurora, 2016

Thomas F. Yezerski, *Meadowlands: A Wetland Survival Story,* Farrar, Straus and Giroux, 2011

Ken Leinbach, *Urban Ecology: A Natural Way to Transform Kids, Parks, Cities, and the World,* Morton James Publishing, 2018

Sheri Amsel, *The Everything Kids Environment Book,* Everything, 2007

Harriet Rohmer, *Heroes of the Environment: True Stories of People Who Are Helping to Protect Our Planet,* Chronicle Books, 2009

Laurie Lawlor and Laura Beingessner, *Rachel Carson and Her Book That Changed the World,* Holiday House, 2014

Christine Burillo-Kirch, *Bioengineering: Discover How Nature Inspires Human Designs,* Nomad Press, 2016

Resources

https://biomimicry.org/what-is-biomimicry (Biomimicry information, curriculum materials)

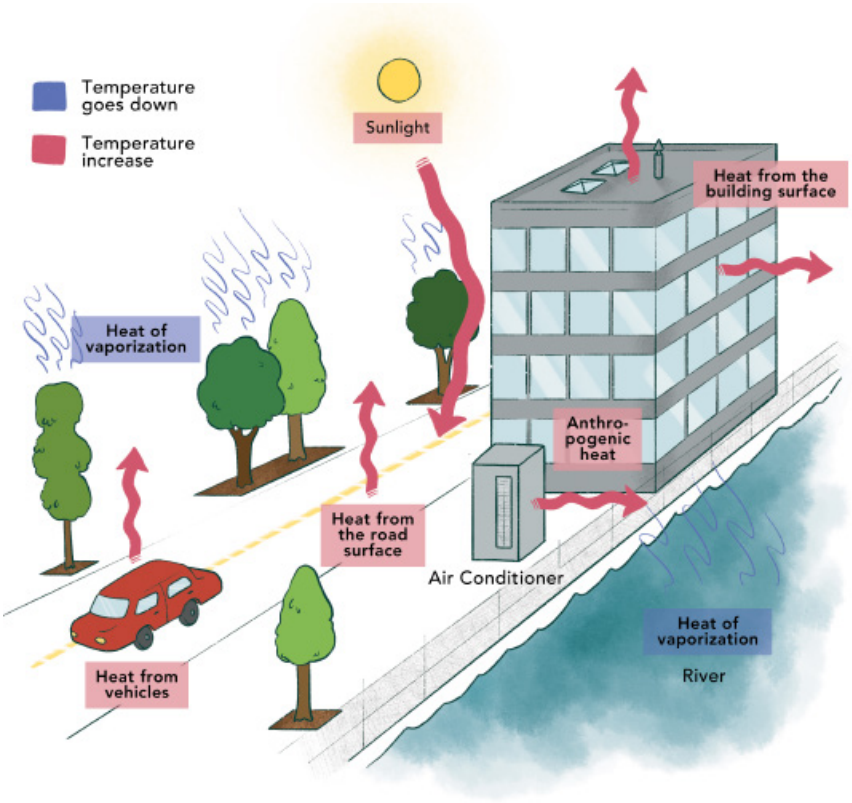
www.nyc.gov/html/dep/html/environmental_education/newtown_wwtp.shtml (Newtown Creek Wastewater Plant)

https://tryengineering.org/teacher/filtration-investigation (STEM water filtration system lesson plan)

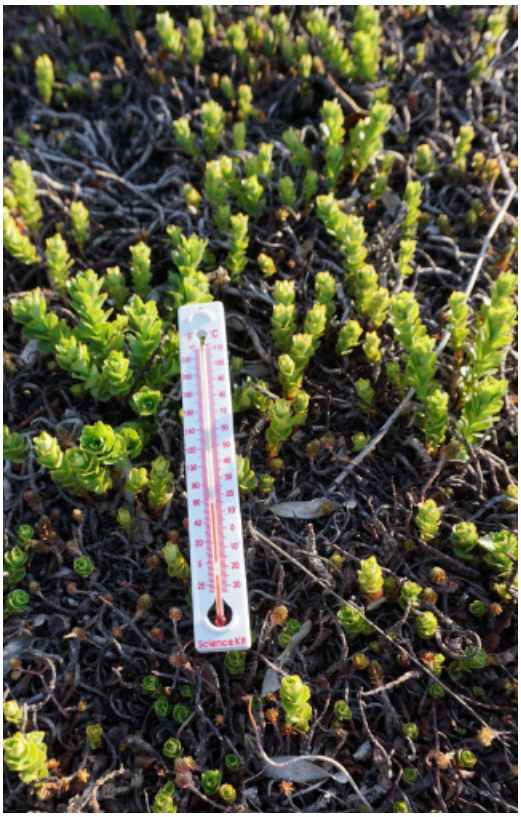
Teri Brennan/Greenpoint Eco-Schools

Andrew Maas/NYCA

Zee Lehar



Vicki Sando



Clockwise from top left: Sewer in a Suitcase, available at Kingsland Wildflowers to demonstrate the combined stormwater and wastewater system in New York City. Seed pods and other plant structures can inspire design solutions, an approach known as biomimicry. Measuring the rooftop temperature. Urban heat island effect.

Grade 5 and up

Essential Question 1: How can models represent concrete evidence or design solutions to improve our community?

1A. Designing a School Green Roof

Supplies: computer, school architectural plans (ask school custodial engineer), model-making materials

After touring Kingsland Wildflowers at Broadway Stages, researching other notable green roofs, and receiving mentoring by green roof experts, fifth-graders apply what they have learned to design a green roof on their school building. Using Google Maps and architectural plans (if available), students develop a potential green roof for their school. What type of green roof is possible on top of their school building? Is the roof accessible and does it have open spaces for a green roof? What components would they include on their green roof to make it functional and educational? Students research the requirements for installing green roofs on school buildings and interview the school administration and the custodial engineer to understand the funding process and potential building issues. Working in teams or as a class project, students analyze and interpret their findings and draw an architectual rendering of the rooftop space. Students also develop a marketing proposal for the green roof to spark interest in the school and neighborhood community. For the final stage, students build a model of the green roof and present their project to the school community.

1B. City Planning

Supplies: chart paper, grid paper, maps, post-its, rulers, pencils, colored pencils

How can communities be redesigned to include green infrastructure? Working in teams, students identify the critical elements in a livable city. Where should essential services be located? What are the different modes of transportation? How does the landscape affect where infrastructure is designated? After touring Kingsland Wildflowers and the Newtown Creek Nature Walk educational trail, teams can develop their designs, or the class can construct a model from combined ideas. See Resources for lesson plans.

Essential Question 2: How can we design and build green projects that have a positive impact?

2A. Building a Green Roof Test Station

Supplies: weather-resistant wood, building supplies, garden filter fabric, soil, sedum plants

Exploring the benefits of green roofs doesn't have to be limited to having one on a school rooftop. With adult assistance, students design and build a model green roof for their school grounds. Depending on space availability and budget, students compare surface temperatures of green, black, and white roofs. Students measure stormwater runoff on green and flat surface roofs and determine whether insects are attracted to the green roof module.

2B. Vertical Garden

Supplies: plastic bottles, X-Acto knife or scissors, wire or plastic ties, soil, plant seeds

An excellent hands-on, low-cost class project is for students to make a vertical garden from recycled plastic bottles attached on a schoolyard fence or other freestanding structure. Students learn how to repurpose plastic bottles into planting containers and carry out investigations to test different types of seed germination, plant growth, and food production over the school year. Vertical gardens are also ideal for schools with limited space. See Resources for examples.

Vicki Sando

Vicki Sando

Left: Student model of a school green roof.

Right: Student urban planning model incorporating green infrastructure.

Science Extension: Kingsland Wildflowers Colonization Plot

Supplies: magnifying glasses, microscopes, clipboards, colored pencils, measuring tape

How do seeds travel from one location to another and propagate? Students conduct observations of a colonization research plot—a rectangle of exposed soil on the newest section of green roof being built at Kingsland Wildflowers—to record which plants take root and grow over time. How did these plants migrate to this bare space? Did the seeds get carried by the wind or by birds? Are they native or non-native plants? What is the distance between new plants in the colonization plot and the same species on other parts of the green roof? Students record which types of plants are growing; use magnifying glasses and microscopes to observe how they produce seeds; measure the distance between seedlings and other plants of the same species nearby; and hypothesize how they migrated to the colonization plot. As a classroom STEM activity, students design seed prototypes made from readily available materials and test how far they can make them travel by wind, water, or sticking to a surface. See Resources for a lesson plan.

STEM Extension: Pollution Monitors

Supplies: cardboard pieces, paper plates, wax paper, plastic wrap, string, masking tape, duct tape, scissors, Vaseline, magnifying glasses, microscopes

Situated in the center of an industrial zone, Kingsland Wildflowers at Broadway Stages provides an ideal testing lab for students to monitor and compare air quality to their own school community. Students design and construct low-tech air pollution monitors to place on the green roof, a non-green section of the Kingsland Wildflowers building, and their school grounds. After a designated period, they compare the monitors, using hand lenses to identify trapped particles. (Even with the green roof, Kingsland may have higher particulate levels than the school community because of its industrial neighbors.) Students graph results and write a research report about air quality in their community.
See Resources for a lesson plan.

Book Recommendations

Kate Ascher, *The Works: Anatomy of a City,* Penguin Books, 2007

Barbara Beck, *The Future Architect's Handbook,* Schiffer, 2014

Philip Steele and Steve Noon, *A City Through Time,* DK Children, 2013

Anne Millard and Steve Noon, *A Street Through Time,* DK Children, 2012

Gail Hedrick, *Something Stinks!,* Tumblehome Learning Inc., 2015

Resources

www.k5architecture.org (K-5 architecture curriculum)

https://tryengineering.org (Lesson plans for critical load, waterproof roof and pollution patrol)

https://balconygardenweb.com/plastic-bottle-vertical-garden-soda-bottle-garden (Plastic bottle projects)

www.scholastic.com/teachers/search-results/?search=1&filters=&text=bats (Scholastic lesson plans about bats)

www.oasisnyc.net/map.aspx (NYC mapping resource tool from 1609-present)

https://www1.nyc.gov/html/dep/html/environmental_education/newtown_wwtp.shtml (Newtown Creek Wastewater Treatment Plant information)

www.plt.org/stem-strategies/have-seeds-will-travel (STEM lesson plan on seed dispersal)

www.asla.org/greenroofeducation/teacher-resources.html (Green roof lesson plans and resources for grades 6-8)

Mitch Waxman/NCA

Kingsland Wildflowers at Broadway Stages.

Glossary

Arthropod. An invertebrate animal with an exoskeleton in the phylum Arthropoda. Includes spiders, crabs, pill bugs, and insects such as bees and flies.

Combined sewer. A type of sewer system that captures wastewater and stormwater in the same pipes and directs it to treatment facilities.

Compression. The process of squeezing something until it becomes smaller.

Critical load. The maximum weight a structure can bear while staying unharmed.

Dead load. Any nonmoving weight on a structure that typically doesn't change over time.

Environmental load. Weight on a structure caused by natural forces such as wind, rain, snow, earthquakes, or extreme temperatures.

Extensive green roof. A vegetated roof with a soil depth of six inches or less and whose plantings are limited to sedums and shallow root native plants.

Green roof. A roof surface predominantly covered with vegetation, a growing medium, and other substrates functioning together as one unit and installed directly on the roof membrane.

Growing medium. A lightweight engineered soil with superior drainage abilities.

Habitat. A space that provides food, water, shelter, access to mates, and/or a place for animals to raise young.

Heat island effect. The occurrence of higher temperatures in areas with more heat-absorbing surfaces and less green space than surrounding areas.

Intensive green roof. A vegetated roof more than six inches of soil depth that can support large plants, such as tall grasses, shrubs, and trees.

Live load. Any weight on a structure that is temporary, such as people walking or cars driving.

Living wall. Plants grown directly on the outside or inside of a building's façade using a support structure, growing media, and irrigation system.

Modular tray system. Plants grown in trays and placed on top of the roof membrane.

Native. A plant or animal that occurs naturally in a habitat, region, or ecosystem without human introduction.

Roof membrane. A roofing system made from synthetic rubber, thermoplastic, or modified bitumen used to move water off of a roof.

Sedum. A genus of succulent plants that retain water in their leaves and stems; many varieties are used on green roofs.

Semi-intensive green roof. A vegetated roof with a soil depth between 25 percent above or below six inches and able to support a mixture of sedums, shallow root native plants, grasses, and small shrubs.

Stormwater runoff. The flow of water that occurs when excess precipitation is not absorbed by the ground surface and enters waterways, often carrying pollutants.

Structural load. A weight or force that is applied to a structure or its components.

Tension. The process of pulling something until it is stretched tight.

Vicki Sando

Teri Brennan/Greenpoint Eco-Schools

Sedum. Extensive sedum green roof at Kingsland Wildflowers at Broadway Stages.

Mitch Waxman/NCA, Vicki Sando, Jake McIntosh/NYCA, Teri Brennan/Greenpoint Eco-Schools

Intensive green roof at Kingsland Wildflowers at Broadway Stages. Insets from top: Living wall at the 9/11 Memorial & Museum. Installing soil medium at Kingsland Wildflowers. Bumblebee on Blanketflower.

GREENPOINT COMMUNITY ENVIRONMENTAL FUND

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