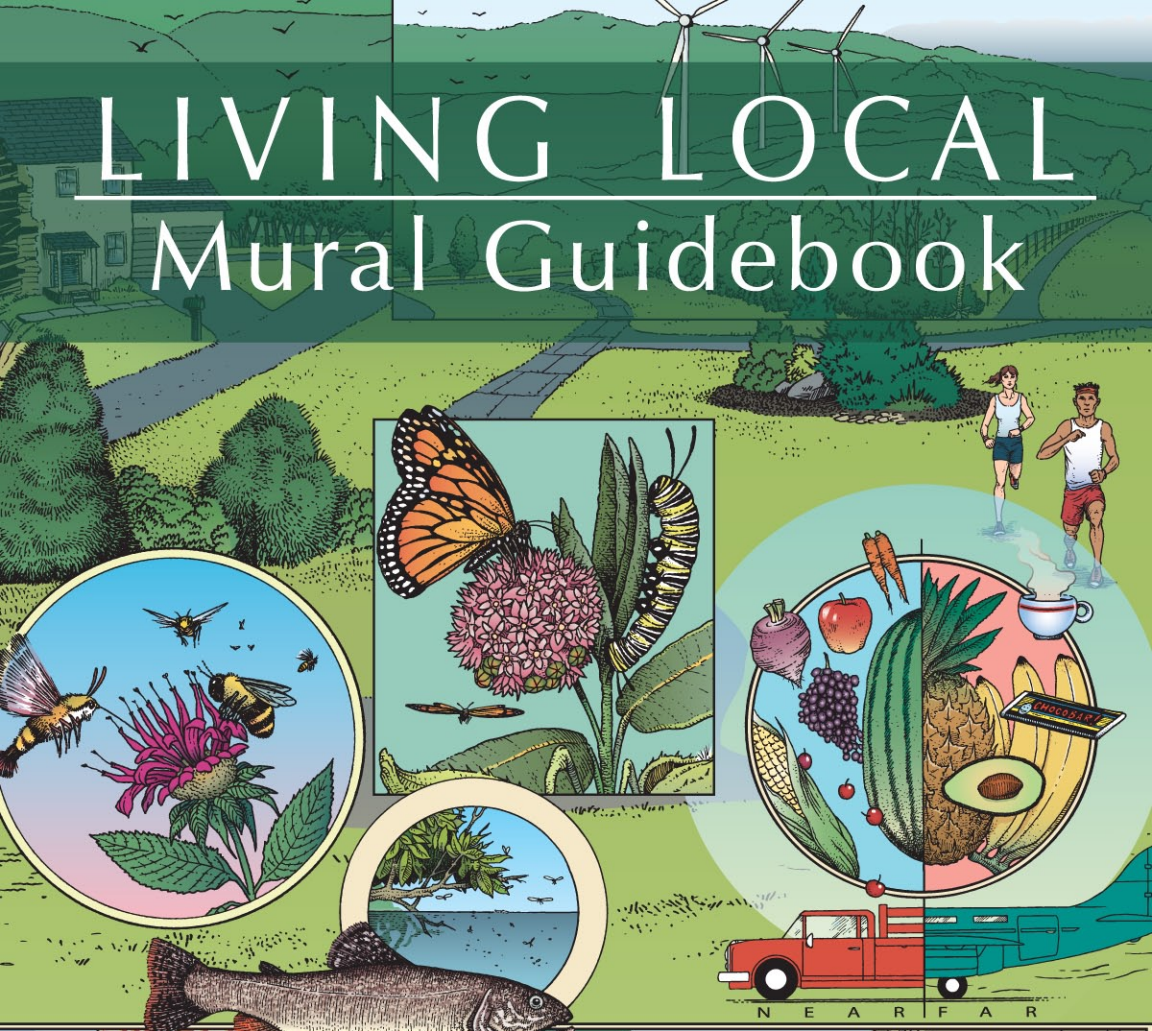
LIVING LOCAL
Mural Guidebook



THE NURTURE NATURE CENTER
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610-253-4432 www.nurturenaturecenter.org

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

General Information

About Nurture Nature Center:
Nurture Nature Center (NNC) is a science-based community organization located in downtown Easton, PA. NNC provides a unique blend of science, art, and community dialogue programs. Home to several art galleries, a breathtaking Science on a Sphere® globe exhibit, and an urban recycle garden, NNC hosts thousands of visitors every year. Science and art programs are regularly held for school groups and public audiences. Additionally, NNC conducts a range of social science research to provide a better understanding of how to educate the public about local environmental risks. Founded in 2007 after repeat flooding in Easton, NNC initially focused on flooding preparedness and flood risk education, but has grown to include a wealth of other programs from kids' crafts to film series and community forums, focused on local environmental issues.

Nurture Nature Center is a joint project of Nurture Nature Center, Inc., and Nurture Nature Foundation.

About the Artist:
Tom Maxfield has been working as a professional artist for over 30 years. He also taught art and drafting for 28 years. Maxfield creates his work using traditional illustration techniques coupled with computer technology, allowing him to construct, colorize and collage elements into a cohesive, expressive whole.

The mural, **"Living Local,"** is 14.5' x 5' and took over 2 years to complete. It serves as a teaching tool for students and the public in order to explore and understand local environmental issues. The mural is a collaboration between Maxfield and scientists **Kate Semmens** and **Kate Brandes.**

Welcome

Nurture Nature Center's project "Living Local Mural: Scenarios, Decisions, and Consequences" was funded through a Pennsylvania Department of Environmental Protection Environmental Education grant (EEF#EE150052). The project consists of a breathtaking 14.5' x 5' curved mural exhibit that is on display at the Nurture Nature Center. This guidebook serves to accompany the mural and help viewers interact with and understand the exhibit. It is also intended for use with school groups as a way to engage students around local environmental issues and can be adapted for a range of ages from elementary through higher education. The mural took over 2 years to create and features over 80 environmental talking points. It provides a comprehensive view of the local environment, including rural, suburban and urban scenes, reflecting typical land use throughout the Lehigh Valley. The work encourages reflection and consideration of how existing environmental conditions affect future health and welfare of the community.

The Living Local Mural complements Nurture Nature Center's global exhibit, **Science on a Sphere®**, a large, suspended globe that shows global earth and atmospheric datasets. The mural is visually attractive in its familiarity and detail, captivating with its depth of inclusion and the multitude of issues and scenarios presented, which provides the capability to connect local situations to global phenomena and visualizations on the Science on a Sphere®.

Taken as a whole, the Living Local Mural fosters viewing the environment as a sum of its parts and is designed to facilitate the learning of ecological processes while communicating the state of local environmental issues and spurring discussion about sustainable decision-making options. The mural creates a context to pose questions, cultivate dialogue, and illustrate the complexity and interdependency of environmental issues. It includes important cross-cutting scientific concepts including sustainability, feedbacks, ecology, habitats, energy, water, invasive species and more.

The use of the mural as a teaching and discovery tool serves to fulfill Nurture Nature Center's goal of environmental education – effectively creating environmental literacy that informs wise, well-deliberated decisions. Providing a comprehensive view of the local environment garners a deeper understanding of important local and regional issues and facilitates further connection and understanding of the environmental concepts learned in the classroom. It is hoped that by focusing on actual, familiar local scenarios students are better able to grasp science concepts and understand their immediate surroundings.

> How to use this guidebook:

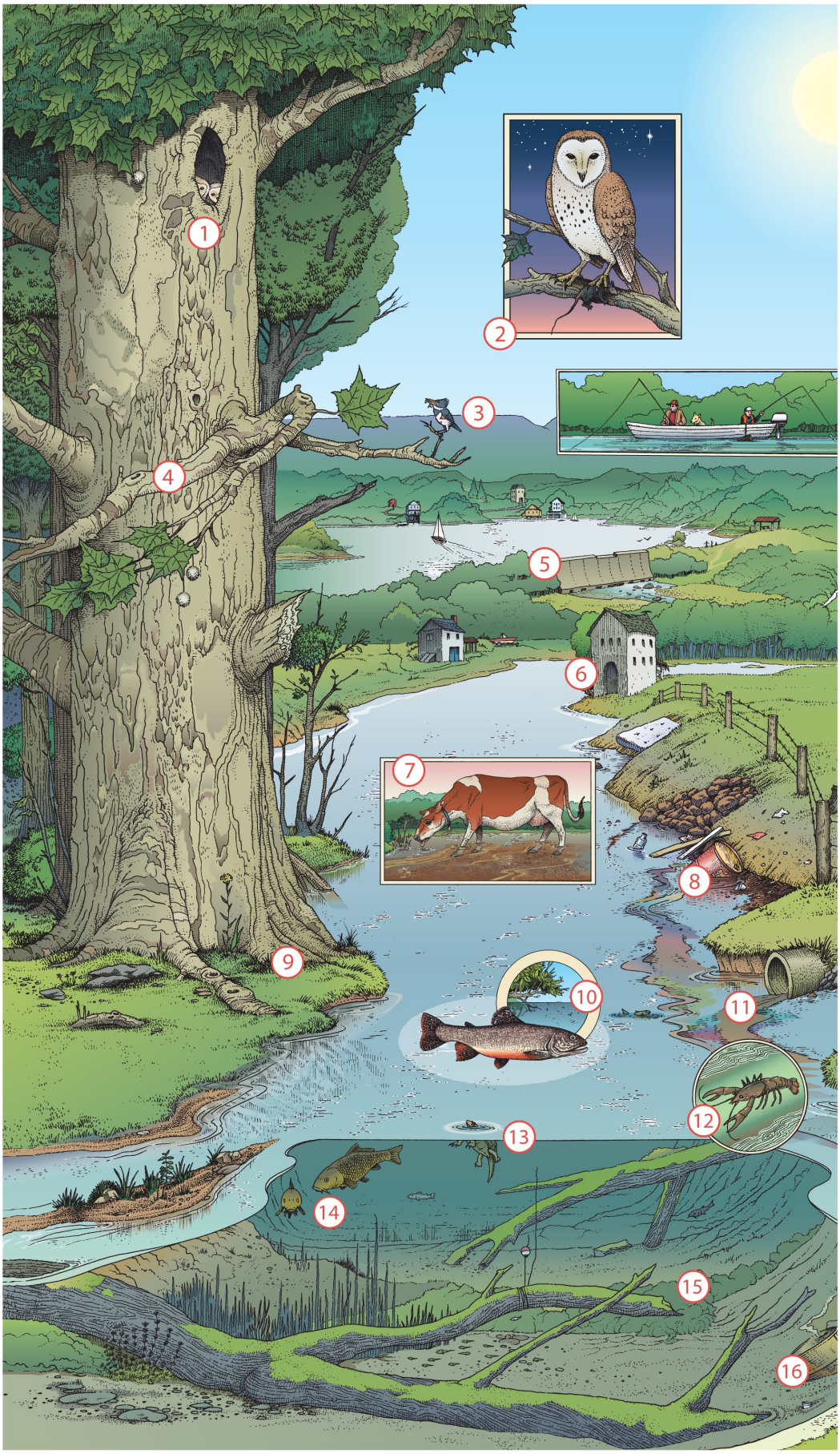
The mural is broken down into 5 panels: ***The River; Water, Water Everywhere; Suburban Life; Sustainability; and Urban Life***. Each panel has its own pull out section that provides an introduction, details about the components of the panel, cross-cutting issues, questions for discussion and reflection, and hands-on activities. There is a resource list in the back of the guidebook. The guidebook is meant as a supplement to the full size mural on display at Nurture Nature Center, as well as a way to interact with the materials offsite, back in the classroom.

LIVING LOCAL

Scenarios, Decisions, and Consequences

INVASIVE SPECIES **SUSTAINABILITY** WATER QUALITY **HEALTH & SAFETY** RESOURCES **ENERGY** REUSE **AIR QUALITY** NATIVE SPECIES **FOOD ACCESS** INDICATOR
LAND USE POLLUTION **INVASIVE SPECIES** SUSTAINABILITY **WATER QUALITY** HEALTH & SAFETY **RESOURCES** ENERGY **REUSE** AIR QUALITY **NATIVE SPECIES**
INDICATOR SPECIES LAND USE **POLLUTION** INVASIVE SPECIES **SUSTAINABILITY** WATER QUALITY **HEALTH & SAFETY** RESOURCES **ENERGY** REUSE **AIR QUALITY**

1	2	3	4	5
The River	Water, Water Everywhere...	Suburban Life	Sustainability	Urban Life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The River

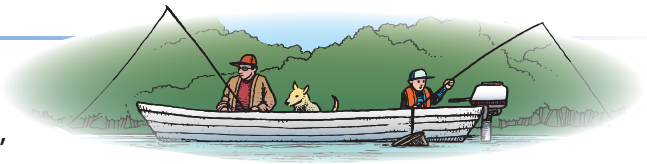
The river – a beautiful resource and habitat – should not be neglected or abused. Often used as a place for waste, it is also our source of drinking water. Historically, humans have tried to control rivers through the construction of dams. Dams allow the river flow to be controlled and provide a place for recreation on the lake that is made behind the dam. However, dams disrupt the natural flow of the river, including the erosion and deposition processes that occur along the river. They also create a build up of material behind the dam which deprives lower reaches downstream of the sediment needed to maintain physical processes and habitats, and results in significant erosion of the riverbed. The lake/reservoir is a completely different system from the free-flowing river and is a slack-water habitat that differs in temperature, dissolved oxygen levels, and chemical composition which results in different (usually non-native and invasive) species taking up residence there.

While humans often view the river as a resource (source of freshwater for our many water needs) or convenient waste receptacle (dumping in rivers used to be common - wisely, modern systems treat the wastewater before it is returned to the river), the river is home to many important species. Some of these species are sensitive to water quality and serve as an indication for the health of the river ecosystem. We would be wise to pay attention to these species, and respect and care for the river if we want to continue being able to use the river for the many benefits we derive from it.

Illustrations - Panel 1

1. Habitat loss - baby barn owls
2. Indicator species: habitat loss - barn owl
3. Indicator species: habitat loss - kingfisher
4. Native species - sycamore, tulip, ash, etc.
5. Dam building/removal - species migration
6. Floodplain impediments - new & historic structures - mill, summer cottage, fences
7. Pollution - stream access for domestic animals - cattle
8. Pollution - illegal & historic dumping
9. Riparian buffers - water quality - protection & removal
10. Aquatic life - food source & water temperature - brook trout
11. Pollution - stormwater outfalls
12. Indicator species: water quality - macroinvertebrates - crayfish
13. Species loss: reptiles & amphibians - snapping turtle
14. Introduced species - common carp
15. Aquatic algal growth - nitrate (run off) pollution
16. Pollution: water quality & toxic materials

The River

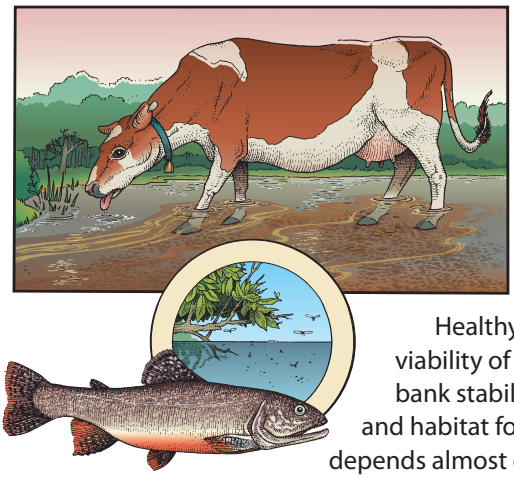


Rivers are the source of life for many plants and animals, as well as human beings. Species have evolved that are closely linked to rivers, streams and other waterways, and many interdependent relationships between plants and animals depend on the environmental conditions of riverine life.

Here, **barn owl chicks (1)** inhabit a cavity nest in an old **sycamore tree (4)**. Sycamores are native flood-tolerant trees and are found in ***riparian*** (waterside) areas throughout Pennsylvania. Natural holes in sycamore trees are the nests of choice for barn owls, and loss of these riparian habitats have made barn owls a rare sight in Eastern Pennsylvania. **Barn owls (2)**, a ***nocturnal*** species, along with the **belted kingfisher (3)**, a ***diurnal*** species, are ***indicator species*** of healthy habitats. An indicator species is a type of animal or plant who is sensitive to the quality of their environmental conditions, thus their presence in an ecosystem indicates the quality of the environment and whether the habitat is polluted.

Dam (5) construction for recreation or economic development can have a strong impact on river and stream habitats. The most notable impacts are associated with ***fish migrations***. Dams also alter river dynamics, changing the flow rate and temperature of the water, and increasing erosion of important streamside habitat. Today, historic dams are being removed for waterway health.

Riverside communities are very familiar with the risk of periodic flooding. Flooding is a natural process that allows for the dissipation of excessive rainfall onto ***floodplains***, which are flat areas next to rivers that can temporarily store large amounts of water. **Buildings, fencing and other structures (6)** that have been built in the floodplain can create impediments to floodwater flow and dissipation and may cause local and upstream flooding to worsen.



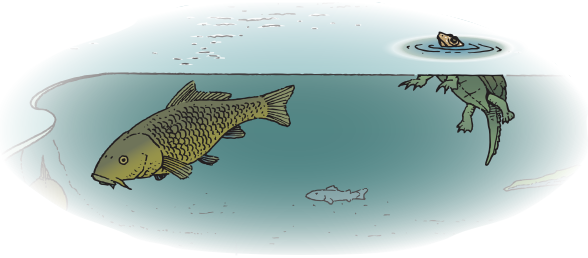
Pollution (7), (8), (11), (16) from many sources impacts the quality of streams and rivers. Garbage from dumping, access by livestock and livestock waste, agricultural fertilizers, and toxins carried by untreated stormwater pollute local waterways, killing wildlife, encouraging harmful **algal growth (15)**, and impairing drinking water sources.

Healthy **riparian areas (9)** are important to ensure the viability of waterways. Streamside vegetation promotes bank stabilization, filters pollutants, and provides food and habitat for aquatic life. The native **brook trout (10)** depends almost entirely on riparian plants to provide it with cooler water temperatures, food, and shelter. Most of the sustenance for native fish species falls from the canopy of streamside trees.

When studying stream quality, scientists conduct ***macroinvertebrate counts***. Macroinvertebrates are small animals without backbones that are visible to the naked eye. These include crustaceans, worms, and aquatic insects and their larvae. Identifying numbers of certain aquatic macroinvertebrate species can indicate water health. The **crayfish (12)**, a crustacean, is an important indicator macroinvertebrate that flourishes in clean waters and perishes in impaired waters. Their presence indicate the quality of riverine and stream environments.

Reptiles and amphibians are species that are particularly threatened by loss of healthy habitat. ***Amphibians*** - salamanders, frogs, and toads - have permeable skins that can absorb toxins from their surroundings, and, even though they have scales, ***reptiles*** - lizards, snakes, crocodilians, and turtles - can build up toxins in their tissues over time.

Snapping turtles (13) are not as sensitive to water quality as other aquatic life, but over their 30-year lifespan they can build up dangerous levels of toxins, making them hazardous to eat.

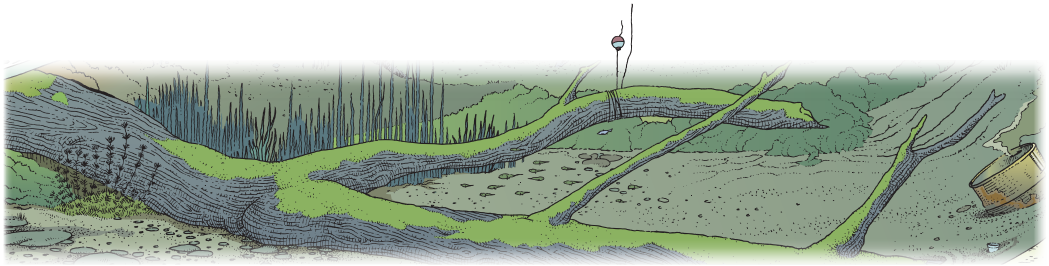


Some non-native species can become ***naturalized*** to local ecosystems. Naturalization is a process in which non-native species adapt to an environment enough to reproduce in sustainable numbers.

The **common carp (14)**, a naturalized species, originated near Asia and was imported into the United States in the mid 1800s. Because this large, hardy fish is tolerant to pollutants and is highly adaptable, it can be found in local streams and rivers in surprising numbers. Carp can be a hazard to native fish and fowl due to their uprooting of vegetation while searching for food and the subsequent muddying of waters. This can reduce the oxygen content of streams, rivers and lakes and destroy the food source for native bird and fish species.

Questions:

- Why is a healthy riparian ecosystem important to maintain? What factors affect the health of the river?
- What effects do invasive species have on the environment?



The River

Cross-cutting Issue:

Habitat - Habitat health has a significant impact on the species that live there. Think of your home - if it is too hot or too cold, or if there is not enough food and water, or if the air is polluted, you would not be able to live there healthfully. The same is true of all habitats and species from the river ecosystems explored in **Panel 1** that are home to numerous fish and amphibian species to the urban fringe vegetation such as milkweed in **Panel 5** that provides habitat for butterflies, birds, and other insects.

Hands-on Activity:

Watersheds - Make a watershed model and learn what happens when rain falls and how water moves through the landscape.

You will need:

- a large aluminum roasting pan
- 10 pages of newspaper
- masking tape
- a sheet of white plastic slightly larger than the pan (you can use a trash bag)
- a spray bottle
- blue food coloring
- paper towels
- markers
- a notebook to lift the end of the tray

Instructions:

1. Crumble the newspaper into balls and rolls - all different sizes and shapes and tape them to the roasting pan.
2. Put the notebook under one end of the pan and lay the plastic bag over the entire pan, pressing the plastic down around the crumpled paper balls (the plastic is the Earth's surface and the lumps are mountains and hills with the areas in between representing valleys).
3. Fill the spray bottle with blue dyed water and spritz the pan to see how water interacts with the landscape. Notice what path the water takes and where it pools.
4. Use the paper towels to dry the model, adjust your landscape and try it again. Can you predict the locations of streams and drainage divides?

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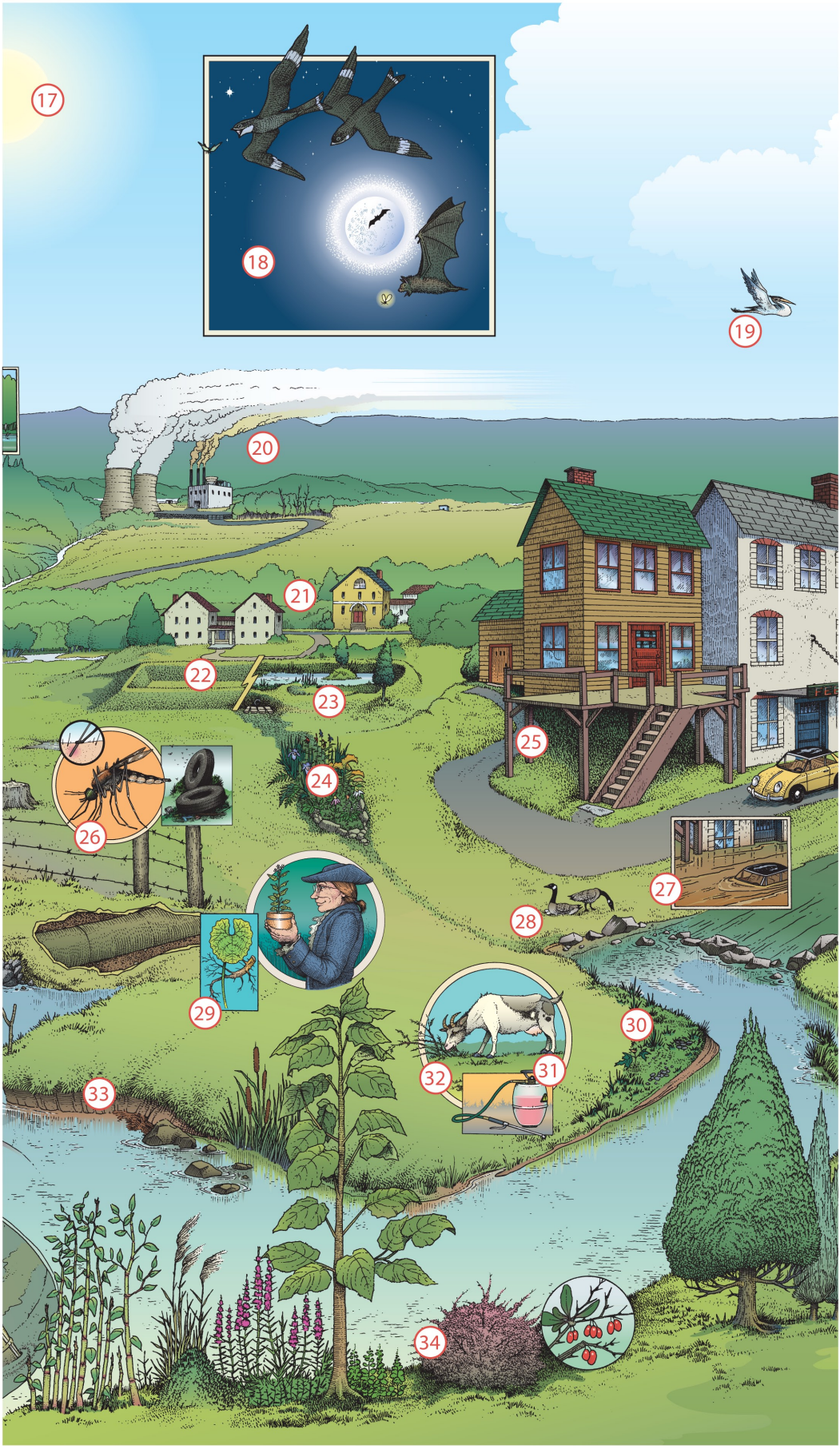
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Water, Water Everywhere...

Water is crucial to live on Earth and it is what makes Earth so unique among the planets in our solar system. Water covers 70.9% of Earth's surface but 97% of that is salt water in the ocean. Only 0.3% is fresh water and most of that is trapped in soil, glaciers, or plants and animals, so there is really only a very small amount available and clean enough for us to use.

The water cycle is the movement of water driven by the sun which heats water in the oceans causing evaporation. This vapor, combined with water transpired from plants and evaporated from soil, condenses into clouds in the atmosphere and is moved around by wind. Precipitation can fall as snow or rain and gravity turns the runoff into rivers leading to bays and lakes and ultimately the ocean. Some runoff is infiltrated into the ground to be used by plants or stored in aquifers which we use for our drinking water.

Water impacts our landscape, carving paths with rivers, eroding soil and transporting it to the oceans. Too much water can create flooding, especially in highly developed areas where paved, impermeable surfaces lead to surface runoff that would normally infiltrate slowly into soil and be drawn up by plants and trees. The risk of flooding can be reduced by maintaining natural riparian ecosystems in the floodplains and keeping buildings and homes out of the floodplain.

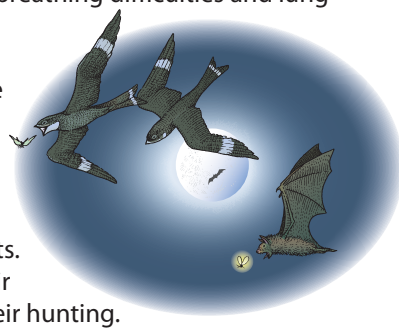
Illustrations - Panel 2

17. Sunlight - UV radiation, haze, & solar energy
18. Nocturnal species - natural pest control - nighthawks & big brown bat
19. Native species - blue heron
20. Pollution - particulates, compounds, air temperature
21. Suburban building - land use
22. Stormwater detention - traditional basins
23. Stormwater detention - naturalized basins
24. Water quality - rain garden - native plant species
25. Floodplain management - raised structure
26. Health risk: West Nile disease & pest management - mosquitoes
27. Floodplain structures & impediments
28. Nuisance species: unbalanced growth - predator loss - Canada goose
29. Introduced invasive species: species displacement - garlic mustard
30. Flood abatement - unimpaired floodway
31. Nuisance species control - natural vs. chemical - herbicide
32. Nuisance species control - natural vs. chemical - goat
33. Streambank erosion
34. Invasive exotic species: displacement of natives

Water, Water Everywhere...

All life is dependent on water. Waterways, streams, rivers and large bodies of water are the centers of existence for countless plant and animal species. Historically, people have built homes, created industry and enjoyed recreation on the banks of our rivers and streams. Often these structural changes affect river and stream health, especially where watercourses are modified or altered for specific human needs. Clearing or destroying riparian areas can have strong impacts on human and wildlife habitats.

The **Sun (17)** provides us with warmth and energy. It is as essential to life as water. However, ultraviolet rays from the Sun can create health problems ranging from sunburns to cancers and cataracts. UV radiation interacts with oxygen (O2) to form ozone (O3) in the stratosphere. This ozone layer exists about 6-30 miles above the Earth's surface and helps reduce the amount of UV radiation that reaches the surface. Ozone at the ground-level (troposphere) is formed from photochemical reactions of **air pollutants (20)** of volatile organic compounds and nitrogen oxides. These reactions may depend on the presence of heat and sunlight which creates higher ozone levels in the summer that we experience as haze, and can create breathing difficulties and lung inflammation.

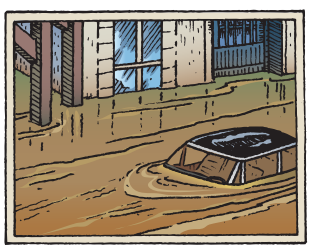


During daylight hours most plant and animal wildlife is active. They are known as ***diurnal species***. Other species, like the **big brown bats** and the **common nighthawks (18)** pictured here, are most active at night. These are ***nocturnal species***. They feed on and help to control pest insects like mosquitoes and gnats. Bats use ***echolocation*** (similar to sonar) to locate their flying prey while nighthawks depend on sight for their hunting.

The **great blue heron (19)** is a large native bird that frequents streams, pools, wetlands and grasslands. Its primary food source is fish and other aquatic life, but it has been known to consume an occasional groundhog. The great blue heron can reach 5 feet in height. Here it is pictured in its characteristic flight position, with its neck in an "s" shape and its legs trailing behind.

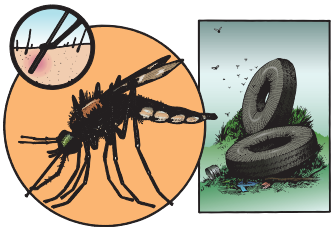
Suburbs (21) came into existence during the mid 20th century when post-war housing needs exceeded available homes. Builders began rapidly developing in the rural areas outside cities and towns. With this building came the need for additional roads, utilities and upgrades to existing infrastructure. Today, this building trend continues, often replacing wildlife habitat and farms. Poorly planned development can create stormwater runoff, pollution and traffic problems for existing neighborhoods.

Traditional suburbs use man-made structures like **detention ponds (22)** to control the quantity of stormwater runoff. In recent years these ponds have been **"naturalized" (23)** in order to improve aesthetics, habitat and especially water quality. These ponds rely on the ability of native plants to absorb toxins and dissipate rainwater. Another recent innovation is the use of **rain gardens (24)**, planted depressions that help to mitigate runoff and **erosion (33)**.



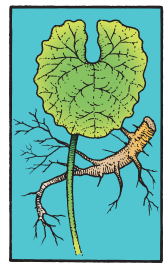
Every year people suffer **catastrophic damages from flooding (27)**. However, steps can be taken to lessen these losses. **Raising homes on stilts (25)** above high

water levels and removing objects and structures from the floodplain can reduce flood losses. Many historic floodplain structures like mills have been flooded many times.

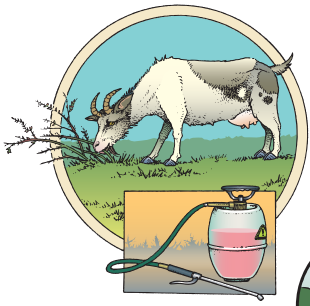


Standing water, like inside the tires pictured here, creates breeding places for **mosquitoes (26)**. Mosquitoes are carriers of diseases like malaria, zika virus, and West Nile disease, which has sickened many in Pennsylvania. Dumping out water collectors after a rainfall prohibits breeding of these disease-carrying insects.

Another nuisance species associated with waterways is the **Canada goose (28)**. Although it is a native species, its adaptability has allowed it to succeed in many types of settings. Its large size, numbers and droppings have impacted many local watercourses. These geese prefer mowed and cut areas, and leaving **unmowed areas (30)** next to water may inhibit nesting.



Introduced species (non-natives) can create difficult conditions for native species. One introduced plant that has become naturalized is **garlic mustard (29)**. Originally brought overseas by European colonists as a medicinal spice, garlic mustard has become one of the most invasive plants in Pennsylvania. It may be found along any roadway, forest clearing or field and spreads through its roots.



Unwanted vegetation has traditionally been eradicated through the use of **herbicides (31)**. Recently, **goats (32)** have been used for vegetation control. Goats are known to eat almost any kind of plant, especially many that are resistant to herbicides. Many people find this approach preferable to using poisons.

Invasive plant species (34) can be difficult to control. Many are hardy and quick-growing, capitalizing on any bit of open or broken ground. The invasive plants pictured here are ***Japanese knotweed, phragmites (Europe, Asia, Australia), purple loosestrife (Europe, Asia), paulownia (China), garlic mustard (Europe, Asia) and Japanese barberry (with detail)***.

Question:

- Have you ever experienced flooding? What are the best ways to manage flooding risk?

Water, Water Everywhere...

Cross-cutting Issue:

Invasive species - Invasive species are not originally found in an environment, having been brought there on purpose for aesthetic reasons, for population control or brought by accident, hitchhiking on materials or bodies. From plants (**the garlic mustard here in Panel 2**) to animals (**the common carp in Panel 1** and **emerald ash borer in Panel 5**) there are examples of invasives in every human altered environment, and they often have detrimental impacts on the native ecosystem.

Hands-on Activity:

Rain Gauge - How much rain is really falling at your house or school? Does the amount of rain compare to how long the showers last? Make your own rain gauge to find out!

You will need:

- a plastic bottle
- some small stones
- masking tape
- a black marker that will write on plastic
- a ruler

Instructions:

1. Carefully cut the top third off the bottle.
2. Place some stones in the bottom of the bottle. Turn the cut-off top upside down and tape it to the bottle to make a funnel top.
3. Use a ruler and marker pen to make a scale on the side of the bottle. Start your scale 1 inch from the bottom of the bottle.
4. Pour water into the bottle until it reaches the bottom strip on the scale.

Congratulations, you have finished your rain gauge!

Put your rain gauge outside where it can collect water when it starts raining. After a rain shower has finished, check to see how far up the scale the water has risen. Graph the rainfall over weeks or months to see how things change seasonally.

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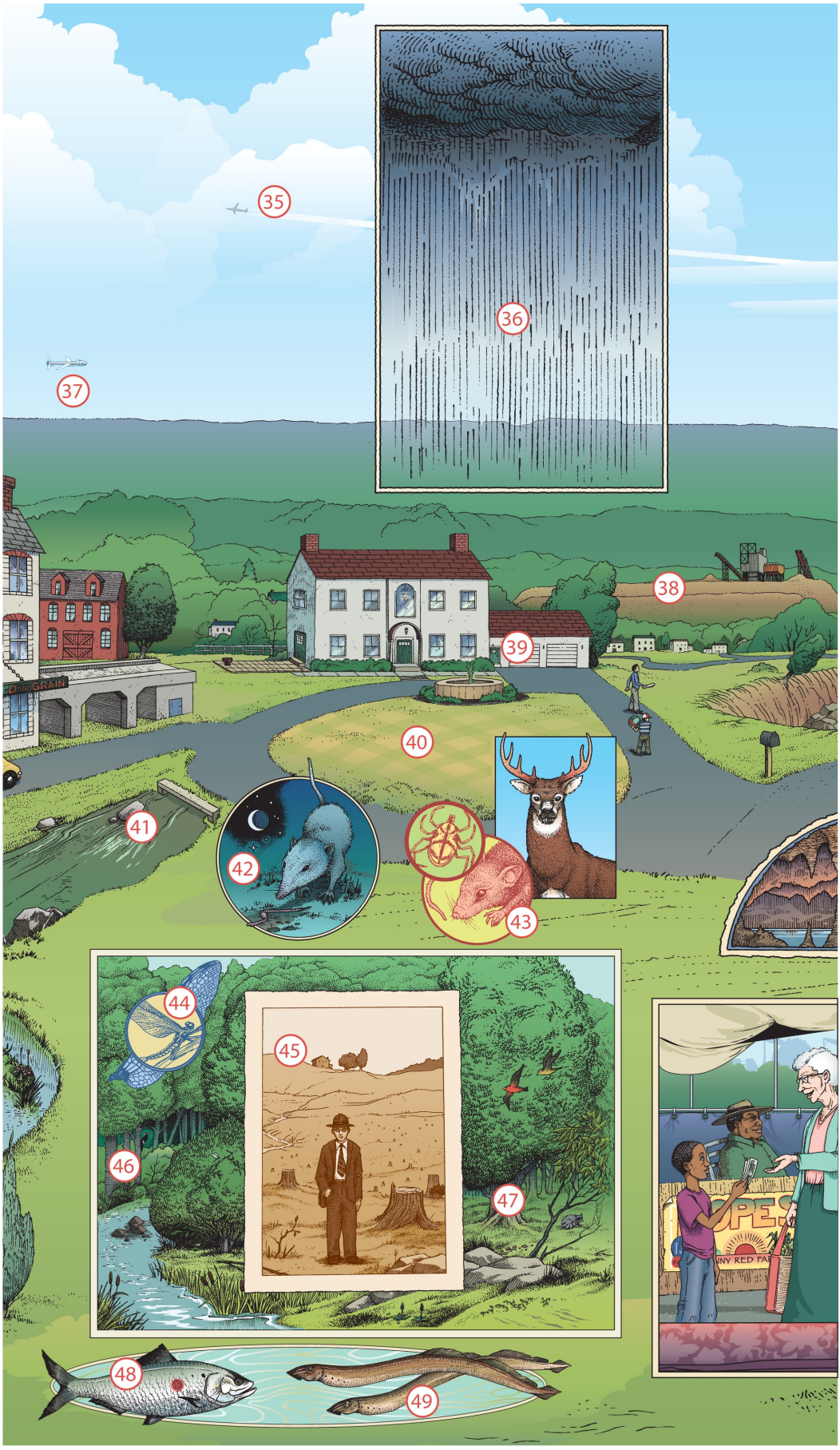
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Suburban Life

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Humans have and continue to alter the landscape significantly. From paving for roads and driveways to building homes and businesses, the human footprint grows everyday. Suburban life has a much larger human footprint (figuratively and literally) than urban life, requiring more space and resources to maintain larger homes and perfectly trimmed lawns, turning the environment into something far from natural.

But what is natural? The landscape we see today is not the same as years past - there is a history to every place. When the first European settlers came to Pennsylvania they encountered a thick, dense woods (this was why it was named Penn's Woods) of Chestnut and other native trees. It has been said a squirrel could travel from Pennsylvania to the Mississippi River without ever stepping foot on the ground. Most of the forest was lost due to clearing for farmland and a result of disease. There are only a few true old growth forests left in the state. The forests we know and love today are second or third growth forests that grew back on abandoned farmland.

Illustrations - Panel 3

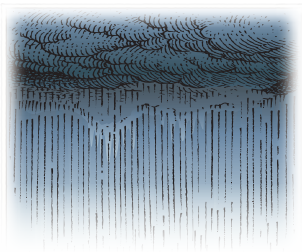
35. Air quality - jet contrails - energy use, atmospheric temperature & reflectivity
36. Extreme weather - major thunderstorm - flooding, property damage & safety
37. Drone - monitoring of habitats & remote areas
38. Open pit mining - water issues: quality, quantity & sink holes
39. Impervious cover - water runoff, water quality & flood exacerbation
40. Lawn - chemical use, energy use, monocultural issues & water pollution
41. Channelized stream - culvert & storm drain system, flood exacerbation
42. Nocturnal species: young opossum - native marsupial & non-native red worm
43. Natural processes - Lyme cycle: tick, field mouse & whitetail deer
44. Indicator species - macroinvertebrates - mayfly
45. Historic condition - removed forest cover and riparian circa 1920
46. Indicator species: pileated woodpecker
47. Riparian area with native & naturalized plant species - current forest cover
48. Native species with lamprey wound - American shad
49. Parasitic species in local waterways - lampreys

Suburban Life

Man's reach has extended from the bottom of oceans to the vacuum of space. It is difficult to find a region or area on Earth that has not felt the touch of humankind. With that touch comes the alteration and modification of our Earth's environment to meet our needs and desires. Many areas have been so significantly changed that they no longer bear a resemblance to or represent conditions that preceded human activity.

Today, there is a growing awareness of human impacts on the Earth, and people are working to lessen these impacts and reduce our "footprint." This affects the planning of our cities and suburbs, and points the way to developing alternate energy sources and smart utilities.

At any hour of any day you can look into the sky and see streaks, or **"contrails" (35),** from commercial planes and other aircraft. The altitudes of today's commercial jets have only been achievable since the 1950s. Since then, scientists have monitored the effects of contrails and found that their reflective nature and density can lower air temperature. This effect increases with the number of contrails in the sky at any one time.



Thunderstorms (36) can also affect the air and ground temperatures of the Earth. Sustained heavy cloud cover laden with moisture can significantly alter local temperatures and, in the case of solar powered facilities, impact energy generation. Conversely, lack of rainfall can create drought conditions that damage livestock, crops and natural and man-made habitats. It is important to realize that rainfall is a major component of the water cycle that makes freshwater available for us to use. With climate change, extreme weather events such as thunderstorms may be more likely because warmer air carries more moisture. For our area, the northeastern US, increased rainfall is projected in the near future, mostly in heavy downpours that create flooding conditions.

A recent technological development with immense possibilities is the **drone aircraft (37).** These relatively small, remote-controlled craft have progressed well beyond the initial military use and are being used for visual access to remote areas and unreachable locales. Use of drones has proven to be a valuable and unintrusive way to monitor natural habitats and wildlife health when done by trained professionals.

As we continue to spread across our planet, we inevitably run into conflicts associated with land use. Often, this takes the form of clashes between industry and residential areas. Pictured here is a **stone quarry (38)** that is in close proximity to homes in a suburb. This proximity can create problems, like water and well pollution, sinkholes and stream impacts from water pumping, noise, dust and aesthetic concerns.

Many **suburban homes (39)** create large amounts of impervious surfaces. Impervious surfaces are ground covers that will not absorb rainfall like natural vegetation and soil would. This can create runoff problems for residents and downstream neighbors because land that would normally absorb water (before building) is now covered and blocked by homes, driveways and patios. That water is then transferred downstream to other properties, increasing in volume and power. This is a major

recognized cause of flooding. Recently, ***pervious (absorbing) materials*** have been developed for residential and commercial uses to help reduce impervious footprints. ***Green infrastructure*** can also reduce storm-water runoff and includes rain gardens, green roofs, and bioswales.

Another aspect of suburban development is the maintenance of lawns. Over mowing (pictured here: **pattern mowing) (40)** uses additional energy and pollutes the air - ***cut your grass for one hour and you emit the same amount of pollutants as 8 new cars driving 55 mph for one hour!*** Application of lawn chemicals, including fertilizers, herbicides and pesticides, results in poisons filtering into our waterways and **groundwater sources (41)**. Lawn chemistry has been identified by researchers as the number one polluter of Pennsylvania's waters and has been found to correspond to instances of adverse health impacts on children and pets.

Some species have adapted well to suburban conditions. Hawks and other raptors are increasing in our cities and suburbs, and some ground species have exploited the opportunities in residential areas. Pictured here is an **opossum (42)**, North America's only native marsupial, hunting a **red worm (42)**, a non-native species originally introduced from Europe. The opossum is a ***nocturnal species*** that has adapted well to the change in habitat, frequenting residential areas and dining on food waste. Recently, opossums have been studied for their resistance to diseases like Lyme's and rabies. They consume large amounts of **ticks (43)** making them valuable to disease control. Infectious ticks are carried by rodents, like the **white-footed mouse**, **white-tailed deer (43)** and other animals, including family pets. Opossums have proven to be very effective at ridding themselves and their environment of ticks at a rate of about 5000 a season.

The **mayfly (44)** is an ***indicator species*** whose aquatic larval (nymph) stage is a sign of clean, non-polluted waterways. Pictured is the winged adult stage that lives a brief 24 hour life that includes "hatching" (emerging from the water) and breeding. Unlike their name may imply, different species of mayflies hatch throughout the summer months.

When European settlers first arrived in America, the Eastern landscape was densely wooded. During the late 1800s and 1900s Pennsylvania's forests were almost entirely cleared for **lumber and farming (45)**. Our woodlands today are **regrowth forests (47)** that are often managed and/or protected. Many areas have re-established dense vegetative growth that provides habitat for rare or stressed species. The **pileated woodpecker (46)** is a bird that has made a comeback in Pennsylvania due to forest regrowth. These large birds prefer stands of deep forest and large, old trees for roosting.

The **American shad (48)** is a native fish that, like salmon, spend most of their life in the ocean and return to the rivers of their birth to breed. In Pennsylvania, dam construction has impaired historic shad runs and reduced their numbers. Pictured is a shad that has been scarred by a **lamprey (49)**, a parasitic fish that attaches itself to a host fish, feeding on its blood. Lampreys can be found in local rivers and streams.

Suburban Life

Cross-cutting Issue:

Pollution - Pollution of air, water, and soil occurs in all environments - rural, suburban and urban. **Panel 1** shows pollution dumped into the river and along the banks. Here in **Panel 3**, chemicals enter the waterway after being applied to lawns and cars, and lawn mowers (frequently found in suburban areas) pollute the air.

Hands-on Activity:

Weather - Make Your Own Thunderstorm - Thunderstorms cause heavy rain and flash flooding. Every thunderstorm produces lightning. Lightning strikes kill more people every year than tornados. When warm and cold air masses meet a thunderstorm can form. More extreme weather is projected in the future due to climate change.

You will need:

- a shoebox size clear plastic container
- an ice cube tray
- red food coloring
- blue food coloring
- water
- colored pencils
- index cards

Instructions:

1. Make ice cubes with water dyed with blue food coloring.
2. Fill the plastic container with room temperature water 2/3rds full.
3. Put a blue ice cube at one end of the container.
4. Add 2 drops of red dye to the water at the opposite end of the container. Observe where the red and blue dyes move.
5. Use colored pencils to draw what is happening. Think about what air mass the red and blue represent and how this relates to a thunderstorm.

The activity shows ***convection*** - cold water sinks and warm water rises above the blue. Convection is warm air rising and cold air sinking - a thunderstorm is caused by such unstable air conditions when warm moist air is lifted by a cold front. The warm air cools as it rises, condenses, forms clouds, and releases heat which helps the thunderstorm grow.

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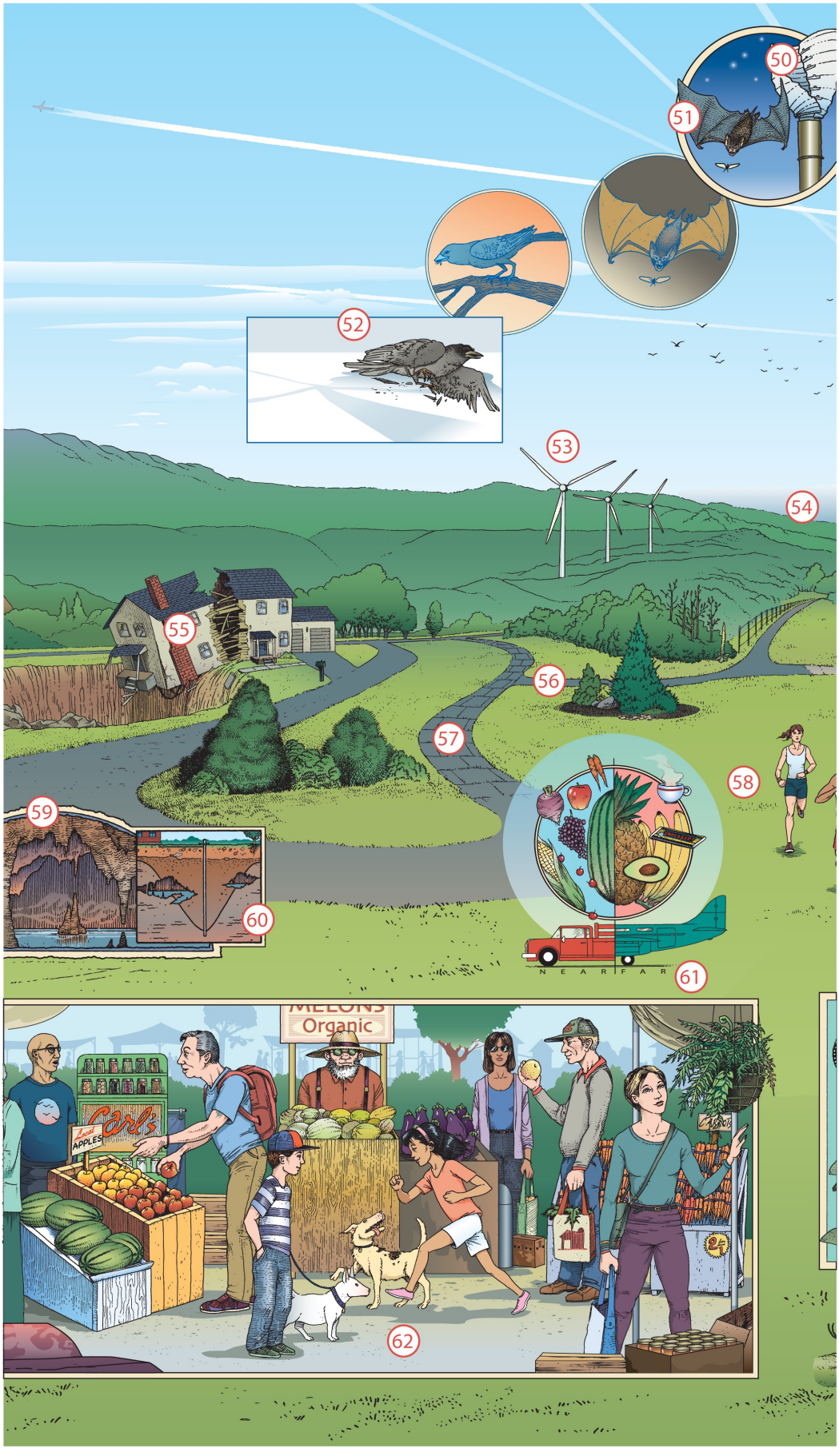
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NEAR FAR
Organic
Local APPLES
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Sustainability

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There are many resources and activities needed to provide us with the materials and qualities of everyday life that we often feel we can't live without. The energy for your phone and TV requires natural resources (either renewable such as wind or nonrenewable such as oil or coal) and a vast system of collection and distribution infrastructure to get the energy in a usable form delivered to your home. Food also requires a tremendous amount of resources - from the soil and water to grow the crops to the transportation of the produce to your local farmer's market or grocery store. We often do not think about the true cost of the materials, food, and energy we consume, but it is important to consider the life cycle of all our consumption, especially related to its sustainability.

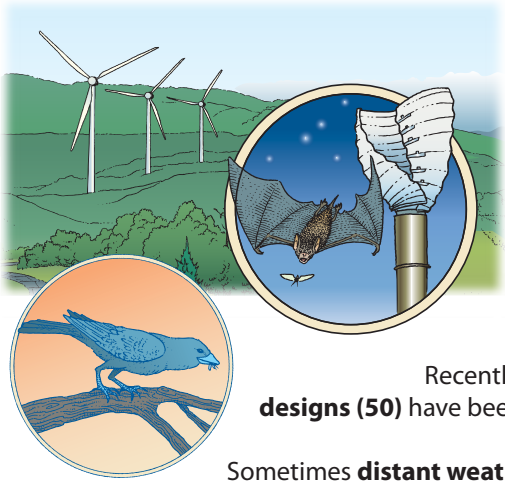
While we might have cheap oil today and easy access to fuel for our cars this will not always be the case. Oil is a nonrenewable resource and once we have used all that is feasible to drill we will need to have developed alternatives if we want to continue the lifestyle we enjoy today. Alternatives that are sustainable include solar and wind energy. Contrary to nonrenewable fossil fuels, solar, wind, and other renewable energy sources have the added advantage of not polluting the air we breathe and not contributing to climate change through greenhouse gas emissions. While we might love bananas we must remember they are not a local food and require a significant amount of transportation to get to our local store. The longer the supply chain the more food waste occurs and the more resources and costs accumulate. Is this sustainable? Supporting local farmers and eating produce that is seasonally available not only helps the local economy but reduces the carbon footprint of our lives.

Illustrations - Panel 4

50. Energy - alternate windmill designs
51 - Energy consequences - little brown bat
52. Energy consequences - wildlife loss - migration patterns - catbird
53. Large-scale wind farm
54. Distant thunderstorm - remote flooding source
55. Karst geology - sinkhole threat & property loss
56. Recreation - walking trails
57. Water infiltration - pervious pavers
58. Recreation - available green space & facilities
59. Karst geology - underground cavern
60. Karst geology - cone of depression intersecting caverns
61. Food - local & remote sources, energy use & availability
62. Food - farmer's market - local food & products

Sustainability

As our lives become more complex our energy needs increase. From transportation to communication, energy powers our lives. Researchers have expressed the need for renewable, sustainable energy. The concept of ***"sustainability" means that an activity can be indefinitely continued without harmful or lasting impacts***. Wind and solar are renewable, sustainable forms of energy that are currently being used to power or supplement our daily needs.

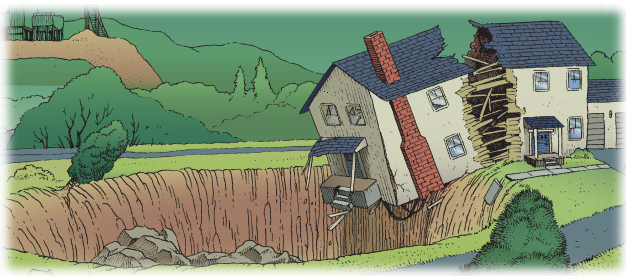


Windmills (53) are becoming common sights in Pennsylvania where they are installed along ridges to capture the optimum air flow. However, windmills have been identified as dangerous to some wildlife, especially **birds and bats (51, 52)**. These creatures fly into the blades and are injured or killed. Recently, slower blades and **alternate windmill designs (50)** have been utilized to reduce or eliminate impacts.

Sometimes **distant weather events (54)** can trigger local impacts. Here, a distant thunderstorm is seen, far away on the upper portions of a river. Even though the rain may never fall locally, an upstream event can cause flooding as local waterways attempt to deal with excess flow. Paying attention to weather alerts can help people prepare for these impacts.

Local areas are underlain with fragile and sensitive geology. In prehistoric times Pennsylvania was a shallow sea, and as a result there are large, low-lying areas of limestone under current residential and industrial land. Limestone is formed by the laying down of countless layers of shelled sea life, like clams, crabs, mussels and coral. This limestone is known as ***carbonate or "karst" geology***. It is easily dissolvable and is prone to **sinkholes (55)**, **caverns (59)**, fissures and collapses that are often triggered by varying levels of groundwater. Drilling a well creates a **cone of depression(60)** in groundwater levels. Sometimes this may lead to sinkholes and collapses due to the loss of support as the water is pumped out.

By using ***pervious materials*** or ***green infrastructure*** people can help to mitigate impacts to groundwater and sensitive areas. **Pervious pavers (57)** have been used for walkways, driveways, parking lots, patios and trails. These pre-cast blocks ***infiltrate rain water (allow water to pass through)*** and help to replenish groundwater supplies.



Pennsylvania communities have constructed **trail systems(56)** to facilitate enjoyment of rural environments. Walking, biking and **running (58)** are popular activities that benefit from these connecting systems.

Some trails are built on old railway routes, and often, trails provide links to other communities, extending the available recreational facilities.

Sustainability, when relating to food, is about local and remote sources. It can also include organic and nonorganic considerations. Foods that we consume every day may have various origins, both near and far. However, the farther away a food source the more expensive it is to transport and the more need there may be for preservatives and protective packaging. Pictured is a **graphic image (61)** that represents these ideas, showing "near" foods that can be transported simply and more cheaply, and "far" foods that require shipping and treatments for preservation and marketing. Energy costs to ship and fly far foods from places like South America, Central America, and Asia can dwarf the expense of transporting near foods.

One recent trend has been a move toward the establishment of **farmer's markets (62)**. These small markets specialize in locally grown foods and products, and provide a source for communities to purchase fresh, healthy produce from known growers and suppliers. Local foods are responsive to seasonal conditions, local weather and regional economies, not to mention they taste fresh and are packed with flavor and antioxidants. These characteristics, along with meeting their local farmers, give people who shop locally a sense of connection to what they put in their bodies and feed their families. Farmer's markets also support local economies and help to sustain local farmers.

Questions:

- What did you eat for breakfast? How far did the food you ate have to travel to get to your plate?
- Do you know any local farmers?
- Do you know how many species of bats there are in our area?
- How large is your energy and water footprint? Think about all of the devices you use on a daily basis. What is your family's footprint? How does this change and impact your local environment? What behaviors can you change to reduce your footprint?

Sustainability

Cross-cutting Issue:

Sustainability -Life is only sustainable given it has all the necessary resources to thrive (food, water, air, and habitat). Similarly, the materials we produce and use are only sustainable if we can keep producing them, meaning the resources (like energy) that go into making them are not finite, any by-products of production are not harmful to us or the environment, and the end product is not simply trash that accumulates. Some of our energy sources are not sustainable, and many of our behaviors (excessive water use, pollution, habitat destruction, development) are not sustainable either. The bright side is that we can change. We can move toward sustainability.

Hands-on Activity

Food Miles and Sustainability - Sustainability issues are embedded in your daily activities.

You will need:

- access to a computer and the internet.

Instructions:

1. Track the food and drinks you consume for one day.
2. Use **www.foodmiles.com** to calculate how many miles your food traveled to get to you.
3. Compare your miles with others.
4. Think about (and research) the process of making some of the items you consume. For example, consider coffee and what happens along its whole life cycle from growing and harvesting the beans to what you do with the leftover grinds. Ask where the coffee came from and who was involved in its production, how far did it travel, and was it fair-trade (who picked/harvested it). For the milk in the coffee, ask where did it come from - a local farmer, the grocery store, etc.

Did you waste any food during your day? Consider the costs associated with making, transporting, purchasing, and preparing that food.

What can you do to reduce your food miles and waste?

Notes: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Urban Life

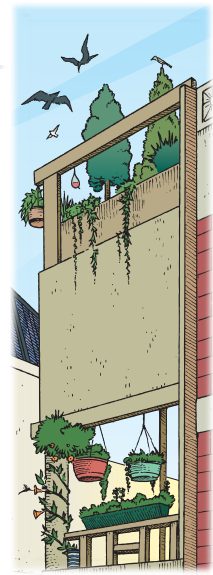
5

Urban life does not have to be devoid of nature. Urban environments have tremendous opportunities to increase efficiencies of the services and materials we consume, ultimately reducing our water and carbon footprints. From green roofs and solar panels to reducing car dependence and increasing opportunities for meaningful engagement with neighbors, urban environments have a wealth of advantages for achieving sustainable living.

Illustrations - Panel 5

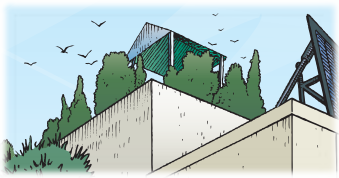
63. Atmospheric conditions - cirrus clouds - weather indicators
64. Green city - rooftop & porch gardens - wildlife habitat
65. Re-use - residential & office structures
66. Green city - rooftop gardens - outdoor living space
67. Energy source - rooftop solar panels
68. Green city - urban planting
69. Free energy - passive - wind drying laundry
70. Connectivity - transition connection to recreation/green space areas
71. Human city - walkability, pedestrian access
72. Recycling - garbage generation & disposal
73. Native species & non-native species
74. Urban design - traffic control: transition to narrower passage
75. Transportation - non-motorized conveyance: bicycle
76. Stormwater control - water pollution - urban inlet to drain system
77. Recreation - opportunities for elderly residents
78. Habitat - monarch butterfly - milkweed life cycle
79. Native species: trumpet vine, hummingbird & butterfly
80. Native species : moth, bees, monarda & detail
81. Historic conditions - land use - transition: woodland to farmland to urban
82. Invasive Species - Emerald ash borer
83. Germinating agricultural crops - monoculture issues & pesticide/herbicide use

Urban Life



Researchers have long recognized that modern cities alter environmental conditions in unexpected ways. Large cities have been referred to as ***"urban heat islands" (UHIs)*** because the buildings, the infrastructure (roads, parking lots), human activity and the expended energy all create heat as a by-product. The lack of trees and other vegetation to help cool temperatures also contributes to the effect as does black asphalt surfaces that soak up the heat from the sun. In some large cities these conditions are enough to alter the **immediate atmospheric and weather conditions (63)**. Tall buildings block the wind that promotes cooling, and warm urban rain runoff raises the temperature of local rivers and streams. The effects of UHIs are most notable at night when cities experience less cooling than rural areas.

One way to mitigate UHI effects is to build **"green roofs" (64, 66)**. Roof top gardens and vegetated surfaces provide many benefits: creating visual relief from the concrete and macadam of cities, improving air quality, providing habitat for wildlife, enhancing human health and reducing the heat generated by urban hardscapes. Additional vegetation planting at street level, **including street trees and urban greenspace (parks) (68, 70)**, can increase these benefits and make cities more enjoyable places.

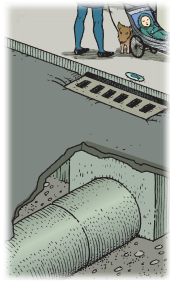


Cities generate tons of waste, from food garbage to construction debris. By **reusing existing structures (65)**, cities can ***reuse*** themselves and cut down on material waste. Historic commercial and industrial buildings have been converted to housing, and old apartments are now used as offices. By installing up-to-date energy sources, like **solar panels (67)**, and using more efficient utilities and materials, old buildings can become environmentally-friendly structures.

Returning to some methods of the past can also save energy. **Hanging clothes outside to dry (69)** uses free wind energy to accomplish the same goal as using modern clothes dryers. By drying outside, households can potentially save hundreds of dollars a year in energy costs.

Automobiles and trucks are powered by petroleum products which pollute air and water. These vehicles produce noise, waste heat, exhaust, and particulates which reduce air quality. In some cities, officials issue warnings on bad air days. Polluted air can be especially harmful to sensitive individuals like the elderly or the ill. By promoting **pedestrian access (71)** and providing for **bicycle traffic (75)**, cities become environmentally friendly and healthier. **Traffic calming structures (74)**, like narrower roads, can increase safety by lowering speeds and limiting vehicular access. Mass transit (buses, subways and shuttles) make a significant positive impact on urban roads. Increased safety encourages use, providing expanded **recreational opportunities for elders (77)** and children.

Recycling (72) of glass, metals and plastic keeps these materials out of the ***waste stream (landfills)***. Being responsible for our waste by recycling, reusing and using less has a positive impact on, not just our cities, but everywhere, including the oceans, because trash gets carried to rivers by runoff and ultimately makes it to the sea.



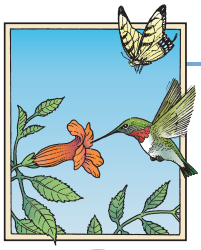
A notable impact associated with cities is polluted stormwater runoff. Urban streets channel stormwater into **culverts and storm drains (76)**. Eventually, the water empties, untreated and polluted with trash, oil, detergents and other toxic substances, into **local streams and rivers (11 - Panel 1)**. Storm drains may display a **small symbol (76)** (sometimes with a fish) that reminds us that these drain systems are connected directly to waterways.

Landscapers and homeowners often plant exotic and invasive plant species in urban areas for their attractiveness and appeal even though they are a poor fit for Pennsylvania environments. This is because the species that control their spread do not exist here. Pictured is the **butterfly bush (73)**, a non-native, invasive plant originally imported from Asia. Although this species is utilized by butterflies for its nectar, it provides little else for local species or ecosystems. Planting non-natives removes 75% of food sources for native birds, insects and other species.

An ecosystem is made up of dependencies: animals dependent on food sources, plants dependent on animals for pollination and animals dependent on other animals as hosts. These relationships are integral to the functioning of ecosystems. If elements are removed from the system, it may collapse.

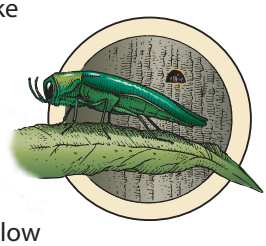
Pictured are some relationships that demonstrate dependency between species. The **milkweed and the monarch butterfly (78)** benefit each other at multiple stages. The monarch feeds on the milkweed nectar, pollinating the plants in the process. The adult lays eggs on the milkweed, and hatchling larvae feed on the plant into their caterpillar stage. When the adult caterpillar is ready for ***metamorphosis (changing to adult form)*** it forms its characteristic blue-green case where it stays until emerging as a winged adult. Another important benefit to monarchs, both adults and larvae, is a toxic steroid absorbed by eating the milkweed. This steroid gives monarchs a disagreeable taste, a ***deterrent*** to predators.

The **trumpet vine (79)** is a vigorous native plant that is frequented by hummingbirds and native insects. Here a hummingbird and a swallowtail butterfly close in on a trumpet vine flower. The bright orange flowers are shaped to accommodate the ***proboscises (tongues)*** of these species.



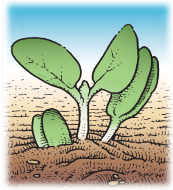
The native **bee balm (aka. monarda or bergamot) (80)** is a large, fragrant, showy plant that provides food for insect and bird species. Hummingbird moths are a type of clearwing moth that is ***diurnal*** and feeds much like a hummingbird does. It has the ability to hover and possesses a long tongue. Other insect visitors include various ground bees (bumble bees) and honey bees.

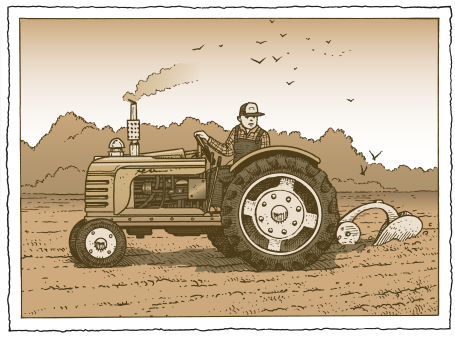
Some insects are identified threats to native plants and trees. The **emerald ash borer (82)** is an invasive insect from East Asia that feeds on species of ash trees. This beetle bores into the wood, tunneling through it, eventually killing the tree. Emerald ash borers leave a characteristic entrance hole shaped like a tunnel.



Today's urban areas in Pennsylvania began as dense forests. Before they became urbanized, these areas were cleared for **agricultural use (82)**. Until the Industrial Revolution in the 1800s, agriculture was the number one occupation in the United States. ***Industrial farming, or "agribusiness,"*** delivered a blow to traditional farmers. By the post-World War II era, farmers were economically stressed and were willing to sell their land for housing. This trend continues today.

Agriculture creates significant impacts on the landscape. Farming requires the clearing of trees and vegetation, which often results in erosion. Large scale farming creates areas of **"monoculture"(83)** in order to efficiently grow and harvest crops. This means that large areas of land are ***used for only one crop, eliminating the species diversity of a natural landscape***. Pesticides and herbicides are used to increase yield, which can damage soils and pollute local streams and creeks. Recently, some farmers have been experimenting with more environmentally-friendly ways to farm, such as ***no-till farming, mixed crop farming and organic farming***. These processes are designed to produce crop yields with minimal impacts to soil and water.





Questions:

- What other relationships can you think of that show dependencies (like the example of the monarch and milkweed)?
- Do you live in a city? A suburb? The country? What things does your community do to be more sustainable (i.e. recycle, biking paths, green roofs)? What do you do individually to be more sustainable (i.e. walk places when you can, recycle and pick up trash)?

Urban Life

Cross-cutting Issue:

Dependencies and Feedbacks - A simple cause and effect scenario rarely exists in reality because everything in the environment is linked to, is affected by and affects a number of other things. These interrelationships and dependencies are not always easy to predict and scientists discover new threads every day. Changing just one small component in an ecosystem can have a cascade of effects and result in unintended (and possibly negative) consequences. Removing milkweed significantly impacts the health of monarchs, not just locally but throughout their habitat range. Since they migrate they need milkweed habitat over a large span of area (from Mexico all the way up to northern United States).

Hands-on Activity:

Urban Heat Islands

You will need:

- a paper and pen,
- an IR (infrared) or digital thermometer.

Instructions:

1. Go outside on a warm, sunny day (for example into your schoolyard) and look around and predict which areas will be warmest and coolest.
2. Collect temperature data from 6-8 different areas you identify - make sure you have a range of paved and grass/natural areas, sunny and shaded areas.
3. Using an IR thermometer (or digital if you don't have an IR) measure the temperature of each area and record it on paper.

   -If using IR thermometers point the thermometer directly at the ground surface to be measured.
   -If using a digital thermometer make sure to keep it in place for at least 2 minutes (shade the thermometer from direct sunlight while taking the measurement). Make sure to take each measurement at the same distance from the ground so they can be comparable.
4. Take 5 temperature measurements in each location and write down a description of the ground cover and sun/shade of each location (pavement and sunny, shaded and grass, etc.).
5. Calculate the average of the 5 temperature readings.
6. Create a chart of the locations. Fill in the data about each location including average temperature, sun/shade, and ground cover.

Are the results what you predicted? Based on these results, which would be warmer: urban areas or rural areas?

Glossary

Amphibians - Vertebrate species that include frogs, toads and salamanders. They are scaleless and develop from larval forms like tadpoles and newts. Amphibians are tied to water environments for at least part of their life cycle.

Arthropod - Invertebrates with an exoskeleton, jointed legs and a segmented body including insects, crustaceans and other animals.

Canopy - The part of a forest that is formed by leaves of tree crowns. Canopy also refers to the highest arboreal habitat in forests. Healthy stream habitats are often covered and shaded by riparian canopies.

Crustaceans - Invertebrate arthropod species that include crabs, lobsters, crayfish, krill, shrimp and barnacles.

Diurnal - A species that is active during daylight hours.

Environment - The surroundings or conditions in which a person, animal, or plant lives or operates.

Feedback - Feedback occurs between two parts when each affects the other, or when the output of a system becomes an input for another part of the system creating a loop of cause and effect.

Floodplain - The flattened area next to a stream or river that is made up of historic flood deposits. Floodplains allow for the overflow of floodwaters and function as temporary storage until water levels recede.

Green infrastructure - Eco-designs that reduce stormwater runoff and promote environmental health. This includes rain gardens, green roofs, pervious surfaces, bioswales and others.

Habitat - The natural home or environment of a plant or animal.

Impervious surfaces - Ground covers or surface treatments that will not absorb rainfall. This can create runoff problems downstream. Land that would normally absorb water is now covered and blocked by hard surfaces, a recognized cause of flooding.

Indicator species - A type of animal or plant who is sensitive to the quality of their environmental conditions, thus their presence in an ecosystem indicates the quality of the environment and whether the habitat is polluted.

Industrial Revolution - An era during the 1800s when the principal occupation of people moved from agricultural to industrial. This change occurred as a result of technological advances in Europe and the United States.

Macroinvertebrate - Small animals without backbones (invertebrates) that are visible to the naked eye. These include crustaceans, worms, and aquatic insects and their larvae.

Metamorphosis - A process of change, usually of insects or other small organisms, i.e. larva to adult.

Monoculture - An agricultural term that means limiting large areas of land for only one crop. This method of farming eliminates or impairs the species diversity found in a natural landscape.

Glossary continued:

Native species - A plant or animal that has developed over time in a defined area or ecosystem and under particular conditions of that area.

Naturalize - A process in which non-native species adapt to an environment enough to reproduce in sustainable numbers.

Nocturnal - A species that is active during night-time hours.

Pervious surfaces - Materials, ground covers or surface treatments that allow water to penetrate and pass through to subsurfaces. Pervious materials are used to reduce impervious footprints.

Pollination - Fertilization of plants by insects, wind or other methods. Bees are examples of effective pollinators.

Pollution - The presence or introduction into an environment of a poisonous or harmful substance.

Proboscis - The extended, tube-like tongue of certain species usually designed to access food sources in flowers. For example, a butterfly possesses a proboscis.

Riparian - The area along a natural waterway that includes stream banks, plant cover and associated wetlands. Riparian areas are generally considered to be 100 - 400 feet from the water's edge.

Recycling - Introducing glass, metals, and plastics back into the manufacturing process for reuse rather than disposing of them.

Regrowth forests - Areas that have re-established dense vegetative growth that provides habitat for wildlife species.

Reptiles - Vertebrate species that includes lizards, snakes, turtles and crocodilians. Reptiles have scales and reproduce by laying eggs.

Sinkhole - A ground level collapse caused by loss of stability of underlying geology. Sinkholes are an indicator of limestone geology, also known as *carbonate* or *karst,* which is formed by the laying down of shelled sea life over eons.

Species - A type or group of animals or plants that are similar and can interbreed to produce young.

Sustainability - Sustainability is when an activity can be indefinitely continued without harmful or lasting impacts (i.e. to the environment).

Toxin - An organic poison or pollutant that can affect living tissue and is capable of causing disease.

Traffic calming structures - Urban and suburban designs that limit traffic impacts, like speed, noise or reduced walkability and safety.

Urban heat islands (UHIs) - A designation applied to certain large cities when infrastructure, expended energy and surfaces produce enough heat as a by-product to alter their immediate surroundings.

Water cycle - The movement of water driven by the sun which involves evaporation, transpiration, condensation, precipitation and infiltration.

Resources:

Agriculture

USDA - U.S. Department of Agriculture
http://www.usda.gov/wps/portal/usda/usdahome

Buy Fresh Buy Local
http://www.buylocalglv.org/ and http://buylocalpa.org/

Easton Farmer's Market
http://eastonfarmersmarket.com/

Food Waste Resources
http://ivaluefood.com/

Civil Eats
http://civileats.com/

Bats

Defenders of Wildlife
http://www.defenders.org/bats/bats

Bioswales

Natural Resources Conservation Service
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_029251.pdf

Birds

Audubon
http://www.audubon.org/birds

Cornell Lab of Ornithology
http://www.birds.cornell.edu/

Ecology

Ecology
http://www.ecology.com/

Energy

U.S. Energy Information Administration (EIA)
http://www.eia.gov/kids/

Energy Story
http://www.energyquest.ca.gov/story/

Environmental Advisory Councils (EACs)

EAC Network
http://eacnetwork.org/

Flooding

Nurture Nature Center
www.focusonfloods.org

Association of State Floodplain Managers
http://www.floods.org/

FEMA (Federal Emergency Management Agency)
https://www.fema.gov/floodplain-management

Footprint

Global Footprint Network
http://www.footprintnetwork.org/en/index.php/GFN/page/calculators/

Resources continued:

Goats as weed tamers

Beyond Pesticides.Com
https://www.beyondpesticides.org/assets/media/documents/weeds/publications/Goat_weed_management.pdf

Green Infrastructure

U S Environmental Protection Agency (EPA)
https://www.epa.gov/green-infrastructure

Green roofs

Green Roofs for Healthy Cities
http://www.greenroofs.org/

Invasive species list and resources

USDA
http://www.invasivespeciesinfo.gov/resources/lists.shtml

Lehigh Valley Greenways

Department of Conservation and Natural Resources
http://www.dcnr.state.pa.us/cli/lvg/index.htm

Mowing

People Powered Machines
http://www.peoplepoweredmachines.com/faq-environment.htm

Pesticides

EPA
https://www.epa.gov/pesticides

Pesticide Action Network
www.panna.org/pesticides-big-picture/pesticides-101

Pollinators

Pollinator Partnership
http://www.pollinator.org/

U.S. Forest Service
http://www.fs.fed.us/wildflowers/pollinators/

Rain gardens

Philadelphia Water
http://www.phillywatersheds.org/whats_in_it_for_you/residents/rain-gardens

Recycling

EPA
https://www.epa.gov/recycle

Renewable Energy

Energy.Gov
http://energy.gov/science-innovation/energy-sources/renewable-energy

Resources continued:

Rivers

American Rivers
http://www.americanrivers.org/

Army Corps of Engineers
http://www.usace.army.mil/

Trout Unlimited
http://www.tu.org/

Bushkill Stream Conservancy
http://bushkill.org/

Clean Water Action
http://www.cleanwateraction.org/

Delaware Riverkeeper Network
http://www.delawareriverkeeper.org/

Sustainability

Alliance for Sustainable Communities
http://www.sustainlv.org/

EPA
https://www.epa.gov/sustainability

Sustainable America
http://www.sustainableamerica.org/

Weather

National Weather Service
http://www.nws.noaa.gov/os/edures.shtml

National Oceanic and Atmospheric Administration (NOAA)
http://www.education.noaa.gov/

Owlie Skywarn
http://www.weather.gov/owlie/

Discovery Education Connect with Weather
http://www.discoveryeducation.com/connectwithweather/

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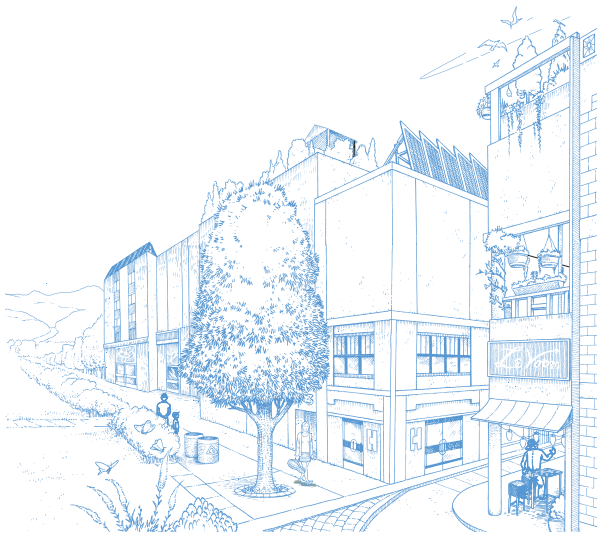
518 Northampton Street
Easton, PA 18042
610-253-4432
www.nurturenaturecenter.org



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