PROGRAM GUIDE

EXPLORE SCIENCE
Sustainable Futures

Ecosystem Engineers

Sustainability is protecting people, planet, and prosperity.

Ecosystem Engineers

GENERAL DESCRIPTION

Type of program

Long activity

Overview

This field trip (classroom-style) program explores the idea that humans can engineer positive changes to our environment through sustainable behaviors and ecologically informed decision-making. *Ecosystem engineers* are organisms that make significant changes to their environment. Learners will investigate an ecosystem interaction web to understand the interconnections between people, other organisms, and habitats. They will then think about how to restore balance after a large disruption event.

Audience

Ecosystem Engineers was developed for students in grades 4 and 5.

This program addresses the following Next Generation Science Standards:

3-5-ETS1 Engineering Design
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

4-ESS3 Earth and Human Activity
4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

5-PS3 Energy
5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

5-LS2 Ecosystems: Interactions, Energy, and Dynamics
5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

5-ESS3 Earth and Human Activity
5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-LS2-5. Evaluation competing design solutions for maintaining biodiversity and ecosystem services.

Big ideas

- Sustainability means healthy people, communities, and environments, now and in the future.
- Sustainability science studies the interaction between people and the planet and finds innovative and responsible solutions to global challenges.
- We can work together to create a sustainable future. Everyone has a part to play.

Learning objectives

As a result of participating in this program, learners will increase their:

- Understanding of big ideas related to sustainable futures.
- Awareness of the ways that sustainability is relevant to their lives and issues they care about.
- Sense of self-efficacy related to sustainability, including their ability to take sustainable actions and participate in conversations about sustainable futures.

Additionally, participants will be able to:

- Identify connections among human and non-human communities, *and* realize that humans are part of the ecosystem.
- Understand that communities change due to natural processes and human-induced disruptions.
- Appreciate that human decisions and activities are both shaped by and shape surrounding ecosystems and environments.
- Reference and build on the United Nations Sustainable Development Goals to brainstorm solutions for real-world challenges.

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BACKGROUND INFORMATION

Sustainability

Sustainability is a big concept. According to the United Nations (UN), a sustainable way of living "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). People's needs include food, water, shelter, work, happiness, and respect. This definition of sustainability prioritizes equity, because it recognizes that people all over the world have needs that are equally important. This view of sustainability also emphasizes the importance of considering how our actions today will affect society, the economy, and the environment in the future.

In 2015, UN countries adopted the 2030 Agenda for Sustainable Development and its 17 Global Goals (also called the Sustainable Development Goals, or SDGs). The Global Goals outline a pathway to a better and more sustainable future for all. They address the interconnected challenges we face, and recognize that ending poverty must go hand-in-hand with strategies that build economic growth, address social needs, and tackle climate change and environmental protection (United Nations, n.d. and 2015).

Quality education is one of the societal (or "people") priorities of sustainability. *Education for sustainability* "cultivates individual and collective potential…to increase the possibility that humans and other life can flourish on Earth now and into the future" (Cloud, 2017). Arizona State University's Sustainability Science Education program provides a brief introduction to education for sustainability (Arizona State University, 2014).

An international group of collaborators have created a companion set of Good Life Goals that explain how everyone can do their part to create a better future. These include 85 ways anyone can contribute toward the Global Goals for sustainable development (SDG Business Hub, n.d.). The Good Life Goals are

more oriented toward individual (personal) action, whereas the Global Goals are more oriented toward collective (government) action.

Habitats and ecosystems

Habitats are the places or types of places where a plant or animal naturally or normally lives or grows.

Ecosystems are communities of organisms that interact with each other and their nonliving environment. Nonliving elements can include things like temperature, precipitation, and the amount of light. They might also be more tangible parts of the landscape, like rocks, rivers, and sand. To be sustainable, communities need many things, including healthy and diverse ecosystems for people, animals, and plants.

Ecosystems are complex **systems**. While certain organisms may appear to dominate at first glance (trees in a forest, for example), a healthy ecosystem is composed of many different components that interact with and depend on each other. In a forest, trees are dependent on the sun for energy, rain and groundwater and on the soil for nutrients. Many other organisms play a part in building up and fertilizing this soil.

When we look at an ecosystem, we are looking at all of the living things, including people, and the environment that they live in. The sun provides the energy for the ecosystem described in this activity. The sun's energy warms the earth, water and air, causing wind currents, and activates the water cycle. The light energy from the sun also fuels photosynthesis.

People are an important part of the ecosystem, too. We share our environment with plants, mammals, fish, birds, reptiles, amphibians, insects, fungi and other forms of life too small to see with the naked eye. In general, all living things impact each other's lives with their actions. Consider your own neighbors. When you mow your lawn, the noise affects your human neighbors, as well as the lawn habitat and the animals that live there. A mosquito trying to survive and reproduce affects the lives of humans and other animals by extracting blood from their bodies, causing them to itch, roll in mud, swat their tails or grab for a bottle of bug repellent! The actions of people have many effects on ecosystems. Likewise, the actions of animals and plants also affect ecosystems and humans. How do we use the land and water within our ecosystem? What effects do these land and water use practices have? Why should we care about keeping the ecosystem clean?

In ecology, the term ***ecosystem engineer*** usually refers to an organism that changes its environment by creating, modifying or destroying its habitat. While this idea is often applied to physical changes, such as a beaver building a dam or a human paving a road, this program explores the idea that humans can also make changes to our environment through our behavior. Examples of this include choices such as eating less meat or supporting businesses that use sustainable practices.

References

Arizona State University. (2014). Sustainability Science Education. Sustainability education framework for teachers: https://sse.asu.edu/ways-of-thinking/

Brundtland, G.H. (1987). Our common future: Report of the World Commission on Environment and Development. Geneva, UN-Dokument A/42/427. http://www.un-documents.net/ocf-ov.htm

Cloud, J., ed. (2017). Education for a sustainable future: Benchmarks for individual and social learning. *Journal of Sustainability Education,* pp. 1-66.

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SDG Business Hub. (n.d.) Good life goals. https://sdghub.com/goodlifegoals/

United Nations. (n.d.) The sustainable development agenda. https://www.un.org/sustainabledevelopment/development-agenda/

United Nations. (2015). Sustainable Development Goals. https://www.youtube.com/watch?v=3WODX8fyRHA

MATERIALS & ADVANCE PREPARATION

Materials

- Graphic files (available to download and print from nisenet.org):
    - Ecosystem snapshot and disruption scenario (one copy) (example provided)
    - Ecosystem component cards (one set)
    - Interaction labels (one set)
    - Action sheets (one of each category per student)
    - Take-home Good Life Goal challenge (one per student)
- Large piece of black or gray felt (approximately 5 ft. x 5 ft.)
- Washi or masking tape in a variety of colors
- Velcro (20-30 dots)
- Markers and/or colored pencils
- Pencils
- Large sheets of paper for group brainstorming and ecosystem “murals”
- Optional: Related examples from the museum collection or natural materials from the selected ecosystem (e.g. plants, feathers, soil, rocks, sticks, leaves, acorns). (Sample animal prompts are available to download and print from nisenet.org)

All graphic files can be downloaded from the NISE Network website (nisenet.org). Other supplies are available at sewing and craft stores or online retailers.

Advance preparation

Program flow and preparation time

The time needed to prepare for this program depends on whether or not you customize the program. The overall program flow is:

- Optional introductory enhancement: Facilitator leads an observation session in an indoor or outdoor habitat *(see description on page 13).*
- Set the scene: Learners listen to a story that describes an ecosystem.
- Interactive ecosystem analysis: Learners analyze an ecosystem web with a story and disruption scenario.
- Be an ecosystem engineer: Learners use action sheets to brainstorm solutions to address the disruption.
- Wrap up: Facilitator helps the group review their learning.

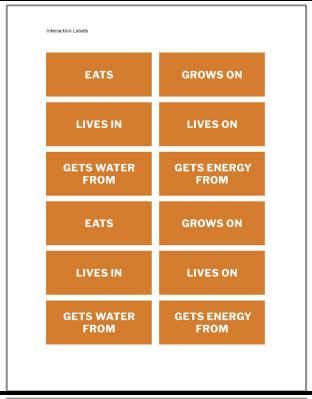
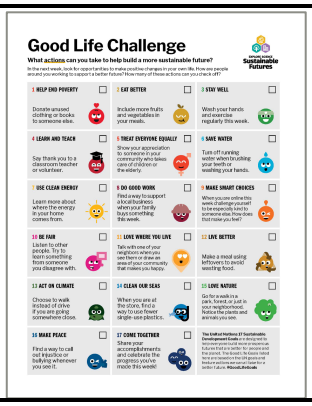
If you use the provided Northeastern freshwater stream story and disruption scenarios, you'll need at least one hour to make ecosystem interaction web in advance of the first program and about 20 minutes of set up time for subsequent programs. If you plan to focus on a different ecosystem, you'll need additional time to write an ecosystem snapshot and disruption scenario, research web interactions, and make new ecosystem component cards. You can use the Northeastern freshwater stream as an example. (More information is provided below.)

Advance preparation steps

1. Print the graphic files

All graphic files are available for free download from the NISE Network website (nisenet.org).

Ecosystem snapshot and disruption scenarios (*reusable*): Use during program delivery (to set the scene and introduce a disruption scenario), or as an example to use when creating a customized snapshot and disruption scenario. If working from the pre-developed Northeastern freshwater stream ecosystem snapshot, you should choose which of the two disruption scenarios is most relevant to your audience. More suggestions for developing your own snapshot and disruption scenario are included in the next section of this guide.	

Ecosystem component cards (*reusable*): Cut apart and laminate one set. You'll use these cards—along with felt, Velcro, and washi or masking tape—to construct the ecosystem interaction web used during program delivery. If you choose to create a customized ecosystem snapshot and associated disruption scenario, you'll also need to create customized ecosystem component cards.	
Interaction labels (*reusable*): Cut apart and laminate. Glue or stick a Velcro dot onto the back of each label so that it can be attached to the felt-based ecosystem interaction web. Interaction labels will be used with students during the "analyze an ecosystem interaction web" portion of program delivery. You won't need to use all the labels during each program, but can keep a set of spares on hand.	
Action sheets (*consumable*): Print *at least* one per student for use during the "be ecosystem engineers!" portion of program delivery. Ideally, print one of each category of action per student, so that students can choose which type of action they would like to take and/or fill out multiple action sheets. For example, if you are facilitating *Ecosystem Engineers* as a field trip program for 25 student participants, you should print twenty-five "Design a new structure or technology" action sheets, twenty-five "Teach and learn!" action sheets, and twenty-five "Change everyday habits" action sheets.	
Good Life Challenge (*consumable*): Print one per student to take home and complete after the program. Participants may also complete the Good Life Challenge is small groups.	

2. Prepare an ecosystem snapshot with disruption scenario

This short read-aloud piece provides a narrative introduction to the ecosystem in question, allowing students to imagine themselves within the scene and call on prior knowledge of ecosystem components and interactions. The disruption scenario, read later in the program, alters ecosystem relationships initially established in the snapshot, bringing key sustainability issues into focus.

You may choose to use the pre-developed ecosystem snapshot included as part of this guide. The ecosystem depicted is typical of Northeastern United States freshwater stream habitats. There are two options for disruption scenarios, giving you the flexibility to choose whichever you feel will be most relevant to your audience.

Alternatively, you may decide to develop your own ecosystem snapshot and disruption scenario to better reflect a local ecosystem following this general process:

a) Identify a local ecosystem of interest, such as a desert wash, moderate elevation mountain, or coastal marsh.

b) Select 10-12 organisms and 4-6 environmental features/habitats that interact in this ecosystem. Be sure to highlight different types of relationships, including predator/prey, parasitism, landscape features that provide shelter, and so forth. You may also choose to focus on organisms and landscapes represented at your institution, in live collections, natural objects, or other exhibits. One of your environmental features should be the sun, which is key for energy flow in most ecosystems. You should also include at least one source of water in your web. You should include the following in your ecosystem:
    - 2-4 producers (plants)
    - 2-3 herbivores
    - 1-2 decomposers
    - 2-4 omnivores, including humans
    - 2-4 carnivores
    - Sun
    - Water source

c) Map out the connections. This will help you to think about disruption scenarios that would impact multiple organisms through environmental change. You'll also use this diagram as the model for the large, hands-on interaction web you create for the program.

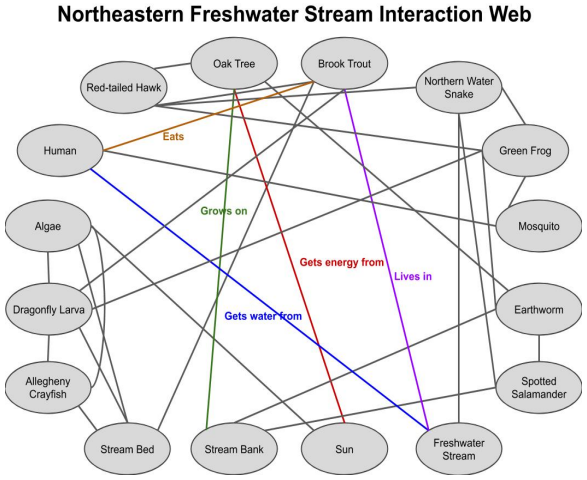
d) Write a short story that helps program participants to visualize the ecosystem relationships represented in your web. What would they hear? see? smell? How do humans fit into this ecosystem? Write the narrative in the second person to help create a sense of immersion and personal connection.

e) Brainstorm events that would disrupt the balance of your ecosystem and create issues for human and non-human communities. Write a "disruption scenario" that outlines the nature of the event (perhaps a storm, new source of pollution, human-induced alteration of the landscape or changes in climate). Allude to the impacts that this disruption might have on

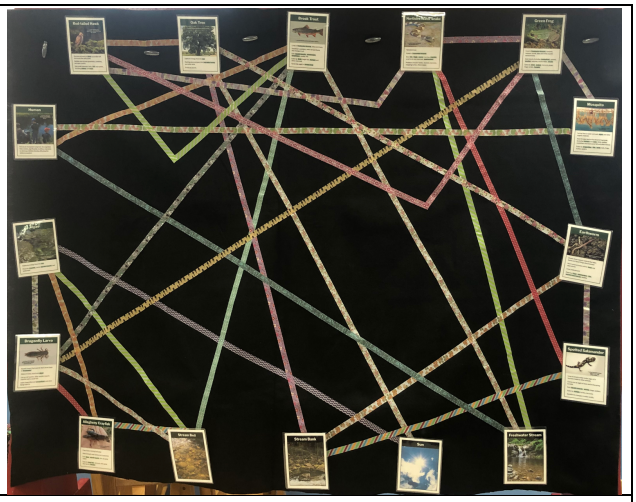
the previously described ecosystem, so that participants can begin to identify key issues to address with sustainable solutions.

3. Make an ecosystem interaction web

This large, hands-on web provides a visual representation of ecosystem relationships among organisms and habitats described in the ecosystem snapshot. These organisms, habitats, and relationships will be affected by the disruption scenario.



Planning diagram (see advance prep step 2c)



Completed physical interaction web (step 3)

Create an ecosystem web using your large felt square as a base. Attach ecosystem component cards to the outside edges of the felt. You can glue them on or use Velcro dots that stick to the felt. If you are working off the provided ecosystem snapshot, you can refer to the interaction web template to help with positioning ecosystem components and identifying connections.

Use washi or masking tape to make connections between ecosystem component cards (organisms and habitats). Tape in different colors allows for more easily distinguishable lines, but it is important to let students know that the colors and/or patterns don't have any special significance. Make sure to also print, laminate, and add Velcro to the back of the interaction labels.

4. Optional: Choose an outdoor habitat or animal display at your organization

You may choose to introduce and open the program by observing animals and plants in their natural environment outdoors or on display at your organization. (See "Optional enhancement" under PROGRAM DELIVERY below.) If you choose to open the program this way, there are sample animal prompts available to download from nisenet.org.

SET UP

Time

20 minutes

Steps

1. Each time you lead the program, you will need to download and print enough action sheets (one of each category per participant) and take-home Good Life Challenge sheets (one per participant) for all participants. You can download the action sheets and worksheet at www.nisenet.org/sustainable-futures
2. Arrange the programming space so that there is an area for students to quickly and easily gather (during the beginning of the program) and a separate section of tables where they can stand or sit on stools/chairs to complete activities.
3. You may find it useful to bring natural objects and artifacts (e.g. sticks, leaves, cactus skeletons, bird nests) into the classroom for students to observe using various senses (sight, smell, touch, etc.) as you "set the scene" at the beginning of the program.

PROGRAM DELIVERY

Time

One hour. The optional enhancement adds another 15 minutes.

Talking points and procedure

Set the scene (5 minutes)

Learners are invited to make personal connections to the natural world. This introduction sets the stage for the following activities and group discussions.

In the classroom or program area, invite participants to find a comfortable seated position, close their eyes, and imagine themselves within the ecosystem about which you are going to read out loud.

Read the pre-selected "ecosystem snapshot" to set the scene and immerse participants in imaginative exploration. You may choose to verbally emphasize the bolded ecosystem components in the snapshot so that listeners can begin to make connections. These components each appear in the ecosystem interaction web.

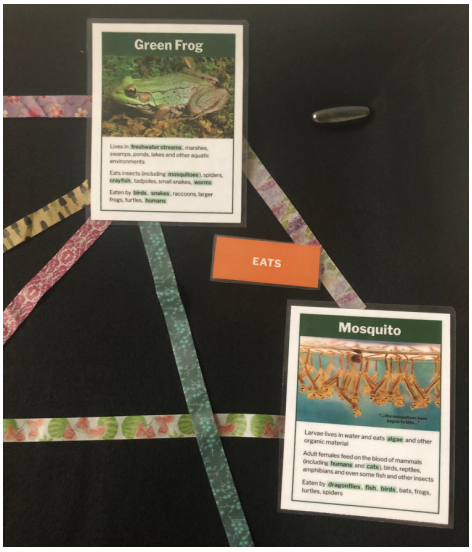
After reading the ecosystem snapshot, pause for input from participants. This is an opportunity for them to share memories. As facilitator, encourage storytelling! Prompt reflections on personal connections to nature and community by asking questions like:

- Have you ever been to a place like the one described in this scene?
- Did this description remind you of anything?
- What do you think it would smell like? What sounds might you hear around you?

- How did you feel imagining yourself in this place?

Analyze an ecosystem interaction web (10 minutes)

Learners identify connections among human and non-human communities, and realize that humans are part of the ecosystem.



Next, introduce the ecosystem interaction web. "The *ecosystem* we just heard about is composed of living and non-living (abiotic) things that interact with and impact one another. This web helps to show how all of the different elements connect with and affect one another."

Work together as a group to label some different types of interaction. For example, you might say: "Based on the story we just heard and the information on our web, how would the brook trout be connected to the crayfish?" or "What is the relationship between humans and mosquitoes?" Label a few connections together as a group, using pre-made interaction labels to specify the nature of each connection. You can refer to the story to guide this exercise. Be sure to highlight different types of interactions, e.g. "Eats," "Lives in," and "Grows on."

Once you've identified the nature of a few connections as a group, reiterate the idea that the ecosystem in question is made up of habitats, energy sources, and organisms, and they are all connected. When one part of the system changes, it affects many parts of the system.

Note: You *do not* need to explicitly label all of the lines on the web. This brief exercise is intended to produce a visual aid to anchor and inform future discussions.

Introduce a disruption scenario (10 minutes)

Learners understand that communities change (due to natural cycles and human-induced disruptions).

Remind participants that healthy ecosystems are constantly cycling and changing, but need to maintain balance between all of the different components. Then, read a "disruption scenario" for your ecosystem.

Have participants identify organisms, habitats or relationships on the ecosystem interactions web that are affected in the disruption scenario. Refer to the scenario-specific background information and discussion prompts to guide this whole-group conversation, and keep a list of issues that students identify for future reference. As facilitator, try to steer the conversation toward the "Key Issues" identified at the bottom of your disruption scenario.

Be ecosystem engineers! Brainstorm solutions and positive ecosystem actions (30 minutes)

Learners appreciate that human decisions and activities have a profound impact on surrounding ecosystems and environments (i.e. humans are "ecosystem engineers"). Learners reference and build on the UN SDGs to brainstorm solutions for real-world challenges.

Introduce *ecosystem engineers*: "As we just discussed, environmental shifts and changes in human or non-human communities impact ecosystem interconnections and balance. As humans, we can be *ecosystem engineers*: organisms that create, significantly modify, maintain or destroy habitat, thereby affecting the entire ecosystem. We also have the unique ability to reflect on our place in the web, change our behaviors, and balance our impact on other aspects of the ecosystem."

"Let's do some ecosystem engineering! We're going to think about ways to solve the problems that we identified, or create a healthier ecosystem in general." Explain: "We can work together in many different ways to make our communities more sustainable. For example, we can build new structures or spaces, develop new technologies, or make new rules about how we use resources and treat each other. Your job is to think of some specific things we could do to solve the problems we identified, or to protect similar ecosystems in the future." Distribute action sheets with different categories of intervention—"Change everyday habits," "Teach and learn!" or "Design a new structure or technology"—to each table. These worksheets include questions to prompt the types of solutions that might fit into each category.

Give students a chance to write out or draw the specifics of their idea to solve one or more ecosystem problem(s). For example, they may build perches/nesting sites for birds to replace trees, or imagine a new technology that can convert energy harnessed through photosynthesis into electricity for human use. Make sure to circulate and discuss ideas with students as they work. If they are tending toward a negative outlook, help to reframe things to be more positive. You may choose to have students work in pairs, to encourage conversation and collaboration and keep them accountable to the goal of creating a more balanced, healthier community.

Once individuals or pairs have completed their action sheets, break into small groups with diverse action categories represented in each group. Students should work together to create a "mural" representing what the post-disruption ecosystem might look like once their solutions have been applied. This may take the form of an altered web, an interpretive drawing, or a brainstorm list. Reinforce the idea that many minds and ideas are needed to create more sustainable communities. It's okay if this step ends up centering on the human community!

Ask each group to share their post-disruption ecosystem mural and highlight:

- How has the ecosystem changed for the better?
- How has life improved for human and non-human communities?
- Are there any new connections or ecosystem components that have emerged as a result of the solutions?
- Are there any remaining challenges or new problems still faced by ecosystem participants?
- Could there be any unintended consequences for the solutions you brainstormed? Could any of your solutions accidentally introduce new problems?

Wrap Up (5 minutes)

Remind students what they have accomplished and the types of thinking they engaged in throughout the program:

- "Together, we engineered some ecosystems that were very different from the one we started with in response to ecological change."
- "You, as humans, were able to think creatively and critically about how to make a healthier and more sustainable place to live now and in the future."
- "This is a skill you can use in your everyday life!" Distribute the take-home Good Life Goal Challenge sheets (or leave with the teacher). You may also choose to pass out Good Life Goals - Pack of Actions cards for students to take home (https://docs.wbcsd.org/2018/09/Good_Life_Goals/Pack_of_Actions.pdf).
- Encourage participants to follow up by exploring any relevant sustainability-focused exhibits on-site at your museum before they leave.

Tips and troubleshooting

Some kids will struggle with the meditative exercise when you set the scene, and that's okay! They can choose to act out the narrative (preferably from a seated position to minimize disruption to those around them), fidget with a natural object, or even point to components on the web as they are mentioned.

Optional enhancement

If you have access to live collections at your organization, add 15 minutes at the very beginning of the program (before entering the main program area and reading the ecosystem snapshot) to guide the group through an ecological observation process. Ask questions about the animals' display habitats, which have been constructed to mimic their natural habitat:

- Where are the animals hanging out?
- What other living things (plants) or environmental features are around them?
- Do you see any other information on the signage about what they eat, where they live, or their behaviors?
- Given what we now know about this species, what other living things might you guess they interact with in the wild?

You can break students into small groups, with each group responsible for observing and answering prompts about a specific animal. (Sample prompt cards are available to download and print from nisenet.org)

Alternatively, if you have access to an outside area, you may take 15 minutes prior to the start of the program to bring students outdoors. Work with them to identify different components of the natural and built landscapes, with particular attention to living things or signs of life (e.g. a tree, a bird, a squirrel nest, scat, or a person walking their dog).

If you do choose to introduce the program with either of these optional enhancements, be sure to prompt students to reflect on their experience after reading the ecosystem snapshot. Ask:

- Did this story remind you of anything that you just observed or read about in the museum/outside?

Going further…

Here are some resources you can share with program participants:

"Good Life Goal Challenge sheet':
https://www.nisenet.org/catalog/ecosystem-engineers

"Good Life Goals Pack of Actions":
https://docs.wbcsd.org/2018/09/Good_Life_Goals/Pack_of_Actions.pdf

Project Looksharp "Media Constructions of Sustainability: Upper Elementary" curriculum (for teachers):
https://www.projectlooksharp.org/front_end.php?kit_id=12

CLEAN UP

Time

10 minutes

Steps

Remove the labels from the interaction web to reset for the next program. You can send ecosystem murals back to the classroom as a reminder for students of what they accomplished together. They may also choose to keep their individual action sheets.

UNIVERSAL DESIGN

This program has been designed to be inclusive of visitors, including visitors of different ages, backgrounds, and different physical and cognitive abilities. The following features of the program's design make it accessible:

- Repeat and reinforce main ideas and concepts
- Provide multiple entry points and multiple ways of engagement
- Provide physical and sensory access to all aspects of the program

LICENSE AND CREDITS

The ecosystem web activity exists in many forms. This extended version focusing on positive solutions toward creating a sustainable future was created by the Sciencenter for the NISE Network as part of Arizona State University's Rob and Melani Walton Sustainability in Science and Technology Museums program, supported through funding from the Rob and Melani Walton Foundation.

Mosquito, James Gathany, CDC, https://en.wikipedia.org/wiki/File:Culex_sp_larvae.png

Northern Green Frog, Contrabaroness, https://commons.wikimedia.org/wiki/File:Northern_Green_Frog_-_Tewksbury,_NJ.jpg

Northern Water Snake, Brian Gratwicke, https://en.wikipedia.org/wiki/Northern_water_snake#/media/File:Nerodia_sipedon.jpg

White's Tree Frog, William Kreijkes, https://commons.wikimedia.org/wiki/File:Litoria_caerulea2.JPG

Corn Snake, Public Domain, https://commons.wikimedia.org/wiki/File:Kornnatter.jpg