Smithsonian | SCIENCE *for Global Goals*

ECOSYSTEM RESILIENCE!

How can people and ecosystems build resilience to change?

SUSTAINABLE DEVELOPMENT GOALS

developed by

Smithsonian *Science Education Center*

in collaboration with

iap SCIENCE HEALTH POLICY

the interacademy partnership

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Adrienne Arsht Community-Based Resilience Solutions Initiative

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Dear Parents, Caregivers, and Educators,

As a global community we face many challenges. At times, these worldwide problems can seem overwhelming. We may ask ourselves questions about how to understand these complex problems and whether there's anything we can do to make them better. This community response guide encourages young people to discover, understand, and act on the answers to these questions.

In the years leading up to 2015, people around the world worked together to share their ideas about how our world should be. These ideas became a list of goals, the United Nations Sustainable Development Goals. The goals represent a plan for a sustainable world: a world where peaceful societies collaborate; a world where we live in balance with the environment of our planet; a world in which our economies fulfill our needs; a world that is fair to all.

As youth around the globe engage with the activities in this guide, they will gain an understanding of the science that underlies the Sustainable Development Goals. They will be able to share their knowledge with their community, create tangible ways to help their community make informed decisions, and understand the best places to find additional information on these topics.

Throughout the guide, young people may find themselves asking many questions about pathways to a sustainable future. You do not need to have the answers to any of these questions. The most important thing you can offer young people is the opportunity to question, investigate, think critically and systemically, synthesize, and act. Ask the young people around you how they are feeling and what they are thinking about as they learn this content.

I am immensely grateful to the experts who helped to develop this guide—the InterAcademy Partnership, a collaboration of 140 national academies of sciences, engineering, and medicine; our colleagues across the Smithsonian Institution; and the external subject matter experts who contributed to this guide—for their perspectives and technical support in ensuring the science in this guide is accurate. I also want to say a special thank you to the developers of this guide, Heidi Gibson, Khadijah Thibodeaux, and Andre Radloff, for their thoughtful contributions to the *Smithsonian Science for Global Goals* project.

Working together—scientists, researchers, parents, caregivers, educators, youth—we can make a better world for all. This guide is a step toward that grand collaboration.

Thank you for partnering with us to inspire our youth to build a better world.

Best,

Carol L. O'Donnell

Dr. Carol O'Donnell,
Douglas M. Lapp and Anne B. Keiser
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Education Center

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Student Letter

Dear Student,

This is the last time you will be called a student in this Community Response Guide. Instead, you will take on a new role as an action researcher. Action researchers are interested in figuring out what to do to make their communities better. They use scientific investigations to help understand the natural world around them. They use social science investigations to help understand the people, cultures, and history of their communities. Then they use the information they gather to help solve problems in their own communities. This guide will help you learn more about this process. The most important thing to know is that you will control your own research and make your own decisions.

Think back to a time when you solved a problem. You first needed to know what you wanted, your goal. Then you had to figure out what you needed to do to achieve your goal. This guide is similar. You will think about goals you have for your local community, then figure out what you need to take action to help reach those goals.

You and your classmates will work as a team to think about information you already have about the place where you live. Then you will investigate your local community and how things work. Finally, your team will decide how to make things better. Together you will put your decision into action. Sometimes, making decisions about what to do is difficult. Don't worry, this guide will give you lots of support.

How to Use this Guide

This guide is designed to help you explore and think about problems in your community. The guide is here to help you. That means you can always change it.

Adapting the Guide

You will notice that in this guide there are often suggestions of different ways to share your ideas or do investigations. This is because different people think and work best in different ways. For example, some people like to draw, some people like to talk out loud, and some people prefer to write to express their ideas. This guide has suggestions, but you can always change the method suggested. You can share your ideas using discussions, acting, signing, telling stories, recording your voice, writing by hand, typing

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on a computer, drawing, or another way you choose. Think about the way you and your team learn best together. Including everyone on the team is important.

Safety Tips

This guide asks you to do and think about things that may seem unfamiliar. You will notice physical and emotional safety tips in the guide. These will help you stay safe and supported during the activities. Make sure you follow your teacher's directions about staying safe.

Guide Structure

There are eight tasks in this guide. Each task has three activities. The activities are called ***Discover, Understand,*** and ***Act.*** In the ***Discover*** activities you will focus on thinking about information that you and your team already know. In the ***Understand*** activities you will investigate to find out new information. In the ***Act*** activities you will put your existing and new knowledge into action by applying it and making decisions. Words that may be unfamiliar will be in **bold** the first time they are used. Then at the end of the guide a glossary will list the definitions of these words.

Investigations

You are the one doing the research in this guide. This means often you will develop your own questions and determine the best way to answer them. Developing and answering questions is how scientists find out new information about the world around them. As an action researcher, you need to think like a scientist to discover what you need to know, investigate to find out more information, and think about the meaning of what you found out. For many activities there are resources to give you more information and help you investigate in the *Ecosystem Resilience!* StoryMap website found at bit.ly/EcosystemResilience.

Keeping Organized

In this guide you will have some papers you will need to keep so you can look at them later. You may want to have a folder, notebook, or science journal to help you stay organized. To make sure this isn't confusing, here is a list of papers you will create and refer back to as you work through the guide.

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Identity Map (Task 1, Discover activity)
Resilience Quilt (Task 1, Act activity)
Our Resilient Future (Task 1, Act activity)
Ecosystems Investigation (Task 2, Understand activity)
Ecosystems Model (Task 2, Understand activity)
Human System Investigation (Task 2, Understand activity)
Human System Model (Task 2, Understand activity)
Action Planner (Task 3, Act activity)
How to Adapt (Task 5, Discover activity)
Ecosystem-Based Adaptation Drawing (Task 5, Understand activity)
Winning Strategies List (Task 6, Discover activity)
Biomimicry Engineering Design Challenge (Task 6, Understand activity)
Resilience Assessment Chart (Task 7, Discover activity)
Redesign Sketch (Task 7, Understand activity)
Action Plan (Task 8, Discover activity)

Teams

You will be working with other classmates as part of a research team. Your team will conduct investigations and make decisions together. When conducting research, there may be many things to figure out as a team. You will need to be creative. There will not always be a clear right and wrong answer. Sometimes the team might not agree. This is okay. Just make sure to respect your teammates. There is no one right answer to the problems faced by your community. There is just the best answer for you and your team.

Getting Started

You will be thinking about complex problems. Sometimes this can feel difficult. Be patient. You will be guided to consider different parts of the problem. By the time you are making big decisions, you should have lots of information. Always remember, your work is important. Decisions you make can change your community. You are an important part of making your local and global communities better.

Thank you for working to make your community better.

The Smithsonian Science for Global Goals team

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Find out More!

For additional resources and activities, please visit the *Ecosystem Resilience!* StoryMap at bit.ly/EcosystemResilience.

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Ecosystem Resilience Planner

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 1: How will resilience be part of our future?					
Discover	Develop a personal *Identity Map* showing the different parts of who you are and how you have changed over time. Reflect on a personal memory where you have shown resilience.	• Paper • Pens or pencils • 3 different colored markers or pens		45 minutes	2
Understand	Share and analyze a story of resilience. Collect oral histories to understand resilience in your local community.	• Recording device (optional)		30 minutes + Investigation time	7
Act	Learn about how quilts can showcase stories of resilience. Create your own quilt to represent past resilience. Envision a resilient future and how that relates to the UN Sustainable Development Goals.	• Paper or cloth squares • Pencils, pens, or markers • Tape or glue • Sewing materials (optional)		40 minutes	10
Task 2: What is ecosystem resilience?					
Discover	Use a mindfulness activity to reflect on how people are embedded within ecosystems. Create a model of an ecosystem and analyze existing models.	• Large piece of paper, poster, or class board • Pencils, pens, or markers		35 minutes	16

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Understand	Map an area to research and then conduct investigations into the human system and ecosystem found there. Think about what things are causing changes to these systems.	• Existing digital or physical map • Paper • Pencils or pens • Scissors		40 minutes + Investigation time	22
Act	Learn about the Resilience Initiative at the Smithsonian. Use the four perspectives to imagine a resilient future.	• Paper • Pens, pencils, markers • Materials to create a collage • Tape or staples	*Our Resilient Future*	30 minutes	33
Task 3: Grassland: How are diverse ecosystems part of our resilience?					
Discover	Play the *Diversity Match Game* to understand how human diversity helps us respond to challenges. Play the *Grassland Biodiversity Game*.	• 1 set *Diversity Match Card* for each person • 1 set *Natural Disturbance Cards* • 2 sets *Species Cards*	*Identity Map*	45 minutes	39
Understand	Learn about the grassland work of the Smithsonian. Play the *Grassland Biodiversity Game* again, adding in human challenges. Score biodiversity in your own area.	• 1 set *Human Challenge Cards* • Paper • Pen or pencil	*Natural Disturbance Cards* *Species Cards* *Ecosystem Investigation*	45 minutes	49
Act	Use the four perspectives to think about biodiversity and resilience. Share your ideas with others. Plan for a larger action.	• Class board or large piece of paper • Pen or pencil markers • Digital document or paper		25 minutes	55

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 4: Forest: How is ecosystem connectivity part of our resilience?					
Discover	Play the *Finding Connections Game* to understand connectivity. Solve the *Ecosystem Services Connections Puzzle*.	• Printed or digital *Forest Ecosystem Connections Puzzle*		30 minutes	58
Understand	Explore data about deforestation changes over time. Model forest resilience. Use three case studies to understand the differences in connectivity at a local, regional, and global scale.	• Paper • Pen or pencil • 9 paper or plastic cups	*Personal Forest Ecosystem Exploration*	45 minutes	64
Act	Learn about the Smithsonian's work helping to solve the issues raised in the case studies. Create a way to tell the case study story and share it with others. Plan for future actions.	• Class board or large piece of paper • Pen or pencil markers • Digital document or paper	*Action Planner*	20 minutes + Storytelling time	72
Task 5: Shoreline: How is adaptation part of our resilience?					
Discover	Play the *Adapt to Win Game* to understand the need for adaptation. Explore shoreline adaptations and learn about how the Smithsonian is researching past shoreline changes.	• Paper • Table • Small balls, blocks, or other things that can be easily moved (optional)		30 minutes	78

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Understand	Identify cases of shoreline hardening and learn about ecosystem-based adaptation. Research a shoreline through the roles of historian, economist, sociologist, ecologist, and geoscientist.	• Paper • Pen or pencil • Research materials such as books, articles, and pictures about the shoreline • Sticky notes (or small papers with tape attached)	*Shoreline Adaptation Cards*	30 minutes + Research time	85
Act	Redesign your shoreline using ecosystem-based adaptations. Plan for future actions.	• Class board or large piece of paper • Pen or pencil markers • Digital document or paper	*Ecosystem-Based Adaptation Drawing* *Shoreline Adaptation Cards* *Action Planner*		92
Task 6: Desert: How are innovative ecosystems part of our resilience?					
Discover	Pitch the innovation of an everyday object to your team. Learn about desert organisms at the National Zoo. Analyze the innovations of desert species and the strategies they use to survive in the desert.	• Human-made objects found around you • 1 set *Innovator Cards* • Markers • Scissors • Large piece of paper or class board		40 minutes	95
Understand	Explore how humans have used biomimicry to help them solve problems. Use desert organisms from the Discover activity to inspire an engineering design to help solve a problem.	• Materials to use when making models, such as carboard, fabric, water bottles, paper or other found objects	*Winning Strategies List*	15 minutes + Engineering and design time	102

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Act	Pitch your biomimicry design to others in your community. Plan for future actions.	• Class board or large piece of paper • Pen or pencil markers • Digital document or paper	*Action Planner*	30 minutes + Sharing time	107
Task 7: Human Habitats: How can integrated ecosystems be part of our resilience?					
Discover	Create the sounds of a rainstorm to model integration. Assess your local area using a double bottom line, focused on the needs of people and ecosystems.	• Paper • Pencil, pen, or marker	*Ecosystem Investigation* (optional) *Human System Investigation* (optional) Triangle and circle ecosystem models from Task 2	25 minutes + Investigation time	110
Understand	Reimagine the future and be inspired by the Afrofuturism exhibit at the Smithsonian. Create a design for a reimagined future and model it using physical, digital, or other methods.	• Paper • Pen or pencil • Modeling materials such as paper, tape, clay, sand, or others (for a physical model; optional)	*Resilience Assessment Chart*	30 minutes + Design and modeling time	117
Act	Share your reimagined human habitat with others. Plan for future actions. Decide as a team on the outcome you want.	• Class board or large piece of paper • Pen or pencil markers • Digital document or paper • Quilt square of paper or cloth • Tape or glue • Sewing materials (optional)	Reimagined world model *Action Planner* *Identity Map* *Our Resilient Future*	30 minutes + Sharing time	125

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 8: How can we create a resilient future for ecosystems and ourselves?					
Discover	Consider different actions that could help lead to the outcome your team wants. Decide on the action you will take and start to develop an action plan.	• Paper • Pens, pencils, or markers	*Action Planner*	25 minutes	128
Understand	Plan your action, including the specific steps and who will be responsible for them.	• Paper • Pens or pencils	*Identity Map* *Action Plan*	20 minutes	131
Act	Implement your action plan and reflect on your action.	• Paper • Pens or pencils	*Resilience Quilt* *Action Plan* *Our Resilient Future*	15 minutes + Action time	133

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Ecosystem Resilience! How can people and ecosystems build resilience to change?

This guide is about change. How can you and the natural **systems** around you best prepare for and react to change?

While using the guide you will become an **action researcher**. You will identify and help solve problems in your **community**. A community is a group of people who have something in common such as living in the same local area. Action researchers first ***discover*** their own knowledge and the knowledge within their communities. Then they investigate to ***understand*** problems. Finally, they ***act*** on what they have learned to improve their local and global communities.

You will create and keep several sheets of paper or digital documents to help you record and remember information. You may want to use a notebook or folder to help organize these sheets.

Remember: *In this guide you and your team are in charge. You can always change the instructions in the steps to make them work better for you and your team.*

Task 1: How will resilience be part of our future?

Humans, our systems, and the world around us are always changing. Some changes are quick. For example, a caterpillar can become a butterfly in weeks. Other changes are slow. For example, a human child takes years to grow into an adult. Some changes only have a little effect. For example, changing your shirt might not change your life much. Other changes can have a much bigger effect. For example, moving to a new place might change your life a lot. In this task you will start to think about your experience with change.

First you will ***discover*** more about your own changing **identity**. You will gather information from your community to ***understand*** how people in your community have managed change. Finally, you will ***act*** by imagining your **goals** for the future.

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Discover: *Who am I and how am I changing?*

In this guide you will be exploring changing relationships between people and nature. But first, it is important to think about who you are and how you are changing. Our different experiences, backgrounds, and ideas give each of us a unique identity. Your identity is what makes you you. Each of us has a unique identity and a unique personal history.

1. Take out a piece of paper or open a digital document and title it "Identity Map."
2. Take out three colored pens, pencils, or markers.
3. Choose one color to write your name in the center of the page or draw a small picture of yourself.
4. Using the same color, draw a circle around your name or picture.
5. Think about your answer to the question, "Who am I?" The list below can give you some ideas, but you choose what you think is an important part of your identity. You can also include things that are not on the list.
   - Age
   - School or class
   - Race and/or ethnicity
   - Gender
   - Country or place where you live
   - Country or place that is important to you or your family
   - **Values** or beliefs that are important to you
   - Goals that are important to you
   - Topics or subjects that interest you
   - Hobbies or things you like to do for fun
   - Physical traits (such as tall, black hair, blue eyes, wears glasses)
   - Personality traits (such as loud, funny, quiet, kind)
   - Roles you have in your household (such as big sister, helper, cousin)
   - Groups you belong to
6. Using the same color, write each answer on the page around your name. Draw a line between your name and each answer. Figure 1 is an example of an *Identity Map*. You can put your answers at the end of each line.

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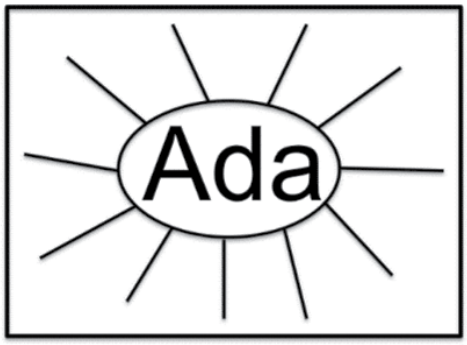

Figure 1: Example of an Identity Map.

7. Now form a team. As action researchers you will work together with your team, made up of your classmates, for the rest of this guide. Your team may be your whole class or a smaller group. Either is fine.
8. Share your *Identity Map* with the members of your team to find out what you have in common. Try to find matching identities with your teammates. For example, if you like to read for fun, see if you can find someone else who likes to read for fun. Find a few matching identities. Then move on to the next step.

> ⚠ **Emotional Safety Tip**
>
> Sharing your identity with someone else can help build trust between you and that person. But it can be hard to share your personal identity with someone else. Only share parts of your Identity Map that you feel comfortable talking about.

9. Find teammates who have different identities from you. Then return to your place.
10. Take out markers or pens in two other colors. Use the three colors to add a key to your *Identity Map*. Figure 2 shows an example.
    a. Use Color 1 to write "Current Identity" in the key. Color 1 is the color of the pen, pencil, or marker you just used to create your *Identity Map*.
    b. Use Color 2 to write "Past Identity" in the key.
    c. Use Color 3 to write "Future Identity" in the key.

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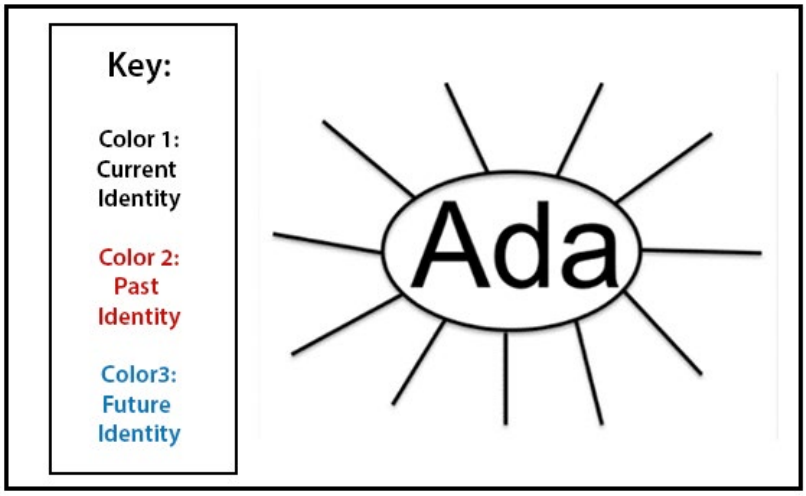

Figure 2: Identity Map with a key.

11. Think about a specific time at least five years in the past. If you can think of a picture of yourself from the past, it may be useful to help you remember what you were like then. Use Color 2 (past identity) to draw or write the answers to these prompts.
    a. Circle anything on your *Identity Map* that would have been there at that time you are thinking about in the past.
    b. Add anything you think you would have listed on your *Identity Map* when you were younger but did not list now.
12. Examine the differences between your past identity and your current identity. What do you think caused those changes? Pick one change and write or draw next to it the experience or event you think might have caused the change.

⚠ Emotional Safety Tip

Some changes in life may be very positive and make you happy or proud. Other changes might bring up negative or mixed emotions. That is okay. Reflecting on challenges in your life can help you realize how you have grown. But if past events feel overwhelming, it is okay to take a break or avoid thinking about them.

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13. Think about a specific time at least five years in the future. Use Color 3 (future identity) to draw or write the answers to these prompts.
    a. Circle anything on your *Identity Map* that you hope will still be part of your identity in the future.
    b. Add anything new you would like to be part of your identity in the future.
14. Examine the differences between your future identity and your current identity. What do you think might help you develop those identities? Pick one future identity and write or draw your ideas.
15. Read *Reflect on Your History with Resilience*.

Reflect on Your History with Resilience

You have changed in the past and will continue to change in the future. The world around you is also always changing. The ability to respond and **adapt** to changes and challenges and have a good outcome is called **resilience**. Adapt means to change in a way that helps you adjust to something new. This guide is about the resilience of people and nature.

Resilience History

Everything on Earth has characteristics that make it resilient. You may not realize it, but you have been resilient many times in the past. Every time you overcame something difficult or kept going despite a challenge, you showed resilience. All humans show resilience in small and big ways as we manage change.

a. Close your eyes and think of a time in your life when you got through a challenging situation. It can be a big thing or a small thing. It can be a challenge related to school, home, friends, groups you are part of, or the world around you. It could be something sudden, such as a natural disaster, or something slow, such as finding a certain subject in school difficult. Pick a memory you do not mind sharing.

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⚠ Emotional Safety Tip

It can be hard to think about challenges in your past. If a memory makes you too uncomfortable, pick another memory to think about.

b. Write or think about how you felt as you faced that challenge.
   - Were there moments you felt discouraged?
   - What gave you the resilience to keep going? Was it something about you and your identity? Was it the support of others?

c. Take a moment to feel proud of yourself for your resilience. Facing challenges is hard. Remembering how you have been resilient in the past can help you feel confident about your future resilience.

16. Turn to a partner and share your resilience memory. Then listen to your partner's story.
    a. For the storyteller: Try to share details about your memory and how it changed you.
    b. For the listener: Pay close attention and think carefully. How did this challenge help make the storyteller more resilient?

⚠ Emotional Safety Tip

Sharing memories can be very personal. Remember that your partner is trusting you to respect them and their memory. Make sure you listen carefully and stay open to the story, even if it feels unfamiliar or strange to you. If you are not comfortable sharing one memory, pick a different one to share.

17. Keep your *Identity Map*. You will need it again.

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Understand: *How can we be resilient to change?*

Change is always happening. Change happens to individuals, to communities, and across our planet. Some changes are caused by people and some are not. Some changes are rapid, others are slow. In this guide you will think about ways to prepare for and adapt to changes and challenges.

1. Read *Stories of Resilience Instructions* and *Resilience Oral History Instructions* and consider the best way for you to investigate examples of resilience in your community. You may remember a community is a group of people who have something in common. In this guide, you will be learning more about your local community—the group of people who live near you.

Stories of Resilience Instructions

Think of one of your favorite stories. It could be a spoken story. It could be a written story, such as a book or article. It could be a performance, such as a play or movie. It could be a visual story, such as a painting or sculpture. It could be a story for adults or one meant for children.

Often the stories we tell involve someone or something overcoming challenges or adapting to changes. These are stories of resilience. Sometimes the stories we tell about resilience actually happened. Sometimes someone imagined them. Both types of stories can help us imagine a way through the challenges we face.

For thousands of years, people have been sharing stories of resilience to help encourage others and provide ideas about new ways to solve challenges. Passing on knowledge through storytelling is an action anyone can take. Telling stories of resilience can help you build your personal resilience and can encourage others to be resilient.

Some stories show the resilience of people—how individuals or human communities overcame a challenge. Some stories show the resilience of nature—how living things or other parts of nature adapt or face challenges.

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a. Choose a story you know that you feel is a story about the resilience of people or nature. This can be any story about managing a challenge or change.
b. Create or find a record of this story. If this is a story that has already been told by others, you can find existing writing, drawings, pictures, or videos that tell this story. If this is a story that is personal to you, you can write or draw a picture of this story.
c. Analyze the story you chose and add information about how this story shows resilience to your record. Be sure to answer the following questions.
    - What is the challenge in this story? Does this challenge exist in the world today?
    - How did people or nature respond to this challenge?
    - What does this story teach you about ways to respond to a challenge?

Resilience Oral History Instructions

All stories of resilience can help inspire us, especially stories about the people and places around us. When you talk to people and record information about their past, it is called an **oral history**. An oral history lets people share stories from their past. You can use these stories to gather information about the history of your community's resilience. Oral histories can be as simple as sharing a personal story or memory, like you did with your resilience memory in the Discover activity.

Now each team member will gather an oral history of a resilience memory from your local community. Oral histories can help you understand how people have been resilient in the past.

Choose Your Questions

One way to conduct an oral history is to ask a person to tell you a story about their past. For example:

a. What is a challenge you or your community faced in the past?
b. How did you respond to that challenge?
c. What did you learn?

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Choosing People to Talk to

Try to include people who represent different parts of your community. If it is easier, you can collect an oral history from family members or friends. The *Ecosystem Resilience!* StoryMap has links to resources you can use for your oral histories if you do not have time to gather new ones.

Recording an Oral History

Find a way to record the oral history. It may be best to use a recording device, but you can also write or draw to record the ideas that are shared with you.

Tips for Collecting an Oral History

a. You can talk to people in person, over the phone, or using the Internet.
b. Make sure you ask permission to record and share a person's answers to your questions.
c. People might be more willing to talk if they can remain **anonymous**. Anonymous means their name their name or other identifying information is not shared.
d. A person may have photographs, drawings, or other objects that help them tell their oral history. Ask the person to describe the object and make sure you record their description.
e. Let the person you are talking to answer the questions in the way they want. Be patient. Listen carefully. Understand that they might give answers that you didn't ask for.

Safety Tips for Talking to People

Talk to your teacher for guidelines. They will know what is safest in your community.

⚠ Physical Safety Tip

When gathering oral histories, always make sure you feel safe. You can always include a trusted adult or classmate when recording. You might want to suggest recording the oral history in a quiet public place.

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⚠ Emotional Safety Tip

It can be hard to talk to other people in the community. You may feel shy or nervous. Someone may tell you they don't want to talk. That's okay! It doesn't have anything to do with you. It just means they don't want to share. You can show respect by thanking them and moving on to another community member.

2. As a team, decide if you will collect and analyze stories or oral histories. If you have time, it may be helpful for your team to complete both investigations. You can also have different team members do different investigations.
3. Have each team member collect a story or an oral history by following the instructions. Create a record of the story or oral history. This record could be written notes, a drawing, an audio recording, a video recording, or another way that works well to help you remember the information you gathered.
4. Use the record of your story or oral history to share a summary of what you learned with your team. As a team, discuss how each of these stories and oral histories relates to your community's resilience. Keep these records close to you. You will use them again in the next activity.

Act: *How can we imagine a resilient future?*

Just as in the past, there will be many changes in the future. Thinking about resilience in the past can help inspire you for the future. Envisioning a positive future is an important part of resilience. Knowing what you want to happen is the first step toward achieving your goals. Planning how to adapt or overcome changes and challenges is also an important part of resilience.

1. Read about the quilts at the Smithsonian to understand how communities have used quilts to tell stories.

At the Smithsonian

For centuries, quilting has connected people around the world to art, history, science, and **culture**. Quilts are functional items, placed on beds or shoulders to provide warmth and a sense of care. But quilts are also forms of artistic expression showing people's values, the challenges they've faced, and their connection to the world around them. The Smithsonian National Museum of American History is home to the National Quilt Collection. This collection of over 500 quilts helps people understand home and community life through more than three centuries of American history.

Each quilt tells a story. Sometimes this is the story of an individual and sometimes it's the story of a whole group. The complexity of creating quilts means they are often **collaborative** pieces of art. Over the centuries, quilts have brought communities together through sharing fabric, sharing patterns of quilt squares, and sharing the labor of creating a quilt.

The National Quilt Collection features quilts made from the early 1700s to the early 2000s. Many of these quilts were created by groups who were largely **excluded** from the historical record. For people seeking to understand the stories and resilience of these excluded groups, quilts provide valuable insight.

Laura Johnson, the **curator** of this collection, says, "Quilting can give a voice to those whom recorded history often overlooks or silences. Quilts allow diverse groups of people to memorialize and share their stories." For example, though women in the 18th and 19th centuries were sometimes limited in how they were allowed to participate in politics or voice their opinions, the quilts in this collection reveal their thoughts about science, family, education, marriage, religious values, connections to nature, and politics, among other subjects.

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Figure 3: Harriet Powers' Bible quilt (1885–1886).

Quilts featured in this collection also show how groups found solutions to the challenges they faced. Harriet Powers, a formerly enslaved woman, created the quilt shown in Figure 3 to share stories from the Bible that were important to her. Though Powers was literate, there were many laws that prevented other enslaved people from learning to read. Her choice to create a quilt that told stories from the Bible through images communicated the importance of religion in the African American community, while creating a way for those who could not read to connect to these stories.

Quilts are rich and complex. They can help warm us both physically and emotionally. Quilts can build community, tell stories, share solutions, and preserve history. To learn more about the National Quilt Collection and explore the quilts that are part of it, visit the *Ecosystem Resilience!* StoryMap.

2. Take out the record you created of your story of resilience or the oral history you collected in the Understand activity.
3. Give each member of your team a square piece of paper or cloth. This will be a quilt square you create. If you use cloth, choose something inexpensive that you can draw on.

4. On your piece of paper or cloth, make a drawing to represent your resilience story or the oral history that was shared with you. You can also add other items, such as small pieces of fabric, to help create your quilt square.
   If you prefer, you could knit or crochet a quilt square. You can visit the *Ecosystem Resilience!* StoryMap to learn more about creating quilts and other forms of collaborative art.
5. Make a *Resilience Quilt* by joining each team member's quilt square to make a large rectangle.
6. Examine your *Resilience Quilt* and discuss with your teammates:
   a. What are some challenges our community has faced?
   b. What makes us hopeful about the future when looking at the resilience of the past that's represented on the quilt?
7. Take out a large piece of paper or poster for your team and title it "Our Resilient Future." In this guide you will be investigating how to create a resilient future. Resilience is about meeting challenges and having a good outcome. You will use this paper to think about those future outcomes.
8. Start to imagine how you want your future, the future of your local community, and the future of the world to be. Don't worry, we know life is not always perfect. Right now, it is time to dream. You can use your *Resilience Quilt* and the future you mapped out on your *Identity Map* to help you think.
9. Have each person on your team write or draw to show their ideas about the future on the *Our Resilient Future* document. Make sure each person adds at least one thing. You can use some or all of these questions to help you think about the future you hope for.
   a. What needs do you think should be met?
   b. What wants do you think should be met?
   c. What would you want to see or notice in your community?
   d. What would you not want to see or notice in your community?
   e. How would you expect to feel?
   f. How do you hope your community will respond to changes or challenges?

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10. Read *The Sustainable Development Goals* and consider what might be a future that is **sustainable**. Sustainable means an approach that balances different **perspectives** and can keep working for a long time. A perspective is a way of thinking about the world around you.

The Sustainable Development Goals

The ideas listed on your *Our Resilient Future* paper show what you want to happen in the future, your goals.

Similarly, people around the world have been setting goals for their future. The **United Nations**, also called the UN, is a global organization designed to help governments and people around the world **collaborate** and use their shared knowledge and skills to solve problems faced by many communities around the world.

As the year 2015 approached, the UN asked countries and people around the world to imagine a better world and a better future. They worked together to determine a list of goals, based on many different hopes and concerns for the future. These goals for the global community are called the UN **Sustainable Development Goals**, or SDGs. Figure 4 shows the SDGs. When you and others around the world work toward goals in your own local communities, you may also be working toward improving the global community through the SDGs.

Figure 4: United Nations Sustainable Development Goals (SDGs).

Task 1

11. Examine the SDGs in Figure 4. Are there any additional ideas you would like to add to your *Our Resilient Future* document? Add those ideas now. For example, maybe you had forgotten about the need for reduced inequalities, but now you want to add that to your paper.
12. Keep this paper. You will add to it in Task 2 and use it throughout the guide.
13. In this guide you will have some papers you will need to keep so you can look at them later. You may want to have a folder, notebook, or science journal to help you stay organized.

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Task 2: What is ecosystem resilience?

In this task, you will first ***discover*** how you are connected to and think about natural systems around you. You will gather information to ***understand*** the connections between human systems and natural systems. Finally, you will ***act*** to reimagine the relationship between human and **ecosystem** resilience now and in the future.

Discover: *How are people embedded within ecosystems?*

We all have ways of thinking about ourselves and the world around us. Sometimes we are so used to thinking in one way that it doesn't occur to us that a different way is possible. In this activity you will examine different ways of thinking about the relationship between people and the natural world.

1. Take out a large piece of paper or use a class board such as a chalkboard or whiteboard.
2. Have each team member write and circle their name on the paper or board.
3. Find a comfortable place to sit.
4. Have one person, such as a teacher or a teammate, slowly read aloud *Mindfulness: Embeddedness*. Follow the instructions.

Mindfulness: Embeddedness

Relax your body and, if you feel comfortable doing so, close your eyes. **Embedded** means being deeply connected with and surrounded by something. Think about the natural world around you. You will be considering how you are embedded within it.

Breathe in deeply and then breathe out. As I talk, keep breathing in and out at a pace that is comfortable for you.

Breathe in. Think of a glowing web extending out from you as far as you can imagine. Notice each living thing the web touches. You are all sharing space. You are all connected.

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Breathe out. Send your senses into the world around you. Imagine your connection to living things through your senses.

Breathe in. Imagine the smells, the tastes, the touches, the sights, and the sounds you might receive from the natural things covered by your web.
Breathe out. Imagine your breath extending along your glowing web to a plant nearby. Connect as you send the carbon dioxide from your breath to the plant.

Breathe in. Imagine the plant sending you the oxygen you need. Each time you breathe, you connect.
Breathe out. Feel the cycle of your breath with the plants around you.

Breathe in. Imagine the water you use and the water within you. Water cycles around the planet.
Breathe out. Imagine the water covered by your glowing web. Water that you use connects you to the rocks, the rain, the dirt, and the living things around you.

Breathe in. Imagine the food that enters your body. Extend your web to the living things that provide that food. Each time you eat, you connect.
Breathe out. Send out your feelings along the threads of your glowing web. Take a moment to find peace as you connect to the natural world.

Breathe in. Take in the intricate beauty of each living thing and the complex web of connections.
Breathe out. Think about how the things covered by your glowing web changed your personal history or your community's history.

Breathe in. Think about how the things covered by your glowing web are part of your culture.
Breathe out and extend your glowing web in all directions, up and down and outward. Everything is connected.

Breathe in. You are embedded. You are part of nature and nature is part of you.
Breathe out.

Breathe in and out a few more times, then open your eyes when you are ready.

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5. By yourself, pick one natural thing covered by the glowing web you imagined. It can be something living, like an animal or plant. It can be something nonliving, like a rock or sand.
6. Write and circle the name of the natural thing you picked on the paper or board.
7. Draw a line connecting your name to the thing you picked.
8. Along the line, write a word or two to describe each connection you can think of between you and the thing you picked. Consider the connections you thought about in the mindfulness activity—for example, connections through space, air, senses, water, food, beauty, peace, history, or culture.
9. Examine the class board or paper. Have each team member identify and connect by drawing a line to show:
    a. A connection between that team member and the natural things others added to the board.
    b. A connection between the natural things each person added to the board.
10. Read *Systems and Ecosystems*. Does your paper or class board show an ecosystem?

Systems and Ecosystems

You just represented a **system** by writing or drawing the different natural things, your team member's names, and the connections between them. A system is a group of things that all interact with one another in a network. When the system is made up of natural things, living or nonliving, it is called an ecosystem.

Deserts, forests, **grasslands**, rivers and streams, and the ocean are all examples of kinds of ecosystems. But ecosystems do not really have distinct **borders** or boundary around them. Ecosystems are connected to one another. In fact, Earth is really just one big, connected ecosystem, full of living and nonliving things interacting with one another. You and all humans are embedded within that ecosystem.

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Figure 5: Globe showing many different types of ecosystems.

Often when we think of something complex, we form something called a **model**. A model is a way of trying to represent a situation or concept. You and your team just modeled an ecosystem. Models can help you identify details about relationships within a system. They can also help you uncover more details about the way you are thinking about a concept.

11. Examine Figures 6 and 7. They show two different models of living things within the global ecosystem. Quietly think about both.
    a. How does each model make you feel?
    b. Does one model feel more aligned with how you think about the relationships between people and other living things in the world?

Figure 6: Ecosystem Model 1.[1]

Figure 7: Ecosystem Model 2.[1]

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12. Discuss as a team:
    a. What do you notice about the differences in how each model shows the relationship between people and other living things?
    b. Are there things missing from either model? What would you want to add?
    c. Which model do you think might align most closely with the way you or people in your community think about the relationship between people and other living things?
    d. Which model feels the most **equitable** or fair for people and for nature?
    e. What do you wonder about the different perspectives shown by these models? A perspective is a way of thinking about the world around you. How might your perspective be different if you thought about yourself as top of the triangle, as opposed to somewhere within the circle?

> **⚠ Emotional Safety Tip**
>
> It can be upsetting to think about people or other living things being treated unfairly. Unfair treatment of people and parts of nature has been happening for a long time and is not your fault. However, you can be part of the solution and can help make the future more fair. It is okay to pause or take a break if you feel upset.

13. Read the thoughts of research mentor Dr. Ana Spalding about the relationship between people and ecosystems. Ana is one of six research mentors who will give your team important information throughout this guide.

People and ecosystems are deeply connected. Any human activity will have an effect on the ecosystem. Similarly, any change in the ecosystem will have an impact on human communities associated with that ecosystem.

—Dr. Ana Spalding

Ana is a staff scientist at the Smithsonian Tropical Research Institute located in Panama, and director of the Adrienne Arsht Community-Based Resilience Initiative. Ana's work focuses on how coastal communities can be resilient and create a better future for people and the ocean.

Understand: *How are ecosystems and human systems linked?*

Just like you and other people, ecosystems are also always changing. There are many different types of challenges facing ecosystems. Changes in ecosystems can affect both ecosystems and human systems. In this activity you will investigate more about the ecosystem and human system in your community. You will also think about the challenges these systems face.

1. Read *Deciding Where to Research* and follow the instructions to pick the area you will investigate further.

Deciding Where to Research

As action researchers, you will be conducting investigations into your local community. Before you can do this, you need to decide as a team what part of your local community area you want to focus on. As you make your decisions, you may want to:

- Think about a place in your community you would like to know more about.
- Try to choose a space that is not too big, so you can get to know the area and its problems well.
- Try to choose an area that has a variety of places in it. For example, it probably would be a good idea to choose an area with some housing, some shops, and some public areas.
- Consider access. You may want to choose a place that is easy for your team to reach. For example, if you are in a school, you may want to choose the area around your school.
- Try to pick an area where you have noticed both people and other living things.

Set the Boundaries

When you do research, it can be useful to set a **boundary**, or edge of the area you plan to investigate. Often you can use a map to help you do this.

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a. With a partner or with your whole team, share your ideas about where it might be best to do your research about the people and ecosystems in your community.
b. Decide with your team where you will do your research.
c. Take out a map of your community and mark the boundaries of your research area. Figure 8 shows an example.

Figure 8: Example of an online community map with the boundaries of the research area marked.

Maps can be found online, in local libraries, government planning offices, tourist centers, and with elders or community leaders. If your team uses an existing map, make sure it is **accessible**, or able to be used by everyone on your team. People who are blind or have low vision sometimes use tactile or Braille maps. These maps used raised surfaces to describe where things are.

2. Take out two pieces of paper and draw an identical circle on each. Try to make the circle fill as much of each page as possible. Cut out the circles.
3. Divide your team into two groups. One group will investigate the ecosystem in your research area. One group will investigate the human system in the same area.
4. Read the investigation that matches your group and follow the instructions.

Ecosystem Investigation

You will investigate the ecosystem in your research area. Remember the research area you just mapped. Do not interact with the things in your research area; just observe.

Ecosystem Investigation

a. Take out a piece of paper to record your observations and label it "Ecosystem Investigation." On the paper, create and label two columns "Organisms" and "Relationships." An **organism** is any living thing. Figure 9 shows an example.

Ecosystem Investigation

Organisms	Relationships

Figure 9: Example of an Ecosystem Investigation paper.

b. Go to one location within the boundary of your research area and observe closely for five to ten minutes. If you cannot go out into your community, you can observe through a window or by examining videos and images taken in your community.
c. In the *Organism* column, write down the name or a description of any organisms you observe in your research area. The organisms can be bigger, like trees or large animals, such as humans. Or the organisms can be smaller, like moss or insects. You can also assume organisms are present if you notice things they left behind, such as a nest, tracks, buildings, fur, or feathers. If you can, write notes, take pictures, or make drawings of the organism so that you can return to them later. If you draw, try to include details, such as the shape or color of a bird or plant.

d. For each type of organism, if there is more than one, count how many there are and put that number next to its name or description. For example, if you notice five black ants, you might write "black ants (5)." If there are many of one type of organism, for example, an entire field of grass, just estimate how many of the same organism might be present.
e. Observe your area, paying attention to the relationships between organisms. For example, does one organism use another for food, shelter, support, or another purpose?
f. In the *Relationships* column, write down a description of each relationship you observe. For example, you might write "ants climbing up a tree."

Create Your Model

a. With your group, use one of the paper circles you cut out in step 2. At the top of the circle write "Ecosystem Model." Within the circle, add drawings or words to show all the living things you notice in your research space. Figure 7 shows an example, but you will probably have different parts of your ecosystem.
b. Observe or remember any nonliving parts of nature in your research area. This might include things on the ground, such as dirt, rocks, or sand. It might include temperature, water, air, wind, or sunlight.
c. Within the circle, add drawings or words to show all the nonliving things that you notice in your research space.

⚠ Emotional Safety Tip

Do not be discouraged if it is difficult to find living things. Every research area is different. Some areas may have many living things and some may have very few. It is not your fault if you have trouble finding living things. If you feel sad or wish there were more living things in your research area, remember that you will take action to make this possible!

Visit the Ecosystem Resilience! StoryMap for a printable version of the *Ecosystem Investigation* chart.

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Human System Investigation

You will investigate the human system of people in your research area. Remember the research area you just mapped. Do not interact with the things in your research area; just observe.

Human System Investigation

a. Take out a piece of paper to record your observations and label it "Human System Investigation." On the paper create and label two columns "People" and "Relationships."

Human System Investigation

People	Relationships

Figure 10: Example of a Human System Investigation paper.

b. Go to one location within the boundary of your research area and observe closely for five to ten minutes. If you cannot go out into your community, you can observe through a window or by examining videos and images taken in your community.
c. In the *People* column, write down a description of any people you observe in your research area. You might want to include some details, such as their general age and what you think they are doing there. For example, you might write "small child playing with a ball."
d. If there is more than one person doing a similar activity, count how many there are and put that number next to the description. For example, if you observe a group of adults and children playing together with a ball, you might write "small children (2) and adults (2) playing with a ball."

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e. Observe your area, paying attention to the relationships between people and how they connect to the natural world. For example, are people observing a beautiful view or smelling flowers?
f. Write what you observe in your *Relationships* column.
g. Observe your research area, paying attention to the way people use the area for **social** purposes. Social means the interaction of people in the community and their education, health, culture, and well-being. For example, note if people talk, learn, gather, relax, or play in the research space.
h. In the *Relationships* column write down a description of each social relationship you observe. For example, you might write "two people talking to each other as they walk" or "a person exercising."
i. Observe your research area, paying attention to the way people use the area for **economic** purposes. Economic means related to money, income, or the use of wealth. For example, note if people buy or sell things in or from the space, or work within the space.
j. In the *Relationships* column write down a description of each economic relationship you observe. For example, you might write "someone selling food" or "a person working on a computer."

Create Your Model

a. With your group, use one of the paper circles from step 2. At the top of the circle write "Human System Model."
b. Within the circle, add drawings or words to show the people you noticed in your research space and the relationships they had with that space. For example, use words or drawing to show how people were using and connecting with the space and each other, or using it for economic purposes. Figure 7 shows an example, but you will have different parts of the human system in your research area.

Visit the *Ecosystem Resilience!* StoryMap for a printable version of the *Human System Investigation* chart.

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⚠ Physical Safety Tip

Do not observe a research area by yourself. Always work with at least one other person, which could be an adult or a teammate. Be a good ally to your teammates and notice if they feel uncomfortable or unsafe. Offer to pause the investigation or move to another part of the research area. Always pay attention to local guidance on whether it is safe to interact with people outside of your home and school.

5. Come back together as a team and place your *Ecosystem Model* and *Human System Model* circles side by side.
6. As a team, try to identify as many relationships as possible between the ecosystem and the human system. If you can, use two fingers to show these relationships to your team. For example, you could point to "grass" from the *Ecosystem Model* and "playing with a ball" in the *Human System Model* to show how plants in the ecosystem make a park a pleasant place for people to play.
7. For each relationship you identify, write it down in the *Relationship* column of the *Ecosystem Investigation* or *Human System Investigation,* or both.
8. Think to yourself, if you had to overlap the two circles to show the level of **integration** between the ecosystem and the human system, how much would you overlap these circles? Integration means blending two or more things. For example, if the two circles were completely overlapping and the things in them had many connections, it would show that there is a high level of integration, or blending, between the human system and the ecosystem. If the two circles were not overlapping at all and had few connections between the things in them, it would show that there was a low level of integration between the ecosystem and the human system.

Figure 11: Examples of circles integrated to varying degrees.[2]

9. Discuss the integration of the human system and ecosystem as a team.
    a. How much integration do you think there is between the ecosystem and the human system? If you want, you can physically move and overlap the circles to share your ideas with your team.
    b. Why do you think different people might have different perspectives on this integration between human systems and ecosystems?
10. Take out your *Our Resilient Future* document and write "Now" near the bottom left of your paper.
11. Draw two overlapping circles, like the ones shown in Figure 11, to represent the decision you made about the overlap you think currently exists between ecosystems and human systems. Keep this paper close. You will use it again during the Act activity in this task.
12. Read Ana's ideas about the integration of human systems and ecosystems.

Integration of human and natural ecosystems occurs where they overlap. For instance, a house in the middle of a forest shows physical space overlaps between the human system and the ecosystem. Social processes can affect the way human systems and ecosystems are integrated. If you take an example of the integration between people and the ocean, this might be affected by government policy-making, such as fisheries regulations; entrepreneurship, such as developing and selling products from the sea; and culture, such as oral histories and traditions about the ocean passed down through generations of ocean-dwellers.

—Dr. Ana Spalding

13. Read *System Changes* and have each team member pick a different natural **disturbance** or human-created challenge.

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System Changes

There are many things that can cause change in ecosystems and human systems.

Natural Disturbances

Some change is natural. In this guide these types of changes will be called natural disturbances. Natural disturbances are a part of all ecosystems. Figure 12 shows an example of some natural disturbances.

Small disturbances help create healthy ecosystems, from a tree falling and creating a patch of sunlight on the forest floor to a flood depositing rich dirt next to a river. Natural disturbances can allow new types of living things to flourish and can be part of creating a resilient ecosystem.

However, natural disturbances can also be very difficult for people and ecosystems. For example, a falling tree or flood can destroy a building. A disease can wipe out a population. Here is a list of some natural disturbances.

- Floods and shoreline changes
- Earthquakes
- Drought
- Disease
- Very high or low temperatures
- **Typhoons** (also called hurricanes, or cyclones), tornados, and severe storms
- **Wildfires** or uncontrolled fires in a forest, grassland, brushland, or land sown to crops
- **Tsunamis** or a series of giant waves caused by earthquakes or volcanic eruptions
- **Landslides** or quick downhill movements of dirt or rocks

Figure 12: Different types of natural disturbances.

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Human-Created Challenges

Not all changes happening in ecosystems are natural. In this guide we will refer to changes caused or made worse by people as human-created challenges.

To think about human-created challenges, first examine the list of natural disturbances. In many cases, natural disturbances are becoming more intense or more frequent because of **climate change**. Climate change is the changes in the patterns of temperature and precipitation on Earth.

People can also cause additional challenges to ecosystems and human systems. Here are some human-created challenges to ecosystems and human systems.

- Climate change due to production of **greenhouse gases.** Greenhouse gases are gases such as carbon dioxide and methane that cause the atmosphere to get warmer.
- Introduction of a new type of organisms to a place
- War and conflict
- Removal of a type of organism from a place
- Removing an ecosystem to create land for building, agriculture, or grazing
- **Pollution** or natural and unnatural harmful materials that are introduced into an environment
- Overuse of **natural resources**. Natural resources are living and non-living things that are part of nature and are used by people. Examples include metals, rocks, sand, coal, soil, plants, and animals.
- **Habitat** loss and **fragmentation**. A habitat is the home environment of a living thing. When space is used in different ways, habitats can either disappear or be split into small places. Fragmentation means splitting habitats into separate pieces.

⚠ Emotional Safety Tip

Sometimes disturbances and challenges can be very difficult to think about. If you begin to feel overwhelmed by what you are learning, it is okay to take a break. Though learning about the impacts of people can be difficult, this information can help you change your community and prevent future harm to people and nature.

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You can visit the *Climate Resilience!* guide if you would like to learn more about climate resilience and people. You can visit the *Climate Action!* guide if you would like to learn more about causes of climate change.

14. With your selected natural disturbance or human-created challenge in mind, return to your *Ecosystem Model* and *Human System Model* circles as a team.
15. Share with your team how you think the natural disturbance or human-created challenge might harm the ecosystem and the human system. For example, maybe a wildfire could hurt people and other living things. Try to share as many ways as you can think of, but do not worry if you do not know all the effects on the ecosystem and the human system.
16. Pay attention while each team member shares about the disturbance or challenge they picked.
17. Discuss with your team whether you think the impacts of disturbances and challenges are fair. For example:
    a. Are there people in the human system who are more likely to be affected by the disturbance or challenge?
    b. Are the impacts of human-created challenges mostly felt by the people who created them?
    c. Do you think it's fair that ecosystems are affected by human-created challenges?
18. Next, have each team member share how the ecosystem or human system might help other parts of either system be resilient to the natural disturbance or human-created challenge. For example, maybe the trees from the ecosystem provide shade and help people interact outside even if it is very hot outside. Or perhaps people trim broken branches of a tree after a storm to help it recover.
19. Consider what everyone has shared about the effects of the disturbances and challenges on ecosystems and human systems. Think again about the overlap between the two circles.
20. Discuss with your team:
    a. Do you want to change the amount you think the circles should overlap?
    b. How do you think the resilience of ecosystems and human systems depend on each other?

Act: *How are ecosystems part of our resilient future?*

A resilient future for people is not possible without healthy ecosystems. In this activity you will explore how people and ecosystems can become resilient together.

1. Think quietly to yourself. How do you think people affect the resilience of ecosystems? How do you think ecosystems affect the resilience of people?
2. Read *At the Smithsonian* to learn more about how the Smithsonian is working to build the resilience of people and ecosystems.

At the Smithsonian

How can we ensure a resilient future for people and ecosystems? The Adrienne Arsht Community-Based Resilience Solutions Initiative at the Smithsonian Institution is working with communities to answer this question.

Building resilience requires many people to collaborate, or work together, to protect communities and ecosystems. Similar to your team, the Resilience Initiative brings together a team of people from across the Smithsonian to support efforts toward resilience through research, training, education, and engagement. The Resilience Initiative uses Smithsonian art, science, culture, and history to connect researchers, educators, and community solution implementers. Together they work to understand resilience solutions that work in different places, while balancing the needs of ecosystems and human systems.

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Figure 13: Research led by the Adrienne Arsht Community-Based Resilience Solutions Initiative Director, aiming to integrate traditional knowledge into future conservation strategies.

There are many ways communities can and should interact with the ecosystems around them. Art and history can provide some information and ideas. Science can provide other information and ideas. Bringing together many different perspectives, or ways of understanding the world and the problem, can transform the way we take action. The Resilience Initiative is helping people collaborate to create a resilient future.

3. Take out your *Our Resilient Future* document from Task 1 and remind your team about what you wrote.
4. Read *The Four Perspectives* and follow the directions.

The Four Perspectives

As you have learned, a person's perspective is how they think about something. Thinking about different perspectives can help you understand what a person values, or what is important to them. Balancing different perspectives can help make sure our actions are sustainable. You may remember that sustainable means an approach that will keep working for a long time. When thinking about sustainability, it is important to consider at least four types of perspectives: social, **environmental**, economic, and **ethical**.

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Social is about the interaction of people in a community. The health, education, cultural and community ties, and well-being of people are the most important things from this perspective.

Environmental is about the natural world. Protecting living things, natural systems, and Earth itself are the most important things from this perspective.

Economic is about money, income, and the use of wealth. Economic growth, including making sure people have jobs and enough money, is the most important thing from this perspective.

Ethical means that something is fair. Doing what is right and having a just community where everyone and everything is treated fairly are the most important things from this perspective.

5. Divide your team into four groups and assign each group one perspective: social, economic, environmental, or ethical.
6. Give each group a piece of paper to use to create a **collage** about a resilient future from their perspective. A collage is a group of pictures or words that show a big idea.
7. Read *Perspectives on Sustainability and Resilience* and think about the ideas of resilience related to your group's assigned perspective.

Perspectives on Sustainability and Resilience

What is a **sustainable future** for people and ecosystems? A sustainable future is a future that balances social, environmental, economic, and ethical concerns and that works well for people and the planet. Having resilience is an important part of sustainability. Challenges and disturbances happen. Having resilience enables people and ecosystems to manage challenges that harm communities socially, environmentally, economically, and ethically. In this activity, each group in your team will make a collage about a resilient future from one of the four perspectives. These collages will help you consider what needs to be part of a resilient and sustainable future.

Read the directions for your assigned group and use them to think about the idea of resilience from different perspectives.

Social Resilience

a. With your group, think about what social resilience means. How would you want your community's health, education, cultural and community ties, and well-being to respond to the challenges and disturbances you learned about?
b. Keep in mind that people are embedded in ecosystems. How could ecosystems help you create the social resilience you hope for?
c. Draw pictures or words to create your collage about a resilient future from this perspective.

Economic Resilience

a. With your group, think about what economic resilience means. How would you want your community's economy, including growth, jobs, and income, to respond to the challenges and disturbances you have learned about?
b. Keep in mind that people are embedded in ecosystems. How could ecosystems help you create the economic resilience you hope for?
c. Draw pictures or words to create your collage about a resilient future from this perspective.

Environmental Resilience

a. With your group, think about what environmental resilience means. How would you want your local and global ecosystems to respond to the challenges and disturbances you have learned about?
b. Keep in mind that people are embedded in ecosystems. How could people help ecosystems be more resilient or lessen the challenges they face?
c. Draw pictures or words to create your collage about a resilient future from this perspective.

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Ethical Resilience

a. With your group, think about how you would want your resilience to be ethical. Who should you be sure to treat fairly when planning for a resilient future and responding to the challenges and disturbances you learned about? Are there some people or other things that have often been treated unfairly in the past?
b. Keep in mind that people are embedded in ecosystems. What is the ethical responsibility people have towards ecosystems?
c. Draw pictures or words to create your collage about a resilient future from this perspective.

8. Have each group share their collage about a resilient future with the other groups.
9. Use tape or staples to attach the four collages to the four sides of the *Our Resilient Future* document. Figure 14 shows an example.

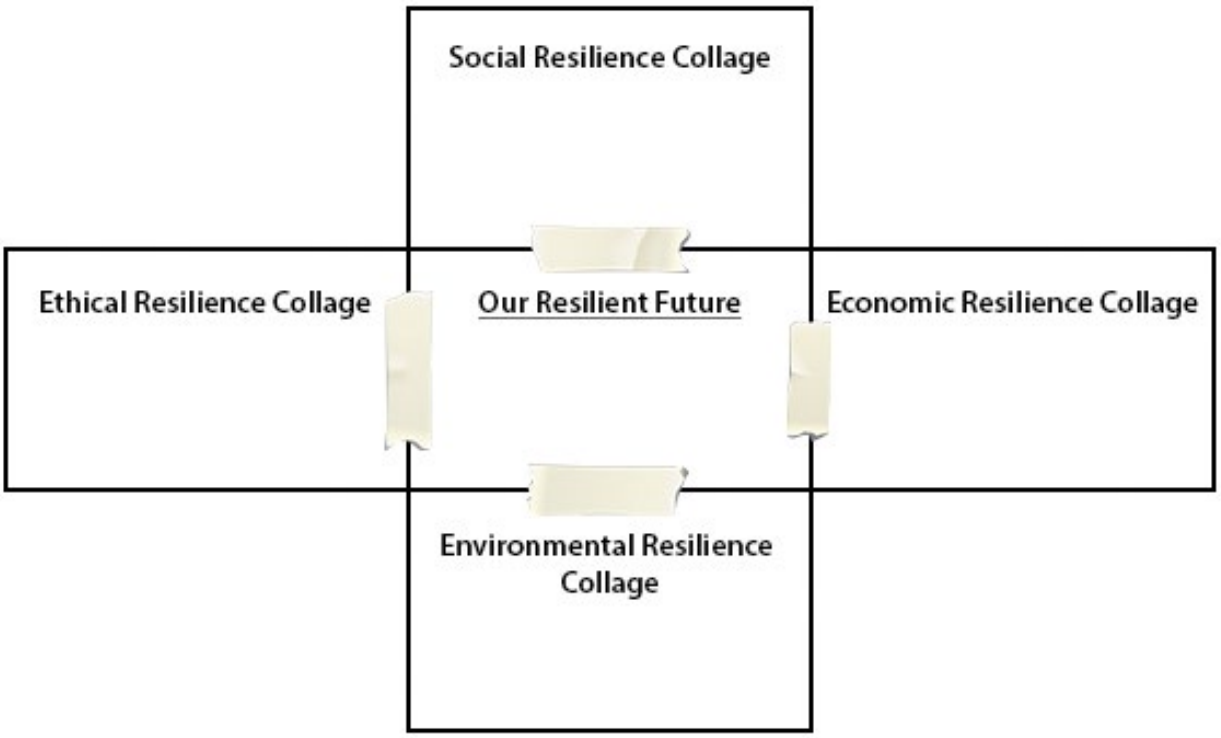

Figure 14: Example of an Our Resilient Future document with four perspective collages attached.

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10. Read Ana's ideas about what ecosystem resilience is and how a resilient future could be created.

Ecosystem resilience is the ability of a system to react, respond, and adapt to external **stressors**. This resilience is a key part of a positive future for ecosystems and people. As we move toward a more resilient future, it is important to have local communities take a leading role in creating and implementing their vision for their future.

—Dr. Ana Spalding

11. Think carefully about your hopes for the future of human systems and ecosystems.
12. Examine your *Our Resilient Future* document and reflect on the overlapping circles labeled "Now." This represents the current overlap between ecosystems and human systems in your community.
13. Near the bottom right of the sheet write "Future." Then draw two overlapping circles to represent the overlap you want to exist between ecosystems and human systems.
14. At the top write and fill in the blank in this sentence: "When I think about my future, I hope the relationship between people and ecosystems can be described as _____."
15. Share your hope with a classmate, a friend, or a family member.
    a. Tell them about the two ecosystem models from the Discover activity.
    b. Share with them about the overlap between ecosystems and human systems.
    c. Ask them what their hopes are for the future relationship between people and ecosystems.
16. Keep your *Our Resilient Future* document. As you continue to find out more about ecosystem resilience, it will be important for your team to use this document to remember what your goals are for the future.

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Task 3: Grassland: How are diverse ecosystems part of our resilience?

A variety of differences is essential for resilience. **Diversity** is a range of these differences. Diversity among groups of people results in different perspectives, skills, and experiences that help them respond to challenges. This brings resilience. Diversity in ecosystems results in a set of living things that can **thrive** in different conditions. In this task you will first ***discover*** how the differences among living things foster resilience. Then you will investigate to ***understand*** the impact people have on the diversity of ecosystems. Finally, you will ***act*** to support **biodiversity** in your local area.

Discover: *How are we linked to (bio)diversity?*

Each individual is different. People, other living things, and whole ecosystems can be diverse in many ways. This diversity is an important part of being resilient to challenges.

1. Take out your *Identity Map* from Task 1. Examine the different parts of your identity closely. You are not just one thing, way of being, or acting. You yourself are diverse. Pick two different parts of your identity and remind yourself of how those diverse parts have helped you overcome challenges in the past.
2. For each person, print a copy of the *Diversity Match Card* in Figure 15 or draw it on a piece of paper. You will use it to explore the diversity of the people on your team.

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Someone who knows multiple languages	Someone who is used to being part of a team	Someone who knows five places in your area to get food	Someone who likes to help others	Someone who has a close relationship with someone over 50 years old
Someone who likes to organize	Someone who knows what to do if a person is cut or scraped	Someone who feels connected to the natural world	Someone who knows someone from a different country	Someone who has experienced an unfair situation
Someone who has experienced a natural disaster	Someone who is a good storyteller	Someone who is good at considering different perspectives	Someone who is used to being a leader	Someone who has lived in your area for more than 10 years
Someone who likes to create art	Someone who has cared for a younger child	Someone who knows how to conserve or save water	Someone who has grown something that can be eaten	Someone who is comfortable speaking to people
Someone who has experienced a major change	Someone who can name five different plants in your area	Someone who knows a local area leader	Someone who is good at working independently	Someone who knows how to spend the night outdoors

Figure 15: Diversity Match Card.

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⚠ Emotional Safety Tip

Everyone has identities, experiences, and strengths that help make your team diverse. When sharing information with your team, it is important to respect your own strengths and to respect what others identify as their strengths. Sharing personal information can be hard. It is okay to choose not to share certain information about yourself with your team members.

3. Have each team member take their *Diversity Match Card* and move around your learning space. When you find another team member with one of the identities listed in any box on your card, write their name in that box.
4. Continue moving around and marking off identities for up to 10 minutes or until you have a name in each box. If you do not have enough people to fill in all the boxes, you can add a person's name to more than one box.
5. Read the challenges listed in Figure 16. For each challenge, by yourself, identify which people listed on your *Diversity Match Card* might be able to help your team be resilient to that challenge.

Disease Challenge
A new disease has arrived and is hurting birds in your area. There is concern it could spread to people. Your team wants to communicate important information to others in your community in an engaging way.
Space Challenge
There are plans to convert an area from natural grassland into farmland. This would bring better access to locally grown food but would affect the ecosystem. Your team wants to propose a different solution to local leaders.
Natural Disaster Challenge
A natural disaster affects your community. Some people are injured and it is hard to find shelter, food, and water. Your team wants to help your community get through this situation.
Climate Challenge
The climate is changing which crops can be grown in your area. Your team wants to help farmers in your area learn from farmers in other places about different types of crops and growing methods.

Figure 16: Challenges.

6. Discuss with your team:
    a. Why is it important to have a team of people with a diverse set of relationships, skills, and roles they like to play?
    b. Think of a time when you, your team, or your community faced a challenge. How did people's differences or diversity help your community respond?
7. Read *Grassland Ecosystems and Biodiversity* to find out more about how the link between diversity and resilience applies to ecosystems as well.

Grassland Ecosystems and Biodiversity

Diversity is important in ecosystems as well as human systems, such as your community or team. The diversity of living things is called biodiversity. You are going to use a grassland ecosystem as an example to help you think about biodiversity and how it relates to resilience. Grasslands are large, open areas of grasses and the associated living things. You may know grasslands by a different name. Grasslands are also sometimes called prairies, savannas, steppes, or pampas.

Figure 17: North American prairie grassland ecosystem with grazing bison.

Even though it may appear that the plants of grasslands are very similar, they likely differ in important ways. There are many different types of plants, including grasses, forbs, shrubs, and others. Each has an important role in the grassland ecosystem.

Just as human systems are challenged by changes, ecosystems also face challenges. As you learned, natural disturbances are natural part of ecosystems. Fire, drought, and the impact of certain **species** all create natural disturbances to grasslands. A species is a type of living thing, such as a wolf, a grasshopper, or a yarrow plant. If an ecosystem is biodiverse, the system is often more resilient to these natural disturbances than if it is less biodiverse. In fact, natural disturbances can increase biodiversity, because disturbances create opportunities for different species to thrive. You can learn more about biodiversity in the Smithsonian Science for Global Goals *Biodiversity!* guide.

8. Read what research mentor Dr. Ellen Welti from the Smithsonian Conservation Biology Institute says about diversity in grassland ecosystems. As you play the *Grassland Biodiversity Game* next, try to find any species that are **ecosystem engineers**.

In the grasslands of North America there was a huge loss of mammal biodiversity after the last Ice Age. We lost animals you may have heard of, such as the wooly mammoth, the saber-toothed tiger, and the giant sloth. Those changes were likely due in part to the changing climate.

But more recently there have been changes humans have played a large role in. For example, the bison of North America went from tens of millions of animals down to around a thousand individuals because of people. This created a **genetic bottleneck**, or a situation where there is low genetic diversity in a population because of a limited number of ancestors. Even though there are more bison now compared to a hundred years ago, they have lost their historic ranges and **migration** routes. This loss changes the entire ecosystem because bison are ecosystem engineers. Ecosystem engineers are living things that substantially change the physical environment of an ecosystem.

Another important ecosystem engineer is the prairie dog. They turn over amazing amounts of soil, but they are also under threat. They currently live in only about 2 percent of the area they used to be in.

—Dr. Ellen Welti

Ellen is research ecologist with Smithsonian's Great Plains Science Program and Conservation Ecology Center. She enjoys studying plants and insects to test questions spanning community and ecosystem ecology of grassland systems.

⚠ Emotional Safety Tip

It can be difficult to think about the loss of plants and animals on Earth. Biodiversity loss is a challenge many ecosystems are experiencing. Though it can be difficult to think about the loss of living things, what you learn in this activity can help you work to prevent biodiversity loss in the future.

9. Print out one set of *Natural Disturbance Cards* from Figure 18 and two sets of *Species Cards* from Figure 19. If you can, use heavier paper to make the cards a little easier to use. Keep the card sets separate. The *Ecosystem Resilience!* StoryMap has cards that are easier to print and use.

Prairie dog communities disrupt the soil and vegetation, creating new habitats and increasing biodiversity. Action: Remove and replace duplicate plant species with non-duplicates.	**Bison migration** creates wet areas through wallows and leaves behind dung, enriching the soil. Action: Remove and replace duplicate plant species with non-duplicates.	**Dung beetles** process the dung of bison and other animals and cycle nutrients back to enrich the soil. Action: Add a new Soil card to your ecosystem.	**Wolf packs** control herbivore populations, especially by eating old or ill herbivores. Action: Remove and replace duplicate herbivore species with non-duplicates.
Fire burns through old vegetation, allowing new, more nutritious plants to flourish. Action: Remove and replace duplicate plant species with non-duplicates.	**Drought**, when it is occasional, encourages plants with deep roots, discouraging erosion. Action: Remove and replace duplicate plant species with non-duplicates.	**Disease** can spread through a population, limiting its size and removing the weak organisms. Action: Remove and replace all duplicate species with non-duplicates of the same type, such as herbivores.	**Grasshopper swarms** eat old vegetation. Their dung enriches the soil and they are a food source for many animals. Action: Remove and replace duplicate plant species with non-duplicates. If possible, add a new herbivore.

Figure 18: Natural Disturbance Cards.

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1 SOIL Soil allows plants to grow.	**1** SOIL Soil allows plants to grow.	**1** SOIL Soil allows plants to grow.	**1** SOIL Soil allows plants to grow.	**1** SOIL Soil allows plants to grow.
2 PLANT **Big Bluestem** Needs: Soil	**2** PLANT **Coneflower** Needs: Soil	**2** PLANT **Yarrow** Needs: Soil	**2** PLANT **Dropseed** Needs: Soil	**2** PLANT **Switchgrass** Needs: Soil
2 PLANT **Little Bluestem** Needs: Soil	**2** PLANT **Blue Grama** Needs: Soil	**2** PLANT **Serviceberry** Needs: Soil	**3** HERBIVORE **Prairie Dog** Needs: Plant	**3** HERBIVORE **Bison** Needs: Plant
3 HERBIVORE **Mule Deer** Needs: Plant	**3** HERBIVORE **White-Tailed Jackrabbit** Needs: Plant	**3** HERBIVORE **Monarch Butterfly** Needs: Plant	**3** HERBIVORE **Big-Headed Grasshopper** Needs: Plant	**3** HERBIVORE **Prairie Vole** Needs: Plant
4 CARNIVORE **Western Meadowlark** Needs: Grasshopper or Butterfly	**4** CARNIVORE **Black-Footed Ferret** Needs: Prairie Dog	**4** CARNIVORE **Gray Wolf** Needs: Bison, Deer, or Jackrabbit	**4** CARNIVORE **Burrowing Owl** Needs: Vole or Snake	**4** CARNIVORE **Plains Garter snake** Needs: Vole or Meadowlark
DECOMPOSER **Dung Beetle** Needs: Plant, Herbivore, or Carnivore Creates: Soil	DECOMPOSER **Soil Fungi** Needs: Plant, Herbivore, or Carnivore Creates: Soil	DECOMPOSER **Earthworm** Needs: Plant, Herbivore, or Carnivore Creates: Soil	DECOMPOSER **Beetle** Needs: Plant, Herbivore, or Carnivore Creates: Soil	DECOMPOSER **Soil Bacteria** Needs: Plant, Herbivore, or Carnivore Creates: Soil

Figure 19: Species Cards.

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10. Read *Grassland Biodiversity Game* and follow the instructions to play the game.

Grassland Biodiversity Game

In this game you will collaborate to build a biodiverse ecosystem using the cards you printed. The more species in your group ecosystem, the higher you will score. As you build the ecosystem, you will face challenges on your *Natural Disturbance Cards*. These *Natural Disturbance Cards* can reduce or help you build biodiversity.

Getting Ready to Play

The game works best with three to five people seated at a table or other shared space. You will use the middle of the table to build your ecosystem together.

Shuffle your *Species Cards* and deal five cards to each player. Place the rest of the cards face down in a pile in the middle. Each time you play a *Species Card*, pick a new *Species Card* to replace it. If you run out of *Species Cards*, replace them by shuffling the cards that have been discarded.

Shuffle your *Natural Disturbance Cards* and place them face down in a pile to one side. You will pick one of these cards at the end of each round.

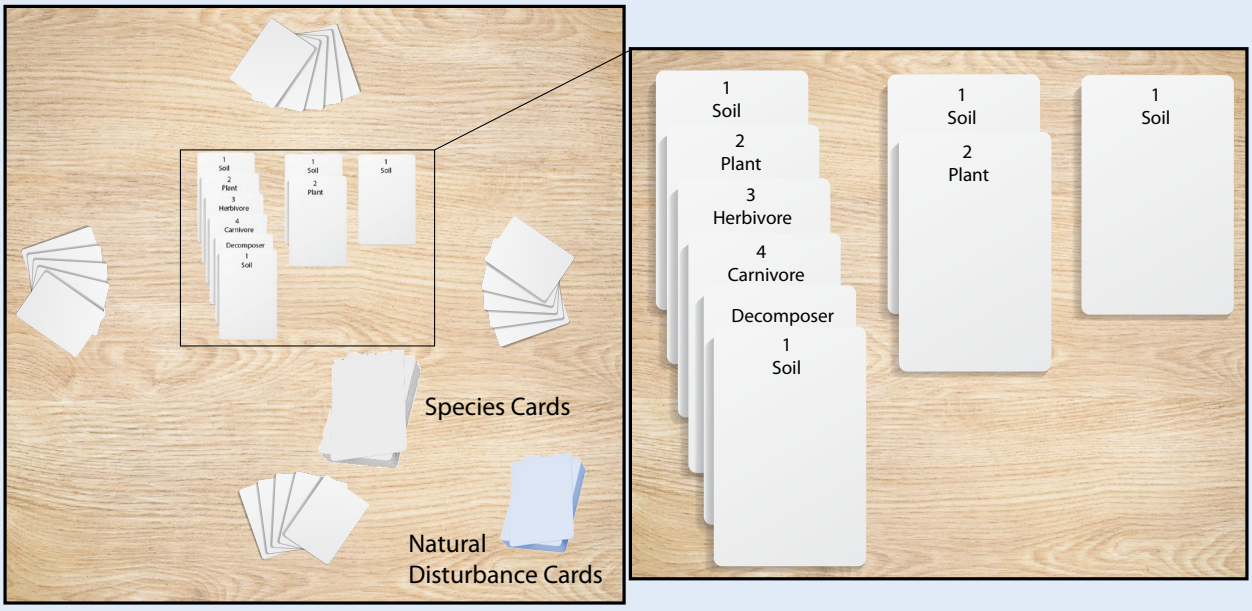

Figure 20: Example of game setup and card building as part of the game play.

Task 3

Play the Game

Go around the circle taking turns and building on top of previously played cards. The ecosystem is built in numerical order: Soil-Plant-Herbivore-Carnivore. An **herbivore** is an animal that mostly eats plants. A **carnivore** is an animal that mostly eats other animals. A **decomposer** is a living thing that breaks down living things after they die and return those nutrients to the soil.

A Decomposer card can be played on top of a Plant (2), Herbivore (3), or Carnivore (4) card. The decomposer creates new soil. If you have or draw a Soil card, play it as an extra turn on top of a Decomposer card, if there is one on the table.

Round 1

Player 1: If you have a Soil card, play it. If you do not, you can discard a card and draw a new card.

Player 2: If there is a Soil card on the table, you can build on top of it with a Herbivore card. Or you can play another Soil card. If you can do neither, discard a card and draw a new one.

Remaining players: Choose whether to play a Soil card or build on another player's card. Follow the directions on your *Species Card* for how to build. For example, a *Black-Footed Ferret* needs to be built on a *Prairie Dog* card. You can play a Decomposer on top of a Plant, Herbivore, or Carnivore. If you play a Decomposer, anyone with a Soil card can add it to the top of that pile.

At the End of Each Round

At the end of each round, pick one *Natural Disturbance Card* and follow the directions. If the card says to "remove," remove those cards and any cards built upon them and place them in the discard pile. If the *Natural Disturbance Card* says "replace" or "add," you can use a *Species Card* from any player's hand.

Additional Rounds

Continue playing and drawing a *Natural Disturbance Card* at the end of each round of play.

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Score the Game

When you have played all the *Natural Disturbance Cards*, count up your group's biodiversity score. Your biodiversity score is the number of different types of *Species Cards* that are on the table. If you have two of the same species, you only get one point. Add on a bonus point for each time you completed a full ecosystem set (1, 2, 3, 4, Decomposer).

If others have played the game, you can compare your score to theirs. Or you can play again and try to get a higher score. What choices create the highest score?

If you want to play this game with species that are part of a tropical grassland ecosystem, you can find those cards on the *Ecosystem Resilience!* StoryMap.

11. Discuss with your team:

    a. As you played the *Grassland Biodiversity Game* with your team, you may have noticed different types of roles, skills, and relationships in your grassland ecosystem. What types of diversity did you notice among the species listed in the game?

    b. Usually people think disturbances such as fire, drought, or disease are harmful to ecosystems. After playing the game, do you think this is always true?

Understand: *What is causing biodiversity changes?*

You have learned that ecosystems are always changing and being disrupted. But human systems are also always changing. Sometimes these changes have a big impact on ecosystems. In this activity you will explore more about how human choices can affect ecosystems.

1. Read *At the Smithsonian* about grasslands in North America and Africa. What human-created challenges can you identify?

At the Smithsonian

Grasslands ecosystems appear in many climates and locations. These different grasslands have things in common. Researchers Dr. Ellen Welti and Dr. Jared Stabach from the Smithsonian National Zoo and Conservation Biology Institute want to know more. Ellen researches temperate prairie grasslands in the northern United States. Jared researches tropical savannah grasslands in Kenya. They also work together to research common threats to grasslands globally.

Living things might be different in the two locations Ellen and Jared study, but there are important similarities. For example, the bison of North America (sometimes called American buffalo) and the wildebeest of Africa (sometimes called gnu) have similar roles in their ecosystems. In the past, these animals migrated in large herds. Some large populations of wildebeest continue to **migrate**. To migrate means to move to and from a different area, often following shifting weather, food resources, or seasonal plant growth patterns. For example, many bird populations migrate between places where they spend the summer and the winter.

Migrating bison and wildebeest change their ecosystems as they travel. They eat a lot of vegetation, allowing new types of plants to flourish. They leave **dung** (poop) behind, enriching the soil and cycling nutrients. And they **wallow** or roll repeatedly on the ground, creating low-lying areas that collect water. These areas can provide resources for other species to flourish.

Bison and wildebeests face many threats, even though they are both very important, or **keystone species** in grassland ecosystems. Wild bison were almost eliminated from prairies in the 1800s and today only exist in protected areas.

In the past, wildebeest populations also declined when they were infected with a disease transferred from cattle (called cattle plague).

Figure 21: Wildebeest herd studied by Jared.

Today migration is difficult because of human barriers that exist across the ecosystems. These barriers include fences, roads, railways, and pipelines. Grasslands are also increasingly fragmented. Fragmented means a larger area is broken into smaller, unconnected pieces. For migrating animals, fragmentation may mean they can no longer travel across their normal range. For both bison and wildebeest, much of the land they used to graze is now used by cattle instead. Changing weather patterns also present a challenge.

Decreases in the bison and wildebeest populations also decrease the biodiversity of each ecosystem, resulting in fewer insects, birds, plants, and predators. Jared and Ellen are studying these changes to better understand how to support resilient grasslands in the future.

For more information about bison and wildebeest and the role they play in grassland ecosystems, visit the *Ecosystem Resilience!* StoryMap.

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2. Print out the *Human Challenge Cards* in Figure 22.

Cropland creation takes grasslands and changes them into areas to grow crops, such as wheat or corn. Action: Remove one Soil card and anything built on it.	**Fencing land** for cattle grazing means other species can no longer migrate. Action: Remove one Bison card and anything built on it.	**Pest control** by spraying insecticides can remove both species thought of as pests and other insects. Action: Remove all Butterfly and Grasshopper cards and anything built on them.	**Animal elimination** removes certain species, often because they either eat cattle or crops. Action: Remove all Wolf and Prairie Dog cards and anything built on them.	**Introduced species** change the ecosystem by bringing in species that have no natural predators. Action: Remove one Plant species and anything built on it.

Figure 22: Human Challenge Cards.

3. Play the *Grassland Biodiversity Game* again. This time, mix the *Human Challenge Cards* together with the *Natural Disturbance Cards* from Figure 18.
4. After you finish the game, discuss with the other players:
    a. How did your biodiversity score for the game you just played compare to your biodiversity score in the previous game?
    b. What differences did you notice between human-created challenges and natural disturbances?
5. Read Ellen's ideas about biodiversity loss in the North American grassland and examine the human disturbances listed in the cards. Can you think of any ways to remove or lessen the disturbance?

There are a lot of pressures on grassland ecosystems. We have a big shift over time in the Great Plains system of North America as bison have been replaced by cattle. Many insect populations seem to be on the decline, but we need more data to understand how insect populations are changing. Many insects, such as grasshoppers, are actively **suppressed** because they are considered a pest species, even though they are **native**. And dung beetles, which previously processed the dung of bison, are instead processing the dung of cattle. However, the drugs given to cattle to try to keep away pests, such as flies, are **toxic** to dung beetles as well and have reduced their populations.

As for plants, there has been a huge shift in those communities. When land is converted to agricultural uses, it is usually plowed, which removes or disrupts most plant communities. Often non-native species are introduced. There are some grassland systems, like the tall grass prairie, that cover only around 1 percent of the area they used to cover. The soils created by this ecosystem were very nutrient-rich, so they are very desirable for agriculture.

A biodiverse grassland is hard to restore. Even 100 years after a field is plowed and abandoned, often it only has a fraction of the species of a native grassland. Ecosystem engineers such as bison can help by eating grass. This allows more competition and increases plant diversity. Increases in plant diversity can lead to increases in insect diversity by providing more resources for insects to live on and eat. This helps build the food chain. The bison are also peeing and pooping everywhere, which is a huge resource input to the system, especially for insects, bacteria, and fungi.

—Dr. Ellen Welti

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6. Read *Scoring Biodiversity in Your Area* and follow the instructions.

Scoring Biodiversity in Your Area

Take out your *Ecosystem Investigation* paper from Task 2 and examine the species you listed.

Find Your Biodiversity Score

Score one point for each species listed on your *Ecosystem Investigation* paper, like you did in the *Grassland Biodiversity Game*. Just like in the game, do not count multiples of the same species. For example, even if you have five ants, that is only one point because they are all the same species.

What is your biodiversity score for your research area?

Biodiversity Is More than a Number

As you learned in the *Grassland Biodiversity Game*, not all organisms have the same effect on the biodiversity of an area. **Native species** are often very important for maintaining high biodiversity. Native species are living things originally from the place where they are living now.

Often when people are involved in an ecosystem, they introduce new species. Introduced species are originally from another place. Introduced species are sometimes called **invasive species** if their populations grow in an uncontrolled way and they harm native species.

Sorting Into Native and Introduced

Try to sort the species you have listed on your *Ecosystem Investigation* paper into native and introduced. You may not know whether a species is native or introduced. If you want to try to find out, you could use a book, such as a plant identification book. You could go online and search for species native to your area. Or you could ask someone who might know, such as someone who works in a nature or garden center, a local grower, or a community elder.

a. Next to any native species you can identify, write "native" on your paper.
b. Next to any introduced species you can identify, write "introduced" on your paper.
c. You may not be able to sort all the species. Just do your best.

Discuss

Plants, animals, and other living things that are native to an area have evolved together. This means a diverse set of native plants are often well-suited to the soil and the climate. It means a diverse set of native animals often are well-suited to eat, pollinate, spread the seeds of, or create habitats for native plants. With your team, discuss:

- Why do you think places with mostly native species also often support high biodiversity?
- Do you think the species in your research area were mostly native or mostly introduced species?
- Were there many of the same type of species in your research area? What do you think that means about biodiversity in your area?

Act: *How can we encourage diversity for resilience?*

You have learned that diversity can be valuable when responding to challenges. This is true for human systems and ecosystems. In this activity you will decide what you want to do to encourage diversity in the systems around you.

1. Use a class board or take out a large piece of paper. Divide it into four sections and label them "Social," "Environmental," "Economic," and "Ethical."
2. As a team, use the four perspectives to think about why biodiversity is important when responding to challenges. Imagine your local area had much more biodiversity. How could this biodiversity help make your local community more resilient? Write or draw your ideas in the matching perspective section on the board or paper. For example:
    a. Social: How might biodiversity help your local community respond to social challenges, such as those related to education, health, well-being, and belonging? For example, could biodiversity help provide places of peace or build community and culture? Often communities have species that are important culturally as part of the stories, traditions, or food of a place.

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b. Environmental: How might biodiversity help ecosystems and human communities respond to environmental challenges? For example, does biodiversity make ecosystems more resilient challenges and disturbances?

c. Economic: How might biodiversity help people respond to economic challenges? For example, could biodiversity be a source of money from tourism or help create better pastureland for your community?

d. Ethical: How might biodiversity help human communities respond to ethical challenges? For example, does biodiversity show how differences can increase resilience?

3. At the bottom of the board or the paper, write, "Biodiversity is important because it helps our community _____." List two or more of the most important reasons you listed in step 2.
4. If possible, share this statement with a member of your community who is not a part of your team, such as friends, family members, or someone in your community who cares for living things.
5. Read Ellen's ideas about what individuals can do to support biodiversity.

There are many things you can do to support biodiversity. As a consumer, you can choose the types of food you eat and make wise choices about how that food is grown or raised.

You can learn and share with others why wildlife is so cool and so important.

You can build biodiversity around you. Planting more diverse native plant species can be helpful for birds, bats, and insects. You can start from the bottom up. More plant diversity helps with more diversity of all species. Planting native species is really important because those species are well adapted to that environment and they are the species that help support native animal counterparts. These species evolved together.

—Dr. Ellen Welti

6. As a team, discuss what you think you personally or your team could do to increase biodiversity in your local area. For example:
    a. Educating others about the role of native or introduced species in your ecosystem.
    b. Planting one or more native plants or a native plant garden.
    c. Paying more attention to the ecosystem around you. For example, not polluting or trampling natural areas.
    d. Investigating more about biodiversity challenges in your local area and telling others about these problems.
    e. Changing your food choices or using another method to reduce some of the human disturbances to biodiversity, such as pesticides, changing land use into grazing or cropland, or eliminating species.
    f. Telling someone else about the connections between biodiversity and resilience.
    g. Or other ideas you come up with. The *Ecosystem Resilience!* StoryMap has ideas if you need support.
7. Choose one action you can personally take in the next week. Turn to a partner and tell them what you plan to do.
8. Open a digital document or take out a piece of paper for your team and title it "Action Planner." In Task 8 you will choose a larger action to take as a team. This action planner will help you remember your ideas from the other tasks.
9. Choose an action or actions you discussed from step 6 or another action that you might want your team to take related to biodiversity. Add a picture or pictures to the *Action Planner* to help you remember your idea. This could be a digital picture, something you have printed out, or a picture you have drawn.
10. Keep your *Action Planner.* You will use it throughout this guide.

Task 4: Forest: How is ecosystem connectivity part of our resilience?

You connect to many different types of things—the people and places around you, the things you touch or use, even the air you breathe. Ecosystems also have many connections. The areas within a type of ecosystem all connect to one another. The living things in the ecosystem are connected. Ecosystems themselves are connected locally and globally. In this task you will learn more about **forest ecosystems**. You will ***discover*** how connections encourage human and ecosystem resilience. Then you will investigate to ***understand*** connectivity issues in forest ecosystems. Finally, you will ***act*** to promote connectivity.

Discover: *How are we linked to the connectivity of forest ecosystems?*

Forest ecosystems are connected locally, regionally, and globally. They also connect to people on all those levels. Thriving, resilient ecosystems provide many benefits to people. The connectivity of forest ecosystems helps build resilience to challenges and disturbances.

1. Get ready to move around your learning area. If your team cannot move around the learning area, think of other ways you can connect members of your team. For example, you could connect team members by moving a ball of yarn from one person to another to create a web of connections.
2. Read *Finding Connections Game* and follow the instructions.

Finding Connections Game

In this game you will attempt to link everyone in your team or class through people you know. If you prefer, you can also choose a different way to explore connections. For example, you could choose places you have been or something else interesting to your team. This game works best if you have at least six people, but can be played with a much bigger group as well.

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a. Find another team member and try to find someone you both personally know. This person needs to be outside your team or class.
b. If you can find a common connection (someone you both know), link arms or find another way to stay connected. If you cannot find a connection, move on to another team member and try to connect with them.
c. As a pair, move to find another individual or group who knows someone that one of you also knows. You just need one linked partner to connect.
d. Keep linking the groups until your whole team is connected.

3. Discuss with your team:
    a. Does everyone know the same people or are there people some team members had in common who were unfamiliar to other team members?
    b. In an emergency, how do you think these connections might help? For example, would you be able to communicate with someone you do not know through the links you just formed?
    c. What other categories, besides people you know, could you choose to show how your group is connected?
4. Now play the *Finding Connections Game* again, but this time have each team member use a connection to forests they have in common with another team member. This could be using a product, such as wood, that comes from a forest, time spent in a forest, curiosity to learn more about forests, a favorite place in a forest, a movie you both watched about a forest, a connection with a living thing found in the forest ecosystem, or a connection through the clean air or water the forest helps provide.
5. Discuss as a team, what are some of the main ways you are all connected to forest ecosystems?
6. Read *Forest Ecosystems and Connectivity* to understand the ways you benefit from forests.

Forest Ecosystems and Connectivity

Forest ecosystems are ecosystems where many trees are an important feature. There are many types of forest ecosystems, from **tropical rainforests** to the **boreal forests** of the far north. Forests are connected in many ways. They connect vertically, from the forest floor to the tops of trees. They connect horizontally through different forest patches locally, globally, and regionally. And forests connect with people emotionally, spiritually, economically, and in many other ways.

Ecosystem services are the ways in which ecosystems benefit people. They include:

- Cultural services: providing personal opportunities for connection to health, recreation, or wellness, such as connecting with nature or exercising in a natural setting
- Resource services: providing products, such as food, wood, or other items people use
- Supporting services: providing biotic services, or services that support the ecosystem's living things, such as pollination, natural pest management, and generating high-quality soil
- Regulating services: regulating abiotic, or nonliving, processes, such as storing carbon to help fight climate change, absorbing stormwater, or cooling local areas

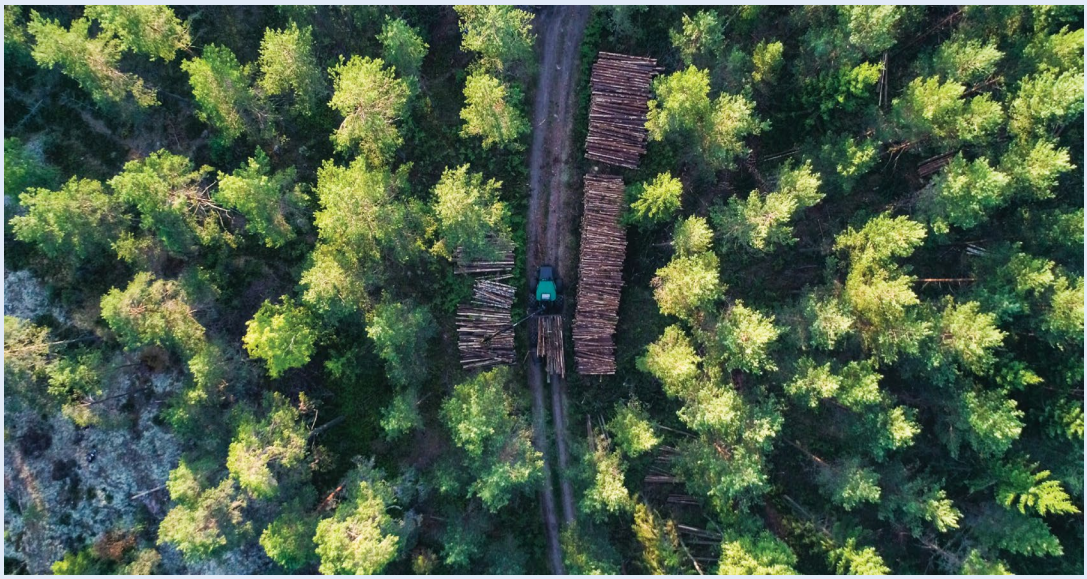

Figure 23: People gathering lumber, which is one ecosystem service forests provide.

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7. Read what research mentor Katherine Araúz Ponce thinks about the connections between people and forests. Katherine is a researcher at the Smithsonian Tropical Research Institute and is conducting research for her PhD. Are there any connections she mentions that you hadn't thought about before?

Many people just feel a sense of connection to forests. Forests provide a cultural and personal benefit, for example through recreation or spirituality. People value and enjoy nature. They love to be around the tall trees, the squirrels, the birds, the monkeys, and all the wildlife surrounding them. Nature can provide a benefit for our health. Some studies show that being in forested areas can increase your concentration, lower your blood pressure, reduce stress, and promote happiness. Communities can also benefit from ecotourism, which can provide a source of income.

There are many other ecosystem services the forest provides. People get resources from the forest, such as wood, fruits, fibers, fresh water, or medicinal plants. Forests also provide habitats or shelter for many different animals, which is a supporting service. These species can provide many benefits, from seed dispersal to controlling pests on farmer's crops.

Forests also help regulate natural processes. Forests along the shoreline, like mangroves, help protect coastal communities from storms and control floods. Forests play a crucial role in regulating local and regional temperatures, helping to create cooler environments. They are also essential for carbon storage and climate regulation. This means that decisions affecting forests in one part of the world have implications for people everywhere and the entire planet.

—Katherine Araúz Ponce

Katherine, a PhD student at the University of Georgia and a Smithsonian Fellow, is conducting research on bird conservation in coffee landscapes in Panama. Inspired by the high biodiversity of tropical mountain forests, she aims to advance conservation strategies and build connections with producers.

8. Read *Ecosystem Services Connections Puzzle* and follow the directions to play the game.

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Ecosystem Services Connections Puzzle

Game Rules

Examine the words shown in Figure 24. They are related to the ecosystem services provided by forest ecosystems. The words can be divided into four categories; each is a type of ecosystem service. Try to determine the four categories and which words go into each category. The answers can be found after the discussion questions in Step 9 of this activity.

Wood and paper	Maintain air quality	Tourism	Medicine
Manage pests and disease	Regulate local climate to be cooler	Bird-watching	Absorb and direct stormwater
Create a sense of calm and mental well-being	Pollinate agricultural crops	Firewood for fuel	Provide habitat for migratory birds
Mitigate climate change through carbon storage	Walking, climbing, and hiking	Mushrooms, berries, and nuts	Maintain soil quality

Figure 24: Ecosystem Services Connections Puzzle.

9. Discuss with your team:
    a. Were there any ecosystem services that surprised you?
    b. Can you think of any ecosystem services from forests that were missing from the game?
    c. Think about the ecosystem around you. What kind of ecosystem services is it providing? Does everyone in your community have equal access to these services?
10. Check your answers from the *Ecosystem Services Connections Puzzle* here.

Ecosystem Services Connections Puzzle Answers

Here are the answers to the *Ecosystem Services Connection Puzzle*.

- Category 1 (Forest Resource Services): Wood and paper; Medicine; Firewood for fuel; Mushrooms, berries, and nuts
- Category 2 (Forest Cultural Services): Tourism; Create a sense of calm and mental well-being; Walking, hiking, and climbing; Bird-watching
- Category 3 (Forest Regulating Services): Maintain air quality; Regulate local climate to be cooler; Absorb and direct stormwater; Mitigate climate change through carbon storage
- Category 4 (Forest Supporting Services): Manage pests and disease; Pollinate agricultural crops; Provide habitat for migratory birds; Maintain soil quality

11. By yourself, examine the *Personal Forest Ecosystem Exploration* list in Figure 25 and give yourself one point for each item in the list that you eat, use, enjoy, or benefit from.

Forest Ecosystem Services	**Score**
I eat: nuts, chocolate, citrus fruits, coffee, palm oil, açaí, bananas, cherries, apples, mushrooms, maple sugar or syrup, avocadoes, cinnamon, pepper, mangoes, figs, durian, jackfruit, vanilla	
I use products containing: lumber, pressed or laminated wood, coconut oil, paper, cardboard, rubber, cork, resin, rayon, wood pellets	
I have enjoyed in a forest: hiking, walking, biking, climbing, rolling, bird-watching, watching other living things, sitting quietly	
My culture includes the following related to forests: stories, myths, movies, religious or spiritual figures, famous artwork	
I have benefited from: the shade of a tree on a hot day, air I can breathe, pleasant temperatures, heavy rainstorms with no flooding	
Total (add up your score for each line)	

Figure 25: Personal Forest Ecosystem Connection Exploration.

12. Compare your score with your teammates' and discuss: Which connections surprised you?

Understand: *What happens when connections change?*

The forest ecosystems today are changing quickly. Many of these changes are related to people. In this activity you will explore the changing connections within forest ecosystems. You will use specific examples to imagine new ways to balance forest ecosystems and human systems.

1. Examine Figure 26 and discuss with your team:
   a. What do you notice about changes over the last 10,000 years?
   b. What do you think is causing these changes?
   c. What do you wonder about the effects of these changes?

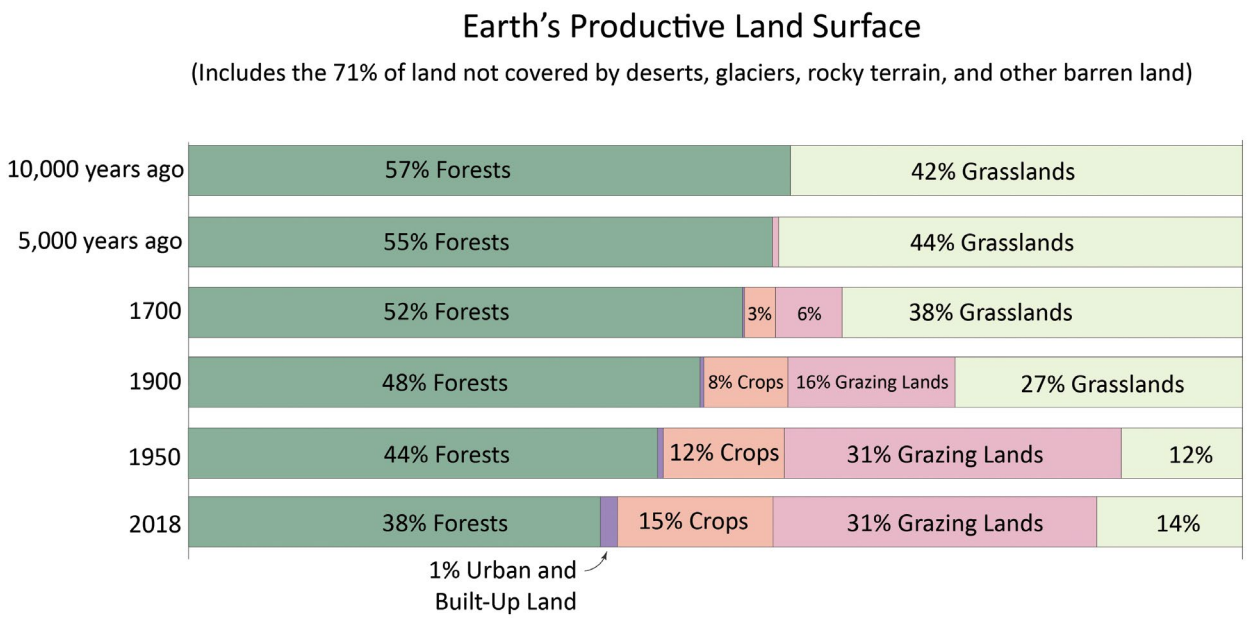

Figure 26: Changes in forests on Earth, from 10,000 years ago at the end of the last Ice Age to 2018.[3]

⚠ Emotional Safety Tip

Examining data about the changing Earth may make you feel angry or anxious. That's okay. Understanding a problem by examining data can be the first step to solving the problem. It is okay to take a break or share your feelings with a trusted adult or friend.

2. Think about the *Personal Forest Ecosystem Exploration* you completed in the Discover task. Compare those connections with the **deforestation** changes from Figure 26. Deforestation is the removal of forest ecosystems. With a partner, discuss:
   a. What are the forest connections that might be linked to deforestation?
   b. What important forest connections do you have that would change if deforestation increased?
3. Read what Katherine says about the causes of deforestation. Are there any causes she discusses that you noticed in Figure 26?

The most significant cause of deforestation is the human need for food. Globally, deforestation mainly occurs in tropical forests where the main drivers are the production of beef, soybeans, pam oil, and other cereals and vegetables. Because we need food, people are turning forests into farms and grazing areas.

Mining is also a significant contributor to deforestation. The modern world uses mining to obtain products such as coal, gold, and iron ore. Technologies and devices that require mineral products put pressure on tropical forests, harming the environment.

Forests can also be cut down to create residential areas. As our global population continues to grow, so do our needs.

Deforestation not only removes parts of forests but also affects the resilience of the remaining patches. When these patches are too small, it becomes difficult for certain plants and animals to live there, leading to a decrease in biodiversity. The extent of this loss is often unknown, as we are still discovering and learning about forest species. The increasing and rapid decline of biodiversity means protecting these diverse ecosystems is urgent.

Generally, larger patches are better for biodiversity because they provide more habitat and resources where different species and individuals can find territory, food, water, and mates. But size and shape play a role as well. Smaller patches are more vulnerable to changes in environmental variables, such as temperatures or winds. This is called the **border or edge effect**, which means plants or animals near the border of a forest face more challenges to survive.

However, there is hope. As individuals, we can find ways to sustainably produce food and other goods without harming the forests. The power to make this change is in our hands.

Forests can be integrated into areas developed by people. We can build pathways or corridors between patches of forest to help living things move. We can create a habitat for birds and insects by planting native species in our garden or yard. We can manage food areas in a way that supports the forest.

—Katherine Araúz Ponce

4. Think about the problems created when a forest ecosystem is broken into patches and becomes disconnected. Turn to a partner and discuss:
   a. Were there any problems related to resilience that Katherine identified that are created by having small forest patches?
5. Read *Modeling Forest Resilience*. Make and test the model as a team or in pairs.

Modeling Forest Resilience

Like all ecosystems, forest ecosystems provide very important ecosystem services for people. However to provide these ecosystem services, forests need to be resilient. Connections in forests are an important part of this resilience. Forest connections increase resilience in many ways, but one of them is to provide protection against wind. In this model you will explore how forest patches affect that resilience.

Gather Your Materials

You will need:

- 9 paper or plastic cups
- A piece of paper divided into two columns, labeled "Size and Shape" and "Results"

Experiment to Find the Most Resilient Configuration

a. Separate the nine cups and arrange them open side down, wide apart, in front of you on a table or desk. This model represents trees in disconnected patches of forest.
b. Draw a representation of this configuration in your *Size and Shape* column.

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c. Try to blow air toward each cup so it moves.
d. What do you notice? Record what happens in your *Results* column.
e. Experiment by placing cups next to each other in different configurations of size and shape to model different forest patches. Figure 27 shows an example of some possible configurations, but there are many more.

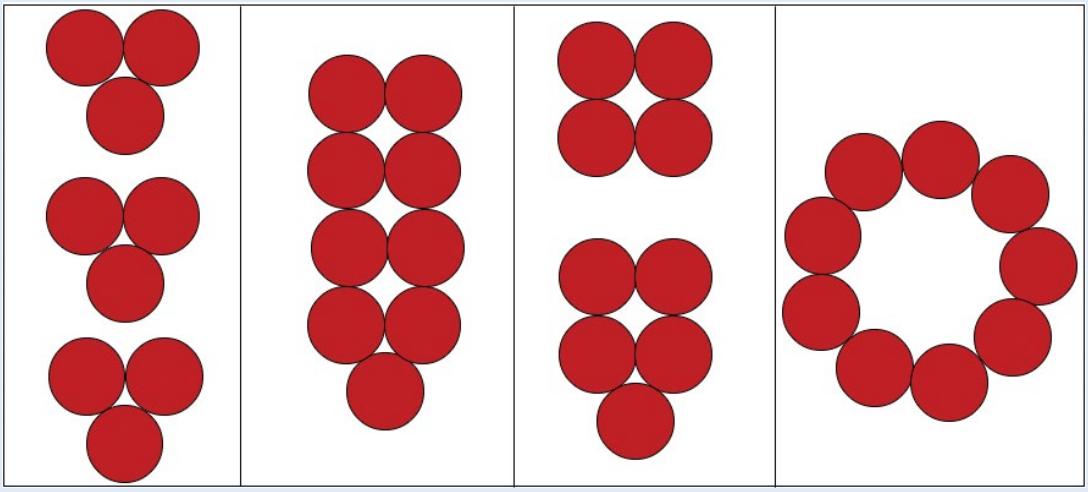

Figure 27: Example of four possible cup configurations (the red circles represent cups).

f. For each, draw a representation of your configuration in your *Size and Shape* column.
g. Blow air from different directions toward each configuration with approximately the same amount of power and record what happens in your *Results* column.
h. Repeat until you feel you have found the most resilient configuration that will allow your modeled forest to be resilient to a windstorm.

Discuss

Share your results with others on your team and discuss:

- Which size and shape of forest is most resilient to wind?
- Remember the edge effect Katherine talked about. Did you notice that shapes with more borders, for example a long, thin shape, moved more in the wind?
- Why do you think shape and size matter when thinking about forest resilience to wind?
- How does this relate to connections between areas in a forest?

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6. Divide your team into three groups. Assign each group one of the three connectivity case studies to explore—local, regional, or global.
7. With your group, divide a sheet of paper into four sections and label each section with one of the four perspectives: social, environmental, economic, and ethical.
8. With your group, read your case study and use your paper to record any important information in the appropriate perspective section. For example, if there is something listed that relates to:
    a. People's interactions, health, education, or well-being, put it in the *Social* section.
    b. The needs or processes of the natural world, including both living and nonliving things, put it in the *Environment* section.
    c. The ability to make money, have jobs, or create a market, put it in the *Economic* section.
    d. Ideas about what is right, fair, or balanced, put it in the *Ethical* section.

Case Study: Local Connectivity

In Sarawak, Borneo, there are many connections between the parts of the local forest ecosystem and human systems. There is a community of **Indigenous** people who live in Sarawak. Indigenous means a group of people who lived in an area before any other groups arrived. This Indigenous community has lived in balance with the forest ecosystem for hundreds of years. But outside threats have increased. Half of Borneo's forests have been lost to deforestation over the past century. Forests have been cleared for valuable timber or to create plantations for palm oil or rubber trees.

Scientists, local people, and others have been working to protect the forest and its living things. Many trees in the forests are a type called **dipterocarps**, which are an important food source for local animals such as orangutans, macaques, sun bears, and cloud leopards. Dipterocarps do something special, called **mast fruiting**. In dipterocarp mast fruiting, the trees only produce fruits every three to five years. Amazingly, most dipterocarps in the forest produce fruit at the same time. Scientists are still investigating to understand this communication and connection between the dipterocarps. When it is a fruiting year, the forest animals

have plenty to eat and seeds from leftover fruit grow into new trees. During non-fruiting years, animals must find other types of fruit to eat.

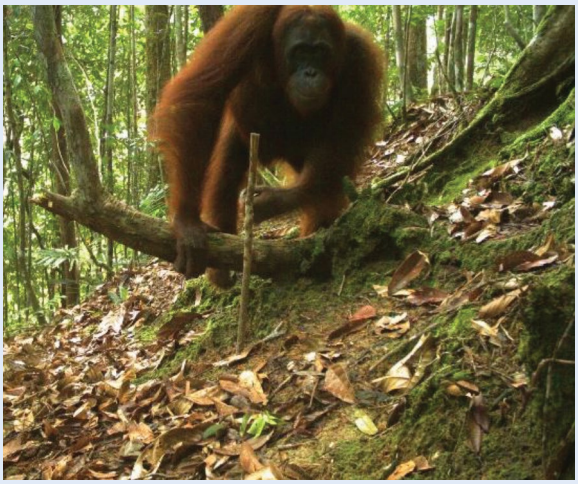

Figure 28: Bornean orangutan photographed during a camera-trap mammal survey in Sarawak, Borneo.

The forests of Borneo also have other fruit trees, such as fig, durian, jackfruit, and mango. These trees are less common, but their fruits are enjoyed by forest animals and people. People living in or near the forest have planted fruit trees near their villages so they can easily access the fruit. However, this brings forest animals close to the village to eat the fruit, creating conflict with the people.

The people of the village often struggle to make money. Recently the government encouraged them to clear areas along the river to plant rubber trees. When they are grown, these trees will produce rubber, which can be sold. But right now the trees are still small and many undesired plants have grown in these cleared areas. Some people in the village hope tourists might come up the river to view the wildlife, but currently most animals are usually found too far away for easy viewing.

Case Study: Regional Connectivity

In the 1980s and 1990s, scientists and bird-watchers noticed a huge decrease in the number of migratory birds in North America. Between 1970 and today, the North American bird population is down 30 percent. Birds face many human-related threats, including being hunted by outdoor pet cats, colliding with windows, and decreases in the insect life they rely on for food. However,

scientists discovered changes to their habitat are also a serious problem. Habitat is where a living thing lives. For migratory birds, there were changes to their North American habitat and the habitat in Central and South America, where they migrate every year.

Figure 29: The yellow warbler breeds in central and northern North America and winters in Central America and northern South America.

So, what changed about their habitats? One big shift was toward sun-grown coffee and cacao (used to make chocolate). Coffee and cacao are shade-loving plants, naturally found in the **understory** of tropical forests. In forests, the tops of the trees is called the **canopy,** and the shady area underneath is the understory. For many years the farmers in Central and South America used an **agroforestry** technique. This meant they cultivated coffee and cacao under the canopy, often leaving the trees of the forest intact. The combination of canopy and understory plants on the shade-grown coffee and cacao farms provided an important habitat for birds. In agroforestry settings, birds can provide a valuable service by eating insects that attack the coffee or cacao plants.

However, by the 1970s, farming began to change. People began to search for ways they could grow more in the same amount of space. They learned they could grow more coffee and cacao if they chopped down the trees. This allowed them to make more money. This was important for farmers struggling to make a living.

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But over time problems arose. Although the land can often grow more for the first 20 years or so, eventually it grows less. Without trees, the soil gets worse and often **erodes** or washes away. Water quality decreases and flooding downstream increases. Workers harvesting coffee or cacao in the sun struggle with the heat. With the changing climate, it becomes harder to grow coffee or cacao in the sun. As the canopy was cut down, birds also struggled. Migratory bird habitats disappeared, and bird populations decreased.

Case Study: Global Connectivity

Too much carbon in our atmosphere is changing the global climate. Climate change affects temperature and weather patterns, raises sea level, and creates many other challenges. Forests play an important role in the story of climate change. For millions of years, trees have been important **carbon sinks**. A carbon sink is something that stores carbon. All living things are made up of carbon. Around half of the dry mass of a tree is carbon. Forests store carbon in soil, plants, and other living things, making them essential carbon sinks!

But forests are under threat, especially from people. Forests are often cut down to provide wood for building materials, furniture, paper, and many other products. Forest areas are also cleared for cattle grazing or to grow plants that produce palm oil, soy, rubber, cocoa, and coffee. When forests are cut down, the carbon stored in them is often released into the atmosphere, increasing climate change.

Figure 30: Example of a forest being cut down.

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A **carbon market** is a trade agreement where a government, group, or individual can receive money for carbon stored on land they own or manage. Different amounts of carbon might be stored in different forest areas. Satellites can estimate the amount of carbon in a forest, but this becomes much more accurate with on-the-ground measurements. Accurate measurements could be important for carbon markets.

In addition to their global connection to climate change, forests provide regional benefits. They cool temperatures, can help create regular rainfall, and decrease flooding. Large, connected forest are also important sources of biodiversity, because they are home to many species of plants and animals.

9. Discuss with your group:
    a. Why is local connectivity important?
    b. Why is regional connectivity important?
    c. Why is global connectivity important?
    d. How are the local, regional, and global case studies connected?
10. With your group, examine the different perspectives about your case study. Think together about any sustainable solutions you can come up with to the problem you learned about. Remember, sustainable means a balance between social, environmental, economic, and ethical perspectives. Record any ideas you have about potential sustainable solutions on the back of your paper. Your sustainable solutions do not have to be perfect; just list anything you think might help.

Act: *How can we encourage connectivity for resilience?*

There are many ways to encourage connectivity to increase ecosystem and human system resilience. In this activity you will learn more about how Smithsonian researchers are doing this work. Then you will decide how you will contribute.

1. Read *At the Smithsonian* to learn about the sustainability solutions Smithsonian researchers are working on. Find the project related to your case study and review it with your team.

At the Smithsonian

The case studies you learned about in the Understand activity are all part of ongoing Smithsonian research and community projects! Smithsonian researchers are working all over the world to help protect forest ecosystems and find ways to balance the needs of humans with the rest of the ecosystem.

Case Study: Local Connectivity

Smithsonian scientists from the Smithsonian Conservation Biology Institute are partnering with local organizations in Borneo to help protect the Sarawak forests. Working with people from local villages, they are implementing a project that will plant fruit trees among the cleared areas of the rubber farms. Their goal is for these fruit trees to create a new food source for forest animals, reducing conflict with local people. They also hope that by drawing forest animals to the rubber farm areas near the water, it will make them easier for tourists to view. Perhaps in the future, the villages in this area can become an ecotourism hub for people who want to experience the biodiversity of the forest. This project helps both the people and the animals living in the forest!

Figure 31: Gardens around a Sarawak community that is partnering with the Smithsonian.

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Case Study: Regional Connectivity

Shade-grown coffee and cacao are better for birds, workers, the soil, and the planet. But in some cases it produces less than sun-grown coffee and cacao. Researchers at the Migratory Bird Center at the Smithsonian National Zoo wanted to support farmers who still grow shade-grown coffee and provide valuable habitat for migrating birds. So they developed a BirdFriendly certification. Researchers work with farmers to certify that they have diverse tree species and are providing valuable habitat on their farms. Consumers can then choose to buy coffee or chocolate that supports these farmers. A small choice when buying can make a big difference to birds!

Figure 32: A certified BirdFriendly farm with shade-grown coffee under the canopy.

Case Study: Global Connectivity

Information about the carbon stored in forests can help stop deforestation. The Smithsonian's ForestGeo program is a network of 78 forest sites and 7 million trees around the world. Each site uses the same methods to identify and measure the trees and plants of the forest. By comparing these sites, researchers can better understand how carbon is stored and the most important areas to protect. This also provides better information for carbon markets. As people around the world become more aware of the need to limit carbon in the atmosphere, the ForestGeo network is providing critical information to help stop climate change!

Figure 33: Map of current ForestGeo sites.

2. Discuss with your case study group from the Understand activity:
    a. How do you feel about the sustainable solution the Smithsonian researchers are working on?
    b. Are there any ideas from the Smithsonian researchers that you want to add to your group's sustainable solution idea?
3. Together with your case study group, pick the best method for you to tell a story, and create a way to share the story of your case study and possible sustainable solutions. For example, you could tell your story by:
    a. Creating a short film or podcast
    b. Creating a poster or infographic
    c. Creating a children's book
    d. Acting out or telling the story orally
    e. Using another method
4. As you create your story, be sure to consider:
    a. What are the most important parts of the story you want to share?
    b. How are you showing the different perspectives?
    c. What is the solution or solutions you want to share?
5. Share your completed story with the rest of your team.

6. If you can, share your story more broadly. For example, share with younger students, share with your families and friends, or with the Smithsonian. For more details, go to the *Ecosystem Resilience!* StoryMap.
7. Together think about your completed stories.
    a. Is there any relationship between each case study and your own local area? For example, does your community have a connection to any of the living things or issues mentioned in the case study?
    b. How do you think choices made by you and others in your local area might affect others globally?
    c. Did the case studies make you think about the choices you make? If so, what changes could you consider?
8. Read Katherine's ideas about ways you can help support connectivity in your local area. Which idea feels most exciting to you?

If we have a patch of a forest or other ecosystem, how can we help the living things around that patch? That might be planting gardens or having more natural areas so that there is an opportunity for animals to move around.

We may depend on forest resources, like wood, but how do we harvest it sustainably? We can make choices to limit our use of a resource or only use resources that are grown without lasting harm to a forest. Our choices as consumers can be very important. What do we choose to buy and how much do we use?

There is also an opportunity for everyone to do research. Citizen or participatory science projects allow everyone to gather and share data about their local area. Projects such as eBird or iNaturalist can help everyone understand the impacts of human actions on biodiversity and connectivity.

—Katherine Araúz Ponce

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9. Take out the *Action Planner* you created in Task 3.
10. If you do not already have an *Action Planner*, create one now by opening a digital document or taking out a piece of paper. Title the paper "Action Planner." In Task 8 you will choose a larger action to take as a team. This action planner will help you remember your ideas from the other tasks.
11. As a team, discuss what you think you personally or your team could do to increase connectivity with forests or within other ecosystems in your local area. For example:
    a. Educating others about the role of forests and their connections locally, regionally, and globally.
    b. Creating habitats in your local area for migrating species, such as putting up nesting boxes for birds.
    c. Thinking about the products you buy, such as paper and wood. Could you reduce the amount you use or reuse the same products?
    d. Considering the food products you consume. Is there a way to make sure they did not come from deforested areas?
    e. Sharing with others the ecosystem services of forests and the role forests play in human resilience.
    f. Researching your local area through participatory science projects.
    g. Or other ideas you come up with. The *Ecosystem Resilience!* StoryMap has ideas if you need support.
12. Choose an action or multiple actions you discussed in step 11, or another action you might want your team to take related to ecosystem connectivity. Add a picture or pictures to the *Action Planner* to help you remember your idea. This could be a digital picture, something you have printed out, or a picture you have drawn.
13. Keep your *Action Planner* to use throughout this guide.

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Task 5: Shoreline: How is adaptation part of our resilience?

Resilience requires **adaptation** in response to disturbances. Adaptation is changing in a way that helps you adjust to something new. As changes happen, ecosystems need to adapt. Human systems also need to adapt. In this task you will learn more about adaptation along **shoreline ecosystems**. You will ***discover*** the connection between changes and adaptation. Then you will investigate to ***understand*** the role ecosystems can play in human adaptation and resilience. Finally, you will ***act*** to promote adaptation to make human and ecosystems more resilient.

Discover: *How are we linked to adapting shoreline ecosystems?*

Change is inevitable. People and human systems are constantly changing. Ecosystems are always changing as well. In this activity you will explore more about adaptation to change.

1. Find a partner and move to a table or desk so you are across from each other.
2. Read the *Adapt to Win Game* and follow the directions to play the game.

Adapt to Win Game

Gather Your Items

You will need:

- A piece of paper titled "How to Adapt" and divided into two columns labeled "Change" and "Adaptation"
- A rectangular strip of paper folded least four times to make a triangle, with the extra paper tucked in the end (Figure 34 shows an example)

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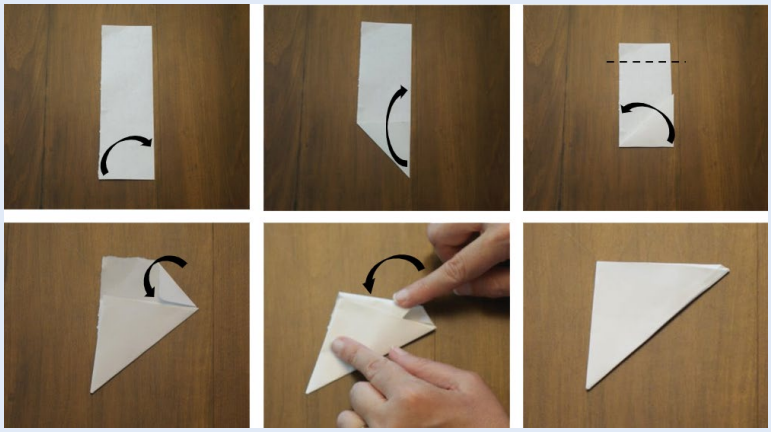

Figure 34: Example of how to fold a paper strip into a triangle.

- Other items, such as small balls, blocks, cotton balls, or other things that can be easily moved

Play the Game

a. Give your folded paper triangle to one partner.
b. The partner with the triangle should use one finger to try to flick the triangle so that it is balanced on edge of the desk or table. The goal is for the triangle to remain on the table but have some part of the triangle stick out over the edge.
c. Each time the partner can balance the triangle on the edge of the table, they get one point.
d. If the triangle does not reach the edge or goes over the edge, there are no points given and the other partner gets the triangle.
e. Figure 35 shows how to play and score the game.
f. Keep playing until one partner gets to five points.

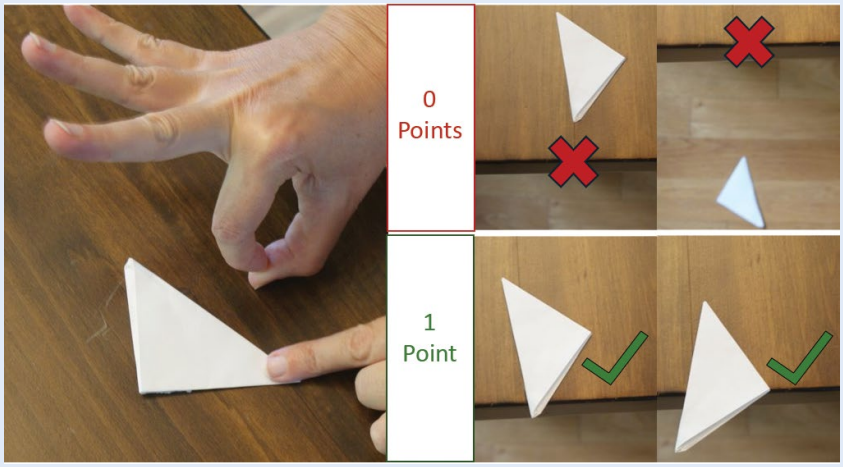

Figure 35: How to play and score the game.

Change the game

Now that you have learned the basics of the game, as partners you will pick different ways of changing the game. For example, you could change:

- The type of item you are flicking back and forth
- The size of the paper triangle, for example, making one much bigger or smaller
- How you flick the item, for example changing from a finger to using an elbow or your breath to move the item
- The scoring system, for example, you could create lines on the table and get points when you go past each line
- The rules, for example, when the item switches between partners or how many points you need to win

Play the Changed Game

Now you will explore how you need to adapt as the game changes.

a. For each change you make, write down how the game changed in the *Change* column of your *How to Adapt* paper. For example, you might write "smaller triangle" or "used breath instead of finger to move triangle."
b. Play the changed game, paying attention to how you need to adapt or play differently to score points in the changed game.
c. Write down in the *Adaptation* column the ways you needed to adapt to play the changed game. For example, did you need to flick the item with more force or did you need to use a different type of strategy to win?
d. Try to play with at least three game changes, each time recording your change and adaptation.

3. Gather with your team and discuss:
   a. What types of adaptations did you have to make as the game changed?
   b. Would you have been successful at the changed game if you did not adapt and kept playing the way you did at first?
4. Draw a line across the *Change* column on your *How to Adapt* paper. Write "Shoreline Changes" underneath the line.

5. With your partner, read *Shoreline Ecosystems and Adaptation* and write down any changes you can think of for shoreline ecosystems in the *Change* column under the *Shoreline Changes* heading.

Shoreline Ecosystems and Adaptations

Shoreline ecosystems are the areas where freshwater or saltwater meets land. Shorelines include the land next to streams, rivers, lakes, and the ocean. They also include the water next to this land.

Shorelines are **dynamic**, or always changing. Many living things in these areas may spend some of their time on dry land and some of their time underwater. Some organisms can live in both shallow and deep water at different times. Freshwater levels change with storms or droughts. Ocean and tidal water levels change daily with the tides. Storm surge or tsunamis can change water levels dramatically. Weather changes daily and seasonally in shoreline ecosystems.

Figure 36: A river and ocean shoreline ecosystem.

Land often shifts in shoreline ecosystems. Shoreline areas shrink through **erosion**, when water or wind wears away the land, which then mixes into the water. Shorelines grow with the deposit of **sediment**, or soil-like material that is left behind by water or wind.

With each change, the shoreline ecosystem needs to adapt. This ability to adapt is the key to the ecosystem's resilience when managing the dynamic conditions of the shoreline.

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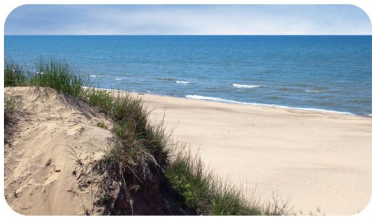
6. Examine the *Change* list of shoreline changes you just created on your *How to Adapt* paper. Consider how the ecosystem naturally adapts in response to each change. Use the *Shoreline Adaptation Cards* in Figure 37 to help you think about this. For each shoreline change write down one or more adaptation on your *How to Adapt* paper.

Mangroves have roots above the ground, which help stabilize tidal areas and trap sediments. Mangroves act as a natural barrier to storm surge.

Coral reefs' jagged structures absorb more than 90% of wave energy, protecting the rest of the ecosystem from storm surge, tsunamis, and flooding.

Wetlands are adapted to frequent flooding. The living things of these ecosystems can act as a sponge to absorb and slow excess or flood water.

Barrier islands are low-lying landforms that protect coastlines behind them. These islands change shape naturally in response to wind and storms.



Grasses along shoreline slopes limit erosion by stabilizing soil and sand through their root systems and trap sediment, maintaining water quality.

Waterways meander or curve as they flow through flatter landscapes, slowing the water and increasing the deposit of sediment along the shoreline.

Figure 37: Shoreline Adaptation Cards.

7. Discuss with your team:
    a. Are there other ways you think shoreline ecosystems have to adapt to the dynamic nature of shorelines?
    b. In what way is adapting to a changing shoreline environment like adapting to the changing rules of the game you played? How is it different?
    c. How does the shoreline's ability to adapt relate to its resilience to change and disturbances?
8. Read about how the Smithsonian is using fossil records from the past to understand the ability of coral reefs to adapt to a changing sea level. What makes you feel hopeful about this work?

At the Smithsonian

Climate change also means changes for shorelines. Sea levels are rising as increased global heat causes glaciers to melt and water volume to expand. This is changing the shape of coasts around the world.

Coral reefs are rich ecosystems that live in shallow coastal waters in the tropics. They offer important protective barriers against storms for millions of people. As sea levels rise, the water around reefs deepens, leaving shorelines exposed. Can corals grow fast enough to keep up with the rising sea levels and continue to protect coastlines?

To explore this question, Aaron O'Dea's team at the Smithsonian Tropical Research Institute tries to travel back in time by studying how reefs grew in the deep past.

Using a six-meter-long aluminum pipe, the team extracts samples from the coral reef that go back thousands of years. These samples, called **cores**, provide the team with a way to observe what the reef was like in the past, because a reef grows in layers, one on top of another.

Figure 38: The O'Dea team preparing to take a coral reef core sample.

Using a technique called **radiometric dating**, the team can then tell the age of each of these layers. By observing the distance between the layers it's possible to calculate the rate at which the reef grew at various times in the past. At some points the reef may have grown 50 centimeters in 10 years, which would be very fast. At other times, the reef may only add 1 centimeter of growth in 10 years.

The team observes the speed of reef growth during times of past global warming. Then they use this information to predict how reefs might respond in the future and whether the coral will be able to grow fast enough to keep up with the predicted future rises in sea levels.

Their findings are encouraging. Even when the sea level was rising fast in the past, many reefs around the world were able to keep up. "Reefs possess a remarkable natural resilience to sea level rise," Aaron explains.

However, he cautions that maintaining the reefs in a healthy state is critical. If reefs are struggling with bleaching due to high temperatures, pollution**,** and other challenges, they will have a much harder time adapting and keeping up. Aaron suggests, "We need to help the corals do what they do best, naturally."

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Understand: *How can systems adapt to change?*

Ecosystems and human systems are adapting to changing needs and situations. People have a huge impact on shoreline ecosystems. They can choose to work with ecosystems to fill their needs or choose alternate approaches.

1. Research mentor Dr. Toh Tai Chong is a marine biologist from Singapore, an island nation nestled in Southeast Asia. Read what Tai Chong says about ways people have adapted shorelines around him. What types of shoreline adaptation have you noticed?

Singapore and many other low-lying areas are particularly vulnerable to sea level rise. We have noticed a lot of coastal erosion and natural biodiversity along the shore losing their habitats. The rate of sea level rise makes it very hard for corals, mangroves, and other living things along the shore to be able to adapt to the rapid change.

Singapore is a small country, so since the 1960s we have been using a technique called land **reclamation** to ensure that we have sufficient space for development. This is typically done by building concrete structures or barriers along the edge of the shoreline, then draining out water and filling in with sand.

We have also started building artificial **sea walls**, which provide a hard concrete structure as a physical defense against sea level rise. We don't usually cover the entire shoreline, because the more sea walls we build, the more habitat is lost. But the downside is that the gaps in the sea walls create a channel of water with a strong current. This leads to erosion in the exposed areas. Another trade-off of building sea walls is that people perceive them as dangerous structures and avoid going close to them. This contrasts with a beach, where people go to play on the beach and in the water.

—Dr. Toh Tai Chong

Tai Chong works as a senior lecturer in the National University of Singapore, and collaborates with communities in Singapore and in Southeast Asia on science-based marine conservation. He believes in partnerships because the integration of expertise and perspectives can create more lasting impacts on our society and the world.

2. Examine the six pictures in Figure 39 and discuss with your team:
    a. What are the wants or needs of people that are shown through the pictures?
    b. How have people adapted the shorelines to serve their needs?
    c. Are there any problems with this adaptation that you notice?

Figure 39: Human adaptations to shorelines.

3. Discuss with your team:
    a. Adding rocks, walls, concrete, or other features so shorelines will not move is called **shoreline hardening**. Do you notice any shoreline hardening in any of the pictures in Figure 39?
    b. Are there human adaptations to shorelines that make them inaccessible or limit people's ability to reach them and enjoy them?
    c. Compare the pictures in Figure 39 with the *Shoreline Adaptation Cards* from Figure 37. Are there any human adaptations of shorelines that would not allow natural shoreline ecosystem adaptations?
4. Read about Tai Chong's work on how to change hardened shorelines. Do you think shorelines could be designed to serve human needs and the adaptation needs of the shoreline ecosystem?

In Singapore, my research focuses on "softening" concrete features along shorelines. Applying the techniques that we have developed for coral reef restoration, we have been planting corals on sea walls. Our initial trials show high coral survival rates. And now we are increasing efforts to create more natural microhabitats. Recently, we have discovered that the coral transplants were able to reproduce. This indicates that corals can thrive on a sea wall.

We are also moving toward nature-based solutions, because coastal ecosystems provide protection for local communities by absorbing energy from storm surge. Our proposition to developers is that they should integrate nature into design. We hope to develop sea walls that are accessible for researchers and communities to enhance biodiversity, such as planting mangroves or coral reefs. In our minds, we are reimagining sea walls that are terraced and infused with multiple habitats for different types of organisms that live along the shoreline.

—Dr. Toh Tai Chong

5. Read *Researching the Shoreline* and follow the directions.

Researching the Shoreline

Rather than using hardening or other similar techniques, there is a growing movement to use **ecosystem-based adaptations (EbA)** instead. EbA is an approach that integrates the natural features of ecosystems to adapt to the changing climate. Using an EbA approach can help solve the problems of human systems and ecosystems.

You and your team will now form an EbA Planning Team to evaluate and design an EbA option for a shoreline. There are five roles on the Planning Team: local historian/community elder, economist, sociologist, ecologist, and geoscientist. If you have more than five people on your team, you can assign more than one person to take on a role. If you have fewer than five people, you can give one person more than one role.

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Research Instructions

a. With your team, pick a shoreline area you would like to investigate. If you live near the shoreline of an ocean, river, stream, lake, or other body of water, pick a place along that shoreline to investigate. This research will work best if you choose a place where people have adapted the shoreline. If you do not live near a shoreline, you can use the Shoreline Case Study found in the *Ecosystem Resilience!* StoryMap to help you complete this activity.
b. Collaborate to create a drawing of the shoreline area you are researching. Use this drawing to show the different parts of the area. For example, you might draw the water area, the land area, and any other key features, whether natural or human-created. This drawing will help your EbA Planning Team remember exactly where you are researching. Figure 40 shows an example of a drawing. If you prefer, you could also use an online map of the area.

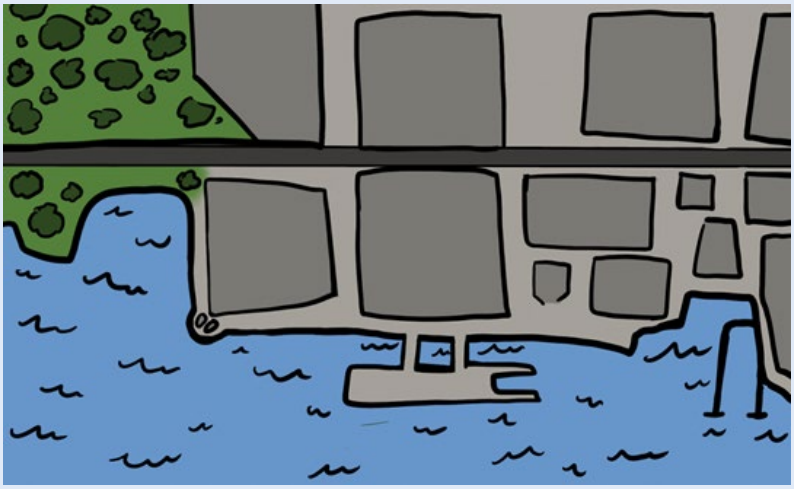

Figure 40: Example of a shoreline Ecosystem-Based Adaptation Drawing.

c. Label your drawing "Ecosystem-Based Adaptation Drawing."
d. Divide up the EbA Planning Team roles among your team.
e. Read the information in this box about your role and the questions about what to research.

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f. Think about ways you could gather the information you need. For example, you could:

- Use information from a library, government websites, data tables, pictures, maps, or online documents
- Conduct a survey or interview people from your community
- Observe an area
- Reach out to an expert to learn more about what they know
- Use another method to gather information

g. Decide how you will do your research. People in different roles may choose different ways of gathering information.

h. Research to answer the questions listed for your role, and any other related questions you have. Make notes about the information you find. You will use it at the end of this activity to plan for an ecosystem-based adaptation.

EbA Planning Team Roles

Local Historian or Community Elder

This person or group will investigate more about the ecosystems that naturally occur along your shoreline and how they have been changed by people.

- Are there things along the shoreline now that were built by people? If so, when and where did those changes happen?
- What used to be along the shoreline before people changed the area? Find out as much detail as you can. For example, what type of natural area was there?
- How has the ways people and other living things use the shoreline changed over time? For example, did people used to swim in the past or could animals more easily reach the water?
- Is the shoreline an important part of the local history?

Economist

This person or group will investigate how people's livelihoods are related to the shoreline.

- Are there businesses located at or near the shoreline?
- Are there other activities that might involve livelihoods related to the shoreline area, for example, fishing or recreation?
- How do economic activities relate to the ecosystem? For example, is a beautiful view important, or access to a waterfront?

Sociologist

This person or group will investigate the living things and biodiversity that could be part of the shoreline ecosystem.

- How is the shoreline related to community interactions and culture? For example, do people meet there, have festivals, or other community events? Are there important foods that come from the shoreline or things that are part of the identity of your community?
- Does everyone have equal access to the shoreline or are only some people able to be near the shoreline area?
- Does the area make people feel connected or disconnected to the shoreline ecosystem?
- Are there problems in the community related to the shoreline, for example frequent flooding or a bad smell?

Ecologist

This person or group will research the living things that are part of the ecosystems along the shoreline.

- What plants and animals commonly live along the shoreline?
- Are there important plants or animals to conserve to promote biodiversity?
- Are there connections to other nearby ecosystems?
- Are ecosystems helping to stabilize or protect the shoreline?

Geoscientist

This person or group will investigate how the land and water of the shoreline interact and the changes in that relationship due to climate change, including researching the physical characteristics and natural disasters along the shoreline.

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- How does the water and land change along the shoreline and what changes it? For example, is there a lot of erosion or does the water level change with the tides?
- Are there specific weather events related to changes in water or land? For example, are there seasonal floods or hurricanes?
- Are there physical features that help limit change? For example, are there barrier islands or bends in a river?
- Is climate change affecting the water levels or other parts of the dynamic shoreline?

6. Have the person or persons assigned to each role on your EbA Planning Team use sticky notes to add the information they found to your *Ecosystem-Based Adaptation Drawing*. Place each sticky note near the place most relevant to the information you found.
7. Use the sticky notes as reminders as you share a summary of what you learned in your role on the EbA Planning Team.
8. After everyone has shared their summary, examine the sticky notes again and move them into three categories on a board or table:
    a. In the *Human Uses* category, place the sticky notes about the ways people use the shoreline for economic, social, cultural, or other reasons.
    b. In the *Ecosystem Needs* category, place the sticky notes about the needs of the living things in the ecosystem and any natural adaptations of the ecosystem.
    c. In the *Ecosystem Services* category, place the sticky notes about any way the ecosystem benefits people—for example, through food, other goods, regulating storm water, preventing erosion, or protecting against storms.
9. Discuss as a team:
    a. What are the problems you noticed related to the shoreline? For example, is there flooding or are there people or other living things that can't access the shoreline?
    b. For each problem, draw an arrow or circle on your *Ecosystem-Based Adaptation Drawing* to show where the problem is.
10. Evaluate your responses. As a team, discuss whether the shoreline could work better for people and the rest of the ecosystem.

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11. Write down your goal for the shoreline underneath or to the side of your *Ecosystem-Based Adaptation Drawing*. Use the following format:

    a. "Our goal is to design a shoreline that people can use to _____, but also meets the needs of the ecosystem to _____ and is able to overcome the issues of _____."

Act: *How can we encourage ecosystem-based adaptation for resilience?*

There are many ways to adapt something so it works better. Often humans build structures around or on shorelines to better meet their needs. However, there are other methods that can be used to adapt. For example, humans can use the natural features of ecosystems to help create shorelines that are resilient to climate change.

1. Read how Tai Chong is encouraging ecosystem-based adaptation in Singapore.

In Singapore, most people would identify themselves as city folks, even though we are surrounded by the sea. We want people to be closer to the sea because the closer they are, the more they will value the sea and marine conservation.

What we have been doing is building boardwalks out into the sea. We want these to be places where people can go out on a walk, chill, look at the sunset, and learn about marine conservation. In some locations, we put in floating trays under the boardwalks to grow corals. This allows visitors on the boardwalk to observe the corals, while scientists and community members can readily check on the corals. Then, when the corals grow to a suitable size, they can be moved to the nearby shoreline and be relocated onto sea walls.

We want people in the community to be part of this effort, to know that they have helped create these reefs, and they can then become part of outreach efforts that educate others about the project. Our community members love this approach and they have grown to be really invested in helping to protect the ecosystem.

—Dr. Toh Tai Chong

2. Take out your *Ecosystem-Based Adaptation Drawing* from the Understand activity.
3. Discuss with your team: What are the ways you think the shoreline needs to be adapted?
4. Examine the *Shoreline Adaptation Cards* from Figure 37. Are there any natural adaptations from shoreline ecosystems that might help you meet your goal for the shoreline? For example, perhaps there is frequent flooding in the area, but you think restoring a wetland might help limit that flooding.
5. Examine Figure 41 to learn about additional ecosystem-based adaptations often used by people.

Riparian buffers are plants that grow next to waterways. They trap pollution, stabilize shorelines to resist erosion, and improve water quality.

Living shorelines are stabilized coastal edges that include elements such as plants, sand, and oysters. They prevent erosion and provide wildlife habitat.

Healthy forests can help regulate water flow and increase rainfall. By absorbing and slowing water, they increase freshwater quality and quantity.

Figure 41: Additional ecosystem-based adaptations.

6. Choose the types of ecosystem adaptations you would like to use on your shoreline, based on the cards in Figures 37 and 41.
7. Add to your *Ecosystem-Based Adaptation Drawing* using colored pencils or markers to draw the ecosystem-based adaptations you would like to add to your shoreline.
8. Share your redesigned shoreline ecosystem with a teacher, another class, or a group of younger students.
    a. Explain to them how you evaluated the ecosystem and the needs of people and the ecosystem.
    b. Share the role ecosystem-based adaptation can have in helping communities adapt and be resilient to climate change.

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9. Take out the *Action Planner* you created in Task 3.
10. If you do not already have an *Action Planner* create one now by opening a digital document or taking out a piece of paper. Title the paper "Action Planner." In Task 8 you will choose a larger action to take as a team. This action planner will help you remember your ideas from the other tasks.
11. As a team, discuss what you think you personally or your team could do to promote ecosystem-based adaptation in your area. For example:
    a. Educating others about how ecosystems can provide important services and can be an alternative to traditional ways of managing natural disturbances such as flooding.
    b. Creating your own ecosystem-based adaptation, for example, by building a rain garden or ditches to slow stormwater.
    c. Discussing with your friends, family, or local government officials ways to redesign areas in your community so they incorporate ecosystem-based adaptation for resilience.
    d. Or other ideas you come up with. The *Ecosystem Resilience!* StoryMap has ideas if you need support.
12. Choose an action or multiple actions you discussed in step 11. Add a picture or pictures to the *Action Planner* to help you remember your idea. This could be a digital picture, something you have printed out, or a picture you have drawn.
13. Keep your *Action Planner* to use throughout this guide.

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Task 6: Desert: How are innovative ecosystems part of our resilience?

Resilience requires **innovation**. Innovations are new ideas or methods of doing something. Innovations that support resilience may include creative ideas and technologies that help systems deal with and recover from tough situations. In this task you will learn more about innovations within desert ecosystems. You will ***discover*** the diversity of innovative strategies plants and animals use to be resilient and balance the resources available for survival in these harsh environments. Then you will ***understand*** innovative ways humans can design solutions to problems inspired and connected to nature. Finally, you will ***act*** to encourage innovation as part of the resilience of all elements of an ecosystem.

Discover: *How are we linked to innovative desert ecosystems?*

Innovation is all around us, making things better and sometimes more exciting. Think about the chair you sit on, the table or desk you use for work, or the technology like smartphones and computers that keep you connected. These everyday items come from amazing ideas and creative thinking. If we take the time to notice, we can observe how innovations from people before us improve our comfort, help us learn, and make our lives more fun today. It's inspiring to realize that creativity and new ideas are everywhere, shaping the world in incredible ways.

1. Read *Identifying Innovations* and follow the instructions for the activity.

Identifying Innovations

In this activity you and your team will be identifying innovations in the objects around you. Innovations can be ideas, tools, methods, or adaptations that make something easier, better, or more enjoyable.

a. Pick one object in the area where you are. You can pick something that feels unusual or something you use commonly, such as a chair or table.

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b. Examine your object closely. Consider:

- What is the **function** of the object? The function of something is its purpose.
- What features does it have that make it good at its function?
- Are there any innovative elements that make it stand out? Even an element that may be common, such as a screw, can represent an important innovation.
- What is innovative about how this object meets a need or solves a problem?

c. Prepare a short sales pitch (about one or two minutes long) to explain why this object is innovative, the strategies it uses, and why someone would want to use or buy it. Focus on how the design and strategies of the object help solve problems or improve on older versions of the same item.

d. Take turns presenting your object to your team. Explain your object's function and its innovative features and strategies.

e. After each pitch, allow a minute for other team members to ask you questions.

2. Discuss with your team:
   a. Were there any features or strategies that you never considered innovative before?
   b. Think about your community. Can you identify any innovations in your community that make it easier, better, or more enjoyable to live there?
3. Read *Desert Ecosystems and Innovation*.

Desert Ecosystems and Innovation

Innovations are important for organisms in many extreme environments, such as the desert. **Desert ecosystems** are places with very little precipitation, such as rain or snow, and extreme temperatures. These ecosystems can be harsh—they can have extreme heat or cold, and very little rain throughout the year.

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Figure 42: Example of a desert ecosystem.

Despite these tough conditions, plants and animals have evolved innovative resilience strategies. Plants like cacti have evolved innovative strategies to store water in their thick stems and have spines instead of leaves to reduce water loss. Animals, too, have evolved innovative strategies, like camels that can go days without water, storing fat in their humps to use for energy and water later. In deserts worldwide, plants and animals can show us innovations that help them be resilient in a desert ecosystem. People can be inspired to increase their own resilience by thinking about these innovative resilience strategies.

4. Research mentor Kyle Miller is an animal keeper at the Smithsonian National Zoological Park. Read about the innovations of some of the animals Kyle works with at the zoo and the different strategies they use to thrive in challenging environments.

There are many different ways animals have adapted so they can thrive in an extreme environment like a desert.

For example, the leopard gecko. A lot of geckos actually don't have an eyelid that opens and closes. But this species does have eyelids. Those eyelids help them a lot in the desert. You're getting desert debris, such as sand, blowing, and that helps give them an extra layer of protection.

Figure 43: From left to right: across the top: leopard gecko and shingleback skink. From left to right across the bottom: blue iguana and glass lizard.

For shingleback skinks the cool thing is that their head mimics their tail. This can confuse predators about which end of the skink is the actual head. The head will kind of be stationary while the tail is wiggling. Something moving and wiggling looks a lot more attractive to a predator, so they may strike at the tail end, mistaking it for the head. This is a strategy they've evolved to evade or survive attacks from predators.

Then there is the way the blue iguana adapts to temperature. They like to bask in really hot temperatures like 50°C (120°F) or more for short periods. No problem. They will move between hot and cooler spots throughout the day in a process called **thermoregulation**. They also have a high **metabolic rate**, which is how fast the body uses energy from food. This helps keep them from overheating.

A final example is from a species called the glass lizard. That's their common name because their tail breaks off very easily. You can see on the body where the tail would break off just below what we call the **cloaca**. So the predator will grab it and break it off. And while they're occupied chowing down on that tail, the lizard gets away to safety.

—Kyle Miller

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Kyle works in the zoo's department of **herpetology** with reptiles and amphibians. His work focuses on feeding, cleaning, training, and enrichment for everything from tiny dart frogs to large crocodilians. He also assists with conservation groups and research projects.

5. Print the *Innovator Cards* in Figure 44.

Gerenuks in East African deserts use their long necks and limbs to stand on their hind legs and reach food on high branches during dry periods.

Desert locusts in Central Africa and the Middle East form large swarms to travel great distances, consuming almost any type of sparse vegetation they find.

Tree tumbo plants in southern African deserts capture coastal fog moisture with their long leaves and channel it toward their root base to survive.

Sand grouse in African and Asian deserts absorb water into their belly feathers, then fly long distances to bring the water back to their chicks.

Baobab trees in African and Australian deserts can store up to 120,000 liters of water in their trunks to endure long droughts.

Thorny devil lizards in Australian deserts collect water from any part of their body with specialized grooves in their skin, channeling it to their mouth.

Figure 44: Innovator Cards. (Continued)

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Aloe vera in North African and Arabian Peninsula deserts store water in their thick, succulent leaves and are coated with a waxy substance that reflects sunlight to keep them cool.

Termites in global deserts build mounds with clay and sand walls and natural ventilation systems inside to regulate temperature and manage heat.

Hair grass in Antarctic deserts perform photosynthesis at low temperatures and use deep roots to absorb nutrients from thin soil.

Desert lilies in the Southwest U.S. deserts remain dormant underground until there is enough moisture to flower.

Barrel cacti in North American deserts store large amounts of water in their thick stems to dissolve nutrients and survive dry periods.

Emperor penguins in Antarctic cold deserts huddle together to conserve heat and have waterproof feathers for insulation.

Figure 44: (Continued)

6. Read *Desert Ecosystem Strategies Analysis* and follow the directions for the activity.

Desert Ecosystem Strategies Analysis

Studying desert ecosystems can help us think and learn more about innovation, because deserts are some of the toughest places on Earth to survive. Organisms have evolved strategies to help them function better in the desert. Understanding these strategies can help inspire communities to innovate to become more resilient.

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Gather Your Materials

You will need:

- Printed, cut out, and shuffled *Innovator Cards* from Figure 44
- Large space for group work and presentations
- Markers, flip charts, or whiteboards for group presentations

Discuss and Identify Problems

a. Based on the number of people on your team, give one *Innovator Card* to each person, pair, or group.
b. Read the specific innovation on your card.
c. Determine the strategy used by the plant or animal on your card to survive and underline it.
d. Determine the problem this strategy helps the plant or animal deal with.
e. Write the problem on the back of your card.

Sort Your Cards

a. As a group, share your animal or plant innovation with the rest of the team. Pay attention as everyone shares their innovation.
b. Then, as a group, discuss and answer the following questions.
   - Do you notice any common problems that different plants and animals have strategies to address? Sort your cards into common problems.
   - Do you notice any common strategies to solve the different problems the team identified? For example, do organisms use similar strategies to get water, food, or deal with temperature?
   - How do these adaptations help the various organisms survive and thrive in environments with the problems you identified?

Create a Winning Strategies List

a. Divide the team into groups, with each group assigned one of the common problems you identified with your cards.
b. In each group, create a list titled "Winning Strategies List."
c. Write your common problem at the top of the *Winning Strategies List.*
d. Add all the winning strategies used by the animals and plants that you underlined on your cards.
e. Keep these lists to use in the Understand section.

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Understand: *How does innovation support resilience to change?*

Desert ecosystems support diverse life forms through remarkable adaptations. As deserts expand due to climate change, the role of **biomimicry** in innovative engineering becomes even more crucial.

1. Read *Human Innovations in the Desert*.

Human Innovations in the Desert

Biomimicry is when humans learn about nature, imitate or emulate its functional strategies, and apply them to human innovation. For example, Figure 45 shows how the design and function of the burdock burr inspired people to make Velcro.

Figure 45: Example of biomimicry: close-up of burdock burr (left) which inspired Velcro (right).

By analyzing how desert organisms thrive under such harsh conditions, engineers can design, create, and **iterate** innovative sustainable solutions for managing water and coping with rising temperatures. Iterate means to do something over again. Biomimicry helps address practical challenges and highlights the importance of innovation and sustainability inspired by nature.

Human innovations can be helpful. But they can also have the potential to cause harm. In the desert, some human activities lead to problems such as water shortages and damaged land. For example, using a lot of water for

farming can dry up important water sources. Building cities without considering the environment can harm the land and local wildlife. Mining in deserts can cause soil erosion and destroy habitats. Bringing more water to desert areas, for example through **desalination** plants, can use a lot of energy and cause pollution. Desalination is the process of removing salt from seawater to make in drinkable.

But biomimicry can inspire a more sustainable way forward by allowing people to learn from nature and copy the strategies plants and animals use to survive in harsh environments, such as the desert. For example, some desert plants can stay cool and store water efficiently. By mimicking these natural strategies, people can design buildings that use less energy and systems that save water.

Biomimicry isn't just about solving problems; it's about finding inspiration in nature. It shows us that people can create innovative solutions that work with the environment. By looking to nature for ideas, we can develop technologies that are both effective and sustainable. This approach helps protect and preserve ecosystems, ensuring they thrive for generations to come.

2. Remember the innovation pitch you made about an object in the Discover activity. Think about and discuss with a partner or your team:
   a. What are the benefits or potential harm caused by this innovation?
   b. Do all people benefit from this innovation?
   c. Is nature harmed by this innovation?
   d. Do you think this object is inspired by nature?
3. Read about the human innovations in Figure 46 that each used biomimicry to inspire their design. As you read about each, identify:
   a. What human problem is the design working to address?
   b. What strategies does the design use to innovatively address human problems?
   c. What plants or animals that you learned about on the *Innovator Cards* in the Discover section could have inspired this design to address the human problem? Discuss with your team to share your thoughts.

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Fog harvesting: Communities in dry regions use large mesh nets on coastal hills to capture moisture from ocean fog, collecting water as it condenses and drips into collection systems.

Adobe homes: Adobe homes use thick walls and natural ventilation to cool interiors, drawing in cool air at the base and expelling warm air through chimneys.

Reflective roof coatings: Light-colored materials or paint on rooftops reflect sunlight and reduce heat absorption, lowering indoor temperatures and energy consumption.

Figure 46: Examples of biomimicry.

4. Now, check your answers from the biomimicry examples. Tree tumbo plants may have inspired fog harvesting, termite mounds may have inspired adobe homes, and aloe vera plants may have inspired reflective roof coatings.
5. Read *Identifying an Engineering Problem* and identify the human problem you want to focus your innovation work on.

Identifying an Engineering Problem

Engineers design and create innovations to help solve problems. As engineers design, they sometimes are inspired by nature. Biomimicry can help them think of new ideas or approaches to the design process by learning from nature's strategies. Starting with identifying specific problems, like intense heat or water scarcity, engineers study local organisms' adaptations—such as the water storage mechanism of the saguaro cactus or the heat reflective properties of desert beetles—to inspire solutions for water conservation and cooling technologies.

Identify the Problem

a. With your team, take out your *Innovator Cards* from the Discover activity. Turn to the back of each card to examine the problems you identified.
b. Pick one problem faced by people and other organisms that you personally want to focus on.

c. Form a group with others who want to focus on the same problem.
d. If you are the only one to pick a problem, you can either join a different group or work independently.

Create Your Prototype Plan

Prototypes are early models or samples of a product used to test and improve it before making the final version. In this activity you will be creating a prototype inspired by the winning strategies of other organisms. Create a sheet like the one shown in Figure 47 and title it "Prototype Plan."

Prototype Plan	
Problem	
Design Phase Notes	
Create Phase Notes	
Iterate Phase Notes	

Figure 47: Example of a Prototype Plan.

e. Add your group's problem to the *Problem* line of your *Prototype Plan*.

6. As a group, follow the instructions in the *Biomimicry Engineering Design Challenge* to design, create, and iterate, to engineer a solution to the human problem you selected.

Biomimicry Engineering Design Challenge

Take out your *Winning Strategies List* from the Discover activity. You can now advance through the design, create, and iterate phases in your prototype plan to create your own sustainable, nature-inspired solutions.

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Design Phase

This phase is focused on coming up with detailed ideas.

a. Start by thinking about the *Winning Strategies List* you created in the Discover step.
b. With your group, discuss which of these strategies will help you solve the problem you listed on your *Protype Plan*.
c. If you can, research additional desert organisms, such as beetles and camels. You can use books, documentaries, magazines, or online resources. Study their survival strategies—such as conserving water and managing temperature. The *Ecosystem Resilience!* StoryMap has resources to help.
d. Identify how these ideas could be applied to a human system to help solve the problem you are working on. Use the biomimicry cards in Figure 46 to help you remember how other people have used biomimicry to solve their problems.
e. Think about where your prototype will be used. For example, will it be outside or underwater? Make sure the strategies you choose will work under those conditions.
f. Sketch your different ideas and add them to the *Design Phase Notes* row of your *Prototype Plan*.

Create Phase

This phase is focused on bringing your design ideas to life.

a. Construct a basic model of your design idea.
    - This model can be made from any materials you have available, such as cardboard or fabric.
    - Think about how you can repurpose materials, such as water bottles or paper, that are typically thrown away.
b. This model will serve as a foundation to identify strengths and areas that need adjustments. Try to create your model in such a way that you will be able to assess how well your innovation works. Discuss your model with your group. What worked well? What didn't?
c. Record your ideas in the *Create Phase Notes* row in your *Prototype Plan*.

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Iterate Phase

This phase is focused on making changes to your design to make it better or more effective.

a. Experiment with changes to your model, focusing on areas such as strength, flexibility, or materials.
b. Test and refine your model design, aiming to closely mimic the adaptations you researched. Each time you change the model, test it and then discuss what needs to be improved and what should be kept.
c. Record your changes and improvements in the *Iterate Phase Notes* row in your *Prototype Plan*.
d. Simulate real-life conditions to test your model thoroughly. Try to make sure it will perform well when it is used for its purpose.
e. Make adjustments before finalizing your design.

Act: *How can we encourage innovation for resilience?*

Sharing innovative designs is important for making us all more resilient. When we share new ideas and ways of doing things, we can work together to solve big problems caused by changes in our environment, the economy, and other big global issues. When different people from different places work together on these new ideas, it makes our communities more flexible, ready to handle future challenges. Also, when we all talk and work together openly, it helps everyone think more creatively and come up with even better ideas. Sharing isn't just about giving information. It is an important way for us all to grow and stay strong together.

1. Read *Pitching Your Biomimicry Design* and follow the directions for the activity.

Pitching Your Biomimicry Design

Think back to the sales pitch about an object you gave in the Discover activity of this task. As you prepare to pitch your design to new people, focus on conveying the hard work and creativity behind your biomimicry design. Pitching your design is

your opportunity to explain the significance of your project. Think about the following as you create your pitch:

- Start by crafting an engaging story about your design process—choosing your problem, identifying desert organisms that address this specific problem, and developing your design.
- Make sure your pitch clearly describes the problem, its importance, and how desert organism adaptations inspired your solution.
- Enhance your pitch with visuals, such as drawings, photos of your model, or a video demonstration to capture your audience's interest.
- Use clear language and visuals such as diagrams or pictures to help the audience grasp the science behind your design. If possible, demonstrate your model in action.
- Highlight the challenges you and your group faced, the solutions you found, and the resilience you built along the way.
- Determine how you want to deliver your pitch to others, such as:
  - In-person pitch
  - Video recording of pitch
  - Audio recording of pitch

2. Take time to share your biomimicry design pitch with people in your community.
3. Take out the *Action Planner* you created in Task 3.
4. If you do not already have an *Action Planner*, create one now by opening a digital document or taking out a piece of paper. Title the paper "Action Planner." In Task 8 you will choose a larger action to take as a team. This action planner will help you remember your ideas from the other tasks.
5. As a team, discuss what you think you personally or your team could do to promote ecosystem-based innovations in your area. For example:
   a. Educate others about the role biomimicry could play in designing for a more resilient future.
   b. Write down some biomimicry ideas that might be relevant to problems in your local area.

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c. Create your own biomimicry-based innovations, for example, by building innovative water collection techniques, or ways to cool homes.

d. Discuss with your friends, family, or local government officials ways to redesign areas in your community so they incorporate biomimicry or innovations inspired by ecosystems.

e. Or other ideas you come up with. The *Ecosystem Resilience!* StoryMap has ideas if you need support.

6. Choose an action or multiple actions you discussed in step 5. Add a picture or pictures to the *Action Planner* to help you remember your idea. This could be a digital picture, something you have printed out, or a picture you have drawn.
7. Keep your *Action Planner* to use throughout this guide.

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Task 7: Human habitats: How can integrated ecosystems be part of our resilience?

People have dramatically changed many parts of Earth. Many people live in areas that were largely designed and created by humans. However, integrating ecosystems into these spaces may be key to future human and ecosystem resilience. Resilience can have many different aspects. You learned about them in Tasks 3 through 6. These aspects are diversity, connectivity, adaptation, and innovation.

In this task, you will ***discover*** how ecosystem resilience is already a part of your local area. Then you will investigate to ***understand*** how ecosystems like those you studied in previous tasks could be further integrated into that area for a more resilient future. Finally, you will ***act*** to share these ideas and make decisions about how you will act for a more resilient future.

Discover: *How are ecosystems integrated within my human habitat?*

A habitat is the home environment of a living thing. As a living thing, you have a habitat as well. It is the area where you learn, work, play, and live. Human habitats are important parts of human systems. They often include buildings and other places designed and created by people. They include parts of the natural world as well.

1. Read *Integration Activity* and follow the directions.

Integration Activity

You have learned about many different characteristics of resilience and resilient ecosystems. But it is important to think about these ideas as integrated, or blended together. Our resilience becomes stronger when these characteristics are integrated and resilient ecosystems are integrated within our human habitats. The integrated whole is stronger than the sum of the parts.

Now you will model integration in a simple way by creating the sound of a rainstorm.

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a. Start by yourself and try to create the sound of a rainstorm using only your body.
b. Next join with your whole team or class and divide into at least four groups.
c. Assign each group one of the following actions: rubbing hands (wind), snapping fingers (light drizzle), lightly slapping knees (light rain), light clapping (steady rain), heavy clapping (downpour), stomping (heaviest rain).
d. Experiment together until you can collaborate to create the sound of a rainstorm. Can you start quietly and build to a huge rainstorm? You may want to assign one person to point to different groups to start and stop making their sound.

Stop and Discuss

You just modeled integration as you created your rainstorm using many different sounds. Discuss with your team:

- How would it be different if one of the sounds was missing?
- Was it possible to create a full rainstorm as an individual? What does this tell you about integration?
- Can you think of other times when integrating different ideas, people, or approaches is important—for example, when creating visual art or music or answering scientific questions?

2. Think back to Task 2 and the overlap of the circles your team created during your exploration of human systems and ecosystems. That overlap is one way of thinking about the integration between human systems and ecosystems. Decide with your team:
    a. What are the lessons shown by the rainstorm model of integration that you think people should remember when thinking about integration between human systems and ecosystems?
    b. How have you noticed integration between human systems and ecosystems throughout this guide?
    c. After what you have learned while using this guide, would you change the amount of overlap between the two circles you created in Task 2?

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3. Read *Human Habitats, Ecosystems, and Integration*.

Human Habitats, Ecosystems, and Integration

The habitats where humans live, work, and play integrate people and ecosystems. It may feel that some places and things are made only by humans, such as a building. But even that building can include things humans did not put there, such as sunlight, dust, insects, or rainwater. On the other hand, you may think the outdoors is all created by ecosystems, but people can add things outdoors too, such as a bench, a planted tree, or a sidewalk. In reality, all places and things are integrations of human systems and ecosystems. Now you and your team will explore integration within your human habitat.

4. Research mentor Adewale Awoyemi works in forest conservation and urban ecology. Read his ideas about how human habitats already integrate ecosystems and how they could do more.

The world does not just belong to humans. We are just a single species. The world belongs to everybody, to all the species. We should try to live in harmony with the rest of the ecosystem because we are interdependent. We need each other. We need the smallest bacteria to survive. You need the air produced by the trees. You need many of the services other parts of the ecosystem are providing to you. You are already integrated with ecosystems. If you notice plants, insects, birds, or any living thing, that is part of the ecosystem around you.

—Adewale Awoyemi

Adewale Awoyemi heads the Forest Center at the International Institute of Tropical Agriculture in Ibadan, Nigeria, and is finishing his PhD at the University of Granada in Spain. His research focuses on the impacts of urbanization on biodiversity in tropical environments. He is motivated by a just world that respects the needs of all organisms.

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5. With your group, read *Double Bottom Line* and follow the instructions to assess your research spot.

Double Bottom Line

A **double bottom line** means assessing something from two perspectives. You will use a double bottom line to think about places in your community. You will assess how the place encourages both human resilience and ecosystem resilience. Using a double bottom line can help you think about how to balance different goals and needs.

Choose Your Location

a. Choose an area in your community that your team can assess for resilience. To get you started, you might think about using your research area from Task 2. Or you could choose another area you know well in your community.
b. Divide your team into groups of three to four people.
c. As a team, divide up your chosen assessment area into places on which each group can focus. For example, if you chose a schoolyard as a team, one group might focus on the front of the building and another on an open area to the back or side. If you chose a neighborhood, one group might focus on one building, another on a nearby park, another on a street. Your area can be smaller or larger, depending on what works best for your team.
d. Assign each group one place. Try to have the different groups focus on places that are near one another.

Create Your Assessment Chart

a. With your group, label a piece of paper or digital document "Resilience Assessment Chart."
b. Create a chart with five rows and five columns. Figure 48 shows an example.
c. Label the columns "Resilience trait," "Doing well," "Could be better," "Human score," and "Ecosystem score." Label the remaining rows "Diversity," "Connectivity," "Adaptation," and "Innovation."

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Resilience trait	Doing well	Could be better	Human score	Ecosystem score
Diversity				
Connectivity				
Adaptation				
Innovation				

Figure 48: Example of a Resilience Assessment Chart.

Conduct Your Assessment

a. If you can, with your group visit the place you will research and record what you find with words or pictures. If you cannot go to your place, find another way to gather information about what is currently in your place and how it is being used. For example, you could have one group member go and take pictures or a video of the area, you could use existing pictures of the place, you could use online mapping systems that show a street level view, or you could find another way that works for your team to gather this information.

b. If you chose to use the same research area as you investigated in Task 2, take out your *Ecosystem Investigation* and *Human System Investigation* sheets and use them to help you get started with your research.

⚠ Physical Safety Tip

Do not observe a research area by yourself. Always work with at least one other person, which could be an adult or a teammate. Be a good ally to your teammates and notice if they feel uncomfortable or unsafe. Offer to pause the investigation or move to another part of the research area. Always pay attention to local guidance on whether it is safe to interact with people outside of your home or school.

c. One at a time, think about the questions for each resilience trait questions, and write down the answers you find on your *Resilience Assessment Chart*. If you think you found evidence that the place is doing well in this way, write your answer in the *Doing well* column. If your evidence shows an opportunity to improve, write your answer in the *Could be better* column. Try to write enough information so that later in this task you remember what you found.
d. With your group, decide on a human score. For each resilience trait, examine how the place is doing well or could be better for people and pick a score from 1 to 10 points, where 10 is the best and 1 is the worst. For example, if you were thinking about the human score for diversity in a place, you would be considering how well the place meets the human need for diversity. So if the place felt very welcoming to all sorts of different people and human interactions, you might choose 8, 9, or 10 out of 10 points. If the place felt like it only really met the needs of a very specific group of people or felt like it excluded some people, you might choose 1 or 2 out of 10 points.
e. Write down your score in the *Human score* column.
f. Use the same scoring system to decide on your ecosystem score. However, for this score think about how well the place is meeting the needs of the ecosystem.
g. Repeat for each resilience trait.
h. Total your human and ecosystem scores and write them below the bottom line of your *Resilience Assessment Chart*.

Resilience Trait Questions

Diversity

- Does this place feel like it welcomes people with many different identities? For example, people of different ages, abilities, or other groups?
- Is there a wide variety of types of plants and animals that can be found in this area?
- Does the place feel alive, like there is a diversity of things happening for people and the rest of the ecosystem?

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Connectivity

- Does this place encourage all individuals and different groups of people to connect to one another?
- Are the natural parts of this place connected or separated? For example, are trees separated into cement boxes or are they all planted together?
- Does this place encourage connections between people and the rest of the ecosystem?

Adaptation

- How flexible is the space in responding to all people's changing needs? Is the place able to be easily changed to meet the needs of different people?
- Is there an opportunity for ecosystems to adapt to challenges in the place? For example, can plants grow in different areas or animals find new habitats?
- Are ecosystems incorporated into the space to help people adapt to changes, such as climate change?

Innovation

- Are people using new ideas or approaches to make this place more pleasant and useful? Are all people's ideas valued equally?
- Are the structure, behaviors, or traits of the plants or animals designed to help them do well in the place?
- How does the design of this place show people are learning from ecosystems?

6. Come back together as a team and compare what each group wrote on their *Resilience Assessment Chart*. Discuss:
   a. In general, are the human or ecosystem scores higher? How does this compare in different places?
   b. Do you notice any trends? For example:
      - Is every place ranking high or low in one type of resilience trait? Why do you think that might be?
      - Are there relationships between the different resilience traits? For example, is there a relationship between diversity and connectivity?
   c. How did considering equity or fairness affect your assessment? Did places score fewer points for being unfair for certain groups of people or living things in your community?

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7. Add any details you just discussed to your *Resilience Assessment Chart* and keep this chart. You will need it in Understand activity.
8. Remember the triangle and circle ecosystem models from Task 2. Discuss with your team: Which model do you think is a better fit for the place you just investigated?

Understand: *How could we change the ways ecosystems are integrated into human habitats?*

In many places, organisms live in human-built environments despite the plans of people. Yet ecosystems can be deliberately included in built environments. This can benefit human systems and ecosystems and make both more resilient.

1. Read *Reimagining the Future*.

Reimagining the Future

Dream about becoming a local superhero, tasked with reimagining your community into a vibrant, resilient ecosystem filled with joy and a sense of liberation. Here's how you can achieve this using four key superpowers.

Diversity: Welcome people with different identities and skills into your community. Introduce a variety of plants, animals, and other species into human habitats. Human diversity and biodiversity can help make your community better able to respond to natural disturbances and human-created challenges.

Connectivity: Link different parts of your ecosystem—both natural and human-made—so that life and ideas can flow freely. Ensure every area of your community connects, creating better interactions and cooperation among its inhabitants.

Adaptation: Prepare your community to manage and thrive during changes and challenges. Give your neighborhood the tools to adjust smoothly to new situations or environmental changes, ensuring long-term resilience and stability.

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Innovation: Your creativity drives innovation, allowing you to design unique, effective solutions that reflect the spirit and needs of your community. Innovation is about using creativity to solve problems and create spaces that are not only functional but also inspiring.

By focusing on these elements, you can reimagine a community that embraces its natural environment and is well-equipped to adapt and prosper, no matter what the future holds. This approach turns your community into a model of environmental and social resilience, showing the power of integrating people with their ecosystems.

2. Read *At the Smithsonian* to learn about how the Smithsonian is helping people to reimagine their futures.

At the Smithsonian

Imagine you are magically transported into the *Afrofuturism: A History of Black Futures* exhibit at the Smithsonian National Museum of African American History and Culture. It's a vibrant adventure where African **culture** and futuristic imagination blend into an inspiring reimagining of the future. Here curators like Dr. Kevin Strait and his team are engaging visitors in an experience that reimagines, reinterprets, and reclaims the past and present for a more empowering future.

As you wander through the exhibit, you experience dazzling artworks and clothing that look like they come from a future where African and African-American traditions meet sci-fi wonders. The air hums with the futuristic songs of Sun Ra and Janelle Monae, turning each step into a space adventure. You dive into the galactic worlds created by Octavia Butler, where fictional heroes tackle future

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challenges with wisdom and courage. Butler reminds us, "You've got to make your own worlds. You've got to write yourself in." Around you, models of cities like the ones in comic books and movies like *Black Panther* show how technology can dance with heritage, shaping skylines that soar with both tradition and innovation.

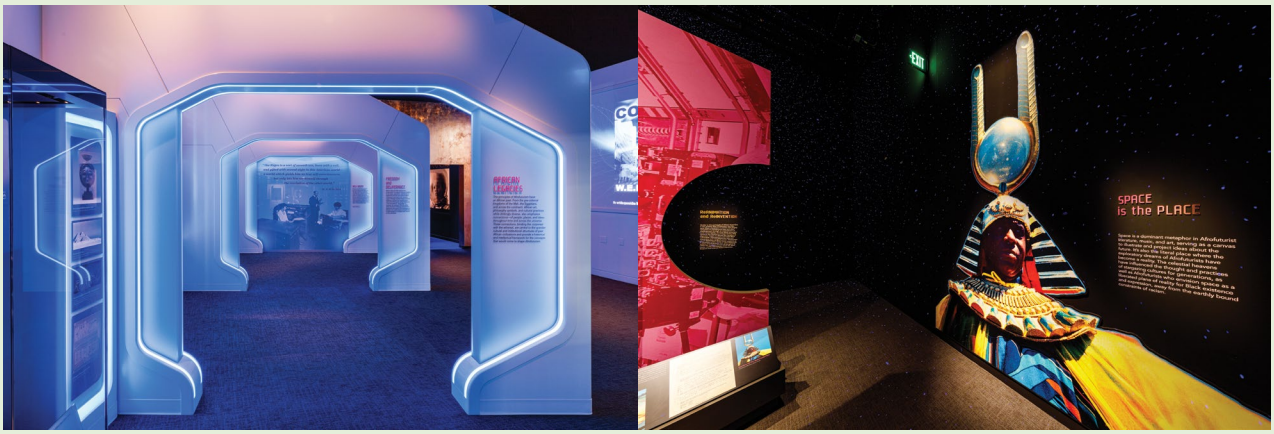

Figure 49: Two parts of the Afrofuturism exhibit at the Smithsonian National Museum of African American History and Culture.

Afrofuturism is about dreaming up exciting new possibilities and imagining the future through a vibrant, creative lens. These kinds of exhibits, and the work of curators like Kevin, inspire us to envision how our own communities could similarly thrive by balancing the essential elements of biodiversity, adaptation, innovation, and connectivity, crafting a future that is sustainable and culturally rich.

The joy and liberation embedded in Afrofuturism guides us in envisioning a future where our own communities are free to grow and prosper in harmony with their cultural and natural environments. This exhibit isn't just a display; it's an invitation to reimagine your own fantastic future, using the rich tapestry of Afrofuturism as your guide. You can learn more about the Afrofuturism exhibit by visiting the *Ecosystem Resilience!* StoryMap.

3. Consider where you get inspired to think about the future in a different way. Are there movies, books, games, or other parts of your culture that inspire you? Share your answer with the rest of your team.

4. Read *Reimagining Our Community* and follow the directions to play the game.

Reimagining Our Community

How can your community be reimagined to better support people and ecosystems? Many people use **world building** to imagine a better future. World building is the process of creating an imaginary world. Worlds built to imagine a better future take on many characteristics from the real world, but also incorporate new things that address current issues. Figure 50 shows some examples of world building from the Afrofuturism exhibit.

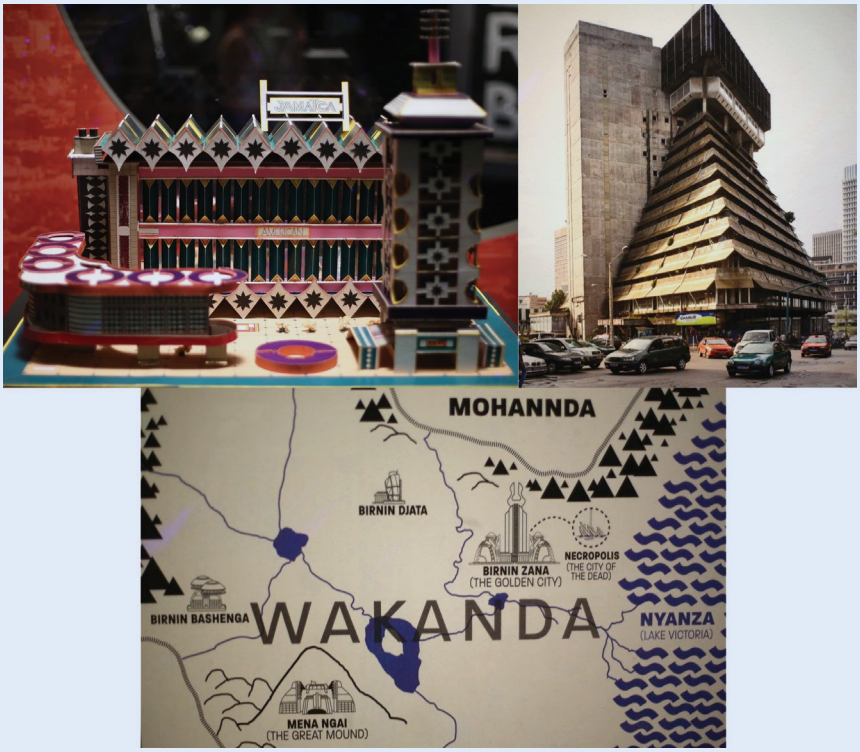

Figure 50: Examples of world building that are part of the Afrofuturism exhibit.

In this activity, your team will use world building to reimagine your community to better support people and ecosystems.

Create a Plan for Reimaging Your Community

a. Take out a blank piece of paper and title it "Redesign Plan."
b. Fold the paper in half. Label one side "Design sketch" and the other "Design goals." Figure 51 shows an example.

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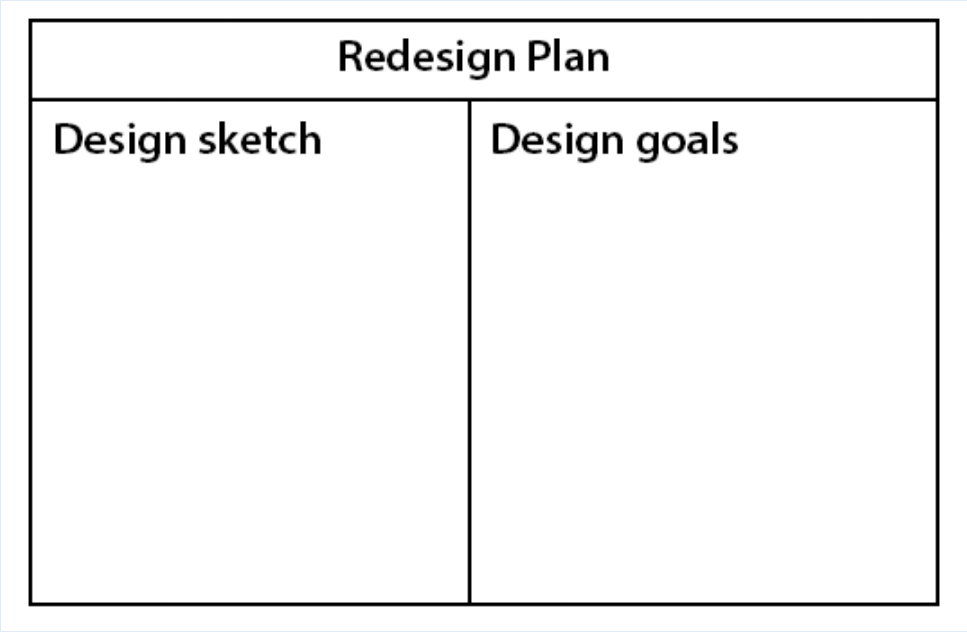

Figure 51: Sample of a Redesign Plan.

c. On the half of your paper labeled *Design sketch*, draw a picture of the place your group assessed in the Discover activity. If you do not want to draw the place you assessed, you can print a picture and attach it to your *Redesign Plan*.
d. Examine your *Resilience Assessment Chart* from the Discover activity and begin to think about how the place you assessed can be reimagined to support a more resilient future for people and ecosystems.
e. Using the scores on your assessment, think about what should be incorporated into your group's *Redesign Plan*. Discussing these questions can help your group identify ways your community can be improved. Write what you discuss under *Design goals* on your *Redesign Plan.*

- Which systems need to be better supported in the place you assessed? Does your group need to prioritize supporting human systems, ecosystems, or both?
- What is written in the *Could be better* column of your *Resilience Assessment Chart*? What should your group prioritize doing to improve diversity, connectivity, adaptation, and innovation in this place?
- What is written in the *Doing well* Column of your *Resilience Assessment Chart*? What parts of this place are a priority to maintain or strengthen?

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f. Discuss possible solutions for meeting your design goals. What could your group add to your design sketch to meet more design goals? It is okay if the solutions you think of don't already exist in the real world. World building often involves imagining creative and innovative solutions to major issues.
g. Represent the solutions you discuss in the *Design sketch* column by writing or drawing.

⚠ Emotional Safety Tip

Sometimes it is overwhelming to think about all the things that could be done to help make a problem better. As an action researcher and action-taker, it is important to understand that you do not have to and could not solve this problem alone. There are many people around the world working to make things better.

5. Come back together as a team and prepare to share your group's *Redesign Plan*.
6. Take turns presenting each group's *Redesign Plan* to the rest of the team. Be sure to share the name of the place you are redesigning, your design goals, and your design sketch.
7. After each group has shared their plan, discuss the solutions represented on the group's design sketch. Could these solutions also help another group meet its design goals? If so, add them to your *Design sketch*.
8. Read Adewale's ideas about land sparing and land sharing. How might these ideas help you design for the future?

In urban ecology we think about concepts called land sharing and land sparing. If you have areas that are designed for conservation, that would be land sparing. In those areas you have native biodiversity thriving and enough space that species that need it can live there. People may go there for recreation, but the needs of the rest of the ecosystem come first.

Land sharing means making sure an area can be used by humans as well as serving the needs of the rest of the ecosystem. You can build, but in an environmentally friendly way that supports biodiversity. This starts with planning. Planning for blue spaces, where there is water. Planning for green spaces, where plant life can flourish. Incorporating buildings, green rooftops, many different types of environments that can support different kinds of biodiversity. Always remembering that the city and the world belongs to all organisms, not just human beings.

—Adewale Awoyemi

9. Read *Building a Reimagined World*.

Building a Reimagined World

People can reimagine the world in many ways. Your team can reimagine your community in whatever way works best for you. When thinking about how you will build a world as a team, it is important to consider the resources you have and the time you have to work.

Here are some ways your team can reimagine your community.

- Physical models: Create a 3D model of your design sketch. Use materials such as construction paper, scissors, tape, clay, leaves, sand, or any other materials your team has access to.
- Digital models: Use design programs to create a digital version of your design sketch. This can be done with a digital art program or by creating a shared slide deck.
- Maps: Use a large sheet of paper or a class board to draw a map of the area you are reimagining. Groups can then redraw or cut out their design sketch and add it to the team map.
- Audio or video: Use audio or video to record yourselves describing your design sketch. This could be a presentation, a song, or another oral or visual method.
- Other methods: There are many ways to reimagine the world. Use whatever method works best for you and your team.

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Build a New World

a. As a team, identify a workspace where you can build an imaginary world. This can be a physical space such as a large tabletop, the floor, a shared digital space, or a natural space such as in dirt or sand.
b. Come to a **consensus** on how your team will build a reimagined version of your community. A consensus is a balanced decision that works for everyone in the group.
c. If you are creating a physical model, digital model, or map, discuss the scale or size of the world your team is building. Think of the group redesigning the largest place. What size should they make their object? Think about the group redesigning the smallest place. What size should their object be? Now think about the sizes in between; other models or drawings should be relative to the smallest and largest ones.
d. If you are building a world using audio or video, decide how long every group should make their recording.
e. Collect the materials your group will need to build your object or create a recording.
f. Return to your group and create a model, drawing, or recording of your design sketch.

Return to the workspace your team identified and combine each group's work to build your reimagined world. It is most helpful to place items in the workspace in the way they exist in your community. For example, if in your community a school is located next to a park, in the world you build you should place the school or drawing of the school beside the model or drawing of the park.

10. As a team, discuss the reimagined world you've worked together to build.
    a. In what ways is this world more diverse, connected, adaptive, or innovative?
    b. How is this reimagined world better for people and ecosystems?
    c. How is your reimagined world more equitable or fair for all living things?
    d. What does this reimagined version of your community inspire you to change about the places around you?

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Act: *How will we integrate ecosystems for resilience?*

We can make choices that allow for ecosystem biodiversity, connection, adaptation, and innovation. If we integrate resilient ecosystems within our human habitats, our human systems also become more resilient. In this activity you will share the power of your reimagined community with others to inspire them as well.

1. Read Adewale's ideas about how to communicate a new vision for human habitats.

Educating people about a different relationship with nature is one of the most important things you can do. If you help people feel a connection to nature, then they are more interested in doing things to help protect it. For example, we asked children to plant trees and then gather data on these trees. They recorded data, including what species they were planting, how many leaves it had, and how tall it was. That connection to the trees they planted continues. They come back five or ten years later and they still feel that connection. When people have these experiences, especially when they are young, they can start to imagine a world that integrates people and nature.

—Adewale Awoyemi

2. As a team, think about your reimagined world model. Choose a group to share it with—for example, students who attend your school, other adults in your learning space, your family, or friends. Pick a group you can reach and that might be able to learn from your reimagined community.
3. Share your design with the people you chose. Discuss with them:
   a. What would need to happen to make your plan a reality?
   b. What types of changes would need to happen in the way people treat each other and the rest of the ecosystem?

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4. After you share your model, come back together as a team and examine your model. Discuss:
    a. If this space was created the way you designed it, are there ways it could help people care for each other and the ecosystem in a more harmonious way?
    b. How can you show care for this space?
    c. What kind of changes in rules, behaviors, or attitudes do you think would help encourage that sense of care?
5. Take out the *Action Planner* you created in Task 3.
6. If you do not already have an *Action Planner* create one now by opening a digital document or taking out a piece of paper. Title the paper "Action Planner." In Task 8 you will choose a larger action to take as a team. This action planner will help you remember your ideas from the other tasks.
7. As a team, discuss what you think you personally or your team could do to integrate people, ecosystems, and resilience traits in your area. For example:
    a. Trying to create changes to the way people care about each other and the world around them, such as the ones you discussed in step 3.
    b. Implementing some of your reimagined changes to the area around you.
    c. Educating others about the need to integrate ecosystems into human systems.
    d. Finding a place at home or another area you can change to integrate ecosystems better or encourage ecosystem resilience traits.
    e. Or other ideas you come up with. The *Ecosystem Resilience!* StoryMap has ideas if you need support.
8. Choose an action or multiple actions you discussed from step 7. Add a picture or pictures to the *Action Planner* to help you remember your idea. This could be a digital picture, something you have printed out, or a picture you have drawn.
9. Take out your *Identity Map* from Task 1 and examine the goal you listed.
10. Take out your *Our Resilient Future* document from Task 1 and 2 and remind yourself of the different ideas you had about your resilient future.
11. Take out your *Action Planner* and remember some of the ideas you had about ways you could take action.

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12. Examine these papers while thinking about the resilience model your team just created. Ask yourself:
    a. What important connections, relationships, or trends do I notice?
    b. After completing this guide, what is the most important outcome I want for ecosystem resilience in the future?
13. Take out a piece of paper or cloth the same size as your quilt square from Task 1.
14. Make a drawing or find another way to represent your ideas about what you think is the most important outcome for ecosystem resilience and human resilience.
15. As you did in Task 1, add these squares to your existing team quilt. This quilt now shows resilience stories of the past and ways you hope people and ecosystems will be resilient moving into the future.
16. Move around the quilt and carefully examine the outcomes your teammates are hoping for.
17. Come back together as a team and discuss what you noticed about similar ideas that people had for a resilient outcome in the future.
18. As a team, find a slow consensus about the outcome you most want.
    a. Find a partner and as a pair find consensus on which outcome you think is most important.
    b. Then in groups of two pairs (four team members) you can build consensus among the four of you.
    c. Then in groups of four pairs (eight team members) you can discuss further to build consensus.
    d. Keep adding groups together until you have found a team consensus.
19. Remember the outcome you decided on. You will use it in Task 8.

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Task 8: How can we create a resilient future for ecosystems and ourselves?

As action researchers you now have a lot of information. You discovered what is important to you and your team. You understand more about the need for ecosystems and human systems to be resilient. You understand the values of people in your community. Now you will put those ideas together. In this part you will decide how your team will act to create the future you want. Then you will put those plans into action.

In this task you will ***discover*** more about creating transformative outcomes for the future. Then you will ***understand*** more about your role in working toward those outcomes. Finally, you will ***act*** on your ideas and work toward a sustainable and positive future.

Discover: *How will we act for a resilient future?*

Knowing what you want to achieve is important, but there can be many different ways of achieving the outcome you want. In this activity you will decide on the action you want to take to move toward the outcome you want.

1. Remember the outcome your team decided on at the end of Task 7.
2. Discuss with your team:
    a. What is the difference between an outcome and an action?
    b. What does it mean to take action?
    c. What do you think will be important to pay attention to as you take action?
3. Take out your *Action Planner*. Remind yourself of some of the actions you and your team thought of.
4. Read *Action Approaches* and think of one idea for each type of action you could take to move toward the outcome your team decided on.

Action Approaches

Even after identifying an issue and how you would like it to change, you still need to determine how you will encourage that change. There are many different types of things you can do. Figure 52 shows five categories of actions people often take.

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Examine the figure and read about each type of action. Then come up with an idea about how to use each type of action to move toward your goal outcome.

FIVE TYPES OF ACTIONS

Figure 52: Graphic from the Institute for Humane Education showing five types of actions.[4]

Service Learning: Joining with an existing organization or project to help solve the problem and reach your outcome

Advocacy, Petition, or Policy Change: Trying to get decision-makers to change policies or rules to try to prevent, stop, or solve a problem

Education or Awareness Campaign: Educating others to help build understanding and awareness about the problem

Invention or Intervention: Developing an innovative method or object to help address or solve the problem

Immediate Action Effort: Taking direct, immediate actions to help solve the problem; these actions can be focused on changing behaviors or places

5. Use a class board or piece of paper to list all the actions everyone in your team just thought about.
6. Think about which actions might be best for your team to take. Think about any actions that would be too difficult at this time.
7. As a team, remove from the list any actions that would not be helpful or that you cannot do.
8. As a team, share your ideas about what action you should take and listen to others. Come to a consensus about which action you will take. There are many ways to come to consensus. Here are some ideas.
    a. List the good things and bad things about each action. Discuss as a team.
    b. Try to find the same values. Are there some actions about important problems or the future that are similar? Try to combine them.
    c. Build a sense of the group opinion. Are there some actions that many people would be interested in taking?
    d. Find a slow consensus, using the same technique from Task 7, Act.
    e. Analyze different perspectives. Think about each potential action from a social, environmental, economic, and ethical perspective. Are there some actions that balance these different perspectives well?
    f. Consider your impact. Think about who would benefit from your team working toward a specific idea about the future. Which group are you most interested in helping?
    g. Align to your goal. Remember the outcome you are working toward. Which of these actions might be most helpful in achieving that outcome?
9. Once your team has reached consensus on the action you want to take, take out a sheet of paper for your team and title it "Action Plan."
10. Write "Who," "What," Where," and "Why" near the top of the paper.
11. Next to *Who* write the people and other parts of the ecosystem you hope will benefit from your action.
12. Next to *What* write a one-sentence description about what you plan to do.
13. Next to *Where* write where you hope to take action.

14. Next to *Why* write the outcome you decided on in Task 7.
15. As a team, examine your *Action Plan*. How could it be even better? To iterate is to change something to make it better or more effective. Discuss with your team:
    a. How could you iterate on your current *Who, What, Where,* and *Why* to make your plan stronger?
    b. Is there any way your action might lead to **unintended consequences**? An unintended consequence is when even though you were trying to help a situation, something harmful happens as a result.
16. Iterate on your *Action Plan* until your whole team feels comfortable with it.

Understand: *What will my role be?*

Now it is time to plan your action. As you have learned, variations among people's perspectives and abilities can make the whole team stronger. Think about what role you will take to help with the team action.

1. Take out your *Identity Map* from Task 1 and examine it closely. Make a note of things about your identity that might help you decide how you would like to act. For example:
    a. Are you part of any groups that you could communicate with?
    b. Do you have any special talents, such as art or music, that might be useful to capture people's attention?
    c. Are you interested in science and engineering or other ways to try to find innovative solutions?
    d. Do you have good planning or organizational skills?
    e. Are there other things about your identity that might help you work toward the future you want?
2. Gather with your team. Write "Team Strengths" on your *Action Plan*.
3. Next to *Team Strengths*, write down all the ideas each person had about things from their identity that might help you all act.

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⚠ Emotional Safety Tip

Everyone has strengths and weaknesses. As a team member, sharing your unique strengths is important, even if it feels uncomfortable. It is important to respect your own strengths and to respect what others identify as their strengths.

4. Write "Assets" on your *Action Plan* and consider what are the places, people, or things your team has access to that could help you take your action. For example, maybe your school would let you use a classroom to hold a meeting or perhaps one team member has a friend or family member who has important knowledge. List every asset you can think of that might help you accomplish the action your team picked.
5. By yourself, consider quietly what are the different steps your team would need to take to accomplish the action your team picked.
6. Write, draw, or use another way to record your ideas on small pieces of paper. Each piece of paper should have one step.
7. Have each team member share their steps by placing their pieces of paper on a table or by using a digital tool for collaboration.
8. Read through the steps from your teammates.
    a. Did you notice any steps that were similar to yours?
    b. Do you think your team is missing any steps?
9. Start to organize your team's steps. You can move the pieces of paper around as you do this. Thinking about your team's steps will help you decide how you will take action.
    a. Group any similar steps together.
    b. Remove any steps you don't think are needed to help your team take action.
    c. Think about how each team member will help. Put their names with the steps they would like to help with.
    d. Think about what steps might be missing. Add those steps.
10. Put the steps in order. For example, what do you think the team needs to do first? Place that piece of paper before all the others.

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11. In your *Action Plan* write "Steps" and record the following:
    a. The steps your team would like to take
    b. The order of those steps
    c. Who will help with each step (it might be more than one person)
    d. When and where you will take these steps
    e. Partners or other people you will involve
    f. How you will communicate your action plan to the community
12. Think about what you will do if your plan doesn't work or you run into another problem. For example, what will you do if an adult in your community says you need permission to do something in your plan? Record these ideas as part of your action plan.
13. Remember to create an **inclusive** action plan. Being inclusive means everyone on your team can participate in some way. You may need to iterate on the plan so that everyone feels safe, comfortable, and able to help. Those iterations are okay! They are part of being a good teammate.

Act: *How will I put my ideas into action?*

The time has come to act! You can use everything you have learned to take action to help create the future you want.

1. With your teammates, implement your *Action Plan*. This may take some time. There is no need to worry; take the time you need. When you are finished, come back and complete this activity.
2. Examine your *Resilience Quilt* and think about how you and your team just created a new story of resilience. How are you feeling about the future now?
3. Think quietly about the action you took. Consider:
    a. What went well?
    b. What do you think could have gone better?
    c. How would you change your action if you had to do it again?

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4. Discuss with your team:
    a. What makes you proud of yourselves as a team?
    b. What do you think you have learned for next time?
5. Return to your *Our Resilient Future* document and your goal about the relationship between people and ecosystems. Reflect:
    a. Do you feel you have moved toward that goal?
    b. What will you need to continue to do to transform the way people and ecosystems interact so they are both more resilient?

Congratulations!

You finished the *Ecosystem Resilience!* Community Research Guide!

Find out More!

For additional resources and activities, please visit the *Ecosystem Resilience!* StoryMap at bit.ly/EcosystemResilience.

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End Notes

1. Image adapted from Strom, K. & Kayumova, S. (2024). "Toward Relational and Pluriversal Pedagogies in Science Education." Paper presented at the American Educational Research Association, Philadelphia, PA., with adapted visual from Martusewicz, R., Edmundson, J., & Lupinacci, J. (2015). *EcoJustice education: Toward diverse, democratic, and sustainable communities* (2nd ed). New York: Routledge.
2. Adapted from Inclusion of Nature in Self (INS) scale Aron et al., (1992). "Inclusion of other in the self scale and the structure of interpersonal closeness." Journal of Personality and Social Psychology, 63(4), 596–612 and; Liefländer et al., (2013). "Promoting connectedness with nature through environmental education." Environmental Education Research, 149(3), 370–384.
3. Adapted from Ritchie, Hannah (2021). "The world has lost one-third of its forest, but an end of deforestation is possible." Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/world-lost-one-third-forests.
4. "Solutionary Toolkit Resources: 5 Types of Action." Institute for Humane Education, 2024. https://humaneeducation.org/solutionary-toolkit/.

Glossary

This glossary can help you understand words you may not know. You can add drawings, your own definitions, or anything else that will help. Add other words to the glossary if you would like.

Abiotic: Related to natural but nonliving things, such as temperature, water, and wind

Accessible: Able to be used by everyone on your team

Action researcher: A person who works with their community to discover, understand, and act on local and global problems they learn about

Adapt: To change in a way that helps you adjust to something new

Adaptation: Changing in a way that helps you adjust to something new

Agroforestry: A farming technique where the forest canopy remains intact and crops are grown in the understory area

Anonymous: With holding a name or other identifying information

Biodiversity: The diversity of living things

Biomimicry: When humans look at nature to get ideas for solving human problems

Biotic: Related to a living thing

Border: An edge or boundary

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Border or edge effect: When plants or animals near the border of a forest face more challenges

Boreal forest: A forest ecosystem found at high latitudes, where evergreen trees are the dominant species and temperatures are freezing for six to eight months of the year, also known as taiga

Canopy: The top of the tallest trees in a forest ecosystem

Carbon market: A trade agreement where a government, group, company, or individual can receive money for carbon stored on land they own or manage

Carbon sink: Environments or living things that store carbon

Carnivore: An animal that mostly eats other animals

Climate change: Changes in the patterns of temperature and precipitation on Earth

Cloaca: An opening in some animals' bodies that is used for getting rid of waste and for reproduction

Collaborate: Work together

Collaborative: Work together in way in which everyone tries to reach a common goal

Collage: A group of pictures or words

Community: A group of people who share something in common, such as a space

Consensus: A balanced decision that works for everyone in the group

Cores: A cylindrical sample of naturally occurring substances

Culture: A shared way of life and understanding of the world

Decomposer: A living thing that breaks down living things after they die and returns those nutrients to the soil

Deforestation: The removal of forest ecosystems

Desalination: The process of removing salt from seawater to make it drinkable

Desert ecosystem: A place with little water and extreme temperatures

Dipterocarps: A type of tree family commonly found in Southeast Asia, and particularly Borneo

Disturbance: A situation that causes change

Diversity: A range of differences

Double bottom line: Assessing something from two perspectives

Dung: Poop

Dynamic: Constantly changing

Economic: About money, income, and the use of wealth

Ecosystem services: The ways in which ecosystems benefit people

Ecosystem: A system where living things and nonliving things all interact in an area

Ecosystem-based adaptation (EbA): An approach that integrates the natural features of ecosystems to adapt to the changing climate

Ecosystem engineers: Living things that substantially change the physical environment of an ecosystem

Embedded: Deeply connected with and surrounded by something

Environmental: About the natural world

Erosion: A process when water or wind wears away the land which then mixes into the water

Ethical: Something that is fair

Excluded: A group that is left out

Forest ecosystem: An ecosystem where many trees are an important feature

Fragmentation: Splitting habitats into separate pieces

Function: Purpose

Genetic bottleneck: A situation where there is low genetic diversity in a population because of a limited number of ancestors

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Goals: What you want to happen in the future

Grassland: A type of ecosystem that consists of large, open areas of grasses and associated living things

Greenhouse gasses: Gases such as carbon dioxide and methane that cause the atmosphere to get warmer

Habitat: The home environment of an organism

Herbivore: An animal that mostly eats plants

Herpetology: The study of reptiles and amphibians, such as snakes, frogs, and turtles.

Identity: The characteristics that make you

Indigenous: A group of people who lived in an area before any other groups arrived; Indigenous peoples are sometimes referred to as First People or First Nations, Aboriginal, or Native Peoples

Innovation: A new idea or method of doing something

Integration: blending two or more things

Iterate: to do something over again

Invasive species: A living thing that was not originally part of an ecosystem, but is introduced

Keystone species: A very important species within an ecosystem

Landslide: A quick downhill movement of rock and dirt

Local community: The group of people who live in the area near you

Mast fruiting: When a tree species fruits only periodically and in coordination with all local trees of the species

Metabolic rate: The speed at which your body uses energy to keep you alive and active.

Migrate: To move to and from a different area, often following shifting weather, food resources, or seasonal plant growth patterns

Migration: The process of organisms moving from one area to another, often seasonal or linked to changing food sources

Model: A representation of a situation or concept

Native: An organism that has grown in an area for hundreds or thousands of years

Native species: Living things that are originally from the place where they are living now

Natural resources: Living and nonliving things that are part of nature and are used by people; examples include metals, rocks, sand, coal, soil, plants, and animals

Oral history: Recording information from people about their past

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Organism: Any living thing

Perspective: A way of thinking about the world around you

Pollution: Natural and unnatural harmful materials that are introduced into an environment

Prototype: An early model or sample of a product, used to test and improve it before making the final version

Radiometric dating: a technique used to find the age of materials

Reclamation: A technique that creates additional land for humans to use, for example by creating concrete structures and filling them in with sand from the ocean bottom or other locations

Resilience: The ability to respond and adapt to changes and challenges

Sea wall: A hard structure along a coast to protect an area of land from ocean water

Sediment: Soil-like material that is left behind by water or wind

Shoreline ecosystems: The living and nonliving things found in the area where water and land meet

Shoreline hardening: Adding rocks, walls, concrete, or other features so shorelines will not move is called

Social: Relating to the interaction of people in a community

Species: A type of living thing, such as a wolf, grasshopper, or yarrow plant

Stressor: Something that causes stress on a system

Sustainable: An approach that balances different perspectives and can keep working for a long time

Sustainable Development Goals (SDGs): Seventeen goals for a better world created by the countries of the United Nations

Sustainable future: A future that balances social, economic, environmental, and ethical concerns and that works well for people and the planet

Suppressed: Attempting to decrease the population of a species, often because it is considered a pest

System: A group of things that all interact with one another in a network

Thermoregulation: How living things control their body temperature

Thrive: When something is working or growing well

Toxic: Harmful or poisonous

Tropical rainforest: A forest ecosystem with high rainfall found near the equator; broad-leaved trees are the dominant species

Tsunami: A series of giant waves caused by earthquakes or volcanic eruptions

Typhoon: A tropical storm, also called a hurricane or cyclone

Understory: The lower, shady area underneath the canopy

Unintended consequences: When even though you were trying to help a situation something harmful happens as a result

United Nations (UN): A global organization designed to help governments and people around the world collaborate and use their shared knowledge and skills to solve problems faced by many communities around the world

Values: What is important to a person or a community

Wallow: Roll repeatedly on the ground

Wildfire: An uncontrolled fire in a forest, grassland, brushland, or land sown to crops

World building: The process of creating an imaginary world

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Ecosystem Resilience!

How can people and ecosystems build resilience to change?

Community Response Guide

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