Global Climate Change in the 21st Century

Coursebook

Oak Meadow

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Introduction

> *"Twenty-five years ago people could be excused for not knowing much, or doing much, about climate change. Today we have no excuse."*
>
> **Desmond Tutu**

Welcome to *Global Climate Change in the 21st Century*. This introduction will lay out the big ideas of the course along with the kinds of work you will be doing and general expectations. Before you dive in, take a minute or two to reflect on why you chose to take this course. Think about what you hope to gain from studying climate change and what makes this topic important to you. You may want to jot down some of your ideas.

Please read this entire course introduction before beginning lesson 1. This information will help you be more successful and get the most out of the course.

Course Materials

The following materials are used in this course:

- Oak Meadow coursebook *Global Climate Change in the 21st Century*
- *Tales of Two Planets*, edited by John Freeman

You will also be selecting and acquiring one additional book on your own. Please refer to lesson 7 for a list of titles to choose from.

What Is This Course About?

NASA defines **climate change** as "a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates," adding that the shifts observed in climate since the early 1900s "are primarily driven by human activities, particularly fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere, raising Earth's average surface temperature" ("Overview"). According to NASA, this definition is representative of the consensus of

over 97 percent of active climate scientists as well as the majority of scientific organizations. Thus, it will be the definition that you work with in this course.

Arriving at and accepting this consensus is part of the nature of science (which is something you will explore in this course). Students may have varying perspectives on climate change and its causes, but it is still valuable to learn how scientists understand these phenomena. Student assessment in the course will be based on your understanding and analysis of the concepts. Whenever possible, student work will be based on original data for an issue, and you will take time to examine what multiple sources say as well as the credibility of their findings.

In this course, your learning will be guided by the following essential questions:

- How do we understand our natural world and climate?
- How do humans relate to climate change?
- What should we do about climate change?

These questions are broad and cannot be thoroughly answered solely from a science perspective. Thus, while you will receive a science credit for this class, your work will include **interdisciplinary** elements. *Interdisciplinary* means using multiple branches of knowledge to examine and understand a concept. In exploring climate change, you will use climate science and environmental science, but also economics, art, Traditional Ecological Knowledge, literature, anthropology, history, math, and psychology. Throughout the course, if you see ways to bring in other topics or disciplines that you feel passionate about, talk to your teacher about how you might incorporate these elements into your assignments.

Althought the course is interdisciplinary, you will primarily be focusing on two areas: science and Indigenous studies. Why? Scientific thinking is critical in gathering the data needed to track and model climate change as well as in understanding the complex interactions between climate and other systems. As we learn more about climate change and how to address it, rising to this challenge requires learning from multiple perspectives and making changes in the globally dominant ways we have been approaching things. You will examine many different perspectives, but a consistent theme will be the voices of the Indigenous peoples who manage the regions and resources that you will learn about.

The focus on Indigenous studies will also include examining the disproportionate impacts of climate change on marginalized groups. Globally, many people face higher risks from climate change due to factors like poverty, racism, and political instability. Specifically, you will be doing a deep dive into the ways Indigenous communities in particular are dealing with climate change around the world. This course will explore case studies of Indigenous communities impacted by climate change as well as the ways Indigenous leaders and activists are playing a major role in finding solutions.

Key Understandings

Here are the key elements that students will explore in this course.

- Current understanding of climate change is supported by many valid lines of empirical evidence that also indicate human activities as a causal factor.
- Human understanding of our climate is informed by scientific data as well as Traditional Ecological Knowledge, which focuses on a connection to the natural world, a close look at system interactions, and an assessment of long-term outcomes.
- Changes in climate have many impacts on human and ecological communities, with disproportionate effects on marginalized communities.
- Human action can limit the negative impacts of climate change.

How Will You Approach Indigenous Studies?

You will already have taken many science courses before you start this class and therefore have background knowledge on how to approach this discipline in an appropriate and scholarly way. You will take some time to review these practices in the first few lessons.

However, many high school students have not had the opportunity to become familiar with the practices for approaching Indigenous studies. (This may or may not be true for you.) Please take time to read the norms and expectations below, which describe how you will be working in this discipline during this course.

Indigenous Studies Norms and Expectations

- You will use correct terminology for Indigenous peoples and groups. Indigenous, Native, and First Peoples are general terms used to refer to groups of people who are the descendants of those who first inhabited a land. Other general terms include Native American, American Indian, and Indian. These terms are always capitalized.
- You will use the name of the specific community to which you are referring whenever possible. For example, when writing about a scientist who is Waanyi, you will identify them as such instead of simply as Indigenous. These names will also always be capitalized.
- You will learn and use the correct pronunciation for Indigenous names and groups. Phonetic pronunciation will be provided in this coursebook.
- You will learn about Indigenous cultures from a primary source whenever possible. For example, when doing research, first check out online resources published by the group or members of the group being referenced.

- You will avoid any actions or activities that appropriate or imitate Indigenous cultures and traditions.
- You will recognize and explore the differences between Indigenous groups. It is critical to recognize that there is no single Indigenous identity or experience, and thus no individual or specific group should be seen as representative of all Indigenous peoples.
- You will recognize that Indigenous groups are modern, vibrant communities in their own right. Indigenous cultures are not a thing of the past, dying out, or separate from other modern cultures.
- You will respect all peoples and cultures equally.

How Is This Course Organized?

As you progress through this course, it is important to keep in mind the major questions, concepts, and skills that you are moving toward. To that end, the table below outlines the three units of the course and the primary skills and understandings in each. If at any point you are confused about the central points of a unit, you should reach out to your teacher to get support on how to develop further understanding in these areas.

Unit I **Lessons** 1–6	**Unit II** **Lessons** 7–13	**Unit III** **Lessons** 14–18
Question: How do we understand our natural world and climate?	**Question:** How do humans relate to climate change?	**Question:** What should we do about climate change?
Topics: • Earth systems • Climate and weather • Traditional Ecological Knowledge	Topics: • How climate change works • Climate change causes and impacts • Future projections	Topics: • Climate change solutions • Environmental justice • Climate activism
Unit Project: Citizen Science Project	**Unit Project:** Climate Fiction Project	**Unit Project:** Climate Action Project
Skill Focus Areas: Analyze complex systems. Make and assess science models. Evaluate evidence and claims. Use evidence to support ideas. Design and refine solutions to real-world problems.		

As shown above, each unit will culminate with a project. In each lesson, you will be given a component of the project to complete, and you will finish and submit the project in the final lesson of the unit. It is critical to complete the project components for each lesson and reach out to your teacher early on if you need help getting started. You are also welcome to look ahead and read the full project descriptions for each unit project in advance to help with your planning. The Unit I project is described at the end of lesson 2, the Unit II project is described at the start of lesson 7, and the Unit III project is described at the start of lesson 14.

The **Citizen Science Project** (Unit I) will involve designing or joining an existing citizen science project related to climate change. You will contribute weekly data to the project as you learn about the related issue and reflect on your experience and impact.

In the **Climate Fiction Project** (Unit II), you will choose a novel that deals with climate change. You will read this novel while assessing the accuracy of the science behind the novel and what its depiction of climate change shows about the ways humans deal with this issue.

For the **Climate Action Project** (Unit III), you will identify a problem related to climate change that interests you and that you can take action on locally. You will learn about the issue, make a plan, take the steps you have identified, and reflect on your impact and learning.

You will get the most out of each of these projects if you choose a topic that you are genuinely passionate about. Make sure you take time to think about ways you can connect your work to your interests or to things that matter to you in your daily life. Your teacher is a good resource if you need to do some brainstorming on this!

How Should You Approach Each Lesson?

This course is divided into 18 lessons, and each lesson is intended to take about one week to complete. This course is designed for independent learning, so hopefully you will find it easy to navigate. However, it is assumed you will have an adult (such as a parent, tutor, or school-based teacher) supervising your work and providing support and feedback. If you have a question about your work, ask your teacher for help.

Each lesson includes the following components.

Lesson Introduction: This brief section will get you started thinking about the big ideas of the lesson and why they matter.

Essential Information: This section will mainly focus on the science skills and content of the lesson. Take time to read this thoroughly, and carefully study any graphs or diagrams. Key terms will be in **boldface** so that you can identify them easily. These are terms you will want to fully understand. You are encouraged to annotate or take notes as you read this section, which will help you remember and better understand the information.

Read, Watch, Reflect: In this section, you will be directed to resources like articles, simulations, and videos that focus on current events and deepen your understanding of the lesson. You may want to discuss the ideas introduced in these resources with friends or family members to further develop your thinking. After reviewing these resources online, you will write a reflection (usually a five- to eight-sentence paragraph) in response to the given prompt. You may choose to complete these reflections as video or audio files. This reflection will be submitted to your teacher.

Questions: These assignments will be a series of questions or brief tasks where you can continue to develop your understanding of the lesson topics and demonstrate your skills and knowledge.

Unit Project: This section includes a series of tasks to complete for the unit project.

Activities: You will usually complete one or more activities, and you will often be given a list of options to choose from. These activities allow you to connect what you learned to your life or interests as you build more advanced skills and take your understanding to a deeper level.

Further Study: This section includes optional activities, readings, or resources that you can choose to investigate if you are interested. You can ask your teacher if you can complete these activities for extra credit or instead of other parts of the lesson.

Share Your Work: This section has information on submitting your work to your teacher.

When you begin each lesson, take a few minutes to look over everything included in the lesson so that you can gather any materials, ask your teacher any questions you might have, and plan your time. An assignment checklist appears on the first page of each lesson. Check off tasks as you complete them so you can see at a glance what you still need to do. Each lesson will end with a reminder to share your work with your teacher.

This course has an extensive bibliography in the appendix. You will find citations throughout the text that tell you where you can find the source of the information stated. In-text citations are noted in parentheses with the author's last name or the first few words of the title, whichever appears first in the full citation in the appendix. You are encouraged to refer to the original source whenever you want more information.

Lessons have been designed to flow from input work (reading the Lesson Introduction and Essential Information) to processing time (the Read, Watch, Reflect section) to synthesis and output work (the questions, projects, and activities). While the bulk of your time will be spent engaging in the questions, projects, and activities, the input work and processing time are key to synthesizing what you've learned and producing meaningful work. As you start the course, pay attention to the ways you are spending your time and what things you find the most meaningful and engaging. If the lessons or specific lesson components are requiring more time than expected, check in with your teacher about how to manage the workload more effectively.

Similarly, you are encouraged to reflect on how engaged you feel in the material and work of this course. Throughout this course, you are given many choices of activities or topics to explore. You will get the most out of this course if you choose options you are genuinely passionate about or if you find ways to connect the work to your interests and daily life.

You are encouraged to look for ways to adjust activities and projects so that they relate to your interests. You can work with your teacher to tailor this course to your learning goals. Make this course your own!

Due to all the options in this course (as well as the fact that our understanding of climate change is constantly progressing), you will regularly be asked to use online research in your work. You may want to review the appendix on how to identify credible sources and how to cite these sources in MLA format.

Study Tips

The study tips below can help you be successful in this course.

- Track your understanding and skill development with the learning objectives of each lesson.
- Use a planner or other organizer to manage your time and help you complete your lessons on a consistent schedule so you can finish the course within the expected time period.
- Start each lesson by looking through all the tasks, materials, timing, and work you will submit. Make a plan, and reach out to your teacher for any support, if needed.
- Pay attention to key terms (highlighted in boldface). If you do not understand a term, look it up. If you are still having trouble understanding the term or its significance, discuss it with your teacher.
- Plan your work on unit projects so you can complete what you need to each week and are done by the end of each unit.
- Follow the guidelines in the appendix for research and citations to avoid any issues with plagiarism.
- Check in with your teacher regularly, and let them know if you have questions about your assignments or how to get the most out of this course. Advocate for yourself when you need help! Your teacher and other supportive adults want to help you be successful.

Academic Expectations

This is a science course, and you are expected to use scientific terms and best practices in your work. Proofread your written assignments before sharing them with your teacher to best demonstrate your knowledge and skills. You are expected to submit original work and cite all sources referenced in your responses.

The appendix contains important material that you will need to read and incorporate into your work throughout the year. Take some time to familiarize yourself with the resources in the appendix. You will find information about original work guidelines, tips on how to avoid accidental plagiarism, and details on citing sources and images.

A Note About the Workload

Students vary greatly in terms of reading speed, reading comprehension, and writing ability. Some may find the reading in this course takes longer than expected; others may find the writing assignments or activities take a great deal of time. In general, you can expect to spend about five hours on each lesson. If you need more time to complete the work, you can modify some lessons to focus on fewer assignments or skip activities in some lessons to spend more time on other assignments. Modifications like these will allow you to produce work of a higher quality. Each lesson in this course can be customized to suit your needs.

Keep an eye on the workload as you progress through the course. Make adjustments so you have time for meaningful learning experiences rather than rushing to try to get everything done. Always consult with your teacher before making adjustments to the workload. They may have alternative ideas for you to consider.

UNIT I: Ways of Knowing

How do we understand our natural world and climate?

Who has seen the wind?
Neither I nor you:
But when the leaves hang trembling,
The wind is passing through.

Who has seen the wind?
Neither you nor I:
But when the trees bow down their heads,
The wind is passing by.

Christina Rossetti

(Image credit: Mike Green)

Lesson 1

Ways of Understanding the Natural World

Learning Objectives

In this lesson, you will:

- Identify how changes in one environmental factor (such as precipitation or land use) may contribute to changes in another part of the ecosystem.
- Explain how certain species have adapted to specific environments and predict how they could be impacted by changes in environmental conditions.
- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

ASSIGNMENT CHECKLIST

- ☐ Read the Lesson Introduction and Essential Information.
- ☐ Complete the Read, Watch, Reflect section.
- ☐ Answer the lesson questions.
- ☐ Complete Activity A: Australian Fire Visualization.
- ☐ Complete Activity B: Local Area Knowledge Interview.

Lesson Introduction

Think about a time you stayed at someone else's house—maybe you spent a holiday with a relative or had a sleepover with a friend. Was there anything their family did that was totally different from how you are used to doing things at home? For example, maybe you are used to taking a shower every morning, but in this other household, people only shower at night. Or perhaps your family thinks it's fine to use paper towels, but the other family views this as wasteful and uses cloth napkins and cleaning rags.

When you grow up doing things a certain way and surrounded by people who have the same habits, it's easy to take that approach for granted. We may not even notice that we have a particular way of doing things until we are confronted with something different. If you think back to your memory of staying in someone else's house, were there any differences that you hadn't even realized could exist? Were there things you thought everyone did but found out were actually unique to your family?

You and your family have certain habits of thought and behavior, and the same is true on a much broader scale. Different cultures and countries have specific ways of doing things or seeing things.

When it comes to the issue of climate change, the global community is coming to terms with how our recent approach to things has led us to our current predicament. As we explore how climate change works, its impacts, and solutions, it is important to consider ways of understanding and acting that are different from what we might be used to. It is a critical part of the problem-solving and innovation needed to address climate change.

In this lesson, you will examine a case study of people who deal with a climate-related problem by reevaluating how they are used to doing things and using a different way of understanding natural systems to find a solution. As you work through this lesson, reflect on the ways that you tend to understand the natural world and your place in it.

Essential Information

> *"You can see the ashes on the air, landing on the trees up here and it's like a mourning for the country."*
>
> **Victor Steffensen, a Tagalaka (pronounced Tah-gah-LAH-kah) Indigenous fire practitioner in Australia**

Australian Fire Seasons

The "Black Summer" 2019–2020 fire season in Australia was a particularly devastating one. The fires burned almost 19 million hectares (around 72,000 square miles, an area larger than the entire country of Syria), killed 35 people and over a billion animals, and destroyed thousands of homes and businesses. This fire season was unprecedented in its duration, burn area, and economic costs. However, the Australian landscape is no stranger to wildfires.

"Black Summer" fires in Australia
(Image credit: Australian Wildlife Protection Council)

Southern Australia experiences four distinct seasons. The winter season (June to August) is responsible for most of the yearly precipitation. By the end of spring (September to November), much of the moisture from winter is gone and the transition to summer (December to February) comes with hot, dry weather and strong winds. This is the highest fire danger period. In the fall (March to May),

temperatures cool and winds decrease, which can lower fire danger, but the risk is not over until winter rain arrives.

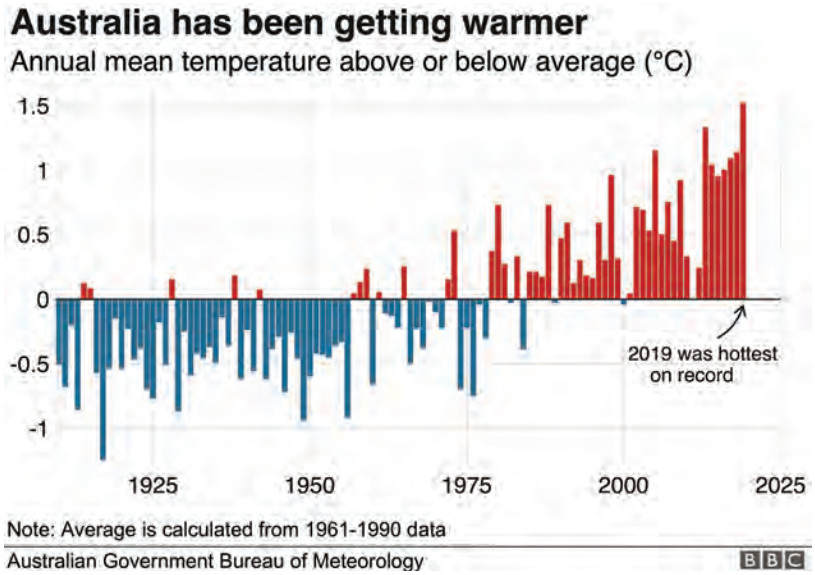
In Northern Australia, the seasons are experienced differently. There is a cooler dry season from May to October (late fall through winter to early spring). The wet season from November to April (late spring through summer to early fall) is characterized by hot weather and heavy rain. The highest fire danger comes in the dry season, with risks increasing later in the season.

With high fire-risk periods in all regions of Australia, wildfires are a normal yearly occurrence, and many native species like eucalyptus are adapted to regular wildfires.

Changing Conditions

If fires are common in Australia, what made the 2019–2020 fire season so devastating? While Australian rainfall for 2020 was about average, the preceding three years were marked by drought; 2019 was also Australia's hottest year on record, with 2020 coming in at fourth.

Droughts and hot, windy weather are certainly risk factors for wildfire, but is there more to the picture?



(Image credit: "Australia Fires")

Land Management

In 2011, the Wunambal Gaambera (pronounced WAN-amble GAM-berra) people's title to their ancestral lands in Northern Australia was recognized, allowing them to start their own land management plans. The Wunambal Gaambera are Indigenous Australians who were moved off their land in the early 1900s. Like many Indigenous groups in Australia, the Wunambal Gaambera practiced fire management techniques that involved slow-moving, low-temperature, controlled burns that were

conducted at the end of the wettest season. These fires removed fuels like dead brush and created fire breaks that prevented large, hot, uncontrolled wildfires in the dry season.

When colonizers from wet European climates arrived in Australia in the late 1700s, they seized lands and began enforcing their approach to land management, which included outlawing Indigenous burn practices. With this transition came the emergence of large wildfires like the Black Thursday bushfires (February 1851) and the Red Tuesday bushfires in Victoria (February 1898). Starting in 2011, the Wunambal Gaambera began reestablishing fire management methods on their land that their people had been practicing for millennia. Wunambal Gaambera who conduct this fire management are called Uunguu Rangers.

The approaches the Uunguu Rangers use involve "right way" fire. Right way fire can vary in different communities and **ecosystems**, but its name references the idea that the fires are lit at the "right" time in the seasons to prevent wildfires and are implemented in ways that burn only the intended area or vegetation types (often determined by the temperature of the fire). Additionally, right way fires are lit following traditional practices where a family member must be present. Uunguu Ranger Neil Waina describes this: "We use the right way fire; we're following our old people, our ancestors. They used to walk the land, burn at the right time, so there wasn't any wildfires" (Cramer).

Ways of Understanding: TEK and Western Science

The knowledge of how to conduct right way fire has been passed down through generations in Indigenous communities. It is an example of something called **Traditional Ecological Knowledge** (abbreviated for the rest of the course as TEK). This is the most common term, but it may also be referred to as Native Science or Indigenous Knowledge. TEK is generally defined as being an accumulating body of knowledge, practices, and beliefs about the relationship of living beings with each other and their environment. This information has evolved over time based on the experiences and observations of Indigenous people, and is handed down from generation to generation.

Because TEK involves things like using observations to form an understanding of natural phenomena and adapt practices like land management techniques, it is often considered to be a kind of science. However, TEK is different from **Western Science**. Western Science is based on the use of the scientific method, where observations are used to form hypotheses that are tested in controlled experimentation to gather data that is published and peer reviewed. Both TEK and Western Science involve scientific thinking, but they take different forms. Western Science passes on information through academic forums and is usually written. TEK is usually passed on orally or through shared cultural practices. The data collected in Western Science is normally objective and quantitative (numbers-based), with a clear distinction between empirical data and spiritual or cultural practices. In contrast, TEK tends to be more subjective and qualitative (description-based), with a holistic focus that does not separate the subject of study from their context in the natural world.

Both of these ways of understanding the world are valid approaches, and each has strengths and limitations. In the case of managing Australian fires, when land is managed by the Wunambal Gaambera using traditional ecological practices, there is a 50 percent drop in the number of dry-season wildfires

("In Fiery Footsteps"). More and more, the Western Science community is coming to recognize the value of TEK, and many projects around the world involve collaboration and incorporation of these two perspectives. For example, not only do the Uunguu Rangers use approaches based on TEK, they also use technology like satellite mapping and aerial burning from helicopters.

Incorporating Multiple Ways of Understanding

As societies face natural hazards like fires in a changing environment, we will be pushed to learn, innovate, and examine our ways of thinking. TEK is an excellent example of this when it comes to climate change. Climate change is defined as long-term changes in weather and temperature averages in a region. In connection with climate change, you may also have heard the term **global warming**. What is the difference? Global warming refers to the way that Earth's average temperatures are increasing over time, leading to a planet that is overall getting warmer. This term is limited to temperature. In contrast, climate change includes changes in precipitation, extreme weather patterns, temperature, and other elements related to climate. In this course, we'll look at how Earth's temperatures are changing, recognizing it as one piece of the complex system of climate change.

As we saw in the example of Australian wildfires, TEK practices help reduce the wildfire danger that has risen with climate changes in the region. In fact, an increasing body of data shows that ecosystems managed through TEK practices are more resilient to the effects of climate change. Since a significant majority of global land is not managed in this way, it is an important avenue to explore. However, the use of TEK and Western Science is certainly not the only example of the benefits of knowing or approaching something in multiple ways. Adjusting to a changing world will involve finding more ways of looking at how we manage everything from international relations, economics, and technology development to personal health, housing, and transportation.

While there are many areas where climate change is pushing us to think and approach things differently, it is helpful in a course of this length to focus on one area to investigate in depth. Thus, in this unit we will be focusing on what the combined knowledge from Western Science and TEK can tell us about our climate and natural systems. Since most of you will be primarily familiar with either one or the other, this is an interesting opportunity to investigate a different perspective. As we examine how climate works within our natural systems, think about your relationship with the place you live and how you understand the living and nonliving things around you.

If you are looking to explore other examples of how climate change is leading to new ways of looking at things, check the Further Study section at the end of this lesson for ideas.

Read, Watch, Reflect

1. Throughout this course, you will be reading selections from *Tales of Two Planets*, a compilation of short stories, essays, and poems about climate change by prominent writers from around the world. Certain stories will be assigned, but you are welcome to read more on your own. (You may also want to read the back cover and introduction for more context on this book).

For this lesson, please read the story titled "Sick World" by Enrique Osorno (243). Think about the different ways of viewing the environment, economy, and politics that are presented in the story.

2. Watch the TEDx Talk below by Albert Wiggan, a Bardi-Kija-Nyul Nyul (these are three separate group names pronounced BAR-dee, GEE-jah, nyull-nyull) consultant and speaker from Australia.

   "The Case to Recognise Indigenous Knowledge as Science"

   youtube.com/watch?v=X5QON5l6zy8

3. Based on what you have read and watched so far in this lesson, write a paragraph (five to eight sentences) reflecting on one or both of the following prompts.

   If you would like to address a different question you have that relates to the big ideas of this lesson, please let your teacher know. Additionally, if you would prefer to do this reflection as a video or audio file, you may. Submit this reflection as part of your work for this lesson.

   If you have anything else you want to mention to your teacher (questions or concerns about the course, supports you need as a learner, or anything you want your teacher to know about you), please add this in as a separate paragraph at the end of your reflection. (This is optional.)

   a. The Australian wildfires are one way changes in climate patterns are impacting people in Australia. Are there ways that you are being impacted by things that are related to changing climate? Discuss what these things are, the connection to climate change, and how you came to be aware of this issue.

   b. What has contributed to the ways that you see and understand the world? Consider things like your experiences as well as the systems and beliefs of the country(ies) and culture(s) you've grown up in. Additionally, has your culture and education included both TEK and Western Science, or just one? As you reflect on these questions, consider why you think this happened and how this has influenced the way you see the world.

Questions

1. It is likely that you have already learned about climate change or have at least heard something about it. Write one paragraph describing your current understanding of climate change. (If you feel like you know very little, you could instead discuss things you want to learn about or questions that you have.) You will come back and reread this answer later in the course, so be detailed and thoughtful!
2. How are the terms *global warming* and *climate change* similar and different?
3. What factors seem to contribute to the increase in Australian wildfires? Why?
4. There is evidence that the Australian wet season is starting later on average than it has historically. What impact would you predict this might have on wildfires?

5. All ecosystems are made up of complex interactions between living and nonliving things in an area. The following questions ask you to examine how living things in an ecosystem besides humans are connected to changes in climate.

   a. Look up one Australian species that is adapted to fire. What are these adaptations, and how do they impact the species' response to fire? (Remember, anytime you use outside sources in your answers, you should cite your source in MLA format. See the appendix for details.)

   b. How would you predict that the species you chose would be impacted by an increase in wildfires? Why?

6. In contrast to the native species you identified in the previous question that has evolved as part of Australian ecosystems, buffel grass is a species from Africa that was introduced to Australia in the 1870s to support cattle farming. This species has spread widely in Australia, and many people are concerned about its impact. To gain a deeper understanding about the complex causes of wildfires and how ecosystem health impacts responses to climate change, read the article below (make sure to also watch the embedded animated video).

   "The Battle against Buffel: Protecting County and Culture"

   alec.org.au/buffel_grass

   Use the information in the article to answer the following questions.

   a. While data links increased wildfire activity to a changing climate, these fires are caused by multiple factors. How might an invasive species like buffel grass play a role in increasing fire danger?

   b. What can we learn from the example of buffel grass about what helps ecosystems be more resistant to the impacts of climate change?

   c. How does this article on buffel grass include perspectives from TEK and Western Science?

      Bonus question (optional): Can you think of any limitations of approaching the buffel grass issue from only one way of understanding the world?

7. The example of Australian wildfires shows how it was beneficial to understand land management not just from a Western Science perspective but also using TEK. (Again, it's important to note that these are not the only two lenses that can be used here, but they will be our focus in this unit because of their broad applicability.) As we continue to learn about our understanding of the natural world in this unit, we will circle back to TEK as a source of information. With this in mind, please answer the following questions.

   a. What Indigenous group(s) live or lived in your area?

   b. What source or sources did you use to find the information about native species in Australia for question 5a? What makes you think these sources were credible and sufficient?

c. In the introduction for this coursebook, there is a section on course norms for Indigenous studies. (If you haven't read this yet, please do so now.) Why do you think it is important to follow the course norms and expectations for learning about Indigenous communities in your work for this course as well as in general?

Activities

Complete both of the following activities:

- Activity A: Australian Fire Visualization
- Activity B: Local Area Knowledge Interview

Activity A: Australian Fire Visualization

Understanding climate and the natural systems it relates to is a huge endeavor. It involves examining complex interactions between a huge number of factors, many of which are happening on a scale that is hard to directly observe. In cases like this, scientists often create models that let them visualize and track these dynamics. As we continue learning about climate, it is helpful to create visual models that help us understand the big-picture system of factors and connections that are involved with any given phenomenon. In this activity, you will create a visual model (using writing, symbols, color, and images) to show what is responsible for the increase in Australian wildfires.

If, instead of the Australian wildfires, you would like to make a visual model about one of the climate change impacts that you have experienced (perhaps one you identified in your response to the Read, Watch, Reflect prompts), this is a great alternative option. You will still complete the following steps, adjusting them to be about your issue instead of the Australian wildfires. You may need to do some additional research on your own, so make sure to cite in MLA format any outside sources you use. Make sure that the issue you choose is related to climate change; if you aren't sure, check with your teacher.

1. Based on the work from this lesson, make a list of seven to ten factors that are related to the issue of increasing Australian wildfires.

   Hint: Consider things like causes and effects, human factors, living and nonliving components, or visible and nonvisible processes. For example, your list might include more wind in the dry season, the destruction of homes, etc.

2. Use words or images to place the factors from your list on a piece of paper. You can do this by hand, digitally, or in any other format you like.
3. Use arrows or labeled lines to show how different factors connect to each other. Every factor in your model should be connected to at least one other factor.
4. Add finishing touches to your visualization model. Is your work clear, or do you need to do a clean version to share with your teacher? Do you want to add color to highlight relationships

between elements? Would more images enhance your visualization? Do you need more labels to show what is happening? Submit your final image with your lesson and save a copy—you will be adding to it in the next lesson.

5. Write an analysis of your model that answers the following questions.
   a. What elements of your visual do you think represent a science-based understanding of this issue? Why? (If you think your visual does not include a science viewpoint, discuss what you might add to represent this perspective.)
   b. What elements of your visual do you think represent a TEK-based understanding of this issue? Why? (If you think your visual does not include a TEK viewpoint, discuss what you might add to represent this perspective.)

Activity B: Local Area Knowledge Interview

In the Read, Watch, Reflect prompts, you considered ways that you have been impacted by climate change, which may have included some ways that the climate where you live has changed. In this activity, you'll see how your understanding of the changes in your area compares with that of someone who has lived there longer. This will involve interviewing an older friend, neighbor, or family member who has lived in your area for a long time.

Note: Instead of writing, you may submit your work for this activity as a video or audio file. If you choose to do this, make sure you do not include the voice and image of the person you interview unless you have gotten their explicit permission after explaining exactly what you will be doing with the video/audio.

1. Below are the three basic questions you will be asking. First, write your answers to the questions, based on your personal experience and without doing any research.
   - What (if any) changes have there been in weather patterns in this area over time?
   - Can you describe any changes you've seen in the species and populations that live in this area?
   - Have any of the changes you've identified led to changes in where people live or their daily habits?
2. Next, write at least two more questions related to changes in your local climate and natural systems that you think would be interesting to ask the person you interview.
3. Set up your interview with an older friend, neighbor, or family member who has lived in your area for a long time. Get permission to record them in audio or video format. If they are not comfortable with that, take notes on the interview, but do not record it.

   Ask your questions one at a time (the three provided in the activity and the ones you wrote). Listen carefully to their answers, and ask follow-up questions if clarification is necessary. Afterward, thank them for their time.

4. Write a paragraph that reflects on your experience and learning from the interview. You may want to consider the following questions:
    - How did your answers compare to those of the person you interviewed?
    - How do you think living in a place for a long time impacts your connection to that place and how you understand it?
    - What role should personal experiences and stories play in our understanding of the natural world?

    When you have completed this activity, share your list of questions, your responses to the first three questions, and your paragraph reflection. If you have permission, submit the video or audio interview. If you did not record the interview, submit the notes you took during the interview.

Further Study

All Further Study assignments in this course are optional. Choose any that interest you.

Interdisciplinary Presentation

Are you interested in exploring how other disciplines or industries are changing how they understand and approach their work in the face of climate change? For extra credit, you can choose an example to learn about and then create a presentation or written report. You may want to begin by identifying a field of study that interests you (like economics or architecture) and then do research on how this field is changing in light of climate change. For example, architects are finding ways to make structures more energy efficient or disaster resistant. Make sure to keep track of your sources and cite them in MLA format.

Additionally, if this topic continues to interest you, look for ways to incorporate it into other lesson assignments. You can also ask your teacher about how to make this topic a subfocus of the course.

Climate Issues in Australia

If you want to read more about climate issues in Australia, check out this compelling article by Alexis Wright, a Waayani (pronounced WAN-ee) Indigenous Australian.

> "We All Smell the Smoke, We All Feel the Heat. This Environmental Catastrophe Is Global"
>
> theguardian.com/environment/2019/may/18/we-all-smell-the-smoke-we-all-feel-the-heat-this-environmental-catastrophe-is-global

If you'd like to learn more about right way fire, read the following article.

> "The Art of Fire: Reviving the Indigenous Craft of Cultural Burning"
>
> thenarwhal.ca/indigenous-cultural-burning

Afterward, compare and contrast what you've learned about wildfires and Indigenous burn practices with what is happening in the Pacific Northwest.

Local Indigenous Research

If you are interested in going deeper with your learning about local Indigenous groups in your area, you may want to complete this research activity. First, identify one Indigenous group that lives (or historically lived) in your area. Next, use a variety of sources to research this group. The best place to start learning about an Indigenous culture is with primary sources, so start your research with resources published by the group or members of the group you are interested in.

Here are some ideas for research topics:

- The official name(s) of this group and any subgroups that are included according to the group. For example, while the term *Navajo* may be familiar to you, this community of people call themselves Diné (pronounced du-NEH). If you are unfamiliar with the pronunciation of any names, we encourage you to use resources like YouTube or reach out to local cultural organizations.
- The lands that currently belong to this group as well as lands that historically belonged to the group.
- At least one individual from this group and why their work or role is notable.
- You are encouraged to choose other research areas based on your interests! For example, if you are interested in cooking, you might research current recipes, foods, traditional cooking methods, etc., used by your chosen group. If you are interested in art, you might find a local Indigenous artisan and ask if you can observe or learn about their techniques.

Finally, present what you learned in the form of a poster, essay, slide presentation, video, or other creative visual means. Make sure you cite all your sources in MLA format.

SHARE YOUR WORK

When you have completed this lesson, share the following work with your teacher:

- Your reflection from Read, Watch, Reflect
- Answers to lesson questions
- Activity A: Australian Fire Visualization
- Activity B: Local Area Knowledge Interview

If you complete any of the Further Study options during this course, you may submit that along with your lesson work. (This is not required.)

Make sure each assignment is clearly labeled. Please proofread your work and make any corrections before submitting it for review. When you have submitted your work, notify your teacher, and then proceed to lesson 2.

If you have any questions about the lesson assignments or how to share your work, let your teacher know. If you would like to modify any of the assignments or activities (now or in the future), please consult with your teacher first.

Lesson

2

Weather or Climate?

Learning Objectives

In this lesson, you will:

- Plan a citizen science project to gather data about climate change.
- Differentiate between weather and climate, and identify factors that influence each.
- Explain the system dynamics of the greenhouse effect.

ASSIGNMENT CHECKLIST

- ☐ Read the Lesson Introduction and Essential Information.
- ☐ Complete the Read, Watch, Reflect section.
- ☐ Answer the lesson questions.
- ☐ Complete the first steps of your Citizen Science Project.

Lesson Introduction

> *"Climate change is sometimes misunderstood as being about changes in weather. In reality, it is about changes in our very way of life."*
>
> **Paul Polman**

Without looking up any answers to the following questions, see if you can recall them off the top of your head:

- What kind of weather did you have exactly one week ago?
- What phase is the moon in right now?

Now, try to picture the plants and animals that live near your home.

- What species are they?
- What is the population of each species in your yard, block, or neighborhood?
- Where are they in their seasonal cycles?
- Which flowers are budding or blooming? Which are dying off?

Reflect on how you did with these questions and which ones you knew less about. Whether we notice it or not, we are surrounded every day by the constantly changing natural world through the air we breathe, our water, weather, the common species in our area, the night sky, and the list goes on.

Unless we make an effort to notice things about the natural world, it's easy to pass them over. If we aren't paying attention to things like what insects are normally out in the summer or when plants start to flower, will we even notice if these things change or disappear?

These observations are not just interesting things to note about your surroundings but can actually provide critical data about climate change. In the next few days, consider taking time to pay closer attention to the natural world around you. Are there things you've never seen before? Do you notice any subtle changes over time?

Essential Information

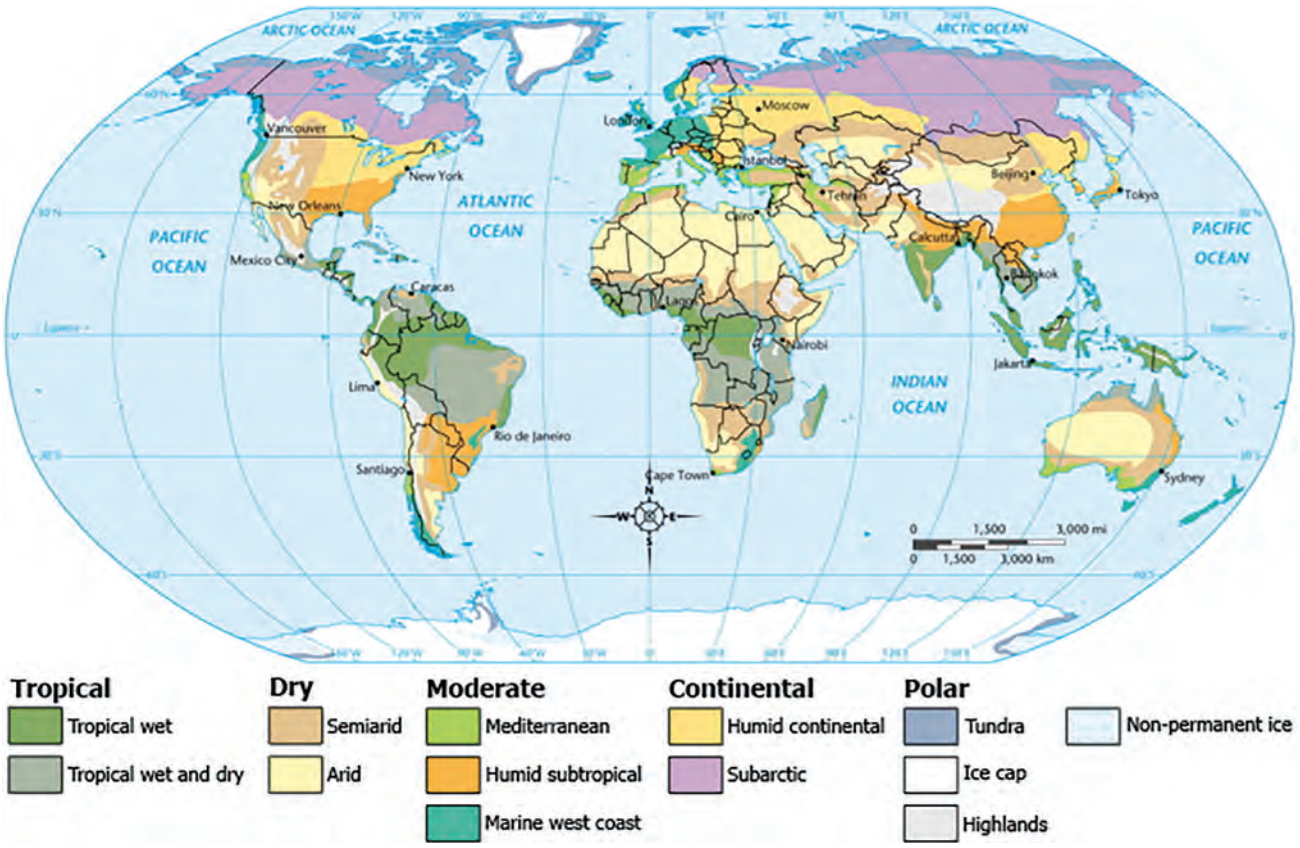
If you've ever spent time learning about koalas, then you probably have come across the popular idea that koalas do not need to drink water because of the moisture they get from eucalyptus leaves, which is their main source of food. However, in 2017–2018, Dr. Valentina Mella, an animal researcher in Sydney, Australia, began getting calls from locals who saw koalas out of their normal habitat drinking water from birdbaths. What could explain this shift in behavior?

From January 2017 to October 2019, this region of Australia (New South Wales) experienced 35 months of consecutive drought with the lowest levels of rainfall in almost a century. During droughts and heat waves, eucalyptus leaves dry out or fall off, limiting the water available to koalas through food. Koalas are forced to travel on the ground to find a new habitat or water source. If koalas are lucky, they are able to travel while avoiding predators and locate the water they need. However, if water remains unavailable, koalas will die of dehydration or overheating.

Australia commonly experiences high temperatures and dry periods. What is so different about these recent droughts that is causing shifts in koala behavior? What factors determine the temperatures and rainfall in a region? And at what point does a dry spell become a permanent condition for an area?

Defining Weather and Climate

At the heart of this issue are weather and climate. **Weather** is the short-term temperature and precipitation conditions that a geographic area experiences over a time period of a few hours up to a week or two. If we take an average of these conditions on a multiyear scale (scientists specifically use a 30-year average), then we end up with the overall **climate** conditions for that region. One way to think about this distinction is that the weather determines the clothes you decide to put on each morning, but the climate determines the range of clothes in your closet overall.



Map of climate types and regions (Image credit: Waitak)

Types of Climate

Generally, there are five main climate types found on Earth. **Polar climates** are characterized by extremely low temperatures that stay under 10°C. **Continental climates** have cold, snowy, windy winters with summers that can be cool to warm. **Temperate climates** (also called moderate climates) have mild winters with summers that are warm and humid with likely thunderstorms. **Dry climates** have low precipitation, high evaporation, and variable temperatures. **Tropical climates** have high temperatures (never dropping below 18°C) with high humidity and more than 59 inches of precipitation yearly. As you can see, climates are characterized by their average temperatures, average precipitation (rain, snow, etc.), and atmospheric conditions like wind and humidity. But what determines these conditions?

Factors Impacting Heat on Earth

The range of conditions seen in Earth's climates are strongly linked to Earth's sun and atmosphere. The sun's rays reach Earth, where they provide light and heat. When this radiation hits Earth, a variety of things can happen to it. Sometimes this radiation is reflected away from Earth back into space. Earth's atmosphere is a layer of gases that surround Earth and reflect a certain amount of solar and cosmic radiation. This can also happen when sunlight travels through the atmosphere and hits glaciers or snow, which reflect these rays in something called the **albedo effect**. (*Albedo* refers to the ability of

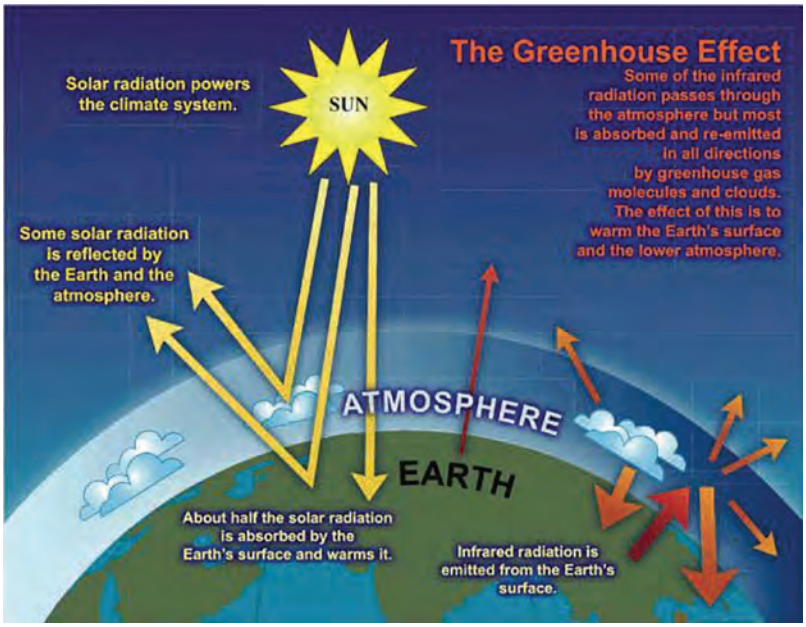
surfaces to reflect solar radiation.) When radiation is reflected, there is less heat near Earth's surface, which lowers temperatures. Conversely, radiation can also be absorbed by soil, rocks, or bodies of water on Earth. When radiation is absorbed by these objects, this added heat can increase temperatures. This heat can stay near Earth's surface or radiate back out into space.

Sunlight reflecting off glaciers or snow can lower temperatures.

Sunlight absorbed by soil, rocks, or bodies of water can increase temperatures.

Albedo effect (Image credit, left: John3. Image credit, right: Firman Kholik)

The balance of how much radiation (and therefore heat) is absorbed or reflected has a direct impact on temperatures on Earth. If more heat is reflected or radiated away from Earth, then temperatures will drop. The opposite is also true: if less heat leaves Earth, then temperatures will increase. One key factor that affects how much heat stays on Earth is something called the **greenhouse effect**. It involves certain gases in Earth's atmosphere called **greenhouse gases**, which include compounds like carbon dioxide (CO_2), methane (CH_4), water vapor (H_2O), and nitrous oxide (NO). These gases have certain properties that absorb the heat that is normally radiated away from Earth and keep it within Earth's atmosphere. This is called the greenhouse effect because light energy is able to move through these atmospheric gases to reach Earth, but the resulting heat energy is not able to leave. This is similar to how light can enter a greenhouse through the glass windows, but

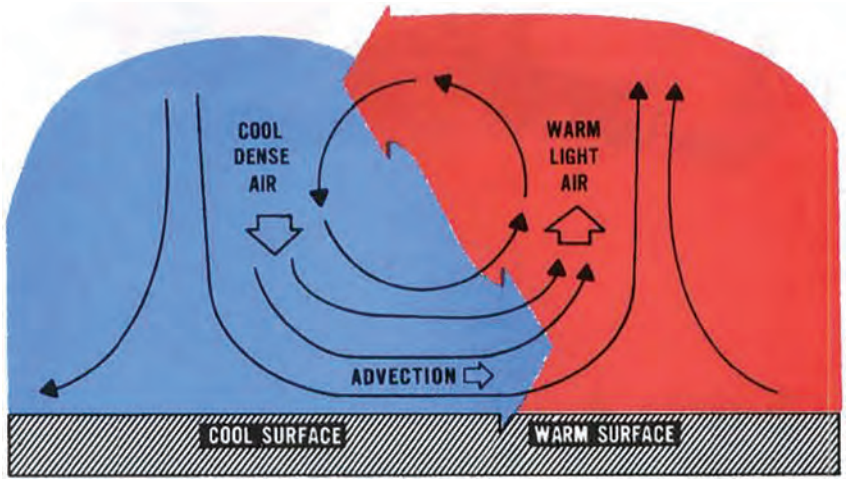


Greenhouse effect (Image source: niwa.co.nz. Image credit: Le Treut et al., 2007)

these windows hold in the heat. When more greenhouse gas is present, more heat is trapped in the atmosphere, which impacts temperatures.

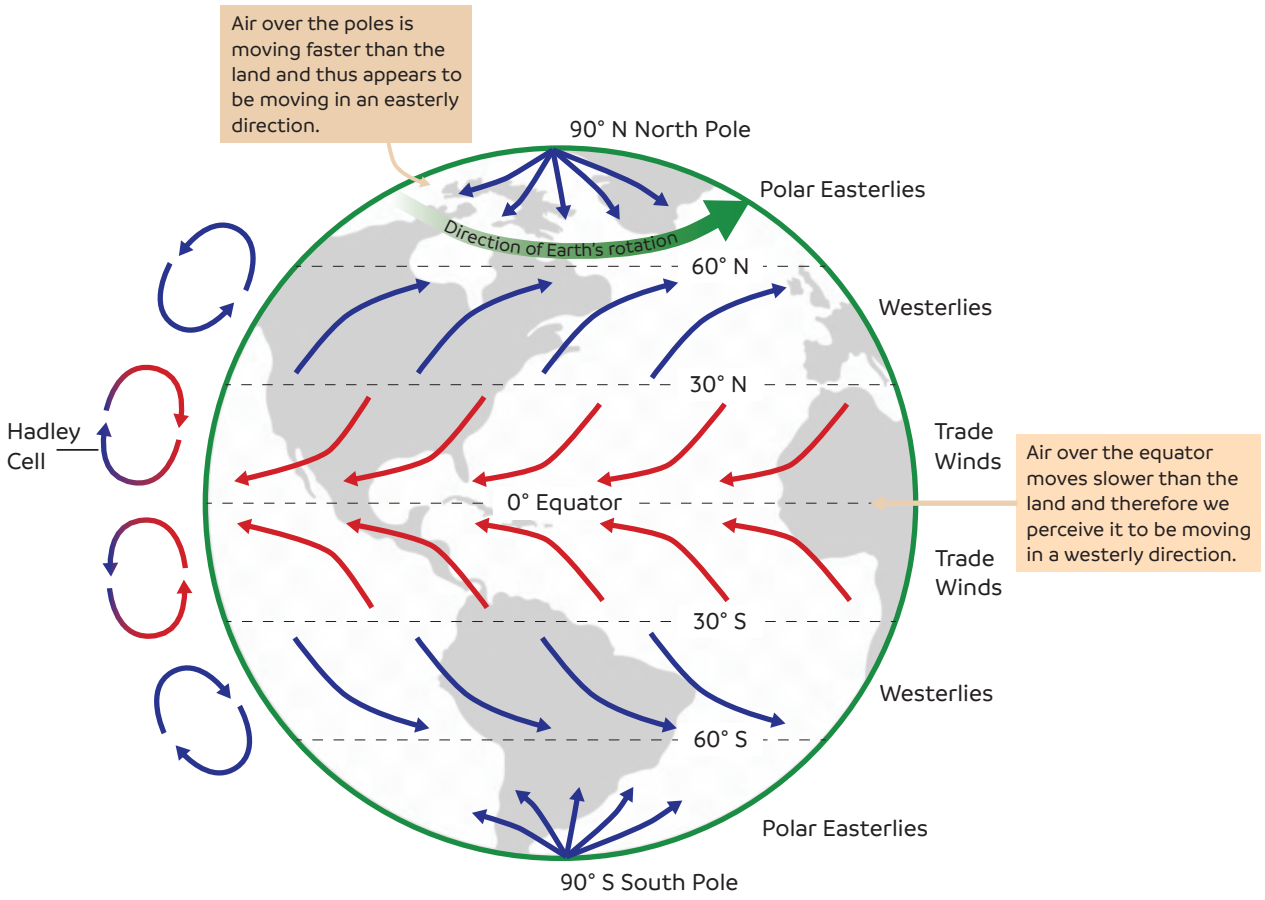
How Heat Moves around Earth

What happens to the heat energy on Earth? One outcome is that the amount of heat energy in the air drives how air moves. When air is cooler, the molecules have less energy, which causes them to move less and be closer together. This configuration makes this air have higher density and higher pressure, which causes cooler air to stay closer to Earth's surface. In contrast, when air is warmer, the gas molecules have more energy and therefore move around more, leading to a lower density and lower pressure. As a result, hot air masses rise. When pockets of warm air rise, other air must flow in to fill this void—often nearby pockets of cooler air. As the rising warm air moves higher into the atmosphere, it cools. This cooling decreases the energy and therefore movement of the gas molecules, making the air become more dense and begin sinking back to Earth. This process is known as **convection**. All this movement of air creates wind (referred to as *advection* in the diagram) and can play a role in shifting the location of clouds and storms.



Convection (Image credit: FAA)

Since the sun's radiation hits Earth more directly near the equator, this region receives more heat energy. As a result, warm air tends to rise near the equator and circulate with cooler air near the poles. This process would result in a simple back-and-forth movement of air between the equator and poles if Earth stayed still. However, as Earth rotates, air near the equator is moving through space more quickly than air near the poles. As the faster air near the equator moves away and into slower regions, it is deflected at an angle that causes air masses to spin in a clockwise (north of the equator) or a counterclockwise (south of the equator) direction. This is called the **Coriolis effect**. You can see this effect if you look at the shape of large storms on a weather report. If you live in the Northern Hemisphere, you will notice that storm systems or hurricanes rotate in a counterclockwise direction, while the opposite is true of storms in the Southern Hemisphere.



In this diagram of the Coriolis effect, as Earth rotates east (to the right), the air over the equator moves slower than the land; therefore, we perceive it to be moving in the opposite direction. This diagram also shows how the hot air at the equator forms Hadley cells; this is the name for air circulation through convection at the equator. When warm air from the cells cycles back to the ground, some of it stays near the equator, while some moves toward the poles. Since land at the poles is moving through space slower than land at the equator, air over the poles is moving faster than the land and thus is seen as moving in the same direction as Earth's rotation. These trends of air currents lead to the winds and storm patterns that we observe in our weather and climate. (Image credit: Wendy Therieau)

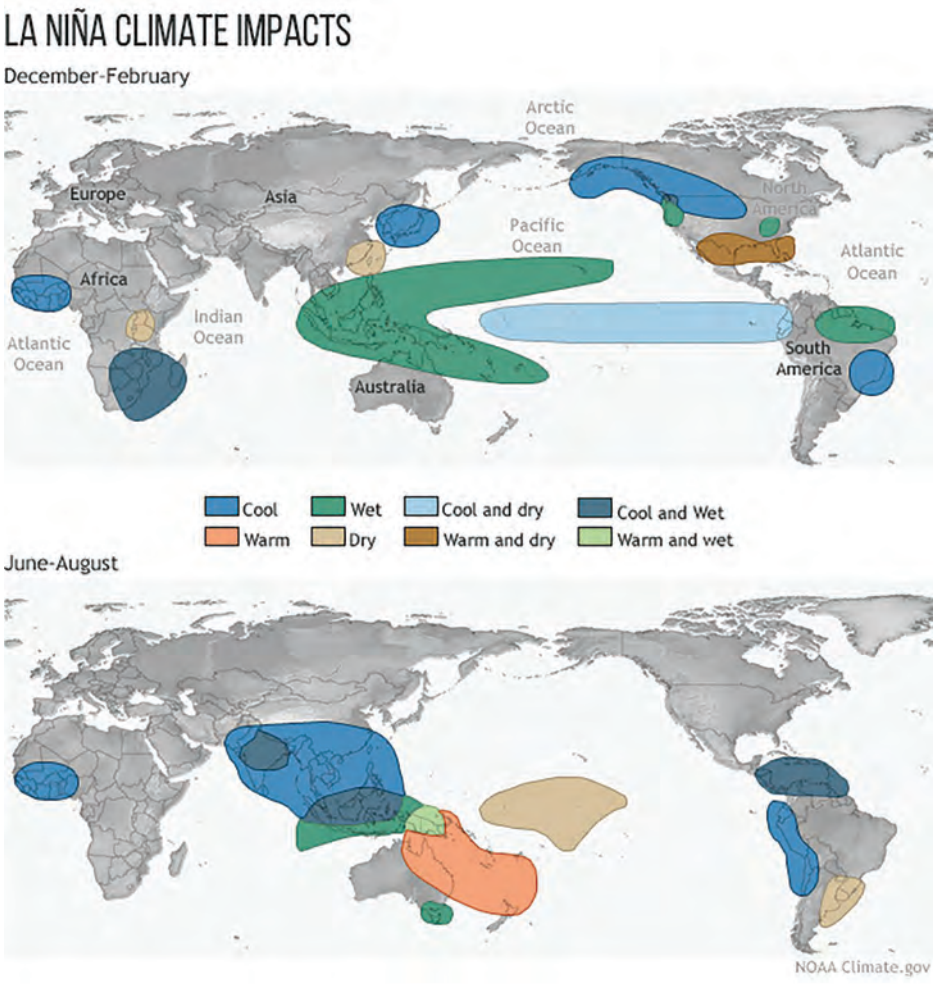
Factors That Impact Precipitation

We've looked at how energy from the sun impacts our air and atmosphere, but what about water and precipitation? Warmer temperatures can increase the rate at which water evaporates into the atmosphere. As this water vapor in the atmosphere cools, it condenses into clouds. The type of clouds that form is determined by the temperature, pressure, and density of the air. When there is enough water in a cloud that it is condensing into larger droplets, precipitation will occur in the form of rain, snow, sleet, etc., depending on the temperature. This is often seen around coastal mountains where warm, moist air from the ocean is forced to rise against one side of the mountain. The increase in elevation causes cooling, which can trigger condensation and precipitation on that side of the mountain. By the time the air mass passes over to the other side of the mountain, it has lost most of its moisture, creating a **rain shadow** or area with little precipitation.

Ocean Temperatures

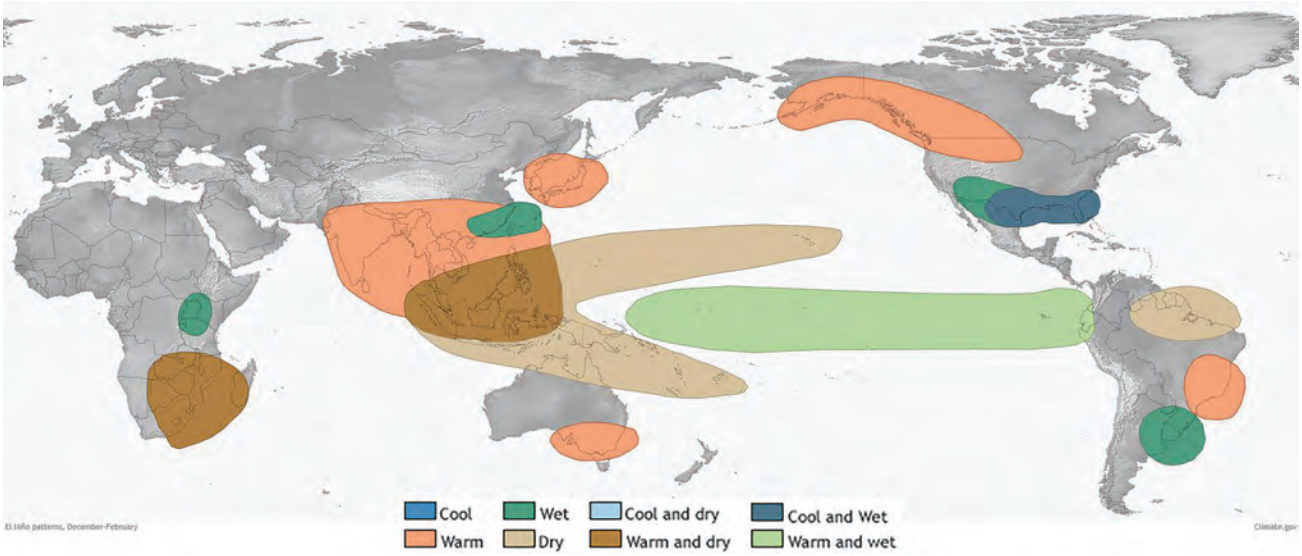
In the oceans, temperature is involved in the same type of convection process as it is in air, but with an added factor: salt. As cold water near the poles freezes into ice, the salt that had been in the seawater does not become part of the ice. Instead, this salt stays in the liquid seawater, making water at the poles saltier. A high salt concentration increases the density of this cold polar water, and it sinks. To fill this vacuum, warm water from the equator moves toward the poles at the ocean surface, while the cold, saltier water moves toward the equator at deeper levels of the ocean. As these different bodies of water reach their respective destinations, their temperatures change to match their surroundings and the process continues. This is called **thermohaline circulation** (from *therm*, which refers to temperature, and *hal*, which means salt). This process drives ocean temperatures and currents, which are critical for sea life and significantly influence climate and weather patterns on land. Thermohaline circulation depends on ice formation at the poles and the existence of a significant temperature difference between the equator and poles.

Ocean temperatures are also linked to El Niño and La Niña events. Due to ocean currents, in neutral years, there is usually a pool of warmer water in the Western Pacific (closer to Australia) and cooler



Impacts of La Niña (Image credit: NOAA)

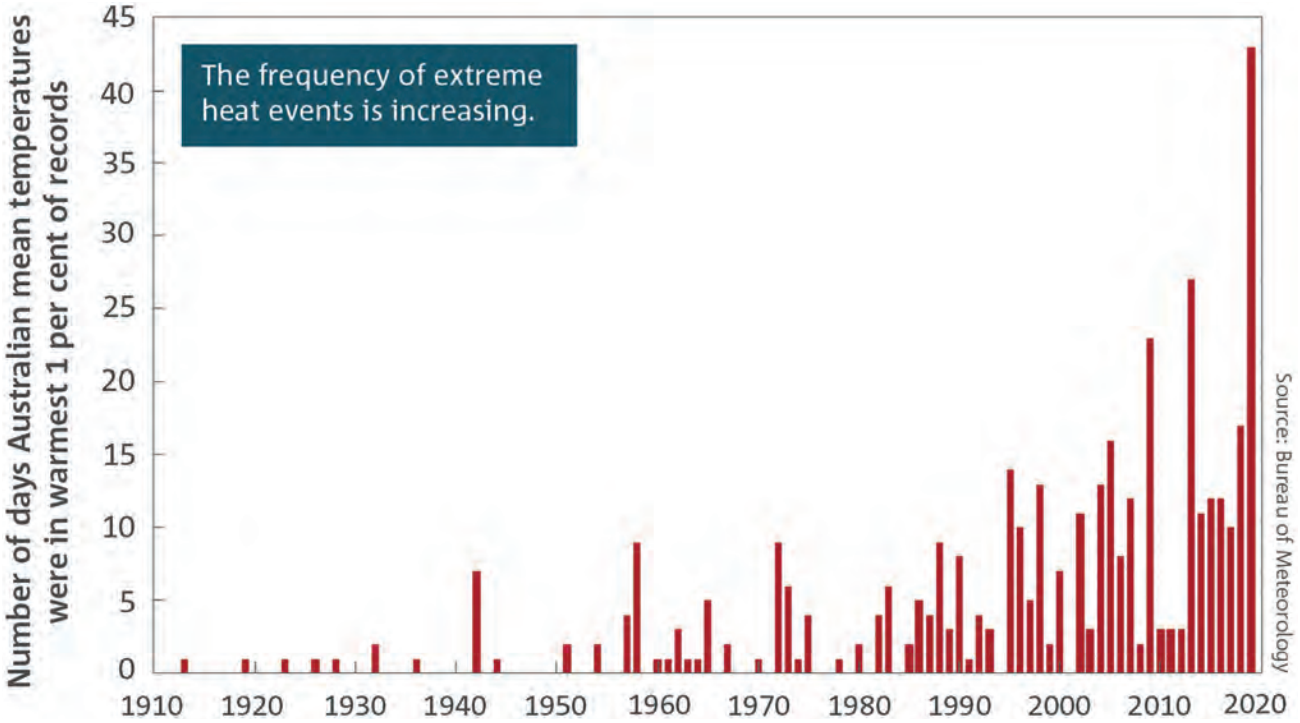
water in the Eastern Pacific (near Mexico and California). During an El Niño event, the Eastern Pacific becomes warmer than normal, and during a La Niña event, this section of ocean becomes cooler than normal. During these shifts, land near regions of warmer water tends to experience wetter weather than normal for its climate, while land near regions of cooler-than-normal water gets less precipitation than expected. These events also influence weather by impacting storm systems. La Niña years are more likely to have an increase in hurricane activity.



Impacts of El Niño (Image credit: NOAA)

Overall, heat and moisture are constantly moving around the globe, driven by processes like convection and the Coriolis effect. The climate (average temperatures and precipitation) of a given region is determined by the latitude (distance from the equator), ocean currents, winds and air masses, elevation, relief (whether there are mountains), and its nearness to water. We can remember these factors using the acronym **LOWERN** (Latitude, Ocean current, Winds and air masses, Elevation, Relief, Nearness to water).

Days of Extreme Heat per Year in Australia from 1910–2019



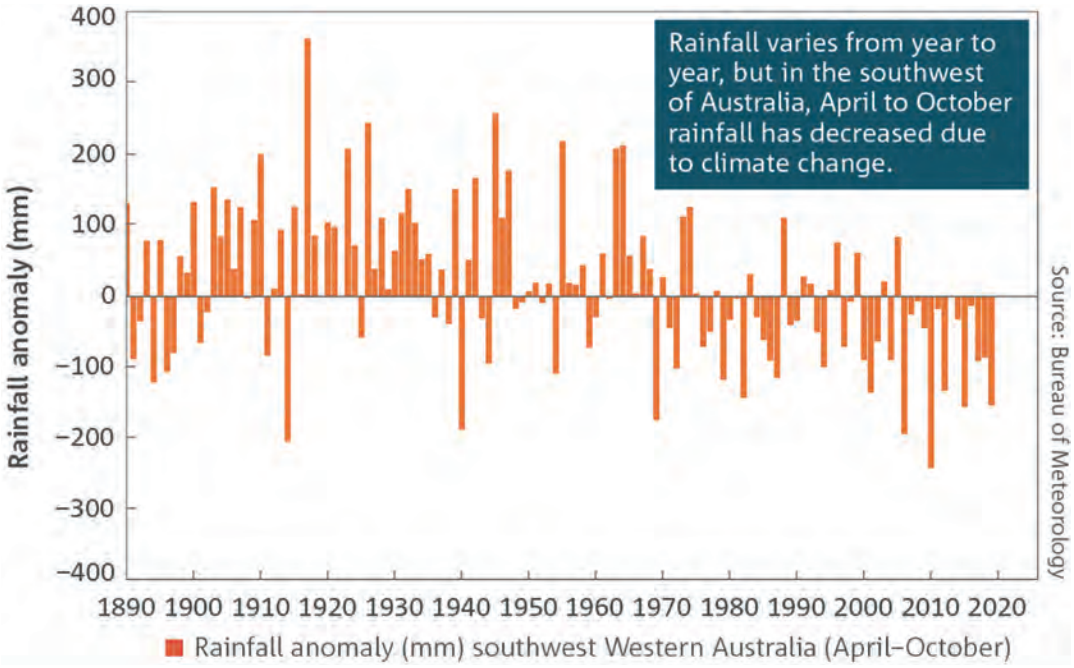
The graph above shows the number of days each year where the Australian area averaged extreme daily mean temperatures for each month. Extreme daily mean temperatures are the warmest 1 percent of days for each month calculated for the period from 1910 to 2019. (Image credit: bom.gov.au)

While these factors influence the overall climate of a region, it is important to remember that climate is an average over many years and the weather seen on a day-to-day basis can vary considerably. The climate of New South Wales in Australia is considered to be subtropical—a variant of a tropical climate where characteristics are similar but slightly different—due to its hot, wet summers (between 18–168 cm/7–66 inches of rain depending on location in the region) and cool winters (where temperatures can drop slightly below 18°C/64°F). However, daily weather will vary from the climatic averages, which can involve temperatures as cold as 2°C/36°F) or rainfall in one day that is higher than the normal yearly average.

Australian Droughts

So, what caused the intense droughts in Australia? There is no one causal factor. Like you saw in lesson 1, New South Wales has been experiencing the same climate trends toward warmer temperatures that have been recorded in Australia as a whole. Rainfall in New South Wales has become more variable, with more significant fluctuations between high and low rainfall years.

Rainfall Anomaly per Year in Australia from 1890–2019



Rainfall anomaly is based on the average rainfall between 1890–2019 (Image credit: bom.gov.au)

Another significant factor in the droughts may be ocean weather patterns. The years 2018 and 2019 were El Niño years, which resulted in cooler ocean water near Australia and lower precipitation. Similarly, a phenomenon called the Indian Ocean Dipole (which works like El Niño) began mid-2019, and it also leads to cooler ocean water near Australia and drier weather. There is evidence that rising global temperatures are making events like El Niño occur more frequently and for longer periods over the last century. Overall, the weather and climate in New South Wales is becoming less predicable. When increases in average temperature are combined with temperature-related events like El Niño, the result can be extreme events, like the Australian droughts of 2017–2019.

Role of Citizen Science in Climate Data

What are the impacts of these droughts? You already looked at the impact of drought on wildfires, but what is the impact on wildlife, such as the koalas? Even without increases in droughts and heat, koalas have been impacted by fires, habitat loss, and fragmentation, which can force them to travel on the ground or cross roads to find food, raising the risk of predation and car strikes. In New South Wales, the koala population is estimated to have dropped by two-thirds between 2000–2020 (Readfearn). Koalas are critical to their ecosystem because their grazing reduces extra biomass (that would otherwise provide additional fuel for fires), their droppings provide fertilizer, and the branches they break send food to the forest floor for other species. Koalas are also a key food source for native carnivores, and they play a major role in Indigenous culture. What can be done to help the koalas?

In response to the calls that Dr. Mella received about the koalas drinking from birdbaths, she began working with local landowners to set up drinking stations for koalas on their land. Footage from these

drinking posts shows koalas are visiting them, contradicting popular thinking about koalas' need for water. Similarly, researchers around Australia have been turning to local citizens to record koala sightings and behaviors. This data is easy for regular individuals (who are not scientists) to collect because it does not require special skills. Scientists then analyze this data to measure things like koala population size and shifts in habitat. While there is always the chance that untrained individuals will make mistakes in data collection, the pool of data is much larger due to how many people are collecting it. Thus, errors that occur will have a limited effect on the overall averages.

When scientists involve members of the general public in data collection, this process is called **citizen science**. Commonly, organizations like the Atlas of Living Australia (ala.org.au) create online platforms where scientists and researchers can post their projects for the public to view and participate in. People can then learn how to collect data and submit it through a website or app where it is compiled and analyzed by the scientists for publication. Involving members of the public in research not only broadens the pool of data, but it also makes research cheaper, speeds up data collection, and can reduce bias (since a solo scientist might be influenced by their background knowledge on the subject). Additionally, this process deepens the connection people have with their environment as they learn more about the natural world around them.

Hopefully, the combined efforts of scientists and citizens will help support the koala populations through whatever weather and climate shifts Australia experiences in the coming decades.

Read, Watch, Reflect

1. Read the article below in which Erin Roger, a scientist and chair of the Australian Citizen Science Association, discusses how citizen science has been used in the aftermath of the wildfires as well as some of the benefits of citizen science overall.

   "Citizen Science Gets Active and Organised"

   cosmosmagazine.com/citizenscience/citizen-science-gets-active-and-organised

2. Watch this video that describes how one citizen science project—Atlas of Living Australia—works.

   "What Is the ALA?"

   ala.org.au/about-ala

3. Based on what you have read and watched so far in this lesson, write a paragraph (five to eight sentences) reflecting on one or both of the following prompts.

   If you would like to address a different question you have that relates to the big ideas of this lesson, please let your teacher know. Additionally, if you would prefer to do this reflection as a video or audio file, that is also fine. Submit this reflection with your other work for this lesson.

   a. Describe your understanding of what citizen science is as well as your familiarity with it. Had you heard of citizen science or participated in projects before this course? Explain.

b. What do you see as some of the potential benefits and drawbacks of citizen science for scientists, participants, communities, etc.?

Questions

1. In this lesson, you learned about how weather is different from climate. Explain the difference using your own analogy (a comparison situation).
2. Explain what convection is and how it is related to climate.
3. The planet Mars has some CO_2 gas in its atmosphere, but the planet overall has almost no atmosphere and an average global temperature of –63°C. In contrast, Venus has an average temperature of 453°C and a thick atmosphere made mostly of CO_2. Use your knowledge of the greenhouse effect to explain how the atmospheres of these planets can be linked to the average temperatures they experience.

   Hint: You might think this is due to Venus being closer to the sun; however, Venus is much hotter than Mercury, which is the closest to the sun! What else might be going on?
4. Your friend states that the greenhouse effect is bad. How would you respond to this and explain how the situation is more complex?
5. Revise your visual model of Australian wildfires (from lesson 1) to include what you've learned about climate and weather in this lesson. If you did not already include the greenhouse effect, El Niño, climate, greenhouse gases, and weather, make sure to add these factors now. Include an image of your revised model.
6. What is your weather like this week? What is the climate where you live? (Remember, this includes things like average temperatures and precipitation, notable changes between seasons, etc.)
7. What local factors are impacted by your local weather and climate? For example, factors may include the time of year that trees lose their leaves, insect populations and hatching cycles, when flowers emerge, when plants die due to frost, geese migration in the spring, etc.

   Brainstorm a list of all the factors you can think of, and then highlight or mark two or more factors that you may want to explore further in your unit project.
8. The websites below are platforms for citizen science projects. Visit each website, and choose two specific citizen science projects to read about in depth.

   Zooniverse (zooniverse.org/projects)

   iNaturalist (inaturalist.org)

   eBird (ebird.org/home)

   BudBurst (budburst.org/the-program)

Afterward, answer the questions below.

a. Consider the topics, time commitment, and materials needed to participate in each of the two projects. Later in this lesson, you will be finding a citizen science project to participate in. What should you be looking for when considering whether or not a project is a good fit for you?

b. List the two projects you chose and describe the connections you see between these projects and climate change.

Citizen Science Project

In this lesson so far, you've seen a few examples of citizen science and hopefully gotten a sense of how critical this work is to climate scientists. Now you will begin work on a citizen science project that you will continue for the rest of this unit (lessons 2–6).

This work is important for several reasons. First, it is a great opportunity for you to get authentic experience with scientific data collection and a firsthand look at one key way we understand climate change: through citizen science! Participating in this kind of data collection process also helps you be more comfortable working with scientific data and interpreting its meaning in figures or articles. Of course, this project will also allow you to contribute in a meaningful way to ongoing efforts of the science community to better understand climate change. Hopefully, this work will also bring you closer to the ecosystem you live in.

You will first find an ongoing citizen science project (or design one of your own) that monitors the impact of climate change on a species or environmental factor in your area. Take time to make sure you are working on something that is both interesting and doable for you. Each week, you will collect and submit a set of data for this project and respond to some prompts that help you learn more about the topic you are working on. In the end, you will submit the documentation of your weekly data collection along with a visual model (like the one you did of the Australian wildfires) of the system that your project topic is part of. The outline of the project is below.

LESSON	TO DO	SHARE WITH YOUR TEACHER
2	Choose your project and do a trial run of your data collection.	• Brainstorming questions • Project planning questions • Documentation of data collection trial run
3	Do a round of data collection and research the factors that relate to your project topic.	• Documentation of your data collection • Research notes and sources
4	Do a round of data collection and use research from lesson 3 to draw a visual model of your project topic.	• Documentation of your data collection • Visual model

LESSON	TO DO	SHARE WITH YOUR TEACHER
5	Do a round of data collection and revise and analyze your visual model from lesson 4.	• Documentation of your data collection • Revised model • Model analysis questions
6	Do a round of data collection and reflect on the experience.	• Documentation of your data collection • Reflection response

This week, complete the following.

1. Look over your brainstormed list from question 7 (or do additional brainstorming now that you know more about this project). Then, respond to the following prompts.

   a. What are some things in your area that are impacted by climate change that you might want to focus on for this project?

   b. Based on these ideas, explore the citizen science project options below that seem relevant to your interests and area. As you look at options, consider which ones will be doable for you based on your time, location, transportation needs, technology requirements, and passions. Make a note of which ones you explored and indicate the one you will choose.

   Note: Some of the options you find may require a certain app, an account, or special equipment. You are not expected to spend money on this project, and many free options exist. Additionally, while you are encouraged to get involved in a project in your area, some projects allow you to contribute remotely, such as analyzing historic climate data. If you come across a project you are excited about, you are not required to limit yourself to a local project.

Option 1: Design your own project

1. Identify the issue you want to address. Consider the following question: How am I seeing climate change impact my area, community, or local ecosystems? You may need to do research to make sure that the issue is linked to climate change in some way and that the kinds of data collection that are required will be relevant and doable for you.
2. Are there other local organizations already collecting data on this issue? An online search or talking with local officials can help you determine this. If an organization is already working on this issue, can you join their efforts?
3. How will you collect data that will give you information about the issue? Include where and how often you will collect data, and describe your data collection practices. For example, if you want to monitor shoreline erosion from increasing storm surges, you might want to identify several areas where this occurs, choose a fixed reference point to measure against, and take weekly measurements from this point to the edge of the erosion.

4. Doing science comes with a responsibility to share your findings with the relevant community (not just your family). What will you do with the data you collect in this self-designed project? (Consider things like sharing it with your local officials, newspaper, college, etc.)
5. What resources will you need to accomplish your data collection and sharing? Consider transportation, equipment, time, etc. Do you need help or support from a teacher or family member?
6. Create a simple form (like the one below) to outline what you will accomplish each week while working on your project.

WEEK	TASKS
1 (this week)	
2	
3	
4	
5	

Option 2: Find a local citizen science project

Many small-scale citizen science projects happen on the local level. If you want to try to find something in your community or something related to a specific interest area of yours, try doing an online search using words like "citizen science" along with where you live and/or what you want to collect data on (such as lake trout or air pollution). Let your teacher know if you need help with this. If you are unable to find a local project, choose project option 1 or 3.

Option 3: Contribute virtually to an existing, large-scale project

Choose from the following projects. You may need to click around the project site if you are trying to get to the page to make an account.

TOPIC CHOICES	WEBSITE
Local Weather	Community Collaborative Rain, Hail, and Snow Network (cocorahs.org)
Plant Phenology	BudBurst (budburst.org/plants-climate-change)
Bird Distribution	eBird (ebird.org/home)
Mammal Distribution	eMammal (emammal.si.edu)
Local Species	iNaturalist (inaturalist.org/projects)

TOPIC CHOICES	WEBSITE
Water	EarthEcho Water Challenge (monitorwater.org) Note: This project runs March–December each year.
Ancient Atmosphere	Fossil Atmospheres (zooniverse.org/projects?discipline=climate)
Aquatic Invertebrates	Leaf Pack Network (leafpacknetwork.org/get-involved) Note: This organization sells a kit to do the data collection, but you can do it with any mesh or string bag and plastic cups.
Varied Topics These organizations provide links to citizen science projects on many topics. Not all of these projects are related to climate change; choose one that is directly relevant.	Zooniverse (zooniverse.org/projects?discipline=climate) EPA (epa.gov/citizen-science/examples-citizen-science-projects-supported-epa) SciStarter (scistarter.org/finder?phrase=climate+change) Smithsonian (smithsonianmag.com/science-nature/75-scientific-research-projects-you-can-contribute-online-180975050)

2. After you have chosen option 1, 2, or 3 above, describe the citizen science project you are going to work on by answering the questions below.

   Note: If you are having trouble finding or choosing a project, now is the time to reach out to an adult or your teacher for help.

   a. What will you collect data on? Be specific, such as pH of local streams, bird sightings, plant species, etc.

   b. How do you see this connecting to climate change?

   c. How will you collect data each week? How often? Where? How is data submitted? What equipment or resources will you need? How much time will you need? Gather as many details as you can so you and your teacher know what to expect.

   d. If you chose to contribute to an existing project, then include a link to the site for the project. If you are designing your own project, then please include the form you completed.

3. Do a trial run of the data collection process you described in part 2c, and then reflect on how it went for you. Does this seem doable and interesting as a multiweek project? How will you document your data collection for this process (for instance, photos, screenshots, data table, etc.)? Describe any issues you ran into, how you will address them in the future, and what supports you need from your teacher or another adult.

Further Study

All Further Study assignments are optional. Choose any that interest you.

TEK Reading

If you are interested in reading about examples of citizen science projects that are connected to TEK, here is a list of them for Australia.

> "Indigenous Ecological Knowledge"
>
> ala.org.au/indigenous-ecological-knowledge

You might also be able to use an online search to find out about research involving TEK where you live.

Modeling Convection Currents

If you want to play around with modeling convection currents, you can complete the activity below. (If you have taken the Oak Meadow Environmental Science course, there is an activity option called "Modeling Global Air Movement" that is similar to the activity below. If you completed that activity, you can still do the activity below but could consider the differences and similarities in how water moves in this activity compared with the air you observed last time.)

Materials

- large rectangular container, waterproof
- 3 heatproof cups or containers of the same size (they must be able to support the weight of the large rectangular container)
- water
- ice
- boiling water
- dropper
- food coloring, 2 colors

Directions

1. Fill the large rectangular container with room-temperature water.
2. Fill two of the cups with ice. Fill the third to the brim with boiling water.
3. Place the cups in a line so that the one with hot water is in the middle, then place the large container on

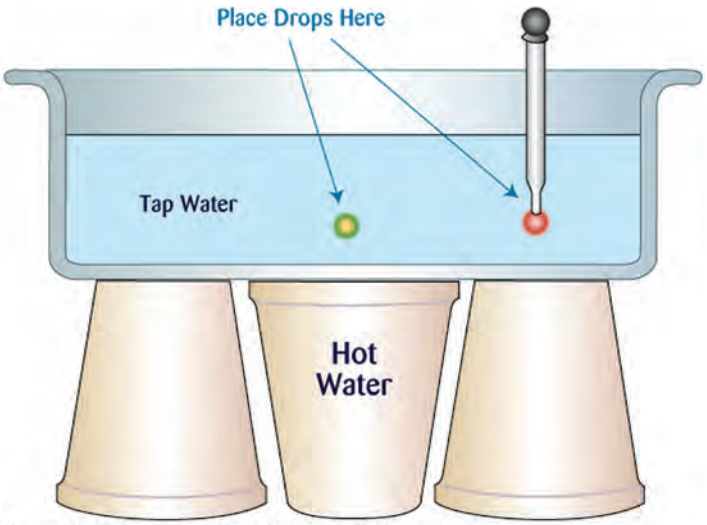


Figure 1. **Diagram showing the lab setup.**

(Image credit: sealevel.jpl.nasa.gov)

top. (You can use extra empty cups to help balance the water-filled container if necessary.) Take a picture of your setup.

4. Let everything sit for a minute or two until the water has stopped moving. Then, drop food coloring into the water in the two locations in the diagram.
5. Observe what happens to the movement of water in the tank as shown by the movement of food coloring pigments.

Analysis and Conclusions

1. Explain what makes this activity a model of convection and whether you observed this phenomenon happen. How do you know?
2. What are some limitations of this model in showing what happens in real life?
3. Would you expect to see something similar with air? Why or why not?

SHARE YOUR WORK

When you have completed this lesson, share the following work with your teacher:

- Your reflection from Read, Watch, Reflect
- Answers to lesson questions
- Your Citizen Science Project assignments

Make sure each assignment is clearly labeled. Please proofread your work and make any corrections before submitting it for review.

If you have any questions about the lesson assignments or how to share your work, let your teacher know.

Lesson

6

Climate and Agriculture: Klamath Basin Case Study

Learning Objectives

In this lesson, you will:

- Evaluate and compare solutions to real problems based on scientific knowledge, evidence, and considerations of priorities and trade-offs.
- Construct an argument based on natural resource allocation that takes into consideration multiple factors and the needs of multiple populations.
- Use analytical data and scientific knowledge to explain the carbon output associated with different types of food.

ASSIGNMENT CHECKLIST

- ☐ Read the Lesson Introduction and Essential Information.
- ☐ Complete the Read, Watch, Reflect section.
- ☐ Answer the lesson questions.
- ☐ Complete your Citizen Science Project.

Lesson Introduction

Take a minute to think about all the ways you use water on a daily basis personally as well as all the ways your community or town relies on water. Now, let's say that something happens that causes your normal water supply to decrease by half. Consider the impacts this would have on your community and your daily life.

In much of the dry western United States, this is not a hypothetical scenario. This region has experienced frequent droughts over the past 200 years, but since 2000, drought conditions have become more extreme. This lack of water creates tensions as people with different priorities compete for a dwindling resource. Communities have to make decisions like how much water should stay in the ecosystem for plants and animals, how much should be used to irrigate crops, and how much should be allocated for home use. Often, there is not enough water for any of these needs to be fully met, which makes decisions particularly challenging.

Reflect for a moment on how you would approach this situation if this was happening in your community. How do you think water-use decisions should be made? What needs would you prioritize?

Climate change is playing a role in exacerbating issues like droughts. Not only does this increase the urgency and frequency of tough decisions, but climate change also creates a set of new conditions in

which the current way of doing things may not work. This lesson examines one specific example relating to water access in the Pacific Northwest of the United States. However, similar conversations are happening around the world as extreme weather becomes more common and access to resources changes. As you work through this lesson, think about how climate-related conflicts might occur in your community and how they could best be approached or resolved.

Essential Information

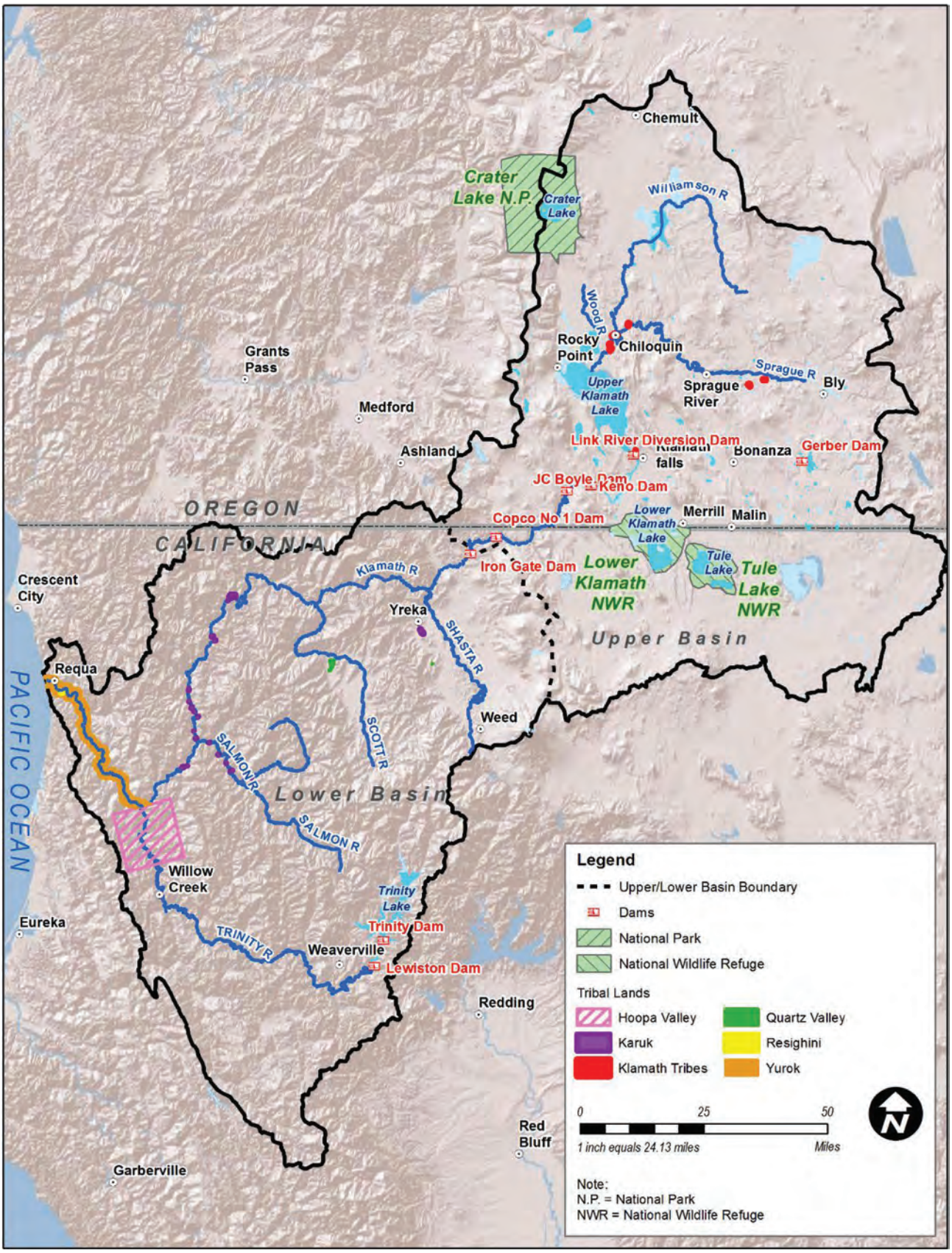
> *"You do a paper on TEK and we talk about specific practices, you write them down on a piece of paper and then the Forest Service thinks that they can take that. 'Okay, we paid for this under a contract for you guys to develop this, so now we are going to take this and apply it.' Just the notion that they can apply those things, within their structure—within the boxes that they have—as if they just knew what they were. 'Tell us what they are, and if you describe them well enough then we can apply those things.' But they can't just apply those concepts, because what they require is cultural practices of a land-based people. They must be used by people who are on the land, not people who are separate from the land as part of a government agency. Government agencies still don't see themselves as part of the land. They don't see themselves that way, and they shouldn't see themselves that way because they are not!"*
>
> **Leaf Hillman, Director of Natural Resources and Environmental Policy for the Karuk (ka-RUKE) Tribe**

Klamath Basin Indigenous and Ecological Communities

For us to examine how climate change is leading to challenging decisions about water management, we need to know more about the natural history of the example area we will be studying.

The Klamath (KLA-muth) Basin is a **watershed** in California and Oregon in the western United States that includes many lakes, streams, and rivers that run from the mountains in the east toward the Pacific Ocean in the west. This area has always been the home of many Indigenous peoples (including the Klamath, Yurok, Hoopa, Shasta, and Karuk), but each of these groups had much of their traditional land taken from them by the U.S. government, a practice that continued into the 1950s.

The Klamath Basin includes the Klamath River, which flows 257 miles to reach its outlet in the ocean. This river is home to several species of fish (including the c'waam, koptu, and coho and Chinook salmon) that are not only important parts of the river ecosystem, but are also critical to different Indigenous groups culturally, economically, and as a food source. These fish species and critical pieces of their habitat have been managed using TEK for thousands of years by Indigenous people in the Klamath Basin. Each fish species is adapted to the conditions of the section of the river that they inhabit and plays an important role in that ecosystem. For example, the threatened coho salmon hatch



Klamath Basin watershed (Image credit: U.S. Department of the Interior, Bureau of Reclamation)

Coho salmon in the Salmon River, Oregon (Image credit: Bureau of Land Management)

in the spring in streams that flow into the Klamath River. For this first part of their life cycle, the salmon (called Alevin or fry) need slow-moving or still pools and side streams, which prevent them from being washed out by flooding into the ocean before they are developed enough. During this period, coho salmon also rely on logs and similar features in the water as protection from predators. In the next stage of development, coho salmon swim downstream to the ocean, where they live for around 18 months. Coho salmon **spawn** or reproduce in the fall. This is when adult salmon swim from the ocean upstream into the Klamath River. Coho salmon are adapted to laying their eggs in the gravelly side stream they were born in. After mating and laying eggs, male and female salmon die. Throughout this life cycle, salmon (as eggs, fry, juveniles, and adults) are important sources of food for other species. After the salmon die, their bodies provide nutrients used by aquatic plants.

Agriculture in the Klamath Basin

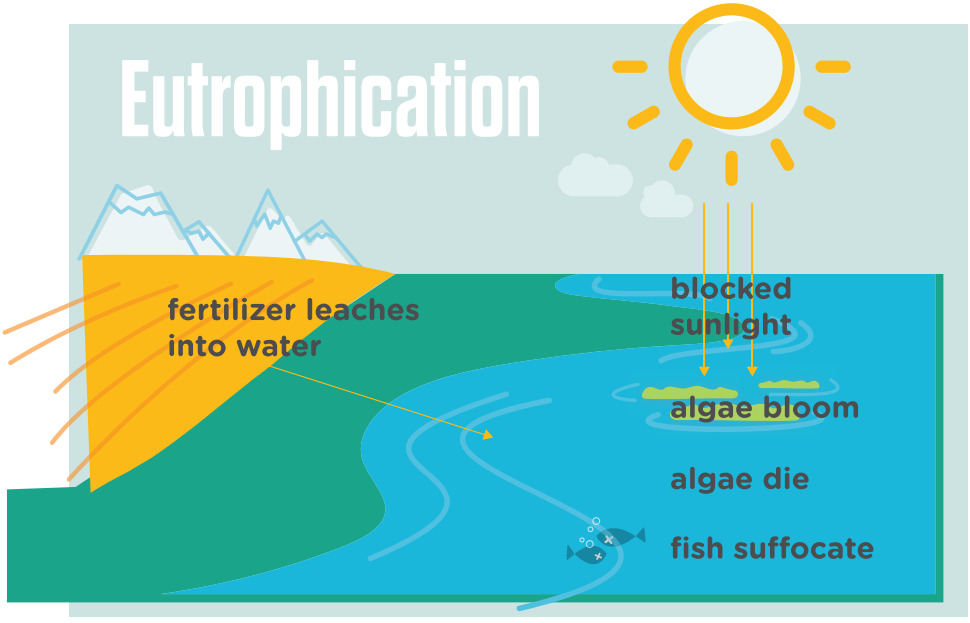
While the Klamath Basin has long been home to Indigenous people and native species, in the mid-1800s non-Indigenous people also came to this area. As towns and cities were built in the Klamath Basin, dams were constructed to form reservoirs for drinking water and later to provide electricity through **hydropower**. The upper basin area (at the source of the river) used to comprise large marshes that were a habitat for many species of birds and fish. Much of this area was taken from Indigenous people, and lakes and marshes were drained to make farmland in the late 1800s and early 1900s. Some of this land was also given to veterans of World War I and II as farms and homesteads. Cattle ranches and farms use water from the river to grow crops like alfalfa, wheat, hay, mint, potatoes, onions, garlic, and more. As of 2019, agriculture represented 10–12 percent of the Klamath Basin GDP (gross domestic product, or the market value of the goods and services produced) and provided roughly one-third of the jobs. Farming is an important cultural touchstone of many Klamath Basin communities, with family farms being passed from one generation to the next.

Impacts of Land Use and Climate Change on the Klamath Basin

As the way land was used changed, these changes caused ripple effects throughout the ecosystem. Without **wetlands** like marshes to absorb flood waters, more dams were built to control flooding while other dams and canals were constructed to **irrigate** farmland. Dams prevent the migration of fish such as salmon. They also change the movement of sediments and logs in the river, which can decrease the available habitat for coho salmon to lay eggs and develop in safety. The diversion of upstream water for drinking water and irrigation lowers water levels downstream, which can change water speeds and temperatures. Additionally, fertilizers from farming and cattle waste from ranching

Gross Reservoir in Colorado (Image credit: Denverwater.org)

near **tributary** streams that flow into the Klamath River introduce high levels of nutrients like nitrogen and phosphorus into the water. The increase in these nutrients leads to a rise in the growth of algae that feed on these nutrients. As the rapid algae blooms die off, bacteria that decompose the algae also use up the oxygen in the water and release carbon dioxide instead. This process, called **eutrophication**, leads to areas where there is not enough oxygen in the water for fish to survive.



The eutrophication process (Image credit: Utah Department of Environmental Quality)

Together, these factors significantly decrease the areas where fish can live in the Klamath River. As fish rely on smaller sections of habitat, diseases like botulism and gill rot spread more easily between fish as well as between the species that cluster to feed on them. These issues are exacerbated by droughts that further decrease the amount of water in the Klamath River. With climate change, droughts have occurred more often in the Klamath Basin. In 2021, the area received only 21 percent of its normal snowpack and 67 percent of the normal precipitation. There has also been an increase in wildfires in recent years. Wildfires and logging remove forests that play a role in keeping moisture in the soil and air, and this loss further dries out the area.

In years with low flows of water in the river, there have been significant mass die-offs of fish, such as the death of at least 34,000 Chinook salmon in the fall of 2002 that died in the river before reaching their spawning sites or reproducing (Belchik). Indigenous communities like the Yurok (yuh-ROCK) people report the impact these mass fish die-offs have on them. In communities with low average incomes, fishing is an important source of income as well as food. The cultural importance of the fish and the Yurok people's use of TEK in managing the fish population also means that mass die-offs have a personal toll. The Yurok along with other Indigenous groups have refrained from fishing certain species for years because of the extremely low population numbers.

Water Rights Conflicts

Farmers in the Klamath Basin are also impacted by climate change. Hotter temperatures mean that more water is needed for irrigation. Accessing this water is a challenge. An 1864 treaty between the U.S. government and the Klamath Basin Tribes took most Indigenous land but granted the Tribes rights to water and fishing that they need to sustain themselves. This treaty has been upheld several times as the oldest **water rights** for the Klamath River. In water rights law, having older rights to a water source means that you get the first pick of the amount of water you need allotted to you. The Klamath Basin Tribes use their water rights to attempt to maintain enough river flow to sustain fish populations. However, in recent years, there has not been enough water in the river to maintain healthy levels even before any water is diverted for agriculture. In 2021, Klamath Basin farmers reported that they needed 400,000 acre feet of water (this refers to an amount of water that would cover 400,000 acres in 1 foot of water) but only received 30,000 acre feet (Marshall-Chalmers). With this amount of water, there is a significant drop in the amount of farming and ranching that can occur in the area. As a result, less food is produced, and farm families struggle to make a living and hold on to their homes.

Climate Change Impacts on Agriculture

The experience of Klamath Basin farmers is shared by other farmers around the world as an impact of climate change. Warmer temperatures can lead to unsafe working conditions in fields. This can limit overall production. Plants and livestock are also adapted to a specific range of conditions in the areas where they are traditionally farmed. As average precipitation levels change (higher or lower), temperatures increase, CO_2 rises, and extreme weather events become more common, the new combination of

conditions may no longer be optimal for current plant and animal species in the region. For example, corn thrives in warmer weather and can survive short bursts of extreme heat, but it is also particularly water intensive and can only survive about two days of flooding. This means corn could thrive as croplands warm but will not do well if that area also experiences droughts or heavy flooding.

When conditions change outside the optimal range, farmers have to deal with problems like a drop in production, needing new farming techniques or tools, or having to switch crops. Additionally, warming often allows weeds and pests to thrive, and heat-stressed livestock are more susceptible to diseases. Decreases in food production, availability, or quality have huge implications for human health and survival. These agricultural challenges also have a financial toll. In the period from 1991–2017, there was an estimated $27 billion payout to farmers from insurance companies to cover losses from high temperatures alone. Increased costs are especially tough for small farms and family farms. The number of these farms continues to decrease as more farming is conducted by larger, industrial farms that currently account for around half of U.S. production ("Farming and Farm Income").

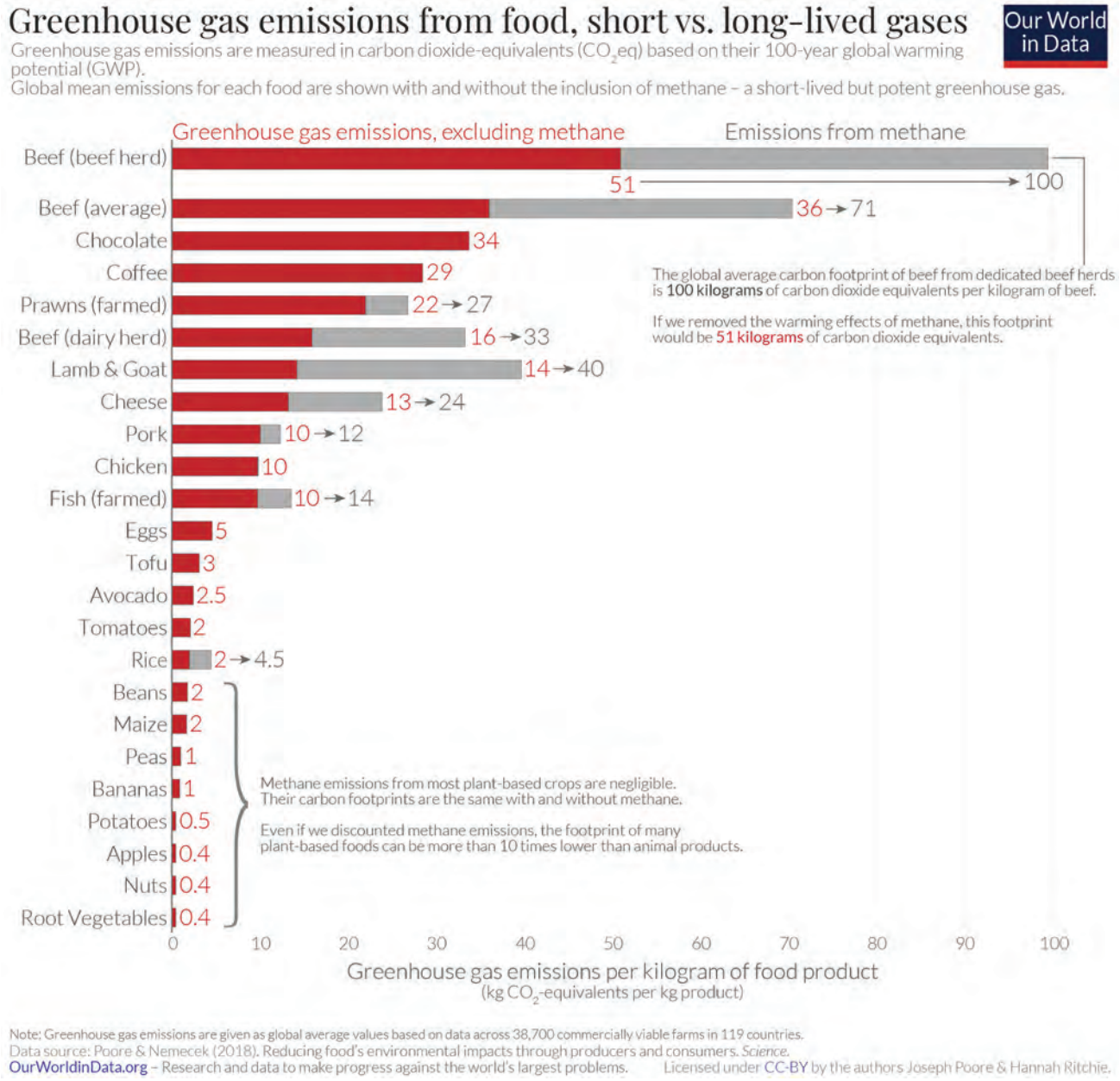
There has been interesting research about the impact that increasing atmospheric CO_2 has on plants. As CO_2 levels increase, some plants, such as soybeans, show increased photosynthesis rates and growth. Not only would this increase production yields, but it could also help remove CO_2 from the atmosphere. However, further research showed that these benefits are seen in plants called C3 plants. These plants (including soybeans, wheat, and rice) perform photosynthesis in a way that increases with CO_2 levels. Plants like corn, millet, and sugarcane are C4 plants that use a photosynthesis process that is not increased with CO_2 levels. Additionally, recent research indicates that increasing CO_2 levels decreases the nutrient concentration in C3 plants, leading to food products that contain lower levels of proteins and essential minerals ("Climate Impacts").

Many common practices in large-scale agriculture make this industry particularly susceptible to the impacts of climate change. **Monoculture** is a practice where a single species and variety of crop is grown in an area. Since this is a single species with a specific growing season, the fields will be bare during the off season (and exposed soil releases more CO_2). Monoculture farming involves more frequent plowing and more synthetic fertilizer use. Together, these practices degrade soils because the soils end up with less organic matter and root systems to hold them together. This can exacerbate drought since poor soil retains less water and worsen the impacts of floods since erosion is more likely.

Focusing on a few crops also makes farmers more vulnerable if climate change results in conditions that no longer support these crops. Additionally, when only one variety of a certain crop is grown, that species will have lower overall genetic diversity. Commercial chicken breeds, for example, have been found to have only half as much genetic diversity as wild chicken species. Less genetic variation means fewer options for possibly beneficial mutations that would help the species adapt to climate change.

These species may struggle to evolve in response to climate change and therefore would need more resources to prevent them from going extinct.

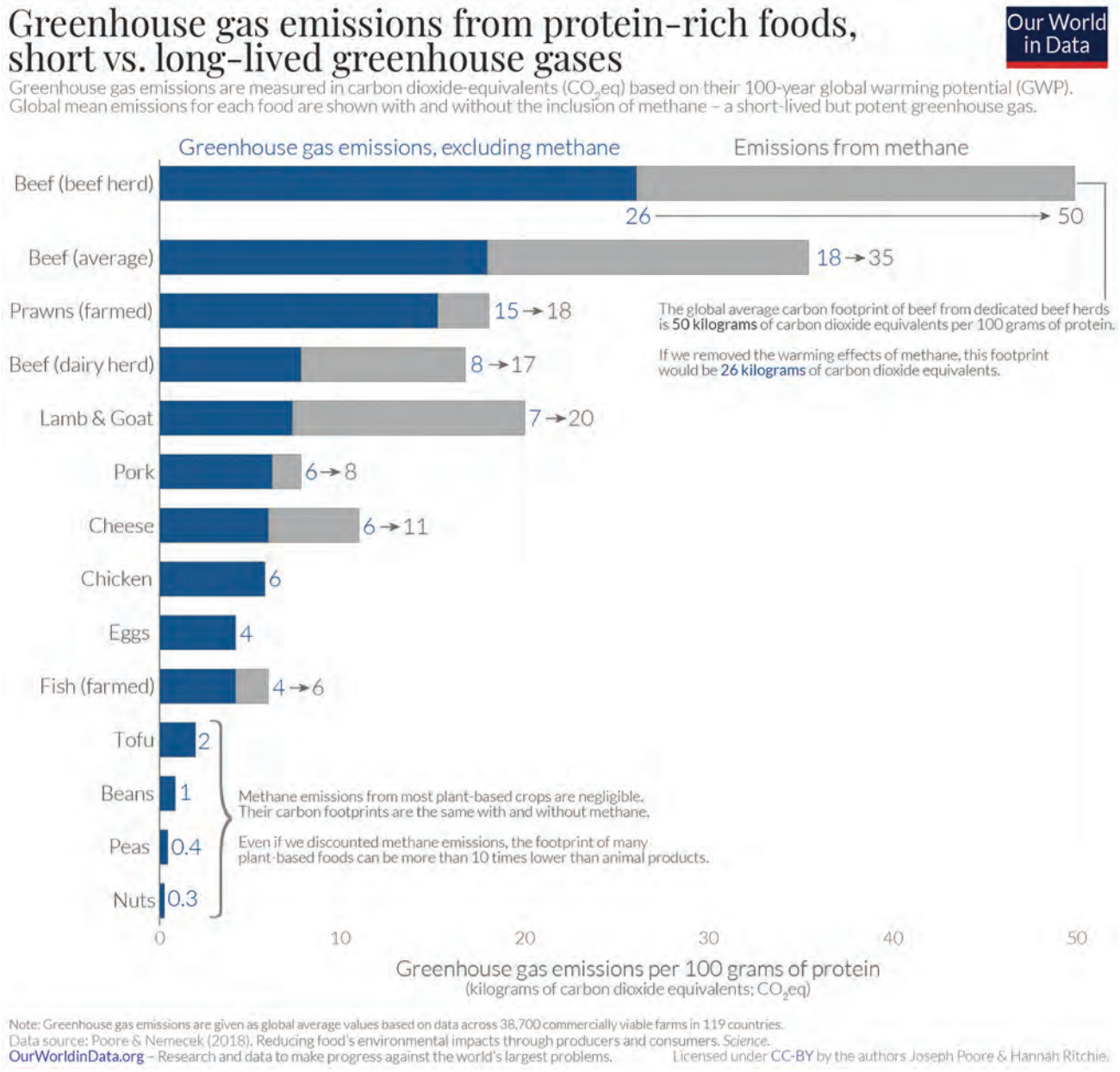
We have touched on many ways that agriculture is impacted by climate change, but this is an industry that also contributes to climate change. The EPA estimated in 2019 that agriculture was responsible for around 10 percent of U.S. greenhouse gas emissions. These greenhouse gases are primarily methane and nitrous oxide (as well as a much lesser amount of carbon dioxide). This is concerning because methane and nitrous oxide are much stronger greenhouse gases than carbon dioxide. Methane is emitted from the biological wastes of ruminant species such as cows. Methane is also emitted by



(Image credit: Joseph Poore and Hannah Ritchie. Image source: ourworldindata.org)

bacteria living in flooded rice paddies. Nitrous oxides are released from synthetic fertilizers as well as in the treatment of manure. Carbon dioxide is released from bare soil as well as from a process called liming. This process adds a compound into the soil to improve soil pH. When the soil gets wet, the compound releases CO_2.

Some crops and livestock species have a larger impact on climate change than others. This can be tricky to practically quantify for three reasons. First, different farming practices release greenhouse gases that have stronger or weaker warming effects. Second, these gases spend different amounts of time in the atmosphere. While methane has over 20 times more warming effect than CO_2, it breaks



(Image credit: Joseph Poore and Hannah Ritchie. Image source: ourworldindata.org)

down after several years in the atmosphere. CO_2 has a weaker warming effect but can last for hundreds of years. Nitrous oxide produces almost 300 times the warming of CO_2 and lasts for just over 100 years in the atmosphere, making it a particularly concerning greenhouse gas. Third, comparing the impact of different foods is challenging because of their relative nutritional value. This comes into play when you have a food with lower greenhouse gas emissions per unit, but you would need to eat much more of it to fill your dietary needs. To address these challenges, the first graph shows greenhouse gas emissions with and without methane (since it has a much shorter lifespan and contributes to warming on a smaller timescale) and the second graph shows greenhouse gas emissions per 100 grams of protein.

You are encouraged to carefully study both graphs. You will be asked to analyze them in one of the assignments for this lesson.

Innovations in Agriculture

While agricultural practices contribute to climate change, this also means that making more farms sustainable and low-carbon can play a significant role in slowing climate change. These changes can support farm families while helping to make our food systems more resilient. For example, planting **cover crops** in fields when they are usually empty can reduce CO_2 emissions and increase organic material in soils, which reduces the need for synthetic fertilizers.

Integrating multiple species on farms, including a mix of plants and animals as well as native plant species, can also help reduce the need for synthetic fertilizers. Varied species make it easier for farmers to adjust to changes in climate because they are no longer dependent on a single crop. Additionally, new crop and livestock breeds, such as drought-resistant corn, can be developed that are more resilient to climate change. This process can occur through artificial selection or genetic engineering. The latter approach raises important questions about the ethical implications and environmental impacts of new breeds as well as the discrepancy between who has the most say in this decision and who is likely to be most impacted by low crop yields.

This is just a small sampling of ways to make agriculture more sustainable. Practices like crop rotations, reduced tilling, integrated pest management, and agroforestry all play a role in reducing greenhouse gas emissions and the overall environmental impacts of agriculture. Many of these practices fall under the umbrella of **regenerative agriculture**, the goal of which is to improve soil quality and sequester carbon while also maintaining food production. Ongoing research is being done to determine the most effective forms of each of these practices as well as develop new techniques. If this is a topic that interests you, check out some of the Further Study options for this lesson (which you can always come back to later in a different lesson).

In Conclusion

It is challenging to quantify or even summarize the value of a river in a simple way. Having ample clean water in the Klamath River is critical for the survival and health of the millions of plants and animals that live around it. It is important for maintaining healthy ecosystems, which reduces the impact of

extreme events like floods or droughts. The river is the foundation of human cultures and traditions, jobs, and recreation (like fishing, swimming, and boating), and it provides food and water for drinking and cleaning. A disappearing river has a profound impact on the quality of life.

Managing a resource like the Klamath River was challenging even before the added stresses climate change put on the system. As droughts and flooding become more common due to changes in climate, existing challenges or weaknesses in management approaches can escalate into emergencies. At present, the Klamath River can no longer be managed solely through TEK practices or through current agriculture and land management practices. Navigating this challenge has involved positive legal and collaborative approaches, but has also involved instances of violence and racism, and many people have shared feelings of being cheated, unappreciated, and undervalued.

Overall, the Klamath Basin is considered a case study of what will happen (or is already happening) elsewhere. The problems we see with managing water in a changing climate are also seen in managing other resources, such as lumber, wildlife, and soil. Agriculture is not the only industry where existing practices are increasingly infeasible due to climate change. Tourism, energy, fishing, insurance, and transportation are some of the many industries that are also heavily impacted.

Finding new approaches to resource management and new industrial practices that are sustainable and resilient to climate change is a critical task that humanity faces. Dealing with these challenges will require innovation, collaboration, and creative problem-solving, along with a willingness to seek out new ways of seeing and understanding the human role in the world. Keep thinking about this theme as we move into the next units, where we look closer at the different impacts of climate change and what we can do about it.

Read, Watch, Reflect

1. Watch the video below on the continuing water issues in the Klamath Basin. Think about how this situation highlights the intersection between elements like Indigenous rights, politics, culture, agriculture, and ecology.

   "American West(s): How the Yurok Tribe Is Reclaiming the Klamath River"

   youtube.com/watch?v=D2mBw-oLw0I

2. The Farming First website below includes an interactive map that shows different case studies from around the world where farmers are using sustainable farming techniques to do things like decrease their carbon emissions, use fewer resources, or manage problems from climate change. Look through a range of the examples and choose one. Then, read the full article about that case study.

   "Case Studies"

   farmingfirst.org/case-studies

3. Based on what you have read and watched so far in this lesson, write a paragraph (five to eight sentences) reflecting on one or both of the following prompts.

   Talk to your teacher if you would like to explore a different question. Feel free to share your reflection as a video or audio file.

   a. The example of water use and climate change in the Klamath Basin has no easy answers since any water allocation plan will cause suffering somewhere. A theme of this unit is reexamining current approaches and ways of seeing the world to better understand and deal with climate change. How do you think this idea could be applied to find long-term solutions to Klamath Basin water issues that benefit everyone? What are your thoughts or personal takeaways about this theme?

   b. The case study of what is happening in the Klamath Basin is also notable because of questions it has brought up with TEK and Western Science. While both approaches have been used effectively separately and together to manage resources in the Klamath Basin, in the 1990s problems arose after confidential TEK practices shared by the Tribes with U.S. government scientists were made public. The quote by Leaf Hillman at the beginning of the Essential Information section also discusses the limitations of using TEK in the context of Western Science. What do you see as the best way to incorporate information from these different approaches in understanding the natural world?

Questions

1. Respond to one of the following prompts.

   a. A major decision point in the Klamath Basin is how much water should be diverted from the river for agriculture. This decision impacts many groups, including the ones listed below. For each listed entity, describe the positive and negative impacts of diverting more or less water for agriculture. Consider impacts on health, culture, economics, quality of life, and any other related aspects or systems.

      - Klamath Basin ecosystems
      - Klamath Basin farmers
      - Klamath Basin Tribes

   b. Many court cases have happened regarding the allocation of water in the Klamath Basin. Imagine you are a lawyer who will be working on a case between the Klamath Basin Tribes, the Klamath Basin farmers, and the U.S. government (who owns and manages the public refuges and wilderness areas in the basin). The case is about how much water should be diverted from the river for agriculture. Since lawyers generally do not get to choose who they represent, you will prepare a one-paragraph (or more) statement for each of these three entities to argue for their interests. These three statements can be submitted as written paragraphs or as a video or

audio recording. You may include outside research and current data to support your positions; if so, make sure your sources are cited.

2. Agriculture is an interesting topic to explore in relation to climate change because it is an industry that not only is heavily impacted by but also contributes to climate change. Write a paragraph (or create a diagram or other labeled visual) explaining why this is. (If there is a different industry like textiles/fashion, electronics production, transportation, etc., that you are interested in, you can research and report on how that industry both contributes to and is impacted by climate change.)
3. Examine the graph "Greenhouse Gas Emissions from Protein-Rich Foods" in the Essential Information section. Choose two foods with different levels of greenhouse gas emissions, and use information from the reading to discuss why the emissions are different. If needed, you can also include cited outside research.

Citizen Science Project

This week, you will complete your Citizen Science Project, write a reflection, and submit a final version of all your work on this project.

1. Collect, record, and submit data for the project you are working on.
2. Write a reflection about your experience with this project that includes the information below. Please write your reflection as one cohesive paragraph.
    - Evaluate the potential impacts of this citizen science project (it may be helpful to refer to your model), and explain any weaknesses or possible improvements that could be made.
    - How has this project impacted your thinking or your connection to where you live or the natural world more broadly?
    - Bonus question (optional): Do you see ways that your work on this project ties into the idea of incorporating multiple perspectives and ways of knowing as we try to understand natural systems and climate change? (Think about things like interdisciplinary thinking or the different approaches of Western Science and TEK.) If not, how could these elements have been incorporated and what impact would that have had?
3. Submit your reflection and your final visual model in this lesson as the final product of this project.

Further Study

Feel free to use one of the following optional activities to further explore the lesson topics.

Klamath Basin Water Crisis

If you are interested in learning more about what is happening in the Klamath Basin, read the article below or use online research to find out more about current events.

> "'There Are No Winners Here': Drought in the Klamath Basin Inflames a Decades-Old War Over Water and Fish"
>
> insideclimatenews.org/news/16072021/drought-klamath-basin-oregon-california-agriculture-tribes-fish

TEK/Western Science Infographic

Read the article below, written by a group of researchers and Karuk members, on how the Karuk are being impacted by climate change. Afterward, create an infographic on the combined role of TEK and Western Science in addressing this issue.

> "Introduction: Karuk Traditional Ecological Knowledge, Climate Change and Knowledge Sovereignty"
>
> karuktribeclimatechangeprojects.com/introduction-karuk-traditional-ecological-knowledge-climate-change-and-knowledge-sovereignty

Fisheries Presentation

In this lesson, we focused on land-based food production in relation to climate change. However, global fisheries are another food industry being heavily impacted by climate change. Choose either a specific species that interests you (salmon, lobster, etc.) or a specific fishing town or region to focus on. You may want to choose a location that matters to you or a species that you or your family eat or fish. You will research the impact that climate change is having on the topic of your choice as well as what is being done to increase resiliency to climate change. Put together your findings in a presentation that combines text, visuals, video, or any other media.

Interview a Local Farmer

Locate a farmer in your area through an online search or community resources like a local farmers market and call or email them to see if they would be willing to speak with you. Do research in advance about crops grown near where you live, the kind of farming your interviewee does, etc. Then, prepare interview questions; base the number of questions on the amount of time the farmer has available to speak with you. Make sure at least one question relates directly to climate change. Conduct your interview and take notes. Use these notes to write a report on what you learned about farming and climate change. (If you are not able to find a farmer near where you live, you can always find a farm online that

is using practices you want to learn more about. If you email them your interview questions, they may write back.)

Sustainable Farm Design

Do some research to learn more about sustainable farming practices. Then draw a map of a sustainable farm with labels that identify the components of your design. In the drawing or on a separate sheet of paper, write out why you chose these components, and explain how they will help your farm be resilient to climate change while also reducing greenhouse gas emissions. If you want to take this activity even further, choose one or more of the features you included, and analyze how doable this approach is compared to less sustainable practices. For example, if you chose to use cover crops, you would want to research if additional costs, resources, machinery, time, etc., are needed and how significant these are.

Legal Action

Interested in law? This activity explores the legal proceedings in a Klamath Basin water court case. First, you will read some background information, then you will review the actual court decision, and write an analysis of the way the case was decided and the ethics of this issue.

Background

Due to water rights issues in the Klamath Basin in the 1990s, the U.S. Department of the Interior gathered information about water use and species management from local Indigenous groups as well as the upstream farmers. Indigenous communities shared significant Traditional Ecological Knowledge (TEK), including confidential information about traditional fishing practices.

This fact was mentioned in the Department of the Interior reports (though the specifics of the TEK that had been shared was not divulged). In response, a non-Indigenous organization in the Klamath Basin called the Klamath Water Users Protective Association (KWUPA) filed a Freedom of Information Act (FOIA) request to learn the details of all the information the Tribes had provided. The KWUPA is a group of upstream farmers and ranchers who also depend on the waterways to provide water for irrigating their farms. In this particular case, it was likely that the farmers and the Indigenous communities would have opposing needs, so the KWUPA wanted to know all the information that the Department of the Interior had gathered.

The Department of the Interior refused to release the TEK on the grounds that it was confidential, so the KWUPA took them to court. The case eventually made its way to the Supreme Court, who ruled that the Department of the Interior could not withhold information it had gathered. This decision was upheld on appeal, and as a result, TEK was made public that would likely not have been shared if communities had known it would not be kept confidential.

This case raised the following issues:

- How should situations like the Klamath Basin case be handled?

- What will happen if communities cease to share important TEK?
- What is the cultural toll of sharing TEK confidentially and then having this information released?
- Is there a point when information must be made publicly available?
- Who gets to make these decisions?

Reading

Read the excerpt paragraphs below of the appeals court decision on the Klamath Basin case. (Omissions and additions are noted by brackets.) The structure and vocabulary are challenging, so you may want to read one sentence at a time, look up words you don't know, and make notes of what you think each section is saying.

The full text is here if you are interested: law.cornell.edu/supct/html/99-1871.ZO.html

> "DEPARTMENT OF THE INTERIOR AND BUREAU OF INDIAN AFFAIRS, PETITIONERS v. KLAMATH WATER USERS PROTECTIVE ASSOCIATION ON WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE NINTH CIRCUIT
>
> [March 5, 2001]
>
> Justice Souter delivered the opinion of the Court.
>
> Documents in issue here, passing between Indian Tribes and the Department of the Interior, addressed tribal interests subject to state and federal proceedings to determine water allocations. The question is whether the documents are exempt from the disclosure requirements of the Freedom of Information Act, as "intra-agency memorandums or letters" that would normally be privileged in civil discovery. We hold they are not.
>
> . . . The dispositive point is that the apparent object of the Tribe's communications is a decision by an agency of the Government to support a claim by the Tribe that is necessarily adverse to the interests of competitors. Since there is not enough water to satisfy everyone, the Government's position on behalf of the Tribe is potentially adverse to other users, and it might ask for more or less on behalf of the Tribe depending on how it evaluated the tribal claim compared with the claims of its rivals. The ultimately adversarial character of tribal submissions to the Bureau therefore seems the only fair inference, as confirmed by the Department's acknowledgement that its "obligation to represent the Klamath Tribe necessarily coexists with the duty to protect other federal interests, including in particular its interests with respect to the Klamath Project." The position of the Tribe as beneficiary is thus a far cry from the position of the paid consultant [whose statements are exempt from the Freedom of Information Act].
>
> Quite apart from its attempt to draw a direct analogy between tribes and conventional consultants, the Department argues that compelled release of the documents would itself impair the Department's performance of a specific fiduciary obligation to protect the confidentiality of communications with tribes. Because, the Department argues, traditional fiduciary standards forbid a trustee to disclose information acquired as a trustee when it should know that

> disclosure would be against the beneficiary's interests, excluding the Tribes' submissions to the Department from Exemption 5 would handicap the Department in doing what the law requires . . . And in much the same vein, the Department presses the argument that "FOIA is intended to cast light on existing government practices; it should not be interpreted and applied so as to compel federal agencies to perform their assigned substantive functions in other than the normal manner."
>
> All of this boils down to requesting that we read an "Indian trust" exemption into the statute, a reading that is out of the question for reasons already explored. There is simply no support for the exemption in the statutory text, which we have elsewhere insisted be read strictly in order to serve FOIA's mandate of broad disclosure, which was obviously expected and intended to affect Government operations. In FOIA, after all, a new conception of Government conduct was enacted into law, "'a general philosophy of full agency disclosure.'". . .
>
> The judgment of the Court of Appeals is affirmed.
>
> It is so ordered."

Written Analysis

Write an analysis of this course case (or present it in an oral or video format). Include the following information:

1. What arguments does the court use to support their ruling?
2. Do you agree or disagree with the outcome of this case? Why?
3. This Klamath Basin case hinges on whether TEK deserves a special status as something that should be kept confidential where other types of information would not be. What problems might arise if TEK could always be kept confidential?
4. The Klamath Basin case occurred decades ago. Read over some of the rules from NOAA (a different government agency) for gathering and using TEK below.
    - Establish at the outset of the project, in conjunction with Indigenous peoples, the acceptable use and means to interpret or share information.
    - Understand and clearly disclose any constraints or limitations regarding the ability to protect sensitive or confidential information before seeking access to TEK.
    - If the Indigenous government or knowledge holder requests protection for TEK that may be shared, agency staff should not write down or electronically record confidential or sensitive information. Agency staff should also discuss with the TEK holder the advantages and disadvantages of keeping TEK confidential. For example, if information is not recorded as part of the administrative record, the agency cannot rely on that TEK as part of its basis for the federal decision.

What do you see as the best policy for how TEK and Western Science should be used in a legal or political setting?

SHARE YOUR WORK

When you have completed this lesson, share the following work with your teacher:

- Your reflection from Read, Watch, Reflect
- Answers to lesson questions
- Your final Citizen Science Project

If you have any questions about the lesson assignments or how to share your work, let your teacher know.

UNIT III: Responding to Climate Change

What should we do about climate change?

> *"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed it's the only thing that ever has."*
>
> **Margaret Mead**

(Image credit: Department of Foreign Affairs and Trade)

Lesson

14

Activism in the Amazon and Beyond

Learning Objectives

In this lesson, you will:

- Identify necessary data needed (including an understanding of the stakeholders) to form a well-reasoned position on an issue.
- Evaluate the relative merits of different actions or solutions designed to make a positive change.
- Create a model to help inform the action steps related to a real-world, climate-related problem.

ASSIGNMENT CHECKLIST

- ☐ Read the Lesson Introduction and Essential Information.
- ☐ Complete the Read, Watch, Reflect section.
- ☐ Answer the lesson questions.
- ☐ Begin working on your Climate Action Project.

Lesson Introduction

> *"There are no passengers on Spaceship Earth. We are all crew."*
>
> **Marshall McLuhan**

Has there been a time in your life where you stood up for something you believed in? Perhaps you did this despite challenges or social pressure. Take a moment to think back on this experience. What did you do? Why? And how did this make you feel?

This unit examines how we can halt or lessen the impacts of climate change. Throughout these final lessons, you will be working on a unit project in which you will choose an issue related to climate change to take action on. This project is explained in full in this lesson. Planning the project is the main focus for this week.

In this lesson, we will be looking at what young people around the world have been doing to fight climate change. We will examine the hallmarks of effective action and change-making. Coming to terms with climate change can be disheartening, but it's helpful to recognize the efforts that are already underway globally. We are not doing this work alone, and there are so many amazing people we can be inspired by!

Essential Information

Helena Sirén Gualinga is a teen who is balancing her regular life and schoolwork with being an environmental activist. She was born in the Indigenous Sarayaku (sah-rah-YA-coo) community in the Southern Amazonian region of Ecuador. For years, the Sarayaku people have been dealing with challenges like illegal mining and oil companies that are extracting resources on Indigenous land without permission from the community. As the Sarayaku pushed back against extractive industries using their land, community members were treated violently, and one company used explosives in some areas, which destroyed sacred sites. Since childhood, Gualinga has worked to raise awareness about protecting the rain forest, violence against Indigenous people, and the importance of valuing Indigenous perspectives in global policy making.

(Image credit: Hyerakk)

More recently, Gualinga has been actively working on climate-related issues. She has shared how elders in her village talk about floods that used to happen once per decade but are now happening up to four times per year and bringing disease. She has spoken publicly about her worries that these shifts in climate in conjunction with the other threats to the region will end up destroying her home. Most people would agree that this is a troubling situation, but what should be done about something like this?

The Process for Taking Effective Action: Understanding the Issue

To take action, one of the first steps is to become educated about the issue so that you are able to identify the specific underlying problem (or problems). In Helena Sirén Gualinga's case, this would involve learning about the economic pressures that affect oil and mining companies, researching the politics and laws around land use, and becoming familiar with the environmental science behind climate change and how land use impacts ecosystems. Can you think of anything else you might need to know about to fully understand the situation the Sarayaku face?

This process also involves identifying **stakeholders**. A stakeholder is a party—a person, group, organization, government, or ecological entity—who is connected to and likely to be impacted by the issue in some way. What are some of the stakeholders in this example? What are their interests and needs? One stakeholder is the Sarayaku people, whose health, culture, and economic system are all impacted by any changes in their land or community. Once a stakeholder is identified, more research is used to understand the specific ways the stakeholder is impacted by various changes in the system, what their wants and needs are, what resources are available, and what limitations or constraints they are working with. In addition to the Sarayaku, other stakeholders could include the Ecuadorian government, the oil and mining companies, other Ecuadorian citizens (who might want a job with the oil company or might experience health impacts from mining contaminants), consumers of the oil and mining products, and the species that live in the impacted sections of the Amazon.

Deciding how to act can become complicated because different needs may entirely oppose each other or have differing levels of importance depending on who you ask. You may end up with challenging questions like whether jobs for some citizens are more or less important than the homes and culture of another set of citizens. There may be creative ways to navigate these issues, but often things do not work out easily.

At this point, all the information can be used to map out a complex system of all the stakeholders, factors, and connections between the parts of the issue. This system helps analyze the dynamics of the situation and allows us to identify one or more specific problems that we can address by taking action. In this case, the system could include the Sarayaku people, whose homes, lives, and culture are threatened by a changing climate and rain forest loss. We would also note that approximately one-third of Ecuador's economy depends on oil and gas companies, who will require new places to drill if they are to continue similar levels of production ("Equador's Economy).

The Process for Taking Effective Action: Action Steps!

Once a specific problem has been identified, it becomes possible to figure out what outcomes will help provide meaningful solutions to the problem in ways that best meet the needs and interests of the stakeholders. We can then use our understanding of the system to determine possible **action steps** that fit with our logistical constraints, which may include the available resources, time, political power, money, laws, etc. Action steps can be a wide variety of things that people do to make change, such as going to protests, volunteering, gathering and sharing data (like you did for the citizen science project in Unit I), writing letters to elected officials, publishing written or artistic work, educating others to raise awareness, organizing boycotts, lobbying companies, planning social media campaigns, etc.

For each action step, we can analyze how relevant, doable, and effective we think it will be based on our knowledge of the system and the outcomes we want. Here we also need to think about the stakeholders we are working with or the audience that we are trying to reach. For example, if our goal is to raise global awareness about an issue, then presenting a report to your parents will not be a very effective action step, but creating a public social media campaign could be.

When you have identified an appropriate action step, you can make a plan for carrying it out and then take action! It is helpful to document this process and to reflect afterward on what worked and what changes you would make next time. You may see immediate evidence of how effective your action was, but in other situations the outcomes may be intangible or long-term. Either way, it is critical to take time to assess your work after the initial launch before continuing the process of making positive change in the world.

Taking Effective Action

Use this checklist to turn your goals and intentions into action.

1. **Identify the problem.** What is the fundamental issue at the heart of what is happening?
2. **Educate yourself about it.**
    - Identify stakeholders.
    - Learn about the context, the issue's history, and what has already been done.
    - Determine related factors and how they contribute to the issue.
3. **Plan your action steps.** Use your knowledge of the issue to identify one or more effective steps you could take, and then make a plan that takes into consideration your skills, resources, time, etc.
4. **Take action!**
5. **Reflect and adapt.** How effective was your work? Why? What is the next step?

In Conclusion

Helena Sirén Gualinga has been using a variety of actions to help her community. She participates in protests. She is active on social media, where she presents data about climate change, informs people about the production of fossil fuels in Ecuador, and shares ideas about ways to protect and value Indigenous lives and knowledge. Gualinga also presented in a panel at the 2019 UN Climate Change Conference in Madrid, where she called for more concrete action to reduce carbon emissions and critiqued the lack of Indigenous voices in decisions made by the Ecuadorian government. In 2020, she started the Polluters Out movement, a campaign driven by a group of young activists who are partnering with scientists, Indigenous communities, and other organizations. The Polluters Out movement has a set of concrete goals that they work to promote, including to decrease the influence of the fossil fuel industry in governments and in the United Nations. Pretty impressive work for a teen who attends high school full time!

As you consider things that teens like Gualinga are doing, ask yourself about the issues that you see in the world, in your region, or in your local community. What are the problems that you care about? What can you do about them?

Read, Watch, Reflect

1. Choose at least three of the young adult climate activists listed below to learn more about. You can choose to read articles about them, view their social media, listen to their music, or watch their speeches. Plan on spending 10–15 minutes per person to get a sense of what they are fighting for and how they do this.

    Quannah Chasinghorse-Potts is an Alaskan activist for climate change and Indigenous rights as well as a model.

    "Quannah on Protecting the Arctic Wildlife Refuge"

    youtube.com/watch?v=mKbExcLfqpM

    Ridhima Pandey is an environmental activist who sued the Indian government for not taking enough action on climate change.

    "11-Year-Old Climate Activist Ridhima Pandey on Fighting Climate Change and Why India Is Vulnerable"

    indiatoday.in/education-today/how-i-made-it/story/india-s-11-year-old-climate-activist-ridhima-pandey-on-her-own-action-against-climate-change-and-why-india-is-vulnerable-1628706-2019-12-16

    Milou Albrecht cofounded the School Strike for Climate Australia, which organizes students to protest the lack of action on climate change.

"Australian Students Plan School Strikes to Protest against Climate Inaction"

theguardian.com/australia-news/2018/nov/07/australian-students-plan-school-strikes-to-protest-against-climate-inaction

Autumn Peltier is a Canadian Indigenous rights and water rights activist. Through her work for clean water access, she has also spoken at the UN Climate Summit.

"'It's Time for Action': Indigenous Water Activist Autumn Peltier to Speak at UN Forum"

nationalpost.com/news/national/indigenous-water-activist-to-speak-at-un-as-part-of-youth-led-climate-movement

Leah Namugerwa is a Ugandan climate activist who has pushed for a plastics ban and led tree-planting efforts that have replanted thousands of native trees.

"16-Year-Old Climate Activist on Mission to Replant Tress in Uganda"

africanews.com/2021/04/22/16-year-old-climate-activist-on-mission-to-replant-trees-in-uganda

Jerome Foster II is a climate change activist and is an adviser in the Biden White House Environmental Justice Advisory Council, where he helps inform U.S. climate policies.

"'I'm Hopeful': Jerome Foster, the 18-Year-Old Helping to Craft US Climate Policy"

theguardian.com/us-news/2021/apr/13/jerome-foster-us-biden-climate-crisis

Artemisa Xakriabá is a Brazilian Indigenous rights and environmental activist. She has fought against the destruction of the Amazon rain forest.

"This Indigenous Teenager Is Fighting to Save the Amazon from Brazil's Bolsonaro"

huffpost.com/entry/indigenous-activist-bolsonaro-amazon-brazil_n_5db31aece4b079eb95a2d409

2. Based on what you have read and watched so far in this lesson, write a paragraph (five to eight sentences) reflecting on one or both of the following prompts.

   Talk to your teacher if you would like to explore a different question. Feel free to share your reflection as a video or audio file.

   a. What trends do you notice in the specific climate issues these young people focus on and the approach they use to make change? Why do you think this is?

   b. What about these examples inspires you?

Questions

1. Imagine your government is debating a rule that would require all cars sold in the country to be low-carbon-emission vehicles.
   a. Identify three to five pieces of information you would want to know before taking a position on this debate.
   b. Identify at least five stakeholders and explain what makes them stakeholders in this issue.
2. Why do you think it is so important to be well informed about an issue before planning and taking action?
3. Of the examples of action steps you have seen mentioned so far, which ones seem most effective, and why?
4. Brainstorm a list of climate-related issues that matter to you. Once you have your list, mark two or three that seem the most interesting and relevant to where you live. Examples could include things like carbon emissions, Indigenous rights, habitat or biodiversity loss, rising sea levels, or climate refugees.

Climate Action Project

In the first two units of this course, we learned about how climate change works and the impacts it is having. In this final unit, our focus is on how we can address climate change. You will be working on a unit project where you plan, carry out, and reflect on an action that addresses a cause or impact of climate change. This climate action project is a culmination of the skills you have been building with research, systems thinking, problem-solving, and climate science. In this project, you will do something real to combat a problem you see in the world. This is an invaluable skill to have to avoid the hopelessness and passivity that can be an easy way out of tackling challenging global problems.

You will have time in each lesson to complete a part of your project (as outlined below), and the final product will be due at the end of lesson 18 when you complete the course.

> Lesson 14: Choose a topic, propose a project idea, and plan out your time.
>
> Lesson 15: Learn more about your topic, refine your plan, and start taking action!
>
> Lessons 16 and 17: Complete the work needed for your action project. (Remember to document what you do!)
>
> Lesson 18: Submit documentation of your work on the project and write a reflection.

The bulk of the work for this project will be the action that you take. This needs to be something beyond your personal life or home. For example, it is not enough to replace your home light bulbs with energy efficient ones, but you could do something like a presentation to your town energy committee on how to switch all town lighting to be energy efficient. Since your teacher may not be able to directly

observe your action step, you need to make sure you document your work through photos, video, logs, etc. These will be submitted at the end of lesson 18 along with a project reflection. (The reflection prompts are listed in lesson 18 if you want to look at them in advance.)

Some example project ideas are listed below—but do not limit yourself to this list!

- **Raising awareness about climate change** and what people can do, using methods such as a publicly shared podcast, handing out leaflets, or a multiweek social media campaign where you enlist your friends to contribute
- **Starting a teen climate action group** with peers where you plan and conduct actions to address climate change
- **Participating in ongoing efforts** (like a forum, protest, or volunteering) set up by an existing group in your area who does climate change work
- **Creating and publishing written or artistic pieces**, such as making a film or photography show about climate change in your community and screening it at your library
- **Advocating for changes in your community** by doing things like presenting at a town meeting or handing out flyers you made
- **Collecting data about climate change or its impacts**, perhaps by working with a researcher at a local university or by continuing with your citizen science project from Unit I

Below are the steps you will complete in this lesson to start planning your climate action project. This should be submitted along with the rest of your work for this lesson. At any point in this process, you can reach out to your teacher if you need help or want feedback on your ideas.

This week, you will home in on the issue you will focus on for your project.

1. Use your brainstormed list from question 4 to pick one issue related to climate change or climate-based environmental justice that you want to work on for this project. Make sure this is a topic you care about and genuinely find interesting. Do some initial research on this issue to see how it is manifesting where you live (stakeholders, causes, etc.), and clarify the issue you want to focus on.

   If you are struggling to find something that resonates with you, try doing some additional research, talking to family members, reviewing topics in this course, or reaching out to your teacher. Describe the general issue you want to explore and why.

2. Use initial research to create a basic visual model of the system related to this issue. For example, if you chose the plight of climate refugees as your issue, you would want to include factors that cause people to leave, all relevant stakeholders, the impacts of migration, etc., and you might want to focus on how this is relevant to where you live (or at least your country) since topics can look different in different parts of the world. Submit a picture of your visual model. (You can complete this by writing a paragraph if that is a better fit for your topic.)

3. Examine the visual model you made and consider which parts of the system present problems that you care about and think you could make a difference with. Narrow this down until you can state one specific problem you want to take action to address. For example, if you picked climate refugees as your topic, you might identify an underlying problem, such as the lack of funding to deal with the increasing severity of hurricanes. Describe the problem in one sentence.
4. Brainstorm two or three initial ideas for action steps that you think would help address the problem you chose to focus on. Make sure to list ideas that seem doable with your skills, resources, and time frame (approximately one month). For example, if the problem is a lack of funding for hurricane relief, some of your action steps could be organizing a fundraiser, writing a letter encouraging a local politician to support disaster relief funding, or designing a social media campaign to raise awareness about the issue online.

   Note: You may not end up doing these specific action steps, but it is important in the planning process to recognize whether or not any doable action steps exist for your problem. If you cannot think of any doable action steps, then reach out to your teacher to get advice. They may have ideas, or they might suggest that you change or further refine the topic of your project.

Further Study

If you are interested in sharing your work more widely, consider the activity below.

Submit Your Action Project to Competitions

Depending on the type of project you are doing for your climate action project, you may be able to submit your final product to local or global competitions, such as science fairs or art competitions. The availability of these opportunities will vary depending on where you live, your age, the topic you are focusing on, and the type of product you are making. Some examples are listed below, but you will probably need to do your own online search for competitions that are specific to your topic or product.

Here are two competitions you might consider:

"NPR Student Podcast Challenge"

npr.org/2018/11/15/650500116/npr-student-podcast-challenge-home

"Treehouse Climate Action Poem Prize"

poets.org/academy-american-poets/prizes/treehouse-climate-action-poem-prize

If you plan on submitting your work, make sure you check out all the information about formatting, requirements, and deadlines now. If they vary significantly from the requirements for this course, reach out to your teacher to figure out how you should complete your work.

SHARE YOUR WORK

When you have completed this lesson, share the following work with your teacher:

- Your reflection from Read, Watch, Reflect
- Answers to lesson questions
- Your Climate Action Project assignments

If you have any questions about the lesson assignments or how to share your work, let your teacher know.

Appendix

Materials List

LESSON	PROJECT	MATERIALS
2	Further Study: Modeling Convection Currents	large rectangular container, waterproof 3 heatproof cups or containers of the same size water ice boiling water dropper food coloring, 2 colors
4	Activity C: Yeast Cellular Respiration Lab	yeast sugar water 3 clean empty bottles 3 balloons measuring tape
5	Activity D: Car Exhaust Particulates Lab	4–6 white tube socks insulated gloves masking tape permanent marker 6 rubber bands 4–6 different vehicles
7	Activity B: Modeling the Greenhouse Effect Lab	2 identical containers soil plastic wrap rubber band movable light source that gives off heat air thermometer
9	Activity A: Sea Level Rise Lab	2 identical medium-size containers clay ice cubes water marker
10	Activity B: Plot Study Experiment	paper and pen materials for your plot* *Materials can vary as long as you have a system to set up a plot with a consistent size. One option is to use a Hula-Hoop. Another option is to use 4 sticks, string, and a measuring tape to mark out 1-meter squares.