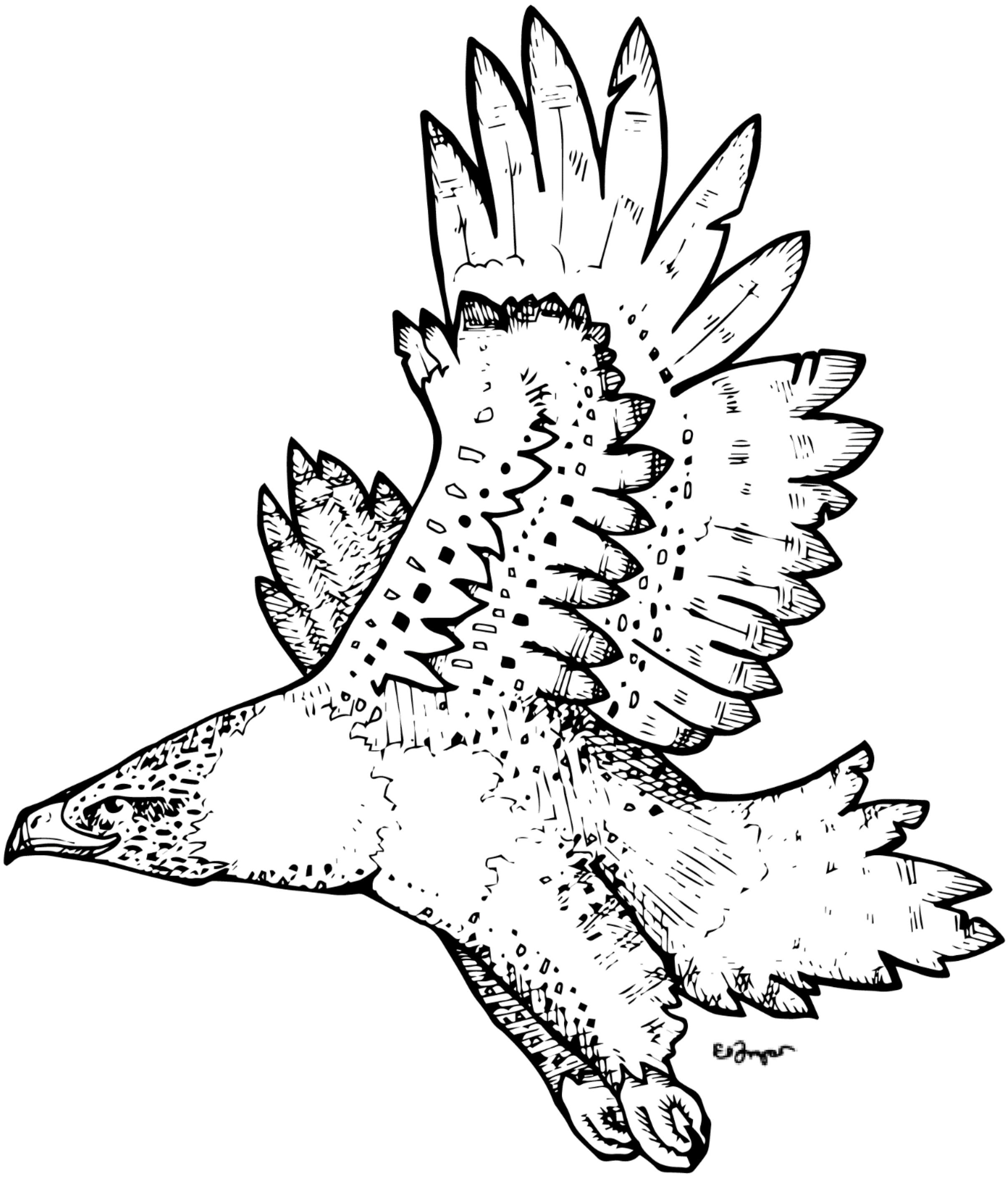
Plumas Audubon Society's

Plumas Environmental Education Program (PEEP)

Birds and Climate Change Curriculum



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Plumas Environmental Education Program
Birds and Climate Change Curriculum

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We offer our deepest gratitude to all of our partners, consultants, supporters, volunteers, friends and families who helped us in various ways as we developed this curriculum. Thank you as well as to the teachers, staff, and youth mentors who invited us into their classrooms and gathering spaces to offer pieces of our developing curriculum to their students and youth.

We dedicate this work to *all* the children of the world.♡

The development of this curriculum was funded by the United States Environmental Protection Agency through the Environmental Education Local Grants Program.

Although the information in this document has been funded wholly or in part by the U.S. Environmental Protection Agency under assistance agreement 99T52701-0 to Plumas Audubon Society, it may not necessarily reflect the views of the Agency and no official endorsement should be inferred.

Plumas Audubon Society's

Plumas Environmental Education Program (PEEP)

Birds and Climate Change Curriculum

(Middle and High School)

Brief Introduction for Educators

The goal of this curriculum is to CULTIVATE STEWARDSHIP in the next generation of learners, thinkers, and doers. This curriculum aims to cultivate stewards of the earth by opening an AWARENESS of climate change and its effects on the natural environment, wildlife, and society; building a RELATIONSHIP with the land, its resources, and the organisms who depend on such, including human communities; developing a sense of RESPONSIBILITY and CAPACITY to address both the problems and solutions to climate change; and fostering a feeling of EMPOWERMENT which calls stewards to take ACTION towards the well-being of the earth.

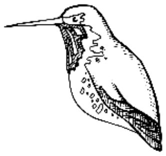
The curriculum is composed of five units, a concluding reflection lesson plan, and associated PAS Birding Journal for students to take into the field. It is desirable but not necessary to start at the beginning, do all lessons, and offer lessons in order as the curriculum units build on each other and are designed to guide students along the path of environmental awareness and knowledge, through critical thinking and problem solving, to decision making and action, and, finally, to a sense of stewardship within and for their communities.

Before embarking on this path, we encourage you to offer your students the Pre-Survey to gauge their familiarity with their surrounding environment and birds as well as their understanding of climate change and its effects. After concluding the curriculum—or a portion of it—you can offer this again as a Post-Survey which, when compared to the Pre-Survey, can indicate student progress along the path to environmental stewardship.

In the lessons that follow, students will explore their natural and built surroundings with all their senses to observe and understand the concepts of climate change, its effects on natural and human communities, as well as think critically about solutions for the future.

Climate change is a daunting subject to teach to our youth, and yet, it is important. Our world is changing and our children are inheriting the consequences of the ignorance of the past and the disregard of the present. The effects of climate change and the rapid acceleration of it are troubling and alarming. We have attempted to present this information in an honest, yet digestible, manner.

Even in the face of climate disruption we can take heart; there is hope! Solutions abound! We *all* can choose to actively take part in solving the climate crisis. We hope you and your students come away from this curriculum with a renewed sense of empowerment, optimism, and courage for the future. May you "be like a hummingbird" and may you be well.



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Plumas Audubon Society's

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Birds and Climate Change Curriculum

(Middle and High School)

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Plumas Audubon Society

PEEP Birds and Climate Change Curriculum
Pre-/Post-Survey

Name ___________
Date ____________

1. Name up to five (5) different birds that you've seen in the Upper Feather River Watershed or Plumas County.

__________________ __________________ _________________ _________________ _________________

2. What are three things that birds use or need from a healthy habitat?

____________________ ____________________ ____________________

3. Name two places in the Upper Feather River Watershed that provide a healthy habitat for birds.

____ ____

4. True or False: Birds can tell us whether the environment is healthy or not.
5. True or False: Birds can tell us whether the environment is changing.

6. Why do you think it is important for humans to help birds?

Native plants are plants that have lived and evolved in our area for a very, very long time.

7. True or False: Native plants tend to use less water than other plants.
8. True or False: Native plants provide food, water, shelter, and cover for birds.

9. What is climate change? (Check one answer.)
   - ☐ Changes in weather from day-to-day
   - ☐ Changes in weather from year-to-year
   - ☐ Changes in weather patterns over a long time period (eg. 10 years or more)

10. True or False: Most scientists (97%) agree that climate change is mainly caused by humans burning fossil fuels (coal, oil, natural gas).

11. Climate change is causing: (Check all that apply.)
    - ☐ many birds, other wildlife, and plants to move northward
    - ☐ many birds to migrate earlier
    - ☐ many birds to lay their eggs earlier
    - ☐ snow in our mountains to melt earlier in the spring
    - ☐ more human migration
    - ☐ more water in the oceans and higher sea levels
    - ☐ more wildfires
    - ☐ bigger storms
    - ☐ more flooding
    - ☐ worse drought (very little to no water)
    - ☐ coral reef die-offs

12. How is climate change affecting you or your community now?

13. Why is it important for humans to work together to solve environmental problems, including climate change?

14. What can you do to help solve the climate crisis?

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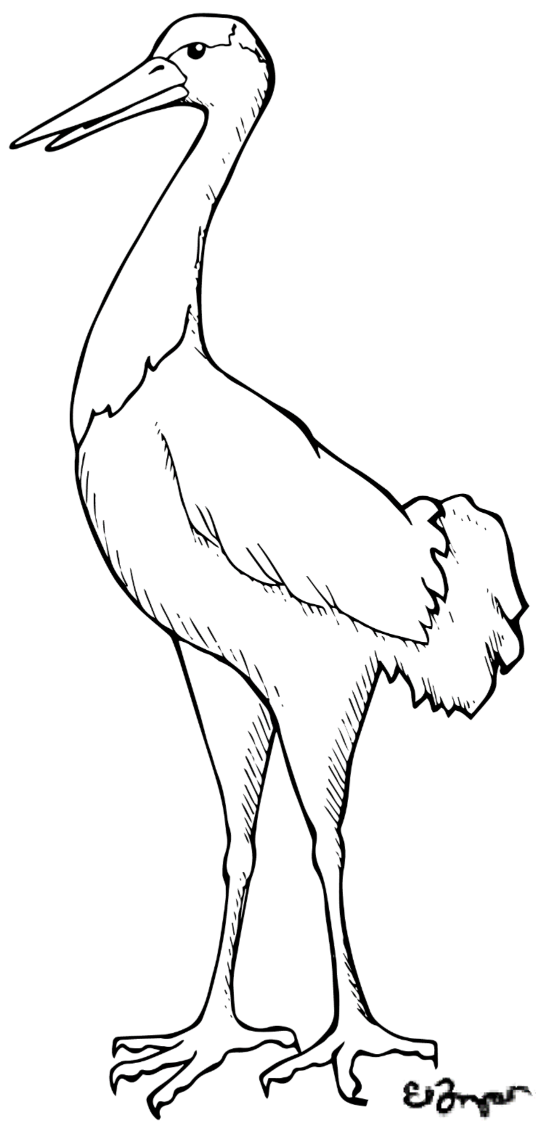
"I realized that if I had to choose, I would rather have birds than airplanes."
— Charles Lindbergh[1]

Unit 1: AWARENESS
Why Birds?

- Lesson 1.1: Why Birds Matter
- Lesson 1.2: The Language of Birdsong
- Lesson 1.3: Bird Behavior Scavenger Hunt
- Lesson 1.4: What's That Bird? Species Identification
- Lesson 1.5: Community Science: Introduction to eBird



[1] Lindbergh was an aviator, author, inventor, explorer, and environmental activist. He made the first solo, non-stop transatlantic flight.

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Plumas Audubon Society

UNIT 1: AWARENESS
Why Birds?

Lesson 1.1

Lesson Objectives:
- Understand why and how birds serve as indicators of global climate change
- Learn how climate change threatens over half of bird species North America
- Think like a scientist: ask questions and consider how scientists go about finding answers to these questions.

NGSS:
Middle School

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

High School

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Time: *60 minutes*

Materials:
See next page

Why Birds Matter

Summary:
This lesson explains why this curriculum teaches climate change through the study of birds. Students will learn that birds serve as indicators of a changing climate and can help us to explore and understand the broader effects of climate change on the world as a whole and in our local environment. This lesson begins with a short video screening (on YouTube) and a brief reading from the California Birds in a Changing Climate booklet that can be done in class, before, or after the screening. You, the educator, are provided with information below to use in class to reiterate what was seen in the video and read in the reading. From there, the lesson ends with discussion questions.

Background:
Besides being beautiful and intriguing life forms worthy of wonder, respect, and appreciation in their own right, birds also matter to us because they provide a wide variety of ecosystem services that benefit humans both directly and indirectly: they pollinate flowers, disperse and plant seeds, cycle nutrients throughout and between ecosystems, and devour pests. Birds can tell us a lot about the environment. By observing birds, we can learn a lot about an ecosystem's health. What might it mean if we notice multiple individuals of a bird species not before seen in a specific region? What might it mean if a bird species we used to regularly see in one spot has declined or even disappeared in recent years? The presence, absence, abundance, or behavior of birds can offer clues about what may be happening in an ecosystem. We consider certain bird species "indicator species." Monitoring indicator species informs us to changes in environmental conditions. We can learn about, understand, and anticipate changing conditions by studying birds!

An historical and often referenced example of an indicator species is the canary in a coal mine. Until the 1980s, canaries were used to detect risks to human health in coal mines: miners would bring canaries into the mines to warn of dangerous levels of toxic gases. If a canary began to show signs of poisoning or died when exposed to the atmosphere in the mines, miners knew their own lives were at risk and were smart to exit the mine tunnel immediately. We also refer to species such as the canary as sentinel species because their behavior can warn us of environmental risks to humans.

Many bird species around the world can be considered "canaries in the coal mine" to alert us about different environmental changes and degradation, including those caused by climate change. Birds are among the best indicators of environmental health and change because:

- Birds are highly sensitive to environmental change. They are usually high up in the food chain and have relatively long life-spans, therefore environmental stresses that accumulate over time are evident in bird

Materials:

- Computer with internet access
- Projector/media player
- Napa Solano Audubon's *California Birds in a Changing Climate* booklets

populations and behavior.

- Birds are everywhere; they are found in almost every ecosystem across the planet.
- Birds are relatively easily seen or heard and, thereby, easily observed and identified. Birds are the one form of wildlife most people see or hear everyday. Not many other organisms call or sing out revealing their presence and identification.
- Birds have been very well studied for a long time. We know a lot about them: their biology, their life-histories, their behaviors, and their migratory patterns. Because of this, we have a strong baseline against which any change can be easily identified and monitored. Much of this data comes from "community scientists," everyday folks who like to birdwatch and note what they see, when and where. This information is compiled with thousands of other records, resulting in a huge amount of data to draw on. Even you and and your students can add to this data, you don't have to be an expert! Lesson 1.5 later in this Unit provides an opportunity to contribute to eBird, a community science database that provides valuable information to scientists studying bird populations and migrations.

Because they are such good indicators of environmental health and biodiversity, bird populations, behavior, and reproductive success often closely reflect the stability of an ecosystem.

Currently, birds are telling us that climate change is real and environmental conditions are changing dramatically and rapidly. Half of North America's bird species are considered climate threatened or endangered because they are expected to lose more than half of their current range by the end of this century (2080) due to changing climatic conditions. In order to give birds a chance we need to do two things: 1) Protect the places on the ground that we know birds will need today and in the future, and 2) work together to reduce the severity of global warming.

Activity:

BIRDS AND CLIMATE CHANGE SUMMARY

Pass out Napa Solano Audubon Society's booklet *California Birds in a Changing Climate: 170 Species At Risk.* Ask students to read pages 6-9 independently (sections "Climate Change and Birds" and "The Audubon Birds and Climate Report," should take approximately 10 minutes).

After students have read pages 6-9 in the booklet, watch as a class National Audubon Society's "Climate Change and Birds" video (3:25 minutes): https://www.youtube.com/watch?v=aN2-a82_3mg

After the video, have the students read pages 10-11 about projected changes specific to California bird species as a result of climate change.

Use the background information as a guide to review and discuss what the class just read and watched. Ask students the following questions about the material covered in the reading and the video:

1. How are birds being affected by climate change? Cite from the reading or video ways birds have noticeably been affected by climate change.
2. Why do we need birds? Provide some examples from the reading or video or get student-inspired ideas.
    - *[They plant trees, they pollinate, they bring us joy, etc.]*
3. What data did Audubon use to create the Birds and Climate Report?
    - *[Data from community science projects like the annual Christmas Bird Counts since 1900, data from the USGS North American Breeding Bird Surveys since 1966, and research from leading climate scientists.]*
4. What are the three classifications Audubon gave to birds to help identify how they will be affected by climate change by 2080?
    - *[Climate endangered, climate threatened, and climate stable]*
5. How much of their current range are climate endangered and threatened species predicted to lose by the 2050 and 2080, respectively?
    - *[50% or more; over half!]*
6. What are the two main things we can do to help birds facing climate change according to the National Audubon Society's report?
    - *[1. Reduce carbon emissions, 2. protect bird habitat]*

CONNECT WITH PLUMAS COUNTY BIRDS

Pass out the abbreviated checklist of common Plumas County birds. Instruct students to check off the birds they have seen before—perhaps in their own backyard or schoolyard—but to leave the checkbox blank next those birds that they have never seen in real life. Students can put a star next to the name of a bird they really hope to see!

Educator Tip:
A slideshow of some common Plumas County birds can be found and downloaded at: http://www.plumasaudubon.org/birds-and-climate-change-curriculum.html

Show the class the slideshow of common Plumas County birds that students will likely have seen before or will likely see on a fieldtrip this year. Allow for some interaction and connection with the content of the slideshow by asking students to raise their hand if they have truly seen that type of bird before. If time allows, select students to share where they've seen each bird.

PLUMAS COUNTY BIRDS AND CLIMATE CHANGE

Ask the class, "Are *our* birds in trouble?" Let's find out!

With the class, visit climate.audubon.org, click on the "All Species" tab, and then use the search bar to try to look up a given species. Have students offer suggestions for which local species to look up from their checklist.

If a given species cannot be found, then it is considered "climate stable", meaning that by the end of the century (2080 in the Audubon study) the species is expected to either gain or lose less than 50% of its current range due to climate change.

If a given species is found, click on the link to the species page to see whether the bird is considered "climate threatened" or "climate endangered". Climate threatened species are projected to lose more than 50% of their current range by the year 2080. Climate endangered species are projected to lose more than 50% of their current range by the year 2050.

Also, look at whether the bird's range is expected to shrink or shift in the future. Zoom in to California on the interactive map to see if the species will still be likely to be seen in Plumas County at the end of the century.

Extension:

THINK LIKE A SCIENTIST

What do scientists do? In general, a scientist observes the world, asks a question based on observations, and then goes about trying to answer that question (which more often than not leads to many more questions).

Ask your students to imagine themselves as scientists--curious, observant, and judicious. Ask them to consider investigating, as a scientist, the ways that birds can inform us about the health of the environment and climate change. Have your students brainstorm and write their ideas on the board for the following:

- What kind of question(s) might we ask to better understand the connection between birds and the environment?
- How could you go about answering such question(s)?
- How can you feel confident that your answers are correct?

Take this extension activity a step further by encouraging your students to research one or more of the ideas they came up with to see if there have been real studies conducted on the topic and what such studies found. Have students report back to the class.

ECOSYSTEM SERVICES

Have your students research on a particular example of an ecosystem service that birds provide and the importance of that ecosystem service. Students can present this information in the form of a report or to the class in the form of a poster or slide presentation.

Plumas Audubon Society

UNIT 1: AWARENESS
Why Birds?

Lesson 1.2

Lesson Objectives:

- Students will listen to birds singing and begin to learn how to distinguish and identify different species based on the calls they hear.
- Practice making and noting detailed observations, and forming conclusions based on observations

NGSS:

Middle School
MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
High School
HS-LS2-7. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Time: *30 minutes*

Materials:

- Access to an outdoor space, preferably at a time when birds are nearby
- Bird Journals and pencils
- Whiteboard or blackboard (optional)

The Language of Birdsong

Summary:

This lesson is a teacher-guided observation activity to build awareness of birds followed by a journaling activity in which students find a quiet place to sit and listen to bird vocalizations. Students draw a map of the area in their journal, placing themselves in the center. When they hear a song, they will write down the location and description of the song, trying to be as descriptive as possible.

Background:

Often, birds can be heard before being seen. Identifying bird songs can tell us more about the environment than our eyes alone. Birding by ear is an important skill to develop as it can help you identify a bird that is otherwise hidden by dense foliage or night, is too far away, or looks very similar to another species. Even if you don't know your bird calls well enough to identify the species by its call, this is still an extremely useful and important skill to practice as it helps the birder know where to focus attention. With more practice, bird calls and songs can become easy to recognize as the voices of familiar friends.

Birding by ear is an important ingredient to a successful bird walk and attempting to translate the sounds you hear into written words can be entertaining and challenging.

Most bird guidebooks will offer descriptions about vocalizations from certain species. For example, Great-Horned Owls are often described as having a deep, rhythmic, "hu hu hoo, hoo, hoooo" while Mountain Quails make a loud, clear whistling "quee ark" call. These types of descriptions are usually followed by the author's caveat:

- "Word syllabifications in most books vary; ears differ." (Peterson 1990)
- "Words at best provide a very feeble sound impression." (Sibley 2000)
- "One birder's chip is another's tsip or chik or even peek." (Dunn and Alderfer 2006)

There are two ways to describe bird song; analogy and phonetic descriptions: **Analogy** is comparing one sound to another (eg. "it sounds like a squeaky door"). **Phonetic** is transcribing the sound into human words or sounds (eg. "weee", "quack", "here, sweetie", or "cheeseburger").

Neither of these methods is perfect. Analogy will only be useful if the listener has a good idea of what the comparison sounds like. Phonetic descriptions are limited by our own human vocal range and are not able to describe many qualities of birdsong such as pitch or tone. This activity will allow students to be creative while communicating their observations to each other. It will be helpful to first have students share ideas as a group and figure out some ways to describe certain sounds.

Activity:

<u>Introduction</u>

Before going outside, play a few recorded bird vocalizations for the class. Species commonly seen/heard in our area and distinctive suggestions are listed below. You can search these species in online bird guides and play their songs and calls (Cornell Lab of Ornithology, https://www.audubon.org/bird-guide; Audubon, https://www.audubon.org/bird-guide). Ask for volunteers to try and describe what it sounds like to them and write their analogous or phonetic descriptions on the board to show how people describe songs differently. Ask if students can identify the bird based just off of the sound.

- American Robin
- Common Raven
- Cedar Waxwing
- Mountain Chickadee
- Red-tailed Hawk
- Red-winged Blackbird
- Sandhill Crane
- Song Sparrow

Educator Tip:
In addition to online bird guides, there are many free birding apps for smartphones, including features to play recorded bird vocalizations. Check out:

- Audubon Bird Guide App: find it in the App Store or on www.audubon.org

<u>Listening Circle</u>

When you get outside, take 5-10 minutes to settle the class and get everyone tuned in to their senses. Our senses are some of the best tools that we have out in the wilderness. When you are paying attention to all of your senses you can be better at hearing where water is, noticing animal tracks, feeling wind direction, etc. The following activity can help get you and your students more tuned in to your senses and more tuned in to the rhythms of nature which can help us be more aware of what is in front of us, behind us, under us, above us, around us, and in us!

Educator Tip:
Offer the Listening Circle and other mindfulness activities regularly to help improve your students' cognition and focus, along with many other mental and physical health benefits associated with practicing mindfulness.

First, ask for a moment of silence in which students take in the landscape around them. Still asking for silence from the group, have students stand in a circle or lie on their backs and pay attention to the suggestions that follow. Wait a few moments between each suggestion to allow everyone to focus on each of the following:

- Close your eyes and take a few deep breaths.
- Feel the ground under your feet/back.
- Feel your clothes against your skin.
- Feel the warmth of the sun/the coolness of the wind on your face. Which direction is it coming from? Is it strong or subtle?
- Now quiet your sense of feel and focus in on your sense of smell. What can you smell in the air?

can you smell in the air?

- Can you smell the plants or soil around you?
- Now shift your focus to your hearing. Listen for the loudest or most obvious sound that you can hear.
- Listen for the softest sound you can hear.
- Listen for the farthest sound.
- Listen for any sounds of wildlife. What do you hear?
- Slowly open your eyes now and with a soft gaze try to see everything in your field of view with an equal, soft focus.
- Now, notice all the different colors and shades of color in the landscape.
- Look at a tree or bush nearby and see if you can detect any subtle or obvious movement among the leaves or branches.

Invite students to break the silence by sharing with the group what they noticed from this experience. Did anything interesting come to your attention? What have we learned about this area just by sitting quietly for a few moments? Ask students to describe what they heard. Could they identify the sounds?

Educator Tip:
One of the hardest things about bird walks with groups of people is to keep everyone quiet enough to not disturb and flush the birds away before anyone has a chance to see or hear the birds.

One method to help with this is to encourage your students to behave like a group of private investigators or detectives. Before starting your walk, ask your students what behaviors or qualities we tend to attribute to a private investigator or detective, for example, "attentive", "stealthy", "secretive", "quiet", "clever", "curious". Remind students of their role as necessary when on the walk.

<u>Sound Mapping</u>
Next, send students to sit individually throughout the area with a journal or blank piece of paper to write on (there is a Sound Mapping page in the PAS Birding Journal). Instruct them to draw a dot or X in the center of the page representing themselves and then sketch a simple map of nearby habitat or other distinctive features (eg. trees, creek, path) in relation to their location.

When students hear bird calls, have them write down what the calls sound like in the phonetic or analogous form (perhaps both!), recording it on their map in the approximate location and distance of where the sound came. If there seems to be very little bird activity, you can expand the exercise to map anything in the soundscape (eg. wind, insects rustling through leaves on the ground, branches snapping, water flowing, etc.). Ask the students to record as many different bird calls (or other sounds) as possible for five minutes.

If a bird is seen singing or calling, ask the students to also take very brief notes of what the observed bird looks like (color, size, beak shape, etc.). The description of the song or call along with a visual description (as well as the kind of habitat--which would already be illustrated on their maps) can help you later identify the species with the help of a bird guide, online resources, or other birders.

After the five-minute period, gather the group to share what they've found. As students share, ask if others may have heard the same things. For bird calls, ask how students described the call. Did anyone else hear similar calls? How did others describe the call? How many different songs/calls did students hear?

What might the amount of bird chatter--or lack thereof--mean?

Journaling/Discussion Prompt:

It takes quite a bit of energy for birds to make such audible and distinct calls. What might be the benefits of this behavior? Could there be any negative effects? Have students make two lists, one of the benefits or reasons why birds call or sing and one of the costs or risks of calling or singing.

Just as humans use language to communicate information, ideas, and emotions to others, birds also use their songs and calls to communicate to other birds (and other wildlife). What might they be communicating to each other?

Think of the different bird songs and calls that you heard during the Listening Circle and Sound Mapping activities. Did you notice different patterns or rhythms of songs or calls? Look up a songbird (eg. Mountain Chickadee) on one of the online bird guides listed above and listen to the different songs and calls that species tends to have noting the different patterns in cadence and rhythm. What might one pattern you heard mean as compared to another you heard?

Extension:

Thayer's Birds of North America is a birding software with photos, bird calls, and video clips of 1,007 birds found in North America. Identify and record the birds you see, take quizzes, compare two birds side-by-side, and read about the species using the software. Students under 18 can download the software for free by going to www.ThayerBirding.com, selecting the Windows or Mac download, and entering the special code **PlumasAudubonYoungBirder**.

Alderfer, Jonathan, and Jon L. Dunn. *Illustrated Birds of North America.* National Geographic, 2006.

Peterson, Roger Tory. *Peterson Field Guide to Birds of Western North America.* Fourth Edition. Houghton Mifflin Harcourt, 1990.

Sibley, David Allen. *The Sibley Field Guide to Birds of Western North America.* Second Edition. Alfred A. Knopf, Inc., 2003.

UNIT 1: AWARENESS
Why Birds?

Lesson 1.3

Lesson Objectives:

- Practice making, recording and analyzing scientific observations.
- Based on their observations, students will infer explanations for certain behaviors.
- Make a connection between bird behaviors and environmental factors.
- Practice identifying birds.

NGSS:

Middle School

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

High School

HS-LS2-7. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Time: *30-40 minutes*

Materials:

- Binoculars
- Bird Behavior Scavenger Hunt page in PAS Birding Journal
- Field Guide (optional)

Bird Behavior Scavenger Hunt

Summary:

A student driven exploration of bird behaviors. Students walk in groups or pairs and observe birds, recording any behaviors they see. Based on their observations, students will attempt to explain why birds exhibit certain behaviors. Students need not identify to species the birds they see, though behavior can be an important clue in identification and practicing bird identification is always encouraged.

Background:

Birding is a great way to build knowledge, awareness, and a stronger connection with the outdoors. It can be overwhelming to start because it does require skills that take time to develop. The nature of birding involves quickly finding and identifying birds that may only stay in eyesight or earshot for a moment or two. Many bird species look alike, some birds look different based on sex, other birds may be too far away to correctly identify. It also helps to know which birds are found in your area at certain times of the year, which also requires experience.

Fortunately, there are birding techniques that anyone can use even on their first day. Bird behaviors can offer important clues for identification. While your students may not be able to identify birds to species right off the bat, they will surely be able to identify what the birds are doing. Birds may be observed flying, soaring, singing, perching, feeding, fighting, preening, swimming, walking, hopping, or a variety of other behaviors that are all part of a survival strategy. Birds, like all organisms, have **behavioral adaptations**: traits or behaviors a species adopts as it evolves over time allowing them to better survive and reproduce. For example, a bird call is a behavioral adaptation. Birds call or sing to warn other birds away from their territory or to attract a mate. Having the ability to call increases the likelihood of a bird to survive and reproduce. Some bird species (like the Bank Swallow) nest in colonies. This behavioral adaptation of communal nesting helps defend against predators and helps birds stay warm at night. Even migration, the seasonal movement of species to suitable habitat, is a behavioral adaptation.

An organism's behavioral adaptations help to carve out its specific ecological niche within its environment. A **niche** is an organism's specific role and position in its environment, including its interactions with other organisms and its environmental requirements. While many general behaviors are similar between species, differences in the specifics of some behaviors can help create and define different species' niches, thus offering alternative ways for species to meet food and shelter requirements and different ways of survival and reproduction. For example, different raptor species will behave differently

Educator Tip:
Depending on the abilities of your students, you may wish to have them work and walk in small groups, OR lead a large group bird walk, having the entire class focus on one bird at a time.

Educator Tip:
If your students are new to binoculars, Teacher's Supplement 1.3 offers some tips and tricks for how to best use and adjust binoculars.

while hunting: some species tend to search for prey by perching on a tall object while others tend to search from the air—even here there is more behavioral and niche differentiation between high and low altitude flying and high and low speed diving or gliding.

Activity:

Head outside with your Birding Journals and turn to the Bird Behavior Scavenger Hunt page which offers a checklist of some of the common behaviors your students might observe. Alternatively, you may wish to have students create their own behavior lists (the following categories can be useful guides: location and posture, movement and flight pattern, communication, maintenance and care, feeding style) or practice detailed journaling in which the student focuses on one bird at a time, watching it for as long as possible, and describing in detail the behaviors and physical appearance of the bird.

Students can work individually, in pairs, or in small groups. If they know the species, have them write it down. It can be interesting to go to an area with varied habitat. Ecological transition zones or ecotones, are found where two different biomes or ecosystems meet. For example, the edge of a meadow bordered by forest or the bank of a stream are excellent watching locations because the habitat and resources are more diverse and would be home to a diverse set of species. With more biodiversity, your students will have a better chance of observing a wider range of behavioral activities.

When students finish the Bird Behavior Scavenger Hunt, gather the class together and discuss what they saw. Consider the following questions:

- What interesting behaviors did you notice? What would explain such behaviors?
- Did any single species seem to be exhibiting a particularly distinctive behavior? What was it and why do you think the bird does it?
- Were you able to identify a species based on its behavior?
- How do group behaviors like flocking improve chances of individual birds' survival?
- Imagine a flock of birds is sitting somewhere peacefully and then suddenly they all fly away. What does this behavior tell you?
- What does it tell you if in past years you've always seen a certain species in a certain place and then one year you stopped seeing them?

Extensions:

TOWARD A CLOSER ID

Bird behavior can help in generally identifying types of birds and even help with specific species identification. For example: Brown Creepers and Red-breasted Nuthatches are both often seen climbing along tree trunks searching for insects. Both are approximately the same size, but are otherwise distinctive from one another. However, even without knowing what they look or sound like, their tree-climbing behavior could help you identify them: the nuthatch will often climb down the tree head first in a zig-zag pattern but will also climb upward and sideways, while the Brown Creeper will start near the base and hop in a spiral up the tree trunk.

Make a list with your students of behaviors they observed that either can help identify the general type of bird or identify the particular bird species, include any other descriptions of the bird (or its habitat) associated with each behavior. Use this list and compare or refer to your bird guides to look up or figure out particular species observed.

Adapted from Mark Musselman's "Bird Behavior Scavenger Hunt"
for Audubon at the Francis Beidler Forest, available at:
http://web4.audubon.org/states/sc/sc/PDFs/bird_behavior_hunt.pdf

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Teacher's Supplement 1.3

How to Use Binoculars

So, you're leading a bird walk. Great! You've probably realized that the birds don't always show up where and when you'd like. Or maybe the birds show up, but they don't get close enough to show you the markings that will help you distinguish between a Red-breasted Nuthatch and a Mountain Chickadee. Then the closer you try get the further they fly from you. Luckily, though, with a decent set of binoculars, you can view birds from long distances with surprising clarity. Follow these instructions to learn the best way to effectively use your binoculars and enjoy viewing the wonders of wildlife from a safe, secretive distance!

Think of binoculars as being two adjustable mini telescopes that work with our binocular (two-eyed) vision to see things that are far away with depth perception. Most binoculars have a standard design and can be used and adjusted in a similar fashion. Follow the instructions below to get started:

- First and foremost, always remember to **put the strap around your neck**! Binoculars have very precise, delicate pieces of glass and prisms inside of them and dropping a pair can permanently damage them. Also, keeping them around your neck makes sure they are always right in front of you when you need them.

- Remove lens caps. NOTE: Only use lens cloths that come with your binoculars to clean them. Never use your sleeve to wipe the lens as even soft cotton shirts can put tiny scratches on the lens and over time such scratches diminish clarity and visibility.

- Each individual eyepiece is adjustable at the *eyecup* to space the lens the proper distance from your eye. If you wear glasses, you want the eyecup fully retracted. If you do not wear eyeglasses, fully extend the eyecups on each lens by twisting.

- Adjust the distance between the eyepieces so that they are the right width and fit perfectly over your eyes. You should see one clear circle when looking through both lenses; if you see black edges in the view or overlapping circles with a blurry image your eyepieces are either too close together or too far apart.

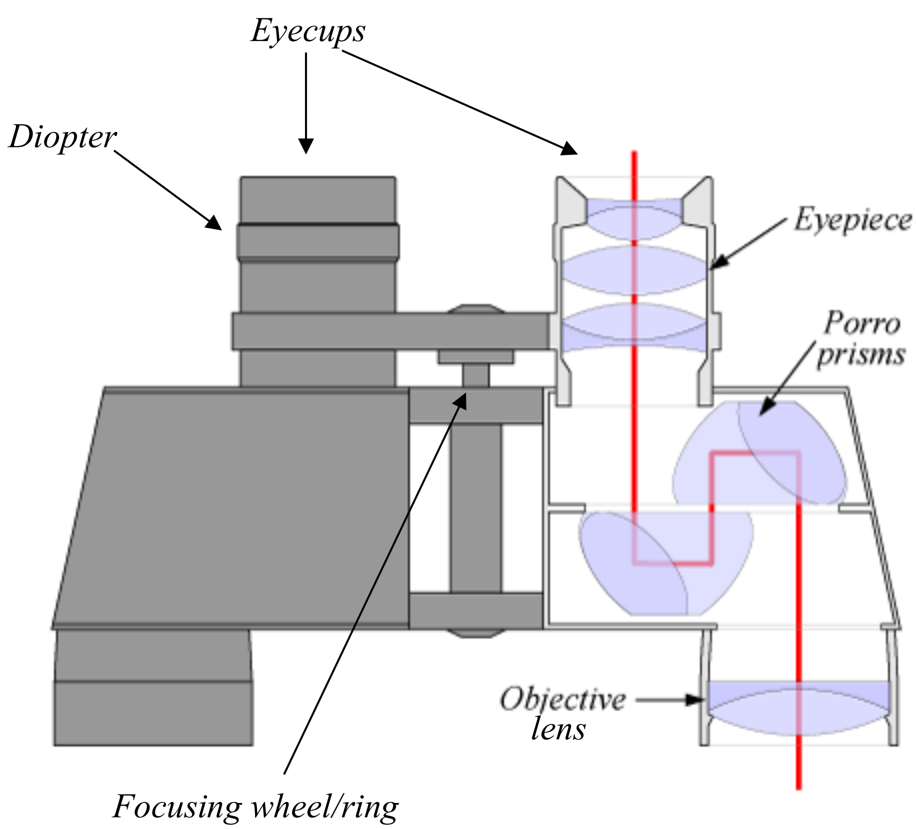
- Next, look through the binoculars and adjust the focus with the *focusing wheel* found in between the eyepieces to get a clear, sharp image.
    - For more customized focusing, first close your right eye or cover the right lens so you are only looking through the left eyepiece. Look at an object through the left eyepiece and adjust the focusing wheel until you see a sharp image. Then close your left eye or cover the left lens and look at the object with only your right eye. Adjust the *diopter ring*--located on the right eyepiece--until you get the sharpest image. For some people adjusting the diopter ring makes a significant difference, for others it can be subtle or even unnoticeable. NOTE: This customized focusing is good practice, but may be too nuanced and time-consuming for large youth groups.

- Now practice focusing on things at different distances. You will need to turn the focusing wheel one way to focus on objects far away and the other way to focus on near objects. The more you practice, the easier this will be and the faster you'll get at spotting and tracking that Lazuli Bunting that just shot by!

TIPS for finding a bird (or other subject/object) through binoculars:

- First, start by using your naked eye to spot a bird. Don't shift your gaze too much and look for movement among branches and leaves. Once you spot a bird lock your eyes on it. It can be helpful to also note any distinguishing physical feature near the bird that you can use as a helpful landmark (this could be a bright leaf or an oddly shaped branch).
- Then, without moving your eyes off the bird, bring the binoculars up to your eyes and align them with your view. Hopefully your eye will still be targeted right on the bird. You may need to use your landmark(s) to find it again, but by bringing the binoculars to your eyes without looking down to grab the binoculars your gaze should be aimed quite close.

Basic Binocular Anatomy



"What do the numbers on my binoculars mean?"

You may have noticed that your binoculars have a set of numbers on them such as "7 x 35", "8 x 42", or "10 x 42". What does this mean? The first number indicates the strength of magnification, so an 8 means the object you see through the binoculars appears 8 times closer than it would without the binoculars. Note: more magnification isn't always better here because the shakiness of your hands also gets magnified! The second number indicates the size of the *objective lens* measured in millimeters. The greater the size here means more light can enter the binoculars allowing you to see the object better. But, once again, bigger is not always better; the larger the lens, the heavier the binoculars will get! Birders commonly use 8 x 42 or 10 x 42 binoculars.

Plumas Audubon Society

UNIT 1: AWARENESS
Why Birds?

Lesson 1.4

Lesson Objectives:
- Practice making and recording detailed observations and make conclusions (identify bird species) from observations
- Learn about species' range and think about climate change may affect these ranges
- Practice using binoculars and field guides
- Learn about scientific illustration in field guides and create scientific illustration of an observed bird species

NGSS:

Middle School
MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
High School
HS-LS2-7. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Time: *30-60 minutes*

Materials:
- Plumas County Common Birds slideshow and a means to project or show in class
- Binoculars
- Field Guides
- Field Journal/notebook for observations

What's That Bird? Species Identification

Summary:
This is a student-driven lesson designed to teach about accurately identifying species. Students will spend time in the field making observations about birds and use field guides to help classify and identify the birds they see. Students will then research the birds they find to determine whether or not they are migratory birds and where else in the world they might be found.

Background:
With nine to ten thousand bird species in the world over 800 species of birds in North America alone, it can feel a bit daunting to identify birds to species. However, with a handful of basic tips and an eye for field marks—those characteristics of a specific bird that help identify it in the field—one can quickly become familiar with common species and even start to find it fun to piece clues together to identify more difficult species.

Scientists group birds into different "families" which can be a useful starting point for identification and, to a degree, can be somewhat obvious to even beginner birders. For example, your students will likely be able to tell an owl from a hawk, and a duck from a goose. Some field marks such as shape, size, proportions, and posture can help you place a bird into the right (or close) group. Encourage your students to use the Groups of Birds page in their Birding Journals regularly.

Some other aids for identification are touched upon in other lessons:
- *Lesson 1.2 Language of Birdsong* addresses the recognition of bird calls and songs which takes a lot of practice, but even beginners can become familiar with common and distinctive bird voices;
- *Lesson 1.3 Bird Behavior Scavenger Hunt* explores behavior; and
- *Lesson 2.1 Ecosystems, Habitats, Resources, and Survival* looks at habitats which are excellent clues in identification.

In this lesson we will focus on visual field marks and touch on range and season as identification aids.

Activity:
REVIEW PLUMAS COUNTY BIRDS
Before setting out on your bird walk, review the abbreviated checklist of common Plumas County birds on the back of the PAS Birding Journals. If you did not already do so in *Lesson 1.1 Why Birds Matter*, instruct students to check off the birds they have seen before --perhaps in their own backyard or schoolyard, but to leave the checkbox blank next those birds that they have never seen in real life.

***Educator Tips*:**
A slideshow of some common Plumas County birds can be found and downloaded at: http://www.plumasaudubon.org/birds-and-climate-change-curriculum.html

Review with the class the slideshow (see sidebar) of common Plumas County birds that students will likely have seen before or will likely see on a fieldtrip this year. With each bird, ask students to point out prominent markings on the bird, bill shape and size, and any other notable features of the bird. This is just the start of the practice of noting field marks. **Field marks** are visible characteristics in color and pattern of plumage, bill shape and size, body shape and size, flight pattern, habitat etc. that will help identify the species.

PARTS OF A BIRD
Now, turn to the "Parts of a Bird" page in the Birding Journal and allow students time to study the image and work individually or in pairs to fill in the blanks. After about five minutes, go over the answers to this page and instruct students to correct any labels where necessary.

LOOKING FOR FIELD MARKS
Pass out binoculars and field guides and head outside! Students can work individually or in groups of 2-3 and have at least one set of binoculars and one field guide per group.

Even if your students have never been birding before, they probably can identify a few very common species of birds. Start by asking students about different groups of birds. Use the journal page on bird groups. If your students have never been birding before, this can be a helpful resource for narrowing down the type of birds they see in the area.

Allow students at least 15 minutes to sit or walk through the area--quietly--to observe birds. Instruct students to make notes in their journal of which types of birds they see (eg. blackbirds, doves, finches, hawks). With each bird species, students should focus on recording specific field marks they notice--these can be physical or behavioral characteristics, and even habitat type. Again, field marks are visible characteristics in color and pattern of plumage, bill shape and size, body shape and size, flight pattern, habitat etc. that will help identify the species.

After the observation period, bring students all back to discuss and share observations:

- What kinds of birds did you see?
- Could any be confidently identified to species? What field marks helped with this identification?
- What field marks did different students notice about the same bird species?
- Did you see anything surprising?

HABITAT AND RANGE
Bring students back to the classroom. Assign or have each student choose one bird species to research, either from a list of identified species just observed in the field or from their checklist of common Plumas County species. Allow them

time to use field guides or online resources find out basic information about the bird to include in their Bird Journals using one of the "Field Notes" pages:

- The bird's full common name (eg. a robin's full common name is American Robin)
- What kind of habitat that bird tends to be found in, and
- Whether or not their species is migratory.

RANGE

All plants and animals live in a geographic **range**--where the species is found. Some bird species are **migratory** and so have winter and summer ranges, others are **resident** birds that can be found in a particular area all year round. Knowing where species tend to be found at which time of year is another helpful clue in identification and can help to rule out species that are not commonly present in a given location or at a certain time of year.

In their Bird Journals, have students turn to the "Range" page with a blank map of California. Using an online guide or field guide book for reference, students should outline or color in on the map the range of their bird. Have them shade the species' winter range and summer range in two different colors or shades, allowing for a mix of the chosen colors or a third color for areas of overlap.

CLIMATE

Birds are sensitive and adapted to particular climatic conditions (primarily temperature, precipitation, and seasonality), therefore, climate can play a large role in each species specific habitat requirements (some species are more tolerant and therefore can be found in a larger range of climates, while others need a very specific suite of conditions in order to survive) and, therefore, where they are found.

A change in climate may cause a species' range to move, expand, or shrink. If an area experiences a sustained change in temperature, precipitation, humidity, or any other climatic factor, the plants and animals living in that area will be affected. Some will be able to adapt, others will have to move, and still others—unable to adapt or move—will be either be extirpated (local extinction) from the area or go extinct.

Have students look up their focal species on climate.audubon.org to see if the bird's range is expected to shrink or shift in the future and to see if the bird is considered climate stable, threatened, or endangered. Students should again go to the "Range" page in their Bird Journals and, in two additional colors, outline or color in the projected future climatically suitable winter and summer ranges for their focal bird species.

Wrap-Up Questions:

- Is your bird species found in Plumas County year round? Where else does your bird species live?

- How far did your bird travel to get here?
- How long might your bird stay in this ecosystem? What might have brought them here?
- What sorts of behaviors did you witness from your bird?
- What might alter this bird's migration pattern in the future?

Extension:

Get to Know Your Bird Better - Draw It!

Students choose a bird species and then draw and color it. Taking the time to look at and reproduce the details of a bird will help students become much more familiar with it. Students will then be able to spot its field marks easier the next time they see the bird in real life.

Many field guides use illustrations as examples for readers. Authors and artists such as John James Audubon, David Allen Sibley, and John Muir Laws are all prolific artists whose works blend art and science to create guidebooks. Show your students some examples of these and encourage them to replicate a drawing based on a bird they've observed outdoors or hope to see.

Plumas Audubon Society

UNIT 1: AWARENESS
Why Birds?

Lesson 1.5

Lesson Objectives:
- Define "community science"
- Learn about and contribute to eBird, a community science initiative
- Understand that community science helps scientists and researchers make observations and conclusions about the effects of climate change on birds

NGSS:

Middle School
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
High School
HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Time:
Bird walk: *30-60 minutes*
eBird data entry: *10 minutes*
eBird exploration: *30 minutes*

Materials:
- Computer with internet access
- Projector screen (optional if doing as an entire class)
- Plumas County Birds checklist
- Handouts 1.5a and 1.5b

Community Science: Introduction to eBird

Summary:
Students will learn about the community science data and research that scientists are using to make conclusions about climate change and its effect on birds. They will observe and identify birds using the skills they've developed in this Unit, and then have the opportunity to add their data to eBird.

Background:
The Cornell Lab of Ornithology created eBird as an online database of bird observations providing scientists, researchers and amateur naturalists with real-time data about bird distribution and abundance. Anyone may contribute their observations to the database. The database's information is accessible to everyone around the world. eBird is an example of community science, where people like you, not just scientists, contribute information to help researchers collect more data and from a wider geographic area than they could collect alone. When tens of thousands of people submit their observations to eBird, it can help show migration patterns, resident vs. non-resident species, changes due to climate change, species distribution, or species abundance. Users can look at others' data to learn more about birds in an area of interest.

Remember the National Audubon Society's *Birds and Climate Change Report* mentioned in *Lesson 1.1 Why Birds Matter*? Data collected by amateur to expert birders alike (folks just like you) from two community science projects--the Audubon Christmas Bird Count (CBC) and the Breeding Bird Surveys (BBS)--contributed to this report! The observations you record on eBird can actually help real scientists answer important questions and make models that help us identify real-world problems and point to real-world solutions!

Recording the number of birds you observe is important
Taking a routine census of bird populations measures the distribution and abundance of species over time--the information from a census basically tells us *how many* of *which birds* are *where*. Doing so can help detect declines in a population, as well as detect and monitor at-risk or endangered species. Bird counts help track the populations of native birds and can help facilitate management plans for conservation and protection.

An estimation offers a lot more information for scientists than simply saying a bird was present. This is because in biological terms the lack, abundance, or any amount in between of a given species reveals information about the health of a particular environment. For example, the difference between 1 bird and 0 birds is presence and absence, a very significant difference. The difference between 1 bird and 10 birds may be a rare and unusual sighting versus a rather common occurrence. The difference between 10 birds and 100 birds may indicate something about the habitat or available resources in a location.

Question Prompts:

- What is community science? How can I become a part of it?
- Why is crowd-sourced information valuable? How might it be flawed?
- Why monitor a population of birds? What does this information tell us?

Activity:

PRACTICE COUNTING

Pass out and review the Tips & Tricks of bird counting on Handout 1.5a and then practice estimating numbers of birds individually, in small groups, or as a class using the photographs in Handout 1.5b in the Supplemental Materials. See sidebar for answer key.

Educator Tip:
Answers to Handout 1.5b:
A) 67; B) 102; C) 164; D) 62; E) 46
Note that these are estimates and so are approximate counts. Therefore, student estimates should be close to these, but do not have to match exactly.

GO OUTSIDE and COUNT SOME BIRDS!

Counting birds can be practiced whether you can accurately identify birds to species or not. Submitting your observations to eBird, however, does require that you you are confident in your ability to accurately identify the birds you report. Refer to the instructions and aid materials provided in the birding lessons earlier in this unit to help hone your identification and bird watching skills. If you do not feel confident in your ability to accurately identify birds, go outside and practice anyway. Practice, practice, practice is the name of the game when learning your birds. You can also consider inviting a Plumas Audubon Society volunteer along on your bird walk!

Head outside, making sure students bring their PAS Birding Journal or a notebook and a pencil along with them on your walk to record the birds they see, their counts, where, and what time of day. Remember to be conservative with your counts! For example, if you are traveling while observing, refrain from counting birds of the same species if you double back or return to the same spot at any point in your walk-- it is possible that these are the very same birds you saw and counted before! Use common sense and try to report the most accurate count you can.

Upon returning to the classroom, remember to only enter in to eBird those counts for which you feel your species identification is sound.

ENTER COUNTS IN eBIRD

Please keep in mind that it is important to accurately identify the birds you saw and counted before you enter your numbers in eBird.

1. Set up an account for your class on eBird.org by clicking on the green “Create an account” in the upper right-hand corner. Enter some basic information and then activate your account via the email sent to you from “Team eBird”.
2. Login to your eBird account and take your class through the submission process:
   a. Click on the **Submit Data** tab.

b. Type in or find on the map the location from where your observations came.
c. Then enter the date, type, time, duration, and number of participants of your observations and click **Continue**.
d. Enter any confirmed sightings into the species list, being as specific as possible with estimated numbers of species when doing so. Remember, you can always enter 'X' to indicate the presence of a bird if you are not sure of the count, but it is best to offer a count estimate and only enter '1' if you saw exactly one bird of a species. You can also click the "Add Details" button next to a species if you'd like to include any descriptions of the bird, its behavior, or its habitat or upload a picture or sound file of the bird.
e. Once you've entered in all your observation counts, answer the question at the bottom right-hand page whether you are submitting a complete checklist or not (you should usually check "Yes" here, but click the question mark button next to this question to review a description of when to select "No").
f. Click **Submit**, then review your entry and make any necessary edits before moving on.

EXPLORE eBIRD

Allow your class time to navigate around this website and explore the different ways to view these community science observation data.

1. On eBird, go to the **Explore Data** tab at the top search bar. This will let you view ways in which eBird is used to share data.
2. Select a search criteria. Choices include:
   a. Explore species
   b. Explore a region
   c. Species maps
   d. Search photos and sounds
   e. Explore hotspots
   f. Bar charts
1. To start, choose either "explore a region" or "species maps". "Explore a region" will allow you to search all species and sightings in a given area (eg. "Plumas, California, US") and "species maps" will show you where specific birds have been seen.
2. Allow your class time to navigate around this website and explore the different ways to view community science observation data.

COOL STUFF YOUR DATA DO

As mentioned earlier, the data submitted into eBird by community scientists is used by researchers to answer a variety of questions and study bird abundance and migration, among others. Check out some of the ways scientists have modeled these data:

Explore samples of eBird's Abundance Models by selecting the **Science** tab at the top of the page and then clicking the **Explore eBird Status and Trends**

Check it out:
eBird Abundance Models available at:
https://ebird.org/science/status-and-trends

Did you know…
"Community science" is a newer, more inclusive term adopted by Audubon in place of the better-known term "citizen science" which is still widely used.

button. Click on various species to look at abundance maps and to watch an animated model of the migration and relative abundance of some species. See if your students can estimate what time of year they might get the rare chance to see a Purple Martin in our area.

Follow-up Discussion

- Why did we see the birds that we saw today? Why are certain birds more common in different places at different times of the year?
- Using field guides, have students look up different species that might be found in the same area at a different time of the year.

Extension:

eBird can be an effective way to research birds without leaving the classroom. An abundance of data makes it easy to see when and where certain birds were recently seen. This can be a helpful tool if your class is studying a specific type of bird. You can even use the data to estimate when to look for migratory visitors. After you get comfortable using eBird, try to check it before bird walks to get an idea of what you are likely to see out there and then submit your accurately identified observations when you return.

MAKE IT A HABIT

Extend this lesson into a weekly or monthly bird count project in one or a few locations to more consistently monitor bird populations in your area. Students will become very familiar with using eBird and are thus, more likely to continue the practice of community science even beyond class.

MORE COMMUNITY SCIENCE OPPORTUNITIES

Encourage participation in other local bird counts and community science projects. There are many community science projects that your class can participate in for a class assignment, extra credit, or just for fun! Below are just a few ideas for community science projects focused on or involving birds, but there are many more out there:

- **Christmas Bird Count** (National Audubon Society): The longest running community science project in the world, this is a census count of bird species in the Western Hemisphere, performed annually between December 14 to January 5. Birders of all skill levels search for as many species as they can identify in a 15-mile diameter circle within a 24 hour period.
  https://www.audubon.org/conservation/science/christmas-bird-count
- **Great Backyard Bird Count** (Cornell Lab of Ornithology and National Audubon Society): Over a four-day period in February this global event involves bird watchers of all skill levels watching birds for at least 15 minutes and submitting their observations on eBird.
  http://gbbc.birdcount.org/
- **Project FeederWatch** (Cornell Lab of Ornithology): This winter-long (November-April) survey of birds that visit feeders at backyards,

community areas, and other locales in North America involves participants periodically counting the birds they see at their feeders and sending in their counts to Project FeederWatch. https://feederwatch.org

- **Climate Watch** (National Audubon Society): Climate Watch occurs over two distinct thirty-day periods each year, in the winter non-breeding (Jan 15- Feb 15) and in the summer breeding (May 15- June 15) seasons. Participants conduct 12 five-minute bird surveys in one day, recording and counting all the birds they can identify within 100m, with special focus on a bluebird or nuthatch species, to help track range changes. https://www.audubon.org/conservation/climate-watch
- **BioBlitz** (various organizations): A BioBlitz is an intense period of biological surveying in an attempt to record all the living species within a designated area. Look for one happening in your area!

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Handout 1.5a

BIRD COUNTING TIPS & TRICKS

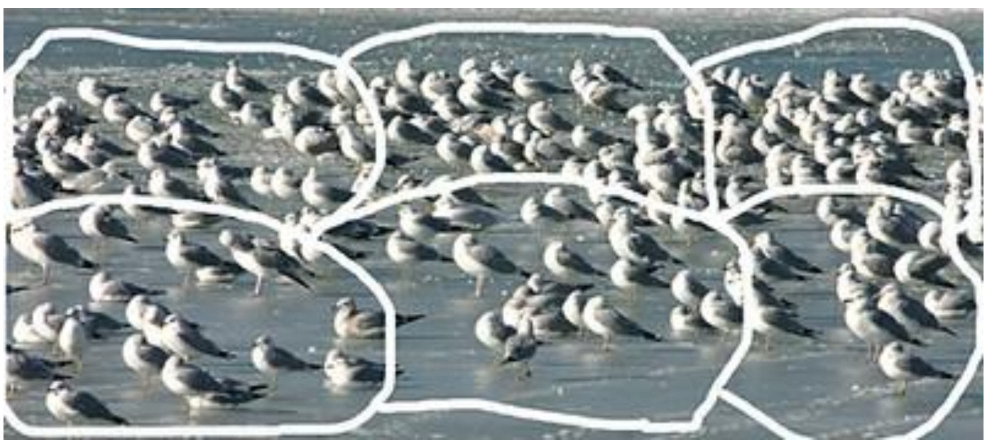
- Write it down: Don't go birding without bringing along a notebook and pen or pencil. Get in the habit of recording what you see, how many of each species you see, where you see them and when. Doing so is easier with a birding checklist-- you can check off species quickly as you go and tally the number you see along the way. This also makes it easier for you to add your count to eBird!
- eBird recommends erring on the conservative side:

  ...If you see a male Northern Cardinal in the first five minutes of your walk, and then see a female later, your count would be two. But, if you see a male Northern Cardinal in roughly the same place on your way back we'd recommend leaving your count at one. While it is possible that two male Northern Cardinals were present, it's best to be conservative. If you saw a male Northern Cardinal at the beginning of your walk, and then another .5 miles away, you should safely count two!
- Counting **flocks:**
  - Relatively small stationary or moving flocks might be easy enough to count individually. Larger flocks, however, may be more challenging.
  - Count in timed increments: if many birds are moving past a location over a period of time (during migration for example) try counting and recording every 15 minutes. It is easier to keep track and add up a grand total at the end of your watch.
  - Count in smaller groupings within a flock to get a size estimate and apply to the entire flock:

Counting 10 in a small section of the flock (circled area) allows us to get a sense of how much space 10 birds in the flock occupies. Then we can apply that rule to estimate the count in the whole flock.

- Remember you are observing birds in three-dimensional space! There may be more birds in a similar sized section if they are farther away in space:

This clump contains 25 birds.



Here is the group divided into similar sized sections visually.

The groupings in the background contain nearly twice as many birds in the foreground!

Images and info from https://ebird.org/news/counting-101/

Handout 1.5b

Practice Counting Birds

Estimating the number of birds in a large group can be tricky. A helpful tip is to break a large flock into visual sections that roughly contain the same amount of birds in each. If you have a pretty good idea of what 10 birds looks like out of a larger group, you can visually divide a big flock of birds into multiple groups of ten birds. Use these images to help you practice estimating.

A) There are 10 birds circled. Use that information to quickly estimate how many birds are pictured.

Photo: Chesapeake Bay Program via Flickr, 2010, Flock of Canada geese flying at sunrise

B) Draw out your own clump of ten birds and estimate the total number of birds in this photo.

Photo: Mick Thompson 2017, Short-billed Dowitchers

C) Circle a clump of 25 birds. Use this to estimate the total number of birds in the photo.

Photo: Mick Thompson 2012, Snow Geese in the Skagit Valley

D) Using the method practiced above, estimate the total number of birds in this photo (hint: this photo has a foreground and a background! Birds in the foreground appear larger than those in the background!)

Photo: Mick Thompson 2016, Snow and Ross's Geese

E) Last one...the furthest birds in this photo just look like dots in the sky!

Photo: Teresa Arrate 2018, Cliff Swallows from Stampfli Lane, Indian Valley

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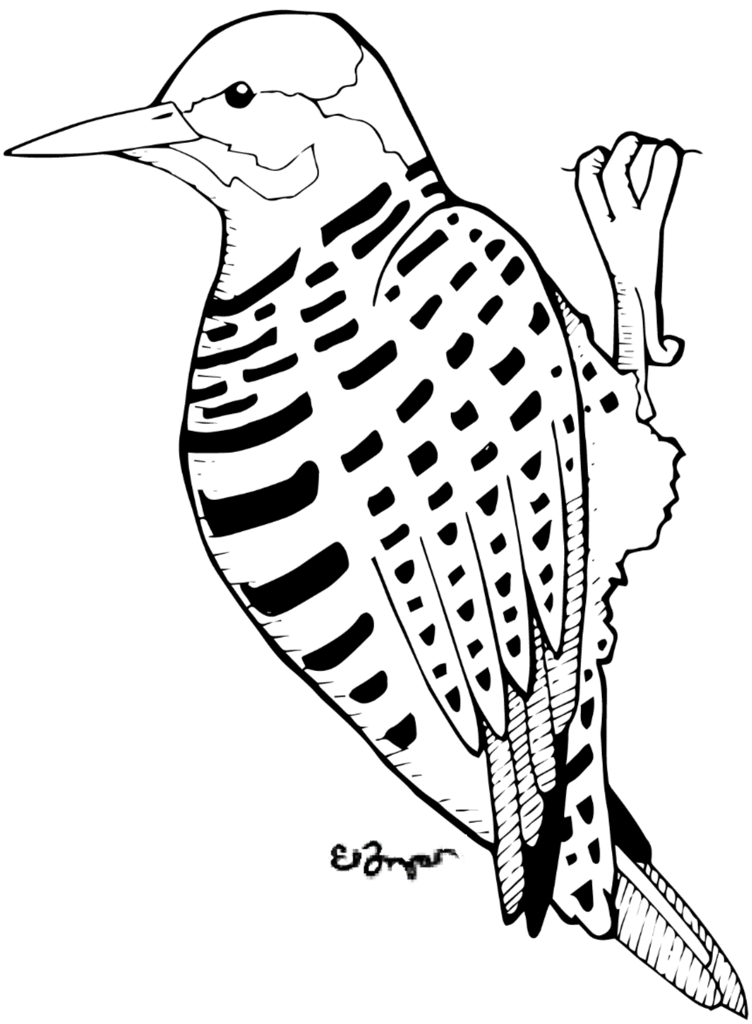
"*Let us live in a way that Earth will be grateful for us*."
— Robin Wall Kimmerer[2]

Unit 2: RELATIONSHIP
Habitats, Resources, and Reciprocity

- Lesson 2.1: Ecosystems, Habitats, Resources, and Survival
- Lesson 2.2: Relationships in Ecosystems
- Lesson 2.3: Environmental Reciprocity
- Lesson 2.4: The Human Relationship to Water
- Lesson 2.5: Sage-Grouse Debate



[2] Kimmerer is an author, Professor of Environmental and Forest Biology at SUNY-ESF Syracuse, and founding Director of the Center for Native Peoples and the Environment. She is a practitioner and proponent of Traditional Ecological Knowledge.

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Plumas Audubon Society

UNIT 2: RELATIONSHIP
Habitats, Resources, and Reciprocity

Lesson 2.1

Lesson Objectives:

- Define "ecosystem" and "habitat"
- Identify characteristics of a healthy ecosystem
- Observe and discuss ways in which birds rely on the environment for their survival needs.
- Learn how different species rely on habitats that provide specific conditions and resources for survival

NGSS:

Middle School
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
High School
HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Time: *30 minutes*

Materials:

- Field journals and pencils
- Binoculars (optional)

Ecosystems, Habitats, Resources, and Survival

Summary:

A habitat is an area that provides enough food, water, shelter, and space for organisms to live and reproduce. This activity will help students explore the habitat needs of birds and make inferences about the birds that inhabit the area and their behaviors. This activity will help students gain background knowledge and understanding for creating a Bird-friendly and Climate-wise habitat in their schoolyard or learning landscape in Unit 5.

Background:

An ecosystem is made up of living (biotic) and non-living (abiotic) elements interacting in a given area. Ecosystems exist at all scales: areas as small as a community of microorganisms in a puddle to as large as the entire Earth can be considered ecosystems. Ecosystems involve the complex interaction of living things (plants, animals, fungi) and nonliving things (water, minerals) in a single, defined space. The different areas in an ecosystem where organisms find the resources they need to live are called habitats. An ecosystem contains many habitats. For example, in a forest ecosystem, there are habitats along river corridors, habitats in meadows, habitats along high mountain ridges, habitats at low elevations, and even underwater habitats all within one section of forest. You would not expect to find the same composition of living and non-living things in every habitat. Some examples of habitat types are described below:

Forest and Woodland- Areas that are mostly tree covered, although they should contain a diverse array of smaller shrubs and herbaceous plants. A woodland is a low-density forest with more space between tree canopies. Forests and woodlands are tiered ecosystems, containing a canopy, mid-layer, understory, and floor. Different bird species prefer different layer types; your class may notice certain species stay primarily in the canopy while other species stay closer to the forest floor, depending on their ecological niche.

Meadow- Dominated by grasses and flowers, meadows act like a sponge, soaking up and storing water. During rain or snowmelt events, meadows often have small creeks running through them. Most wildlife in meadows is present in transitional zones around the edges. However, many ground nesting birds prefer habitat in the dense grasses within the meadow. Insect larvae found in pools or damp soil provides an excellent food source for many birds.

Wetland- Characterized by water, wet soil, and extremely water tolerant plants, wetlands are important bird habitat because they offer protection from land predators as well as food sources like fish or amphibians. In Plumas County, most wetland habitat occurs at inlets of lakes or ponds. Large valleys (like the Sierra Valley) have some of the largest wetland habitat in Plumas County.

Riparian- Habitat found along a river or creek corridor is considered to be in a "riparian zone". Like woodland areas, riparian zones have layers that change based on the plant and tree cover available. Since riparian areas are home to plant species that are more water tolerant, they often attract different bird species.

The various habitats provide the resources (food, water, shelter, space) for every living thing within the ecosystem. Organisms have different needs for **water** and **food** (what kind, how much, how often). **Shelter** (or cover) refers to the availability of protection from weather or predators, as well as a place to raise offspring. **Space** simply means that there are enough of these resources in a given area to support a certain amount of individuals. In general, the larger the organism, the greater their need for space.

Humans are part of some (but not all) ecosystems and affect, directly and indirectly, habitats and entire ecosystems through our land use and energy and resource consumption. Some birds are able to adapt to human created changes to their ecosystem. For instance, Cliff Swallows and Rock Pigeons have learned to nest on awnings of buildings rather than their natural habitats of cliffs and rock outcrops. Other species have a more difficult time surviving when humans make or cause changes to the environment.

In the age of climate disruption it is virtually impossible to find an ecosystem unaffected by humans. However, we can still find healthy, undeveloped areas where habitats are close to their natural conditions. Such areas can offer us a good reference point for how a healthy ecosystem should function and how to recreate some of this function in our built environments (see Unit 5 for more on this).

Questioning Prompts:

- What resources do all living things need to survive?
- How might climate change affect the resources in an ecosystem?
- How are ecosystems different? How does this affect the species living there?

Activity:

LEARNING FROM NATURE

Take your students to an outdoor space with their journals and explain that we are going to try to learn *from* nature rather learn *about* it. Ask them to first just take in, with as many of their senses as they can tune into, the entire ecosystem in which they are standing for a few moments. Help guide their visual and auditory attention to both the living and non-living parts of the ecosystem (trees, other vegetation, insects, wildlife, rocks, streams, etc). Then ask them to identify different habitat types they can see around them. As a group, consider and take note of the following questions:

- What kind of organisms do we see here? What kind of organisms might live here even if we don't see them right now?
- How are living organisms' needs being met here? What resources are they taking advantage of?
- Do these resources appear to be in a healthy state? Why or why not?
- Are these resources abundant or scarce here?
- What challenges are the organisms living here faced with?
- What opportunities are they offered in this place?
- What kinds of adaptations might different organisms have to be able to live here?
- If this area were to receive less precipitation in the future, what would happen to the various resources it currently offers?
- How might a shift in seasonality (eg. shorter or longer seasons) affect the organisms living here?

If any birds are present, ask students to spend a few minutes watching a bird. Ask them to pay careful attention to what the bird is doing and where it is doing it. The important thing to emphasize is the relationship of the bird to other parts of the habitat. Immediately following the observation period, have students note in their journals what they observed and then ask students to share some observations as a group.

<u>A BIRD'S PERSPECTIVE</u>
Now ask your students to imagine that each of them is a bird--any species of bird they might imagine utilizing the ecosystem you are standing in. Ask the students to think silently about the following questions, giving some pause between each question as you ask them to allow students time to answer the question in their imagination:

- What kind of bird are you?
- What are you doing in this particular ecosystem or habitat?
- Where do you find food? What kind of food?
- Where do you get water?
- Where do you sleep?
- Is there anything that might try to eat you? Where would you hide if something was coming for you?
- Where do you lay your eggs? How do you protect your babies?

Pair students together and have them interview each other, asking the same questions. Allow each pair some time to share, then share ideas in a large group. Highlight any major differences you might hear along the way.

Check for understanding: all students should know that species cannot survive in a habitat without enough food, water, shelter, space.

If time and resources allow, offer this activity again at another location in a different ecosystem/habitat type and then ask the students to compare and contrast the various ecosystems/habitats that were visited. Did they notice any differences in community composition (ie. the kinds and numbers of plants and animals found together in an area)?

Extension Activity:

MAPPING A HABITAT

Tell students that they are going to create a detailed map of the area, paying special attention to ways in which the area helps to meet habitat needs of birds and other wildlife. Ask them to draw the map from a bird's eye view and include features of the habitat that would help a bird survive in the wild. They should label at least five of the habitat features on their sketch and what type of resource need each helps fulfill.

After students complete their drawings, but while you are still outside, ask them to spend a few minutes watching a bird. Ask them to pay careful attention to what they bird is doing and where it is doing it. The important thing to emphasize is the relationship of the bird to other parts of the habitat. Ask students to share what they observed. Were there any similarities?

Plumas Audubon Society

UNIT 2: RELATIONSHIP
Habitats, Resources, and Reciprocity

Lesson 2.2

Lesson Objectives:

- Define "biodiversity".
- Define types of relationships in an ecosystem; understand how different types of relationships can influence a system.
- Explain ways in which energy flows through an ecosystem, and how matter cycles within it.
- Understand how parts of an ecosystem are related.

NGSS:

Middle School

MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

High School

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Time: *30 minutes*

Materials:

- Reading 2.2

Relationships in Ecosystems

Summary:

Students read a story about how energy enters and travels through an ecosystem, starting with the sun and moving through different organisms. The story exemplifies both energy and matter cycling through an ecosystem. Students will then take a walk outside (this part of the lesson can be added to a longer bird walk if desired) and identify types of relationships in the local ecosystem, considering how these relationships may change with climate change.

Background:

All life on Earth is connected in a diverse and complex web. **Biodiversity** is the variety of life that exists on Earth or within a defined area, including the diversity within species (genetic diversity), between species (variety of different species), and of ecosystems. More biodiversity in an area offers a healthier, more productive, and more resilient ecosystem and world.

Relationships in ecosystems are complex. Organisms both compete and cooperate for available energy (food) and resources in an ecosystem in order to survive and reproduce.

Here are the types of ecological relationships between species in an ecosystem:

- **Mutualism:** A reciprocal relationship that benefits both species; aka cooperation.
  - EXAMPLE: Birds and plants have a mutualistic relationship: birds feed on fruits and berries of plants, and then scatter the plant's seeds in their feces, allowing new plants to grow.
- **Competition:** Two organisms, within or between species, compete for one resource. In some cases, competition leads to one species outcompeting the other, causing displacement, extirpation, extinction, or evolution (long-term).
  - EXAMPLE: Two or more males of the same species may compete for one female mate (intraspecies competition). The Allen's Hummingbird is a climate-endangered species facing a significant reduction in range due to climate change. This range reduction may force the birds into the territory of other hummingbird species, like that of the Anna's Hummingbird, where they may be out competed for resources (interspecies competition).
- **Predation:** One organism, the predator, eats the other, the prey.
  - EXAMPLE: The Osprey is a large predatory bird (bird of prey) or raptor. Ospreys prey (hunt and feed) on fish and small mammals.

Did you know…
Unfortunately, biodiversity is currently being lost at an unprecedented rate with experts estimating this loss at 1,000 to 10,000 times higher than the natural extinction rate.

The International Union for Conservation of Nature (IUCN) is the largest environmental network composed of government and civil society organizations working to ensure the conservation of nature and the equitable and sustainable use of natural resources.

The IUCN manages and updates the Red List of Threatened Species (www.iucnredlist.org) which has become the most comprehensive inventory of the global conservation status of animal, fungi and plant species, serving as a critical indicator of the health of the world's biodiversity.

- <u>Parasitism</u>: One organism, the parasite, benefits from the relationship while the other, the host, is harmed, sometimes weakened and killed.
  - EXAMPLE: Cuckoo birds and cowbirds lay their eggs in the nest of another bird, sometimes shoving the host bird's eggs out of its nest to make room for their own. Unbeknownst to the host bird, it warms and cares for the eggs of a foreign bird rather than its own.
- <u>Commensalism</u>: One organism benefits from the relationship while the other is unaffected.
  - EXAMPLE: When a bird builds a nest in a tree, the tree is unaffected, but the bird gains shelter and protection from the tree's structure.

All life forms on Earth are connected, directly or indirectly, through communications, energy flows, and relationships in ecosystems. Humans are part of these connections and these connections are a part of us: we are dependent on biodiversity to provide things like clean air and water, soil and food, building materials for infrastructure, medicines, cultural perspectives and practices, livelihoods and economic development, natural spaces for recreation, and much, much more.

As part of Earth's web of life, humans have a responsibility to protect and preserve the planet's rich biodiversity. Many practices in modern human life--like the burning of fossil fuels--disrupt the delicate web of life. Human-induced climate disruption is affecting biodiversity in communities large and small around the world. What happens when the complex relationships in a given ecosystem are disrupted?

Long-term studies show many European and North American birds, other wildlife, and plant species are shifting their distributions pole-wards (northwards in the Northern hemisphere). In 2006, National Audubon Society's scientific analysis of 40-years of Christmas Bird Count data and winter temperature patterns in January demonstrated a 4.5 degree Fahrenheit increase over the contiguous U.S. over the 40-year period (1966-2005) and found that 68% of the 305 species found in North America in winter are on the move, shifting their ranges northward by an average of 35 miles (shifting northward almost 1 mile per year). Additionally, we are seeing earlier egg laying and earlier migration, which is problematic when these shifts throw birds' life cycles out of synchrony with the plants and insects that they depend on.

As species shift their range, they are unlikely to move as an intact community unit, so we will see disruptions of predator-prey, competitive, parasitic, commensalistic, and mutualistic relationships. The consequences of such disruptions are largely unpredictable, but are likely to alter the functioning of most ecosystems the world over. Species inhabiting a new range will alter both the ecosystem they left and the new environment they enter. Climate change is already disrupting these interactions through changes in the abundance of interacting species, the quality and quantity of food supply, and timing of biological processes. BirdLife International and Audubon suggest that the effects of these interaction disruptions caused by climate change have probably been more significant than the direct impacts of rising temperatures and other climatic shifts.

As climate change causes ecosystem disruptions and loss of biodiversity, the capacity for ecosystems to respond to and recover from additional stress or disturbance is reduced. To protect the resilience and health of ecosystems, conservationists are seeking ways to protect habitats, as well as the species and functional ecological relationships within them.

Questioning Prompts:

- What are types of relationships exist in nature?
- Where does all energy come from? Can it be lost along the way?
- How does energy and matter move through the ecosystem?
- What sorts of ecological relationships do you observe in the ecosystem around you? What sorts of ecological relationships do you have with your environment?

Activity:

1. Discuss the various types of interspecific (between species) ecological relationships. Use the questioning prompts above to facilitate.

2. Individually or as a group, have your students read the story “The Seed, the Deer, and the Mountain Lion” (Reading 2.2). After reading have students work individually or in groups to identify and write down the different types of relationships in the story.

3. Next, take a walk outside. Identify and keep a list of the different types of relationships (competitive, predator-prey, mutualistic, parasitic, commensalistic) you can see in your immediate environment.

4. Now think about the birds you see and hear on your walk.
   a) What are the relationships among different bird species that live in the same ecosystem?
   b) What are their relationships with other types of organisms in the ecosystems?

Journaling/Discussion Prompts:

- On your walk, did you observe all five types of interspecific ecological relationships? If you missed any types, what do you imagine an example of such a relationship in that ecosystem would look like?

- Where do we come in? What type of relationship do humans have with the environment? Describe a few examples of the types of relationships humans have with other organisms in the environment. How could these relationships change?

- Consider the movement of energy and matter through an ecosystem and all the various interconnections between different organisms. What kind of broader connections about geology, geography, history, culture, and so on, can you make with this phenomenon? What does it mean to say that everything is interconnected?

- Imagine all of these connections as a complex spiderweb. The strength of this web lies in the great diversity of connections and relationships. Now imagine a second spiderweb, but this one has far fewer interconnections. What happens to each of these webs when disturbed? Which do you imagine to be more resilient?
- Now consider the real web of life: how might relationship/interaction disruptions affect the various organisms, including humans, of a given ecosystem? Of the world?

Reading 2.2

The Seed, the Deer, and the Mountain Lion: A Web of Life story.

By Michael Hall

In the springtime, the warmer temperatures and longer daylight hours signal to a grass seed that the seasons are changing and that it is time to start growing. As the seed sprouts, it uses sunlight to grow. This growth takes carbon from the atmosphere and minerals and water from the soil to build cells. This grass, along with many others in the meadow, helps keep moisture in the soil and filter and slow the water that passes through. After several days a young mule deer walks through the meadow, carefully watching the edges of the meadow for predators. She sees the young grass shoot and eats it slowly. Eating this grass will give her energy to live, and the sugars will be converted into cells, which will help the deer grow to full size.

After many weeks and meals the deer has grown larger, now moving quickly and confidently through the forest. She has ticks buried in her skin. Biting flies circle around her. These insects will eat small parts of the deer, but in such small quantities she hardly notices. She hardly notices either, the California Scrub-Jay eating the ticks off her back. While she drinks from the cool, clean stream of snowmelt, she does notice the sudden departure of her blue avian friend as a large mountain lion creeps slowly towards her along the edge of the meadow. But she barely has time to react before the lion pounces, snapping her neck in one powerful motion.

The deer is now deceased and is carried off by the mountain lion. The large cat eats what he can, then drags the rest to a cache underneath a downed log. Summer is here and the lion knows that there will be many deer out in the coming months. Inside the mountain lion, the deer meat is slowly digested and converted to energy, which is used to help the mountain lion grow stronger and larger. Inside the mountain lion, a small creature no larger than a strand of thread is moving in its intestine. This tapeworm has been living here for weeks now, after hatching from an egg on a piece of scavenged meat the cat ate earlier. It is quickly growing larger and taking an increasingly greater portion of food that the lion has consumed.

Months go by and the lion continues its life in the mountains. Yet for some reason, hunting has been more difficult for him; he feels weak and malnourished. He is losing weight. The deer are too quick for him; he becomes hungry and desperate. It has been many weeks since his last full meal. The tapeworm inside of him continues to consume the lion as a resource. Eventually, the lion is too weak to hunt, he lays down in a shelter near a cliff band. Growing increasingly weak and sickly, this is the last place the lion will lie. He dies several days later.

As days go by, the lion carcass begins to decompose. The smell of rotting meat attracts ravens, bear, coyotes, skunk, and a variety of insects. These organisms feed on the dead lion, anxious to consume whatever food they can before it disappears completely. The lion is quickly consumed, and many animals lose interest in scavenging what little energy remains here. Eventually, microorganisms are all that remain, slowly breaking down the remains into chemical and mineral form.

Time passes and grasses sprout from the place where the lion died. These seeds thrive in the abundance of nutrients left here after the body decomposed. These young sprouts are tender and nutritious; they attract a family of deer. Cautiously these animals eat the grasses. The energy here will help them survive and grow in the forest. One of these deer will soon feed the family and friends of a human hunter.

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Plumas Audubon Society

UNIT 2: RELATIONSHIP
Habitats, Resources, and Reciprocity

Lesson 2.3

Lesson Objectives:
- Learn about and discuss the concept of environmental reciprocity, taught through American Indian teachings and perspectives.
- Review ecological relationships and think about the kinds of relationships humans have with their ecosystem.
- Consider and explain how their actions affect the environment.

NGSS:

Middle School
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
High School
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Time: *60 minutes*

Materials:
- Media player/computer with internet access
- Readings 2.3a, 2.3b

Environmental Reciprocity

Summary:
Daily actions affect the environment and humans have a moral obligation to try to regain a balance with the natural world. The term "**environmental reciprocity**" comes from the idea in indigenous philosophies --from Native American cultures and many native cultures across the globe-- of balanced and mutual interactions and exchanges in communities, not only among people, but also between people and their natural surroundings.

In this lesson, students will connect the principles of American Indian philosophy on human and land relationships to their everyday lives, thinking about how we use the land today, what our current relationship is with the Earth, and what we can do to establish a more mutually respectful relationship with our environment.

First, students will listen to and read Chief Seathl's speech in which he expresses the American Indian belief that humans-- just as plants, animals, mountains, and rivers-- are part of the environment. Then students will read an Abenaki story which describes hunting rites and rituals, showing how the Abenakis respected and gave back to the environment, living in harmony with each other and the natural world.

Background:
American Indian philosophies have certain dominant themes that are common to many native cultures, including the Mountain Maidu. One of these themes is the belief that humans are a part of and connected to their environment. Chief Seathl (European settlers changed the spelling of his name to "Seattle"), an American Indian leader of the Duwamish Nation, gave a speech in response to the proposed Treaty of Point Elliott, under which the Indians were to sell two million acres of their land for $150,000 to European settlers. His powerful speech communicates the idea that humans are just one link in a greater web of life on earth and that they could not *own* the land because they are a *part* of it. The treaty was signed in 1855 and ratified in 1859 establishing the US government's ownership of the Washington Territory and creating reservations for the Native American tribes of the Puget Sound region.

His speech was given in the Duwamish language in 1854. No written original exists: only the transcription in English by Dr. Henry Smith who was in attendance. Because of this, there are many versions and interpretations of the speech. The version your class will hear is interpreted and narrated by Wes Felty. Additionally, excerpts are provided in Reading 2.3a, which will help guide class discussion and reflection. Please note that the video and the written versions provided here are not exactly the same.

After watching/listening, reading, and discussing Chief Seathl's speech, move on to the "Journey the the Abenakis" story, which presents a snapshot into the hunting rituals of the Abenaki tribe who once occupied the region which is now Vermont. The story demonstrates sustainable living practices and philosophies that we can learn from and adapt to our own sustainable living practices in modern daily life showing respect and gratitude for things in nature that we need to survive--the gifts of nature.

Activity

1. Define **reciprocity**. Reciprocity is the practice of exchanging things with others for mutual benefit. Discuss what the meaning or the class's understanding of the term "**environmental reciprocity**" may be.
2. Review the ecological relationships discussed in Lesson 2.2 *Relationships in Ecosystems*:
   - Mutualism: A relationship that benefits both species.
   - Competition: Two organisms, within or between species, compete for one resource. In some cases, competition leads to one species out competing the other, causing displacement, extinction, or evolution (long-term).
   - Predation: One organism, the *predator*, eats the other, the *prey*.
   - Parasitism: One organism, the *parasite*, benefits from the relationship while the other, the *host*, is harmed, sometimes weakened and killed.
   - Commensalism: One organism benefits from the relationship while the other is unaffected.
3. Based on the relationships that exist in ecosystems, ask the class what kind of relationship we as humans have with our environment and discuss why. What kind of relationship would we like to have with our environment? How could we change our relationship with our environment?
4. Play the youtube video of Chief Seathl's speech: https://www.youtube.com/watch?v=e9a70fz6420&t=311s (6:19 min)
5. In addition, or as an alternative, have students read the excerpts of Chief Seathl's speech from Reading 2.3a either aloud as a class or silently to themselves. In discussion, you will want to have students read sentences aloud as they reference the text.
6. After discussing Chief Seathl's speech, have students read silently or read together as a class "Journey with the Abenakis" from Reading 2.3b.
7. Discuss the story using the discussion questions below as a guide.
8. Wrap the discussion up with a reflection on how these two pieces are connected and define environmental reciprocity and sustainability.

Educator Tips:

- This lesson refers to the ecological relationships covered in *Lesson 2.2 Relationships in Ecosystems*, but it is not mandatory to teach Lesson 2.2 before or along with this lesson.
- This lesson can also double as a language arts lesson: the discussion is a guided literary analysis of Chief Seathl's speech.

Educator Tip:

- If video screening is unavailable, playing the audio of the Youtube video is acceptable.

Discussion:

QUESTIONS FOR CHIEF SEATHL'S SPEECH

- What is/are the theme(s) of the speech?
- How would you describe the tone and mood of the speech? How does the speaker establish this tone and mood?
- What types of literary devices does the speaker use? To what effect? Ask students to give examples of literary devices and analyze. What does the use of that particular literary device bring to the speech? Examples of literary devices to include (but not limited to):

    - simile
    - metaphor
    - personification
    - imagery
    - foreshadowing
    - figurative vs. literal language
    - synecdoche

- Chief Seathl's speech was given over 150 years ago and talked about how American Indians historically lived off and with the land. How do we live off the land today? Do you think we have the same relationship with the land in modern life? Do we use the land more or less than Chief Seathl's people?

QUESTIONS FOR "JOURNEY WITH THE ABENAKIS"

- What are the rituals surrounding the hunt?
- Can you think of any comparable present-day hunting rituals, routines, or practices?
- How do the hunters in the story help maintain a balance with nature?
- Can we relate the lessons of silence, respect, sharing, and circles to the ways we use the Earth to survive other than hunting? In what other contexts is it important to remember these lessons?
- What other resources do we use from nature?
- What is the difference between wants and needs?
- How can we use these resources sustainably to maintain a balance with nature? Answer keeping the story's lessons of silence, respect, sharing, and circles in mind.

Reflection:

Reflection on broad concepts can be discussed in class or as journal or essay assignments:

- How do Chief Seathl's speech and "Journey with the Abenakis" relate to each other? What are the shared themes in each piece?
- What is environmental reciprocity?
- What kind of relationships (competitive, predatory, parasitic, commensalistic, mutualistic) do we as human beings have in our local

ecosystem? What kind of relationships do we as human beings have with the environment as a whole?

- People's connections to the places where they live affect how they interact with and treat the environment and its inhabitants. In general, how would you characterize U.S. society's sense of connection to and respect for the land? How would you characterize your own community's sense of connection to and respect for the land? How would you characterize your personal sense of connection to and respect for the land?
- How are you part of the web of life? How do you use the land in your everyday life?
- How can we reciprocate the gifts of the Earth? What can we do to express appreciation and respect for the Earth and all it provides us?

Extension:

QUESTIONS FOR A RESILIENT FUTURE: ROBIN WALL KIMMERER

Watch or listen to the story of Sky Woman, Turtle Island, and snapping turtle climate refugees told by Robin Wall Kimmerer, Professor of Environmental and Forest Biology at SUNY Syracuse and founding Director of the Center for Native Peoples and the Environment. The story offers an excellent illustration of gratitude, reciprocity, and the need to take notice and take action in our ongoing climate change story.
https://www.youtube.com/watch?v=y4nUobJEEWQ (16:56 min)

Michael J. Caduto and Joseph Bruchac: "A Journey with the Abenakis." *Keepers of the Earth: Native American Stories and Environmental Activities for Children*. p 169-170. Fulcrum Publishing, 1997. Reprinted with permission.

The Center for Indian Community Development. *Environmental Protection Native American Lands: A Cultural Approach to Integrated Environmental Studies.* Humboldt State University: Arcata, CA. 1995.

Reading 2.3a

Excerpts from Chief Seathl's Speech, 1854

How can you buy or sell the sky, the warmth of the land? This idea is strange to us.

If we do not own the freshness of the air and the sparkle of the water, how can you buy them?

Every part of this Earth is sacred to my people. Every shining pine needle, ever sandy shore, every mist in the dark woods, every clearing and humming insect is holy in the memory and experience of my people. The sap which courses through the trees carries the memories of the red man.

[…]

So we will consider your offer to buy our land. But it will not be easy. For this land is sacred to us. This shining water that moves in the streams and rivers is not just water but the blood of our ancestors. If we sell you land, you must remember that it is sacred, and you must teach your children that it is sacred and that each ghostly reflection in the clear water of the lakes tells of events and memories in the life of my people. The water's murmur is the voice of my father's father.

We know that the white man does not understand our ways […] He treats his mother, the Earth, and his brother, the sky, as things to be bought, plundered, and sold like sheep or bright beads. His appetite will devour the Earth and leave behind only a desert.

The rivers are our brothers, they quench our thirst. The rivers carry our canoes, and feed our children. If we will you our land, you must remember, and teach your children, that the rivers are our brothers and yours, and you must henceforth give the rivers the kindness you would give my brother.

[...]

The air is precious to the red man for all things share the same breath the beast, the tree, the man, they all share the same breath […] [I]f we sell you our land, you must remember that the air is precious to us, that the air shares its spirit with all the life it supports.

[...]

Whatever befalls the Earth befalls the sons of the Earth. If men spit upon the ground, they spit upon themselves. This we know: The Earth does not belong to man, man belongs to the Earth. All things are connected.

[...]

That destiny is a mystery to us, for we do not understand when the buffalo are slaughtered, the wild horses are tame, the secret corners of the forest heavy with the scent of many men and the view of the ripe hills blotted by talking wires.

Reading 2.3b

Journey with the Abenakis*

Our journey begins in the pine woods. As we walk, the wind sighs through the pine boughs and causes them to wave. Little patches of sunlight shine on the soft pine needles beneath our feet. A twig cracks underfoot. There is a clearing in the distance and gentle curls of smoke rise into the sky. We can smell wood burning as we approach.

[...]

[We watch as] people prepare to go on a hunt by burning tobacco, a sacred plant whose smoke carries their prayers up to the "Owner" or Creator, Tabaldak, and the animal spirits. These prayers ask for permission to hunt. They also express the people's respect and appreciation for the lives of the animals they will soon hunt, and offer thanksgiving for the food, clothing, and other gifts the animals will give the people. Soon the hunters leave the fire ring, carrying their weapons, and walk through the pine grove.

Some faint deer signs are found and two of the hunters begin to follow the trail very quietly. After a long, slow, tiring search, some animals are heard chewing on the buds of a small tree up ahead. The hunters creep closer and look through the branches of a low bush. The animals are deer! And so we learn one of the lessons of survival in nature: SILENCE.

The hunters look carefully at the deer in the herd, recognising each one individually. Two of the deer are pregnant… these two will not be hunted. Finally, the hunters decide on a certain buck as their quarry.

In an instant several arrows are strung and sent whistling through the air. The buck is shot and it falls kicking on the ground, blood flowing from wounds. One deer alone is taken because the others are needed to produce more young to keep the herd alive and because the hunters take only what they need. A second lesson in nature is learned: RESPECT for other life besides human.

[...]

The deer is not kept by the hunters and their families; it is cut into smaller pieces and given to all those who need food beginning with those who are most hungry. Another lesson is learned of how people can survive in the natural world and with one another: SHARING the gifts of nature.

As the meat is prepared, the people burn some fat on the glowing coals of the cooking fire. The smoke that drifts upward is an offering to Tabaldak. Every part of the deer is used, because to waste any would show disrespect to Tabaldak and the animal spirits. Finally, the deer's bones are returned to the land where it was killed. This offering of the bones completes the circle of giving and receiving. The Creator and deer give life through the gifts of food and clothing to the people, and the people complete the circle by giving the deer bones back to show respect, appreciation, and thanks. A final lesson is learned for living well with the natural world.

SILENCE - RESPECT - SHARING - CIRCLES
These are lessons to be remembered each day. If we live by them we will be able to live in peace with each other and in balance with the Earth and all living things.

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*Reprinted with permission from *Keepers of the Earth: Native American Stories and Environmental Activities for Children* by Michael J. Caduto and Joseph Bruchac.

Plumas Audubon Society

UNIT 2: RELATIONSHIP
Habitats, Resources, and Reciprocity

Lesson 2.4

Lesson Objectives:
- Learn about the historic human relationship to nature within the Upper Feather River Watershed.
- Review geography and history of the Upper Feather River Watershed.
- Understand watershed conservation and its importance.

NGSS:

Middle School
MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
High School
HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Time: *45 - 60 minutes*

Materials:
- Upper Feather River Watershed tarp (can be checked out from Plumas Audubon Society) or, alternatively, create your own watershed game map with three long ropes and

The Human Relationship to Water

Summary:
A kinesthetic activity designed to teach students the geography of the Feather River watershed, while learning about the development of water resources, and the subsequent effects on wildlife.

Background:
Everything we need to survive comes from natural resources. Human development systems based on profit maximization rather than about the enhancement of life and culture, however, have driven the short-sighted exploitation of nature and its resources which threatens the capacity of Earth to sustain and support life. It does not have to be this way. We can collectively choose to live within—and as part of—our environments in sustainable ways that ensure we and other life have the resources we need now and into the future.

Conservation is the practice of caring for the earth's air, water, soil, minerals, habitats, biodiversity, nutrient cycles, and ecological processes. Because all life is interconnected by the physical properties of sharing and exchanging air, water, land, and energy, when we conserve the health of the environment, we conserve the health of ourselves.

A **watershed** offers an excellent example of this interconnection: for clean water to drink, humans and animals depend on the rain and snowmelt which saturates the soil and is absorbed and filtered by plants and trees whose roots hold the soil and water. In doing so, trees and plants reduce erosion and flooding. They also shade and cool the stream, helping aquatic life thrive, including the fish that nourish bears and humans alike. Water cycles through a watershed continuously, moving through the air, soil, plants and animals, connecting and sustaining life.

Problems develop and grow, however, when we view our resources as a commodity that belongs to us rather than as a community of which we are just one part. This type of perspective leads to the exploitation and pollution of resources, the loss of biodiversity, and the disruption of ecological functions. Yet the inextricable links that connect us to our environment mean that such harm done to the environment is ultimately bringing harm to ourselves as well.

As residents of the Upper Feather River Watershed, we live at the headwaters of the California State Water Project providing the majority of the water that two-thirds of California's population depends on. How we care for our environment and how we teach our youth to care for it affects not only our immediate communities within the watershed, but also a vast portion of

sidewalk chalk or painter's tape
- Upper Feather River Watershed game map (Teacher's Supplement 2.4a)
- 12 rocks, blocks, or other item to represent the dams
- Spawning ground location cards (Teacher's Supplement 2.4b)
- Multiple copies of laminated fish game pieces, (Teacher's Supplement 2.4c)

Did you know…
A **watershed** is an area of land that catches and channels rainfall and snowmelt to streams and rivers, which eventually flow into a common point like a lake, wetland, or ocean bay.

Anadromous fish are migratory fish. Born in fresh water, they spend most of their life in the ocean and return to fresh water to spawn.

communities downstream and beyond.

Before 1836, the watershed supported an abundance of fish, flora, and fauna as well as a thriving population of Maidu people. Historically, the Upper Feather River Watershed supported Maidu villages throughout the area including in the American, Indian, Genesee, and Sierra Valleys. There was a particularly large settlement at Big Meadows, which was inundated by the reservoir now called Lake Almanor. When gold was discovered at Bidwell Bar on July 4, 1848 prospectors were driven to the Oroville area and the Feather River headwaters. Environmental and cultural devastation ensued. Mining silt contaminated the waters and suffocated aquatic life. Maidu homelands were stolen and destroyed, and the Maidu population was decimated over the course of only three decades with only an estimated 4% (330 individuals) of the original population surviving the epidemics brought by colonizers and the government-sanctioned persecution and bounties.

In the 1920's Pacific Gas and Electric Company began developing water energy infrastructure on the North Fork Feather River including Canyon Dam, Butt Valley Dam, Bucks Storage Dam, Rock Creek Dam, and Poe Dam. Ultimately, this project led to the construction of Oroville Dam in 1967 by the California Department of Water Resources.

As a consequence of dam construction along the Feather River and its tributaries, **anadromous fish** that the Maidu people depended on for sustenance, such as salmon and eel, were unable to reach the headwaters of the Feather River.

Dams interrupt of the natural flow of water affecting everything in the ecosystem both upstream and downstream. Although there are some benefits gained from dams, most have far greater negative consequences affecting aquatic and riparian plants and wildlife, including many birds whose food and nesting habitats are altered or destroyed; displacing the people who live near them; and causing loss of habitat and loss of water downstream.

Questioning Prompts:

- What type of ecological relationship did the Maidu peoples have with the land?
- What type of ecological relationship did gold miners have with the land?
- What type of ecological relationship is reflected in building dams and other water management infrastructure?

Activity:

FEATHER RIVER WATERSHED GAME

This game models the history of human land and water use in the Feather River Watershed and its effects on indigenous peoples, physical bodies of water, and the salmon migration. The game begins with the Maidu people fishing the salmon during their migration from the ocean to their spawning habitat, as they did for thousands of years before the discovery of gold and the construction of dams in the 19th and 20th centuries.

SET UP
Lay out the Feather River Watershed tarp map. Or, if using long ropes, lay out the three ropes to represent the North, Middle, and South Forks of the Feather River and use the Upper Feather River Watershed game map, provided in the Supplemental Materials (Teacher's Supplement 2.4a), as a guide to draw with chalk or painter's tape the additional tributaries, fishing sites, and spawning grounds in their respective places along your map. Do <u>not</u> place dams until game play, following instructions.

To start, half the students will represent Maidu people and can place themselves at any fishing site associated with the following areas: Big Meadows, Mountain Meadows, Humbug Valley, Indian Valley, Genesee Valley, American Valley, Sierra Valley, Little Grass Valley, Concow, and Berry Creek.

The other half of students will be Salmon. At the start of each round, shuffle Spawning Ground Location Cards (Teacher's Supplement 2.4b) and give one card as well as one fish game piece (Teacher's Supplement 2.4c) to each Salmon at the start of each round. Salmon will place themselves in the ocean represented on the map.

PLAY
Before each round, read aloud the title, description, and play instructions (indicated by the arrow ➢ symbol). At the start of each new round, the instructor will place new dams constructed, represented by rocks or blocks, (when applicable) where they belong on the map, and students will follow the instructions with guidance from the instructor.

At the start of each round Salmon receive a spawning location card telling them which spawning ground to try to reach, represented by a numbered orange dot ("**roe**") on the map. Salmon will then swim upstream and Maidu will "fish" for Salmon their chosen fishing site, represented by the net/basket/trap U-shaped symbol on the map. As Salmon pass a fishing site, they will give a fish (game piece) to the Maidu and then continue on toward their spawning grounds. The Maidu population in each area will collect and keep hold of the fish they catch each round. Between rounds, as Salmon journey back to the ocean, Maidu can choose to move to a different fishing site, but they must move before the new round begins and stay at their chosen site until the end of each round.

Did you know…
Roe is the term for the eggs of female salmon.

After spawning, adult salmon die, having expended all of their energy and life in the process of returning upstream to their spawning grounds and reproducing; thus, they do not return to the ocean after this journey--that is the path of their offspring.

As the game progresses, dams will be put in place blocking some Salmon from passing. Salmon that successfully follow a route to a spawning ground will return to the ocean as a new generation of fish to start the next round. Salmon that follow a route that becomes blocked by an impoundment (dam) are unable to access their spawning ground and do not return to the ocean as a new

Educator Tip:
Students out of the game may enjoy helping the instructor place the dams and respectfully ensure that other Salmon follow the rules in subsequent rounds.

generation. Students that cannot return to the ocean are asked to step out of the game, but continue to watch and keep note of what happens as the game progresses. The game ends when Salmon migration up the Feather River is no longer possible.

Round 1: For thousands of years until late 19th, early 20th century

- The Maidu people and their ancestors lived in peace with abundant gifts from the land. They had clean water, plants, and wildlife to sustain a healthy, prosperous, and comfortable life in balance with their resources. Every year, when the salmon returned to the Feather River's headwaters, the first salmon was to be caught by a shaman who returning upstream would cook and distribute pieces of the fish to all persons in the community. Salmon could run freely upstream during this time and only when this ceremony of gratitude was complete would the fishing season open for the year.
  - ➢ Salmon swim upstream to the headwaters. All Maidu receive the gift of salmon (Salmon hand a fish game piece to a Maidu at the fishing site they pass and continue upstream) and all Salmon spawn.
  - ➢ All Salmon return to ocean as a new generation of fish.

Round 2: 1848

- John Bidwell discovers gold at Bidwell Bar in present-day Oroville. The Maidu population is decimated over the course of only three decades with only an estimated 4% (330 individuals) of the original population surviving epidemics brought by colonizers and government-sanctioned persecution and bounties.
  - ➢ All but the three Maidu with the most fish in hand become Salmon. Ties are broken as follows: the Maidu at sites furthest upstream remain Maidu, those closer to Oroville become Salmon.

Round 3: 1910

- Canyon Dam is constructed impounding the North Fork Feather River, inundating Big Meadows and former Maidu villages, and creating "Lake Almanor".
  - ➢ Place dam on map.
  - ➢ Maidu in Big Meadows must relocate.
  - ➢ Salmon swim upstream to the headwaters. Some Maidu receive the gift of salmon. Some Salmon spawn and return to ocean as a new generation. Any Salmon blocked by the dam do not return to the ocean and are "out".

Round 4: 1924

- Butt Valley Dam is constructed impounding Butt Creek, inundating the area, and creating Butt Valley Reservoir.
- Indian Ole Dam is constructed inundating Mountain Meadows and

creating Mountain Meadows Reservoir.
  - Place dams on map.
  - Maidu in Mountain Meadows must relocate.
  - Salmon swim upstream to the headwaters. Some Maidu receive the gift of salmon and some Salmon spawn. Any Salmon blocked by a dam do not return to the ocean and are "out".

Round 5: 1928
- Bucks Storage Dam is constructed impounding Bucks Creek, inundating the area, and creating Bucks Lake.
  - Place dam on map.
  - Salmon swim upstream to the headwaters. Some Maidu receive the gift of salmon and some Salmon spawn. Any Salmon blocked by the dam do not return to the ocean and are "out".

Round 6:
1949
- Cresta Dam is constructed impounding the North Fork Feather River, inundating the area, and creating the Cresta Reservoir.

1950
- Rock Creek Dam is constructed impounding the North Fork Feather River, inundating the area, and creating the Rock Creek Reservoir.

1959
- Poe Dam is constructed impounding the North Fork Feather River, inundating the area, and creating the Poe Reservoir.
  - Place dams on map.
  - Salmon swim upstream to the headwaters. Some Maidu receive the gift of salmon and some Salmon spawn. Any Salmon blocked by the dam do not return to the ocean and are "out".

Round 7: 1961
- Frenchman Dam is constructed impounding Little Last Chance Creek, inundating the area, and creating Frenchman's Lake.
- Little Grass Valley Dam is constructed impounding the South Fork of the Feather River, inundating the area, and creating Little Grass Valley Reservoir.
  - Place dams on map.
  - Maidu in Little Grass Valley must relocate.
  - Salmon swim upstream to the headwaters. Some Maidu receive the gift of salmon and some Salmon spawn. Any Salmon blocked by the dam do not return to the ocean and are "out".

Round 8: 1964
- Antelope Dam is constructed impounding Upper Indian Creek, inundating the area, and creating Antelope Lake
  - Place dam on map.
  - Salmon swim upstream to the headwaters. Some Maidu receive

the gift of salmon and some Salmon spawn. Any Salmon blocked by the dam do not return to the ocean and are “out”.

Round 9: 1966

- Grizzly Valley Dam is constructed impounding Big Grizzly Creek, inundating the area, and creating Lake Davis.
  - Place dam on map.
  - Salmon swim upstream to the headwaters. Some Maidu receive the gift of salmon and some Salmon spawn. Any Salmon blocked by the dam do not return to the ocean and are “out”.

Round 10: 1968

- Oroville Dam is constructed impounding the Feather River, inundating the area, and creating Lake Oroville.
  - Place dam on map.
  - Salmon swim upstream, but cannot access the headwaters. Maidu do not receive the gift of salmon and no Salmon spawn.

GAME ENDS

Conclusion:

DISCUSSION and REFLECTION

- This game generally represents some of the history of the Upper Feather River Watershed and its inhabitants. What happened?
- What effects did the discovery of gold have on the Maidu? Why?
- What effects did the dams have on the Maidu? On the Salmon? What other ecological impacts do you think resulted from the impoundment of our streams and rivers? What effects do these dams have today?
- We often think of conservation at the species level, but what does watershed conservation mean? Why is it important in general? Why is it important to us, specifically?
- What are the implications of current climate change/disruption for watershed health?

Extensions:

SENSE OF PLACE

Developing a “**sense of place**” connects people to their surrounding environment, and establishes a deep knowledge, appreciation, and respect for its gifts. Finding a sense of place is more critical than ever in the age of climate disruption. Here are some ways to learn more about the cultural and natural history of your area and develop a sense of place:

- The Feather River Watershed has been the ancestral homeland for the Maidu people for over 2,000 years. Maidu are a resilient people and are part of our communities today. Invite a Maidu elder to come speak to your class about Maidu culture and life, historical and present, and the area's natural history. If you don't already know someone, contact the Maidu Summit Consortium (530-258-2299, info@maidusummit.org), based in Chester, to introduce yourself, find a contact, and start a relationship.

- Visit the Plumas County Museum in Quincy, Tues - Sat, 10am - 4pm.
- Go outside regularly and get to know, deeply, the environment in which you live. Spend quiet moments feeling in to your place amongst your natural surroundings. Explore your region and expand your sense of place. Birdwatching is a great place to start!

TRADITIONAL ECOLOGICAL KNOWLEDGE

Exemplary of the "sense of place" concept are indigenous knowledge, practice, and belief systems across the globe, also known as **Traditional Ecological Knowledge** (TEK). TEK helps guide traditional interactions with the landscape. TEK is now recognized as equivalent and complementary to scientific knowledge. It is of fundamental importance to the management of natural resources, the conservation of biodiversity and cultures, and the re-establishment of healthy, functioning ecosystems. TEK offers models of sustainable living and important contributions to understanding climate change impacts and adaptation strategies.

Learn more about TEK in California, including Plumas County, and get inspired:

- Watch "Tending the Wild" documentary (1 hour) about the environmental knowledge of indigenous peoples across California, exploring how they have actively shaped and tended the land for millennia and, in the process, developed a deep understanding of plant and animal life.
  - https://www.youtube.com/watch?v=TbxLv9EEzs8
- Select and watch an episode of "Tending Nature", a series that shines light on how Indigenous knowledge can inspire a new generation of Californians to find a balance between humans and nature (<20 min episodes).
  - https://www.kcet.org/shows/tending-the-wild
- Read Farrell Cunningham's (Mountain Maidu) 2005 article discussing and highlighting examples of TEK: "Take Care of the Land and the Land Will Take Care of You: Traditional Ecology in Native California."
  - http://climate.calcommons.org/sites/default/files/FarrellCunningham2005.pdf
- Learn about and support recent and current Maidu land stewardship initiatives involving the application of TEK in Plumas County on various Feather River Land Trust properties and in Tásmam Kojóm (Humbug Valley).
  - ➢ https://www.frlt.org/experience-land/maidu-stewardship
  - ➢ https://maidusummit.org/index.php/mission/

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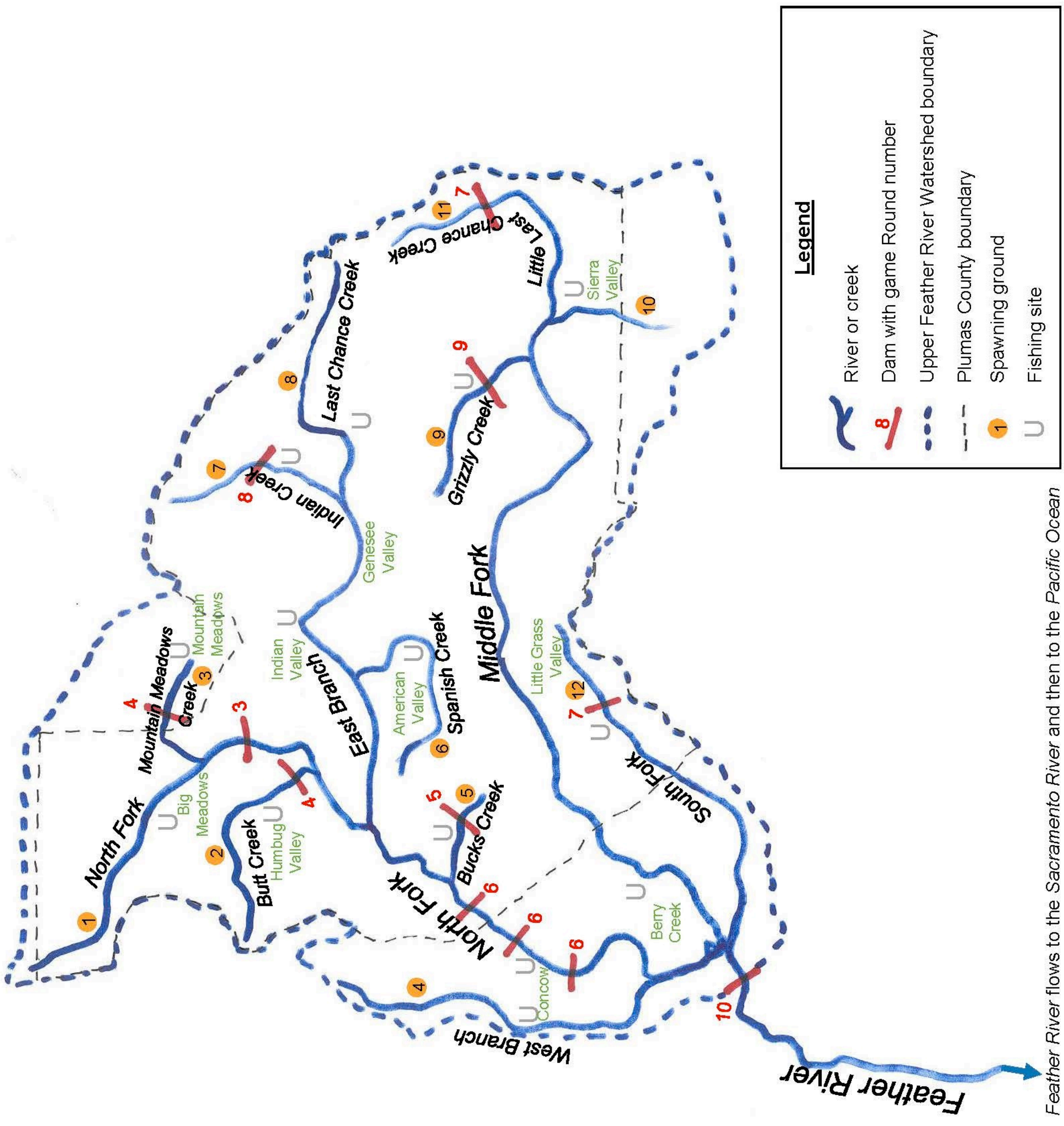
<u>Teacher's Supplement 2.4a</u>:
Upper Feather River Watershed game map



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<u>Teacher's Supplement 2.4b:</u>
Spawning Ground Location Cards

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Teacher's Supplement 2.4c:
Watershed Game fish game pieces












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Plumas Audubon Society

UNIT 2: RELATIONSHIP
Habitats, Resources, and Reciprocity

Lesson 2.5

Lesson Objectives:

- Identify the ways species are dependent upon their habitat for survival and human activity may threaten wildlife.
- Learn about conservation and how environmental regulation may be a means to protect wildlife.
- Consider multiple perspectives on an issue and cooperate to find a collaborative solution to a problem.

NGSS:

Middle School
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
High School
HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Time: *60 minutes*

Materials:

- Media player/computer with internet access
- Handout 2.5a
- Readings 2.5b, 2.5c, and 2.5d

Sage-Grouse Debate

Summary:

Students will learn about a current conservation issue by examining a case-study of the Greater Sage-Grouse and its habitat. Students will explore different perspectives on the issue by role-playing specific interest groups who have a stake in protecting the bird or would be affected by regulations put in place to protect the bird.

Background:

The Greater Sage-Grouse has been at the center of the largest conservation effort in U.S. history. The debate surrounding this bird and its habitat has been largely seen as a successful collaboration between conservationists, private landowners, state and federal government, as well as industry. Greater Sage-Grouse numbers have been declining due to habitat loss since the 1800s, having already lost half of their historic range. A recent study (Garton, 2015) estimated that Greater Sage-Grouse numbers dropped 56% from 2007 to 2013. This drastic population decline made the Greater Sage-Grouse under consideration for protection under the **Endangered Species Act**. National Audubon Society considers sage-grouse a "climate threatened" species, and predicts that it will lose 71% of its breeding range by 2080. Without conservation efforts, the Greater Sage-Grouse could be listed as "endangered" in the near future.

The U.S. Fish and Wildlife commission is responsible for listing species under the Endangered Species Act (ESA) under the following designations:

- **Endangered Species:** Species that are likely to become extinct throughout all or a significant portion of their range
- **Threatened Species:** Species that are likely to become endangered in the near future
- **Critical Habitat:** Habitat which is vital to the survival of endangered or threatened species

Species can be listed based on the following criteria:

- Has a large percentage of the species vital habitat been degraded or destroyed?
- Has the species been over-consumed by commercial, recreational, scientific, or educational uses?
- Do current regulations or legislations inadequately protect the species?
- Are there other man-made factors that threaten the long-term survival of the species?

If scientific research reveals that the answer to one or more of the above questions is yes, then the species can be listed under the ESA

Listing under the Endangered Species Act means that these species receive federal (nationwide) protection rather than being managed by individual states. Federal protection under the ESA has been successful at protecting wildlife, but is often met with resistance from industries whose productivity and profits may be affected by species-specific laws.

The Greater Sage-Grouse is considered an indicator species, meaning that a decline in grouse numbers indicates a decline in the health of the entire sagebrush ecosystem--one of the most imperiled ecosystems in the U.S. The sagebrush steppe is a region that currently spans nine western states (California, Oregon, Washington, Nevada, Idaho, Montana, Wyoming, Utah, and Colorado) and is home to an estimated breeding population 150,000 Greater Sage-Grouse. While listing the Greater Sage-Grouse under the ESA would guarantee protection, many groups feel that grassroots actions taken by concerned citizens would be more effective at preserving the birds and the industries located near critical habitat.

Questioning Prompts:

- What does conservation mean to you?
- What are some examples where you have practiced or observed conservation?
- How do environmental laws affect you?

Activity

DEBATE

Divide students into six groups. Each group will be assigned a role in the debate representing one of six interest groups:

- State Wildlife Commission
- National Audubon Society
- Cattle Ranchers
- Tribal Members
- Private Landowners
- Commercial Miners

Pass out Sage-Grouse Debate Readings 1 and 2 (Handouts 2.5b and 2.4c), two articles about the sage-grouse situation and the issue of an ESA listing. Allow time for students to read the articles, and then, as a class, visit the Sage Grouse Initiative website and scroll down to "Tribal Connections to Sage Grouse" section to watch two short videos (2-3 min each) on tribal perspectives of the sage-grouse:
https://www.sagegrouseinitiative.com/sagebrush-community/the-people/

Then assign groups their roles: pass out the description cards for each interest group (Handout 2.5a—can be cut out before class activity). These cards describe each group's particular perspective and how they may be affected if the Greater Sage-Grouse is listed on the ESA.

Educator Tip:
Resources are provided for this activity. Understanding the politics of the Endangered Species Act, as well as the different interests groups will help explain why the Sage-Grouse debate was so widely publicized. This activity helps demonstrate the political side of environmental policy.

Did you know…
The Endangered Species Act (ESA) is a U.S. federal law, signed in 1973, designed to prevent species extinction, recover imperiled plants and animal populations, and protect the ecosystems on which they depend.

Learn More:
The Sage Grouse Initiative is a partnership-based, science-driven effort that uses voluntary incentives to proactively conserve America's western rangelands, wildlife, and rural way of life. This initiative is part of Working Lands For Wildlife, led by the USDA Natural Resources Conservation Service.

Allow 10 minutes for each group to discuss their interest group's stance on the issue, as well as come up with a plan to help protect the bird and the sagebrush habitat. Each group will prepare a 2-minute speech to give to the class. Encourage your students to cite sources from the information they have been given and/or researched. Quotes, statistics, and anecdotes are all useful tools for arguing a point. After their speech they can answer one question per group about their plan.

As your students are presenting, take time to write down any relevant ideas on the board. Use these to discuss any plans that might overlap. Conservation involves many different partnerships and commitment from different people with different perspectives. How did this work to help the Greater Sage-Grouse?

Conclusion:

Pass out Sage-Grouse Debate Reading 3 (Reading 2.5d) and allow students 5 minutes to read the article. From this reading your students will learn that the Greater Sage-Grouse was not listed under the ESA.

DISCUSS

- What do you think about this decision?
- What might we expect to happen in the future?
- How might our conservation strategy change?
- Take a moment to highlight how groups with different interests (e.g. a mining company and National Audubon Society) both worked together to help conserve a species.

Extensions:

- Ask students to research recent updates to this saga and report back.
- Learn about the applied conservation actions being done to help this bird:
  - Watch a short video highlighting the on-the-ground conservation work of National Wildlife Federation youth interns (4 min): https://www.nwf.org/Our-Work/Wildlife-Conservation/Greater-Sage-Grouse
  - Read a summary of six conservation strategies to help this bird: https://www.audubon.org/news/6-ways-help-sage-grouse-right-now
- Have students research another threatened or endangered species and look into how the ESA affected both the species and other industries. Examples might include the Northern Spotted Owl or the mountain yellow legged frog, both of which are present in Plumas County.
- On occasion, Plumas Audubon Society offers a free guided trip in early April to a Greater Sage-Grouse lek where participants can watch and hear these amazing birds. Check our calendar of events or contact us for more info.

Garton EO, Wells AG, Baumgardt JA, and Connelly JW. 2015. Greater Sage-Grouse population dynamics and probability of persistence. Final Report to Pew Charitable Trust. https://www.pewtrusts.org/~/media/assets/2015/04/garton-et-al-2015-greater-sagegrouse-population-dynamics-and-persistence-31815.pdf

Check us out:
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Handout 2.5a
Interest Group Description Cards

State Wildlife Commission
You are representatives from a local state wildlife department. You have been working hard for years to protect habitat for all types of wildlife. If the sage-grouse becomes federally protected you will have new rules and regulations to enforce. Right now you are getting complaints from hunters about restrictions that could be enforced after listing the sage-grouse as a threatened species. You would like to keep public land open and protect sage-grouse. What actions could you take in your own state?

National Audubon Society
National Audubon Society's mission is to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity. You are representatives from an organization with over 100 years' experience of science, education, and policy towards protecting birds and their habitats. Your goal is to ensure the long-term success of the Greater Sage-Grouse throughout its native range.

Cattle Rancher
You are cattle ranchers who operate on 10,000 acres of public land. You lease the land from the United States government through the Bureau of Land Management. Your family has held grazing rights here for several generations and ranching is your main source of income. Over the years, more restrictions have passed that limit where and when your cattle can graze. You have barbed-wire fencing and gates that enclose large sections of the range where your cattle graze. Sage-grouse have leks (courtship grounds) on and around the land you use. If the sage-grouse becomes federally protected, you may see new restrictions or lose the right to graze cattle.

Tribal Member
You are tribal members whose ancestors lived on this land among the sage-grouse for thousands of years. The sage-grouse are well-respected and traditionally hunted for food by your tribe, and are culturally important to you. Around 1980 your people began to notice the decline in the once abundant sage-grouse. Both the sagebrush and pinyon-juniper ecosystems carry multi-generational cultural significance for your people. Though not sought out enough, your opinion on the listing of the sage-grouse as endangered and how the land is managed for this species is important because this is your current and ancestral homeland.

Commercial Miner
You operate several mineral mines in northern Nevada. You have a mine claim lease from the United States government through the Bureau of Land Management. You have seven claims in different areas and would like to expand. Most of your claims are in sage-grouse habitat and you see them frequently. Two of your mine claims are located near a sage-grouse lek (courtship grounds) and you have been asked by federal wildlife officials to voluntarily close these mines to protect the bird. Closing these mines means a loss of income for you. If the sage-grouse is listed as endangered, it may mean those mines and others will be shut down. What could you do to stay in business and also help prevent the sage-grouse from being listed under the ESA?

Private Land Owner
You are a private landowner who inherited 250 acres of land in northeast California. You have a small house on one section of the land but everything else is left natural. Investors have approached you about the possibility of selling the land to build ranch style houses on. You would prefer to keep the land for grazing cattle as part of your income. However, money is tight and you need some extra funds to keep your ranch operational. You could offer land as a conservation easement to the federal government, or sell to private developers looking to build houses.

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Reading 2.5b:
Sage-Grouse Debate: Reading 1

What's up with the Greater Sage Grouse?

By Martha Harbison (May 29, 2015)
https://www.audubon.org/news/whats-greater-sage-grouse

Since 2002, the Greater Sage-Grouse, a spectacular galliform bird with spiky tail feathers and inflatable banana-yellow air sacs on its chest, has been the subject of a dispute between the federal government, state governments, private industry, and conservation groups. In the 1800s, it numbered in the millions, but habitat destruction has dropped those numbers to between 200,000 and 500,000—a recent study found that the bird's population dropped [56] percent between 2007 and 2013—making the bird a candidate for a federal management listing on under the Endangered Species Act.

[Whether listed or not] the bird still requires devoted conservation efforts to keep its population and habitat strong for the decades and centuries to come. Here's a primer on what's going on with this odd, chicken-sized creature.

What is a Greater Sage-Grouse?

The Greater Sage-Grouse is a two-to-three pound bird that lives in sagebrush steppe in the American West, the largest native grouse species in North America. The most distinctive trait of the Greater Sage-Grouse is its lekking behavior, where groups of adult males perform elaborate dance moves to impress the females.

Also of interest: during the winter, the Greater Sage-Grouse eats nothing but sagebrush, the only bird in the steppe that can survive on this limited diet.

Where does the Greater Sage-Grouse live?

It lives on some 165 million acres of sagebrush steppe habitat in 11 states in the American West, including California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. The federal government owns more than 100 million of those acres, while state governments and private stakeholders own the rest. The Greater Sage-Grouse is currently a state-managed bird, which means that each state implements its own conservation plan surrounding the bird. The U.S. Fish and Wildlife Service considers the Greater Sage-Grouse to be an indicator species on the health of the sagebrush steppe: that habitat is home to more than 350 species, including Golden Eagle, mule deer, elk, and pronghorn antelope.

Why are Greater Sage-Grouse populations declining?

Today, Greater Sage-Grouse occupy only 56 percent of their original range. The birds need large tracts of un-fragmented habitat to survive, as they need both space for their leks and to travel between their wintering and breeding grounds. Grouse are also creatures of habit, going to the same lek sites every year, no matter how disturbed the habitat might be. This can make conservation a challenge. Agricultural conversion, infrastructure (transmission towers, energy development, fences, roads, etc), urbanization, invasive plants, intense wildfires, and lack of regulatory mechanisms to protect sagebrush ecosystem, have all contributed to habitat degradation.

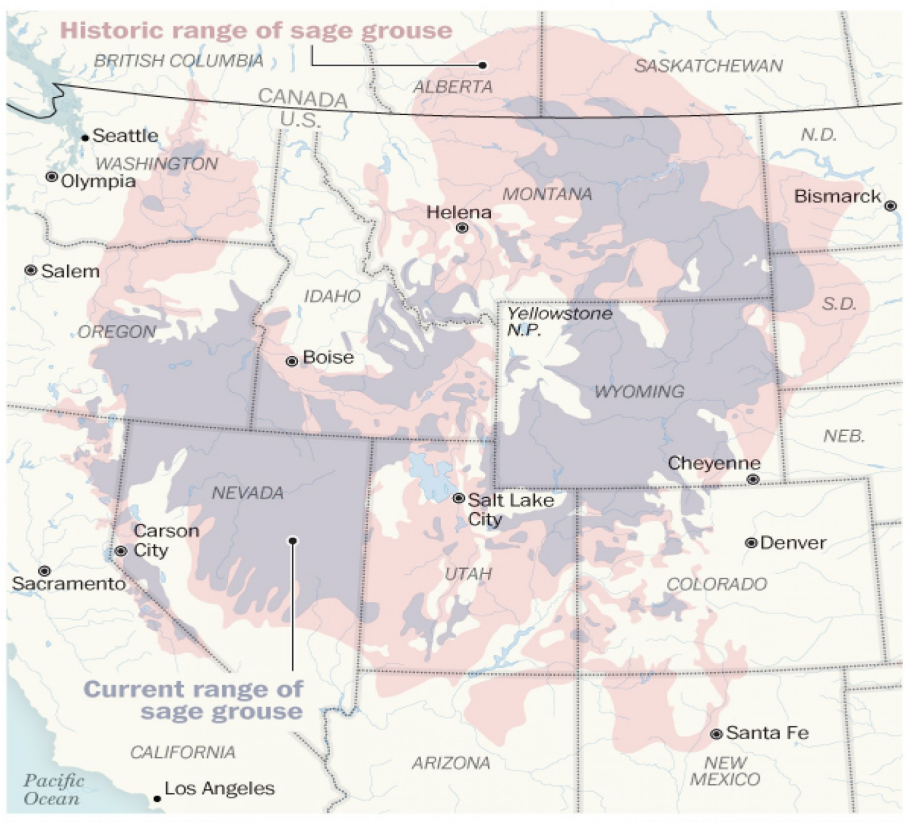
What is being done to save Greater Sage-Grouse?

The U.S. Bureau of Land Management has undertaken an ambitious effort to incorporate protections for Greater Sage-Grouse. This process is on-going and encompasses approximately 60 million acres. In addition, many of the states have either developed or are working on sage-grouse conservation plans. And the Natural Resources Conservation Service works with landowners to implement protections for the bird on privately owned land.

But what are people actually doing on the ground to save the Greater Sage-Grouse?

Removing invasive conifers, marking fences to make them bird-safe (the birds end up clothes lining themselves on the wires because they can't see them), building bird ramps in cattle watering troughs (otherwise the birds fall in and drown) and financially rewarding private landowners who place their space in conservation easements.

Greater Sage-Grouse. Photo: Verdon Tomajko/Audubon Photography Awards



Reading 2.5c:
Sage-Grouse Debate: Reading 2

Western states worry decision on bird's fate could cost billions in development

By Reid Wilson (May 11, 2014)
https://www.washingtonpost.com/blogs/govbeat/wp/2014/05/11/western-states-worry-decision-on-birds-fate-could-cost-billions-in-development/?utm_term=.e05780aa6e52

MINERAL COUNTY, Nev. – In the frozen chill of a high-desert morning, Tony Wasley, the director of the Nevada Department of Wildlife, peers through a range finder down a dirt path and points out a group of birds strutting and preening among a low scrub brush. It's mating season for the sage grouse, and dozens of males are descending upon breeding grounds, called leks, to show off their plumage to the hens.

The 40 or so grouse at this lek near the Nevada-California border look ridiculous. They waddle around, occasionally heaving their bodies into flight, sometimes chasing off younger males and always trying to one-up each other. They are the avian equivalent of a club-goer showing off his shiny new coat.

They are also at the center of a years-long battle that pits environmentalists who want the sage grouse protected under the Endangered Species Act against ranchers, gold miners, energy producers and Western state governments that stand to lose billions of dollars in tax revenue and economic activity if tens of millions of acres are blocked off from development, exploration or use.

…Some state officials fear a decision to list the sage grouse, which would severely limit everything from grazing to energy development on a huge swath of land, could create [tension between the federal government and Westerners who use government-owned land].

"Western states never welcome outsiders coming in and telling them how to do something," said Colorado Gov. John Hickenlooper (D), who co-chairs a bipartisan task force working to conserve sage-grouse habitats and prevent its inclusion on a list of threatened animals.

The fight over the sage grouse is similar in many respects to the debate over the Northern spotted owl, which in 1990 was listed as threatened. That decision shut down timber operations across more than 24 million acres in Northern California, Oregon, Washington and British Columbia, contributing to the industry's precipitous decline.

Much of the sage-brush range already is being drilled for oil and natural gas, while thousands of new wells wait for permits. Renewable energy sources, such as solar and wind farms, dot the sage-brush range. Even a gold mine in rural eastern Nevada would be affected.

"It's going to affect agriculture, oil and gas, wind, all kinds of different industries," said Kathleen Sgamma, vice president of government and public affairs at the Denver-based Western Energy Alliance. "We're talking about such a wide-ranging impact."

The sage grouse has a long history in the American imagination. They are represented in Native American traditional dance and artwork. Lewis and Clark brought back drawings of a bird they called the spiny-tailed pheasant. Conservationist Rachel Carson warned in her seminal work, "Silent Spring," that sage-brush habitat was being converted to grassland for livestock.

Sage grouse populations have "been declining significantly in numbers, and it's very susceptible to development," Interior Secretary Sally Jewell said in a December interview with The Washington Post. "When you look at the Western landscapes and you look at what's happening, there isn't a state where there's this habitat that's not in some form of trouble."

The federal Fish and Wildlife Service, which ultimately is responsible for deciding whether to include an animal on the endangered-species list, has been considering the several subspecies of sage grouse for about 15 years. In 2005, the agency decided it would not list the grouse as threatened. Environmental groups filed a lawsuit, and a federal judge overturned the finding two years later. In 2010, the agency said the bird warranted protection.

Under an agreement between Fish and Wildlife and the environmental groups, the agency has until the end of September 2015 to propose rules governing the bird's habitat or to decide to change its mind.

Environmentalists say protecting the sage grouse and its habitat is crucial to saving many more species, such as the pronghorn and the pygmy rabbit, that call the high desert home.

"The sage grouse is an umbrella species, so it's sort of the canary in the coal mine," said Randi Spivak, the public-lands program director at the Center for Biological Diversity, one of the groups that initially sued the Interior Department to force it to recognize the sage grouse as threatened.

It's not just industry that wants to keep the sage grouse off the endangered-species list. States are working desperately to convince the federal government to decline to list the bird. The 11 affected states set up a bipartisan task force in 2011…aimed at working with Fish and Wildlife, the Bureau of Land Management and other federal agencies to coordinate conservation strategies and resource-management plans.

"The focus of all this is, how do we demonstrate that we're going to do a better job of creating a proactive strategy?" Hickenlooper said. "We can probably do a better job with our local programs and partnerships than Fish and Wildlife can, trying to regulate from afar."

The stakes involved in Fish and Wildlife's decision are huge. The bird's historic range covers 160 million acres across the Mountain West region, including huge swaths of Montana, Idaho, Wyoming, Oregon and Nevada, along with smaller parts of Washington, California, Utah, Colorado, South Dakota and North Dakota.

"The Fish and Wildlife Service . . . must follow the best available science, and it must make sure that whatever's being done is proven to be effective. And so we're trying to keep all governors at the table," Jewell said. "If one state doesn't play, it could impact all of them."

A listing decision could harm state conservation efforts, some officials said. Putting the sage grouse on threatened status "will be an incredible disincentive for states to develop voluntary conservation strategies," said Shawn Reese, Mead's policy director in Wyoming.

Estimates of the total economic impact depend on which conservation plans the government chooses. Plans calling for the strictest conservation measures could cost up to 31,000 jobs, up to $5.6 billion in annual economic activity and more than $262 million in lost state and local revenue every year, according to a widely cited study conducted by lawyer Lowell Baier that is accepted by interests on both sides of the debate.

…

State land and wildlife managers almost uniformly believe the Fish and Wildlife Service will rule against them and list the sage grouse as threatened. "They're leaning toward listing it as threatened," said John Harja, head of Utah's Public Lands Policy Coordination Office and a member of the multi-state Sage Grouse Task Force. "We have great concerns."

If the greater sage grouse is listed as threatened, the 11 states could be on the hook for as much as $1 billion in conservation costs. Adding to that burden, most states fund land programs through user fees, rather than out of general funds; declaring a species threatened makes it harder to generate those fees.

"If the hunters can't hunt, if the miners can't mine, if you don't have that capital, then you lose," said Leo Drozdoff, director of the Nevada Department of Conservation and Natural Resources. A billion-dollar tab to save greater sage-grouse habitat, he added, "is almost insurmountable."

Reading 2.5d:
Sage-Grouse Debate: Reading 3

Unprecedented Conservation Efforts Keep Greater Sage-Grouse Off Endangered Species List

By Alisa Opar (September 22, 2015)
https://www.audubon.org/news/unprecedented-conservation-efforts-keep-greater-sage-grouse-endangered-species

Today the U.S. Fish and Wildlife Service announced that the Greater Sage-grouse, an iconic bird of the American West, does not warrant listing under the Endangered Species Act.

Conservationists, ranchers, politicians, and industry have been on edge for months in anticipation of the decision, which was announced just days before a court-ordered September 30 deadline. The possibility of a listing had sparked fears of huge economic losses in the sage-grouse's expansive habitat out West, as it would have restricted energy development, livestock grazing, and residential construction. States and federal agencies that control public lands have scrambled to create updated sage-grouse recovery plans in order to avert a listing and many conservationists worried that a formal listing could undermine the serious—and pioneering—voluntary efforts taken to protect the bird's sagebrush habitat in recent years.

Indeed, Secretary of the Interior Sally Jewell confirmed in a video released on Twitter this morning that a major factor in the determination was the cooperative efforts of federal agencies, states, private landowners, industry, and green groups to safeguard the chubby, chicken-sized bird. That includes the Bureau of Land Management's 14 new sage-grouse recovery plans—consolidated from 98 distinct land use plans, all of which were officially formalized today—that will conserve 35 million acres of federal lands across 10 states. In total, the collective plans to protect the bird "significantly reduced threats to the Greater Sage-Grouse across 90 percent of the species' breeding habitat," enabling the organization to conclude that the bird did not warrant listing, FWS stated in their release announcing the decision.

"This is truly a historic effort—one that represents extraordinary collaboration across the American West," Jewell said in FWS's statement. "It demonstrates that the Endangered Species Act is an effective and flexible tool and a critical catalyst for conservation—ensuring that future generations can enjoy the diversity of wildlife that we do today."

"This is a new lease on life for the Greater Sage-grouse and the entire sagebrush ecosystem," said National Audubon Society President and CEO David Yarnold. "Unprecedented cooperation by private landowners, states, and the federal government has created a framework for conservation at a scale unique in the world."

When FWS first announced that the bird would be considered for a federal listing in 2010, regional conservation efforts had already been underway. "This is exactly what Audubon has been working toward for 10 years," says Brian Rutledge, VP and Central Flyway policy advisor for Audubon. Rutledge and his team helped create a science-based approach to sage-grouse protections that significantly reduces disturbance in core habitat—an approach that's been adopted in state and federal plans alike. "This is the kind of cooperation the Endangered Species Act was designed to encourage," he says. "It wasn't intended to list everything under the sun; it was to motivate conservation before listing became necessary."

The Enormous Effort to Stave Off a Listing

The sagebrush steppe is an old-growth forest in miniature, with some species of the fragrant shrubs living for more than a century. Development has cut the habitat to half its historical size, and today it spans 173 million acres across 11 states. The sage-grouse is inextricably linked to this sagebrush ecosystem: The plants provide cover from raptors and other predators, serve as shelter for nesting birds in the summer, and supply the grouse's sole source of food in the winter—in fact, the birds actually gain weight eating the leaves during the harsh winter months. But as the habitat has shrunk, the birds' numbers have plummeted, from millions a century ago to between 200,000 and 500,000 today. (Scientists count males at leks, or mating grounds, to extrapolate a rough population estimate; obtaining an exact count is impossible because the birds are essentially invisible in the vast sagebrush sea.)

The Greater Sage-Grouse is an indicator species of the health of this entire ecosystem. The desire to keep the bird off the list—and stave off the many restrictions that come with a threatened or endangered status—has generated a rare show of cooperation from those interested in using the habitat for drilling, ranching, or other economic endeavors. In consultation with conservation groups and government agencies, they have made ambitious commitments to protect enough space for the bird while still permitting some development. Today's announcement is a ratification that the approach is working. "We're seeing landscape-scale conservation like we've never seen before," says Audubon's Rutledge.

Rutledge helped create a Wyoming sage-grouse management plan that allows sage-grouse and industry to co-exist. The state is home to 37 percent of the sage-grouse population, and is also a major producer of coal, natural gas, and beef—all of which rely on the same sagebrush habitat. Under Wyoming's plan, surface disturbance—from roads to wind turbines to gas wells—in areas critical to sage-grouse are limited to a maximum of 5 percent per square mile. Since Wyoming adopted the scheme in 2010, it has successfully protected 15 million acres of sagebrush habitat. Following this success, other states put similar plans in place, thus reducing threats to birds on tens of millions of acres while still allowing for development.

Private landowners have also stepped up to implement protections for the bird, in exchange for guarantees that they won't be required to jump through additional hoops should the grouse ever be listed. Through the Sage Grouse Initiative (SGI), a voluntary program created by the USDA, by the end of 2014 more than 1,100 ranchers have restored or conserved 4.4 million acres on private lands in 11 states, many in the form of conservation easements, which preclude the land from being developed or converted. They've also altered their grazing systems, removed conifer and invasive cheatgrass that encroaches on sagebrush, reseeded former rangeland with native plants, and removed or marked lethal fencing (the bird's sideways-pointing eyes are great for spotting predators, but make them blind to fences directly ahead).

This rancher involvement represents an enormous shift. For instance, the SGI reports that the amount of land set aside for Natural Resources Conservation Service-sponsored easements increased 1,809 percent since the partnership began. The Big Empty, as the sagebrush ecosystem has been called, is finally getting the attention, and economic support, that it deserves, says Rutledge. In August, the USDA announced that it would invest $211 million through 2018 in the program; to date, SGI and its partners have invested more than $420 million. Industry has gotten onboard in unexpected ways as well, altering their practices to better suit the bird. For example, since 2010, the state has seen a 60-percent reduction in conventional drilling, and a 1,600-percent increase in directional drilling, which allows companies to access deposits from the side, thus protecting sensitive lands directly above.

The majority of the bird's habitat, 64 percent, is on federal lands, and the Bureau of Land Management controls most of those approximately 60 million acres. Earlier this year, the BLM and U.S. Forest Service released management plans for public lands in 10 states. The plans, developed over the past three years with the states and with input from local stakeholders, including ranchers, conservationists, and industry representatives, place restrictions on 35 million acres of priority bird habitat to prevent degradation. Even though the plans weren't formalized until today, the drafts were taken into consideration, says Pat Deibert, national sage-grouse coordinator for the FWS, who was responsible for crafting the sprawling species report—chock full of information on the major threats facing the bird and efforts to combat them—that drove the listing decision.

"There's been a lot of criticism of the plans—some say they didn't go far enough, others say they went too far," says Deibert. Some environmental groups, including Western Watershed, have threatened to sue if the bird is not listed, because they believe the federal plans allow too much development and don't go far enough to protect sagebrush habitat. However, recent research suggests that coexistence between the bird and the boom is possible; for example, a report from the Western Values Project demonstrates that sage-grouse habitat overlaps with just 2 percent of prime drilling area. Rutledge says the plans will evolve and improve as sagebrush conservation continues—and conservation must continue, because as Rutledge points out, there's still a long way to go before the ecosystem is restored.

The Future of the Sagebrush Sea

Deibert says that her office will closely monitor the implementation of the newly approved state plans, as well as continue to track other on-the-ground activities. FWS will also continue to enroll private landowners in sage-grouse conservation agreements. She also says there's talk of establishing one or more new offices devoted to sagebrush ecosystem management. "We have to keep this momentum going, to make sure we don't slip back into our old ways," Deibert says. "That wouldn't help anybody. Not industry, not ranchers—certainly not the bird or the ecosystem."

Rutledge says that in addition to continuing the restoration efforts underway, new research will likely be needed to solve major challenges—like how to grow sagebrush. For such a hardy, long-lived shrub, it's proven tricky to replenish from seed. "This is the beginning of the sagebrush conservation work, not the end," he says. "We've decided how to limit further disturbance, and agreed that we're not going to keep hammering the crap out of the landscape. But it can't recover on its own."

The Greater Sage-grouse is an avatar of the sagebrush landscape, and today's conservation victory isn't about a single species. Core grouse habitat in Wyoming, for instance, was found to overlap with mule deer's winter range, stopover areas, and migration corridors. And a recent study of sagebrush-dependent songbirds in Oregon discovered that removing invasive plants to help retain sage-grouse habitat had a positive impact on other birds—for example, Brewer's Sparrow abundance grew by 55 percent and Green-tailed Towhee numbers increased by 81 percent.

Protecting the Greater Sage-grouse—this odd bird that demands attention with weird pops and whistles during mating season, and then melts into the sagebrush for the rest of the year—ultimately means protecting the some 350 species that call this vast swath of the American West home.

A sunset view on the sagebrush-covered top of Pinedale Mesa and the magnificent Wind River Range. Sublette County, Wyoming. Photo: Dave Showalter

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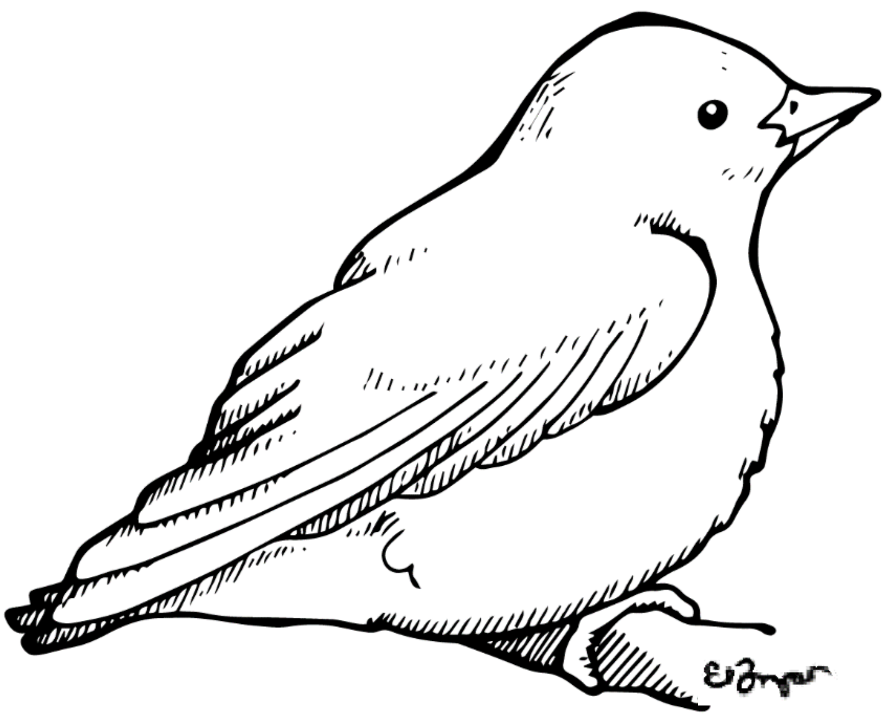
"*So why worry about global warming, which is just one more scale of climate change? The problem is that global warming is essentially off the scale of normal in two ways: the rate at which this climate change is taking place, and how different the "new" climate is compared to what came before*."
— Anthony D. Barnosky[3]

Unit 3: KNOWLEDGE
Climate Change Basics

- Lesson 3.1: Climate vs. Weather
- Lesson 3.2: The Greenhouse Effect: A CO_2 Experiment
- Lesson 3.3: The Carbon Cycle and Greenhouse Gases



[3] Barnosky is an author, Professor of Biology at Stanford University, and Executive Director of Jasper Ridge Biological Preserve. He researches past planetary changes and what they mean for forecasting the changes to come on Planet Earth.

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Plumas Audubon Society

UNIT 3: KNOWLEDGE
Climate Change: The Basics

Lesson 3.1

Lesson Objectives:
- Define "climate" and "weather" and understand the difference between the two terms.
- Analyze and draw conclusions from weather data provided.
- Practice graphing scatterplots and trend lines given a set of data.
- Learn about local effects of climate change.

NGSS:

Middle School
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.
High School
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.

Time: *60 minutes*

Materials:
- Handout 3.1a, 3.1b, and 3.1c
- Media player with internet access (optional)
- Graph paper (optional)

Climate vs. Weather

Summary:
Weather and climate are two terms that are often confused and used mistakenly. This lesson describes the differences between weather and climate, and provides examples of ways in which weather and climate affect or influence each other. After understanding the difference between climate and weather, students will understand that climate change is a non-random shift in weather trends measured over several decades or longer. Students will observe changes in regional weather and overall climate trends by graphing Plumas County weather data over the past century.

Background:
Weather and climate are two terms that are often confused and used mistakenly. **Weather** refers to the state of the local atmosphere at a given point in time. Wind, rain, temperature, cloudiness, etc. are examples of atmospheric conditions that describe the weather of a specific place at a specific time. **Climate** refers to trends in weather conditions that occur over longer periods of time--decades or more. A period of intense cooling, like previous ice ages would be considered part of a climate trend. An exceptionally warm month in the middle of an ice age would be considered a period of warm weather, not necessarily indicative of climate. Plumas County's climate has generally been characterized by cold, wet winters and hot, dry summers even though the weather may be warm on a given day in the winter or wet and cool on a given day in the summer. However, recent years have seen warmer and drier conditions in many parts of Plumas County than in the past, indicating a shift in our regional climate.

Climatology, or climate science, is the scientific study of climate, including study of the causes and long-term effects in variation in regional and global climates, including those affected by humans. Climatologists look at long time periods of weather data from various sources to recognize patterns and shifts in the climate over a long period of time and use that information to model predictions of future conditions. The vast majority (97% or more) of climate scientists agree that the global climate is currently experience a rapid warming trend caused primarily by human emissions of greenhouse gases into the atmosphere.

This activity will show examples of ways in which climate and weather affect or influence each other. Climatic changes can cause extreme shifts in weather. These shifts are often misunderstood as they do not always reflect the average global climate shift of rising global temperatures.

Activity:

In this activity students will first discuss the difference between weather and climate. Then they will take a look at historical weather data collected in Quincy, CA from 1895 to 2014. Students will be given the average temperature in degrees Fahrenheit in July and the total annual precipitation in inches recorded from the years 1895 to 2014. Students will graph data points that represent the average temperature in July and total annual precipitation as observed over the past 120 years and then use the trend line equation to graph the trend line of the data. Finally, students will analyze the data.

1. Begin the activity by asking students to define weather and climate. Then ask the following questions to help guide the conversation and help students grasp the difference. The answer to each of the following questions should either be *weather* or *climate*:
   a) Which helps you decide what kind of clothes to wear for the day? *[weather]*
   b) Which helps you determine what kind of clothes to buy or have ready for a particular season? *[climate]*
   c) Which changes dramatically from year to year? Example: "We had a very snowy winter last year. This year, we haven't gotten much snow." *[weather]*
   d) When you imagine a faraway place, which helps paint the picture in your mind? *[climate: it's what you expect]*

2. After establishing the definitions of and distinction between weather and climate, you may want to show one or two of the following videos that describe and illustrate what weather and climate are:
   a) National Geographic's Cosmos with Neil deGrasse Tyson (2:09 min): https://www.youtube.com/watch?v=cBdxDFpDp_k
   b) Detailed video for youth by Crash Course Kids (4:32 minutes): https://www.youtube.com/watch?v=YbAWny7FV3w
   c) Educational animated video from Colorado State University (6:24 minutes): https://www.youtube.com/watch?v=VHgyOa70Q7Y&t=16s

3. You can either have your students graph everything by hand using an abbreviated dataset (Handout 3.1a) or start with a graph that already has the full dataset plotted. *[Note: Historical data for Quincy, CA were used as this dataset had the oldest and most complete records in the area.]*

   a) If graphing everything by hand, pass out copies of the 10-year-average datasets (Handout 3.1a) and copies of blank graph sheets (Handout 3.1b) or you can have students create their own graphs from scratch with graph paper. Have the students create two scatterplots and label the axes appropriately. Refer to the Teacher's Supplement 3.1a for what these scatterplots should look like.

      i) The first scatterplot is entitled "10-year-average of Average Temperature (F) in July from 1895-2014, Quincy, CA," where the x-axis represents time in decades, and the y-axis represents

Educator Tips:

- The activity may require prior experience with scatterplots and finding trend lines from data by calculating the slope and y-intercept. For the sake of ease and time, the trend line equations are provided and students will be asked to test the equation by plugging in values. However, the activity may be extended to include defining the trend lines as a class or as homework using a computer (in Excel, for example) or on a graphing calculator. **Teacher's Supplement 3.1a and 3.1b** provides examples of what the scatterplots and trend lines should look like.

- What is meant by 'average'? While your students are probably very familiar with the mathematical definition of an average, it's important to think about what an average means in context. In this lesson, we use 10-year averages of the average temperature data collected in the month of July from the years 1895 to 2014. Walk your students through the data and break down what is meant by average in this context.

Check it out:
Where did we get these datasets and how did we abbreviate them for ease of use in the classroom?

Historical weather data was obtained from the Western Regional Climate Center (WRCC), one of six Regional Climate Centers administered by the National Oceanic and Atmospheric Association (NOAA). These centers collect and disseminate historical and current climate data to the American public. Learn more about the WRCC at: https://wrcc.dri.edu/About/overview.php

The provided datasets are 10-year averages of the total data set available from the WRCC from the years 1895 to 2014. These decade averages were calculated in order to provide a simplified version of the data for the purpose of this activity; the trend they reflect is similar to the trend of the full dataset. The full dataset is accessible at: https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7195

To look up data for other cities, visit WRCC's US Coop Station Map page at: https://wrcc.dri.edu/coopmap/ On this page select a particular state in the drop down menu next to "Select all in state" and that will generate a list with links to datasets for of all the cities with available climate data in that state.

temperature in degrees Fahrenheit.

ii) The second scatterplot is entitled "10-year-average of Total Annual Precipitation (inches) from 1895-2014, Quincy, CA," where the x-axis is time in decades, and the y-axis represents the amount of precipitation in inches.

iii) Instruct students to plot the data point for each decade on the year that decade ends (eg. for the decade 1895-**1904**, the 10-year average of 65.3°F, should be plotted on the graph above the year 1904).

iv) Students can then connect data points to each other to convert the scatterplot into a line graph, which can help aid visualization of the year-to-year variation in temperature and help distinguish these data points from those of the trend line to be graphed in the next step.

b) Alternatively, students can start with a plotted graph of the full dataset. Pass out copies of Handout 3.1c

4. Once students have completed their scatterplots, they should use the following equations derived from the abbreviated dataset and the full dataset, respectively, to create trend lines for their graphs.

a) **Abbreviated dataset** (decade averages) trend line equations:

i) Abbreviated average **temperature** dataset trend line equation (by decade from 1895-2014):

$$y = 0.0384x - 8.2017$$

ii) Abbreviated annual **precipitation** dataset trend line equation (by decade from 1895-2014):

$$y= -0.0591x+151.28$$

b) **Full dataset** trend line equations:

i) Average **Temperature** trend line equation for full dataset (1895-2018):

$$y= 0.0396x - 10.487$$

ii) Total Annual **Precipitation** trend line equation for full dataset (1895-2018):

$$y= -0.0347x+103.79$$

5. Ask students to graph the trend lines onto their scatterplots by plugging in x-values in 20-year increments, beginning with the year 1900. They will have to do this twice: once for the Average Temperature dataset, and again for the Total Annual Precipitation dataset, graphing the trend lines on each scatterplot, respectively.

a) Define y when x equals the following values:

1900, 1920, 1940, 1960, 1980, 2000

b) Plot these six data points on the scatterplot and use a straightedge to connect these points with a line (if working with the abbreviated dataset, have students use a color or line pattern here that is different from that used in step 3a, above). This is the trend line for the data. Refer to the Teacher's Supplement 3.1a and 3.1b for examples of the scatterplots with their respective trend lines.

Conclusion:

End the lesson with a discussion. Facilitate with the following questions:

1. We just graphed both weather and climate. Looking at our graphs, what represents the weather and what represents the climate? *[Students should be able to identify the individual data points as representations of weather and the trend line as a representation of the climate].*
2. What does the data show overall about our region's climate in terms of temperature in July? What does the data show about our region's climate in terms of precipitation?
3. Using the temperature trend line equation, predict the average temperature in July in Quincy in the years 2020, 2050, and 2080. Do the same for annual precipitation using the precipitation trend line equation. What does our future climate look like according to these predictions?
4. Project a copy of Teacher's Supplement 3.1c. Compare and contrast your students' graphs of local climate data to those of regional and global climate data. Are we experiencing a trend similar to the broader U.S. and the globe?

Extension:

JOURNAL

- Considering the historical temperature trend and predicted future trends, what does this pattern of average July temperatures mean for us?
- How do you think this type of change in climate affects your life?
- How might it affect plants and animals?

Quincy, CA historical weather data obtained on 2/28/2019 from Western Regional Climate Center, https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7195

Updates and historical weather data for other locations can be obtained from: https://wrcc.dri.edu/coopmap/

Handout 3.1a

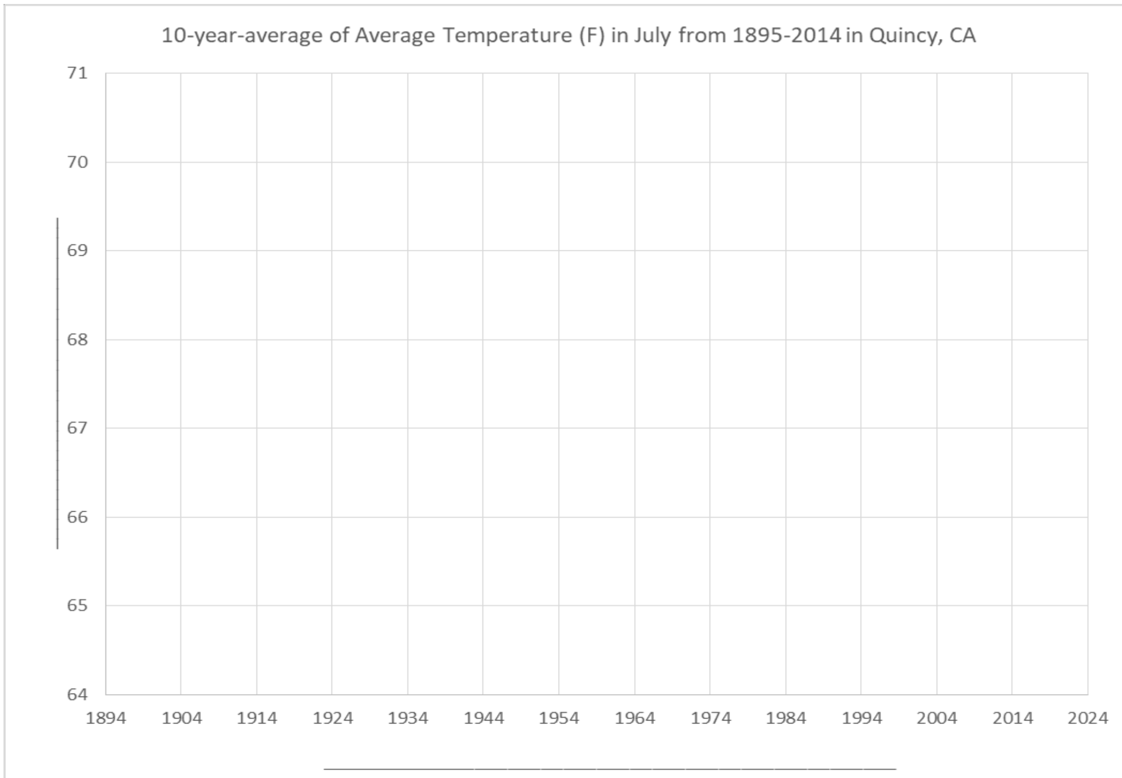
Abbreviated datasets of historical average July temperature and annual precipitation data in Quincy, CA from 1895-2014.

Data represent 10-year averages by decade from 1895-2014. Plot the data point for each decade on the year that decade ends (eg. for the decade 1895-**1904**, the 10-year average of 65.3°F should be plotted on the graph above the year 1904).

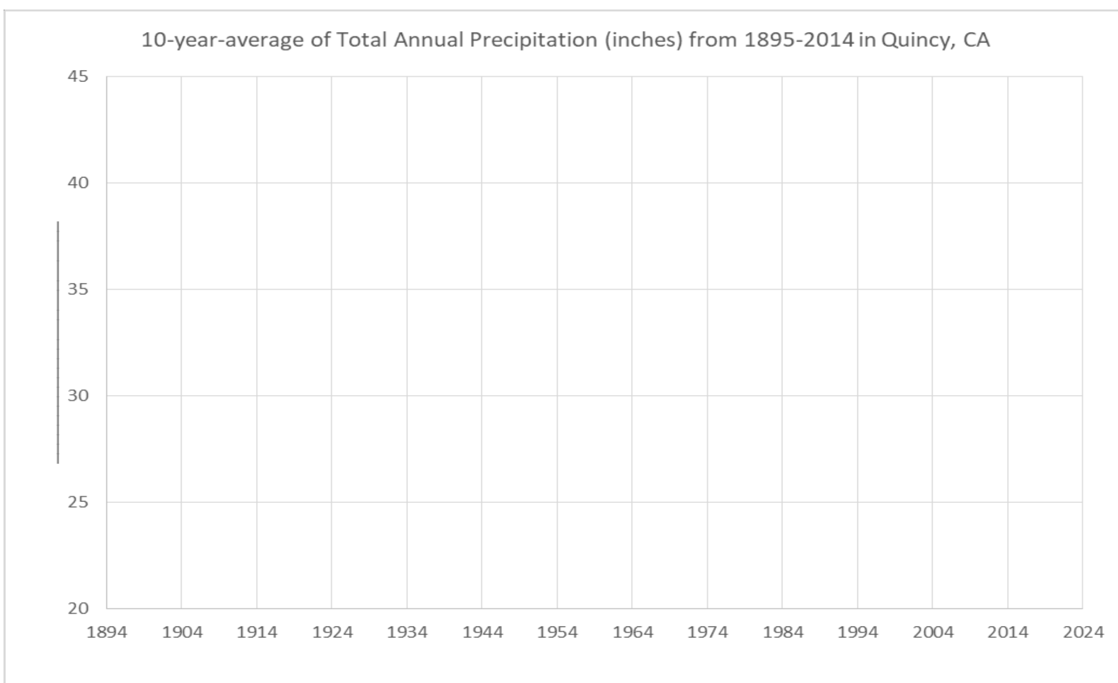
Decade	Average Temperature (F) in July
1895-**1904**	65.3
1905-**1914**	65.0
1915-**1924**	66.4
1925-**1934**	66.8
1935-**1944**	65.7
1945-**1954**	65.8
1955-**1964**	66.4
1965-**1974**	67.8
1975-**1984**	66.4
1985-**1994**	68.5
1995-**2004**	69.0
2005-**2014**	70.2

Decade	Total Annual Precipitation (inches)
1895-1904	43.0
1905-1914	38.0
1915-1924	30.9
1925-1934	30.0
1935-1944	39.8
1945-1954	39.3
1955-1964	40.1
1965-1974	44.7
1975-1984	23.7
1985-1994	22.0
1995-2004	40.0
2005-2014	33.9

Handout 3.1b

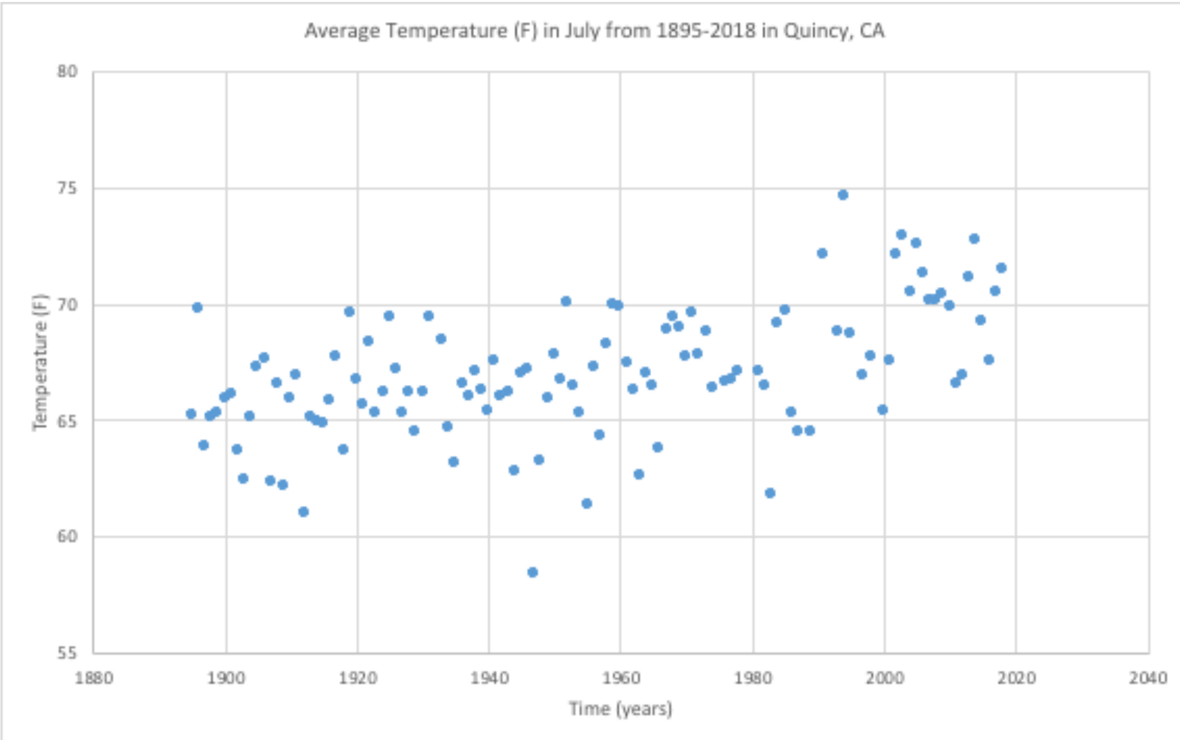


Temperature trendline equation: $y = 0.0384x - 8.2017$

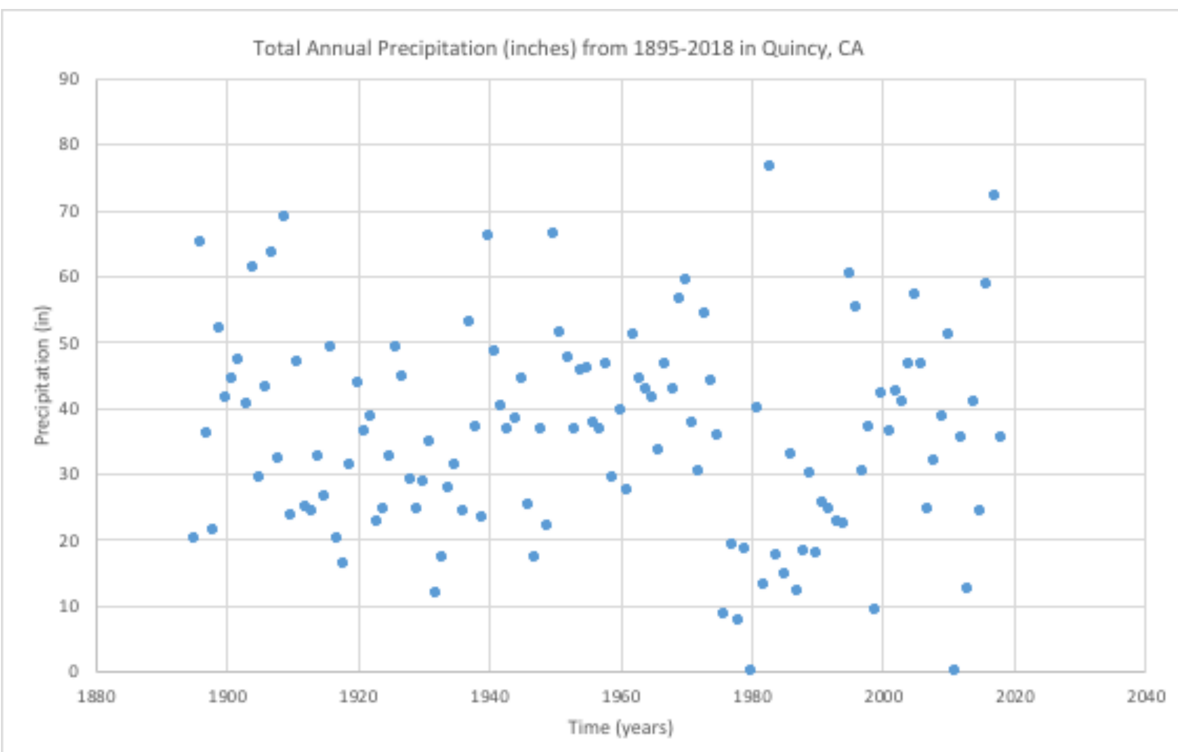


Precipitation trendline equation: $y = - 0.0591x + 151.28$

Handout 3.1c



Temperature trendline equation: $y = 0.0396x - 10.487$



Precipitation trendline equation: $y = -0.0347x + 103.79$

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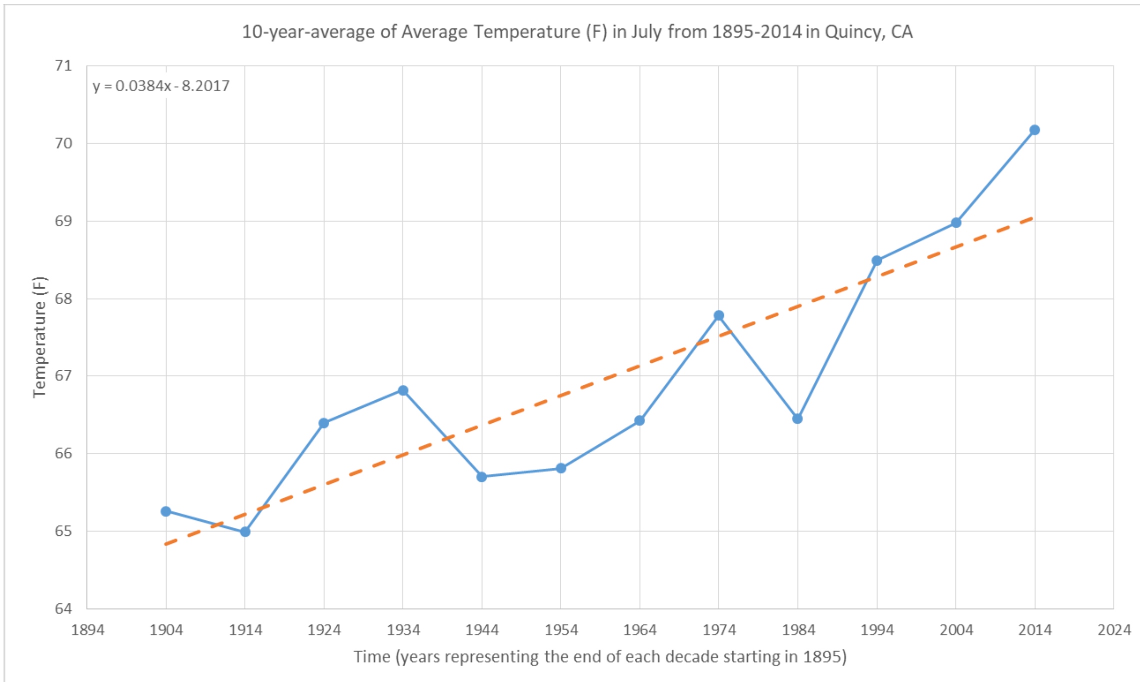
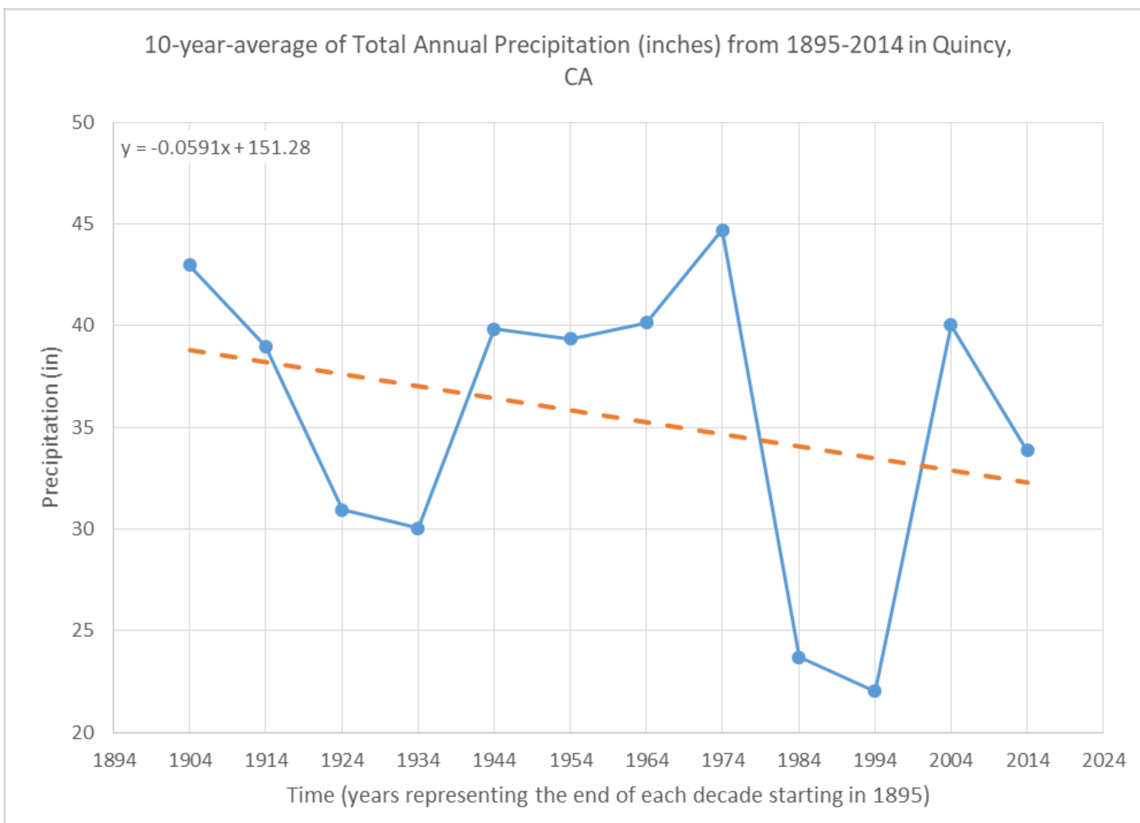
<u>Teacher's Supplement 3.1a</u>

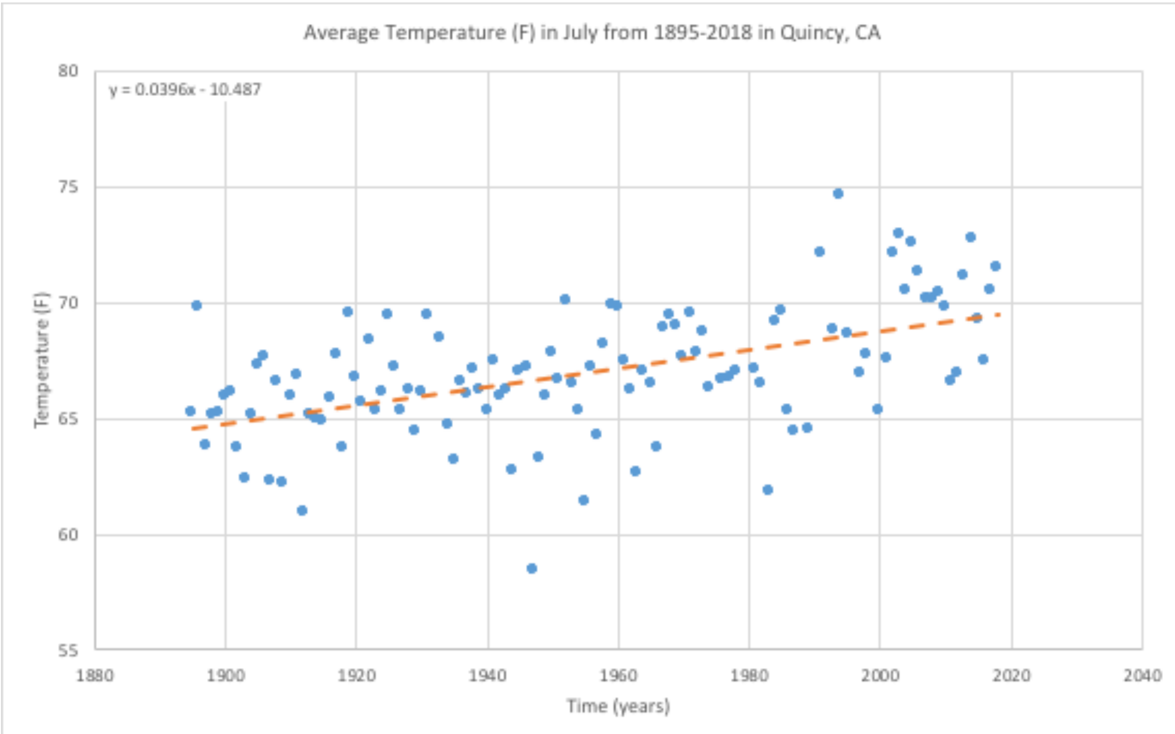
Student line graphs with the abbreviated data set (10-year averages) and trend line should resemble to following:

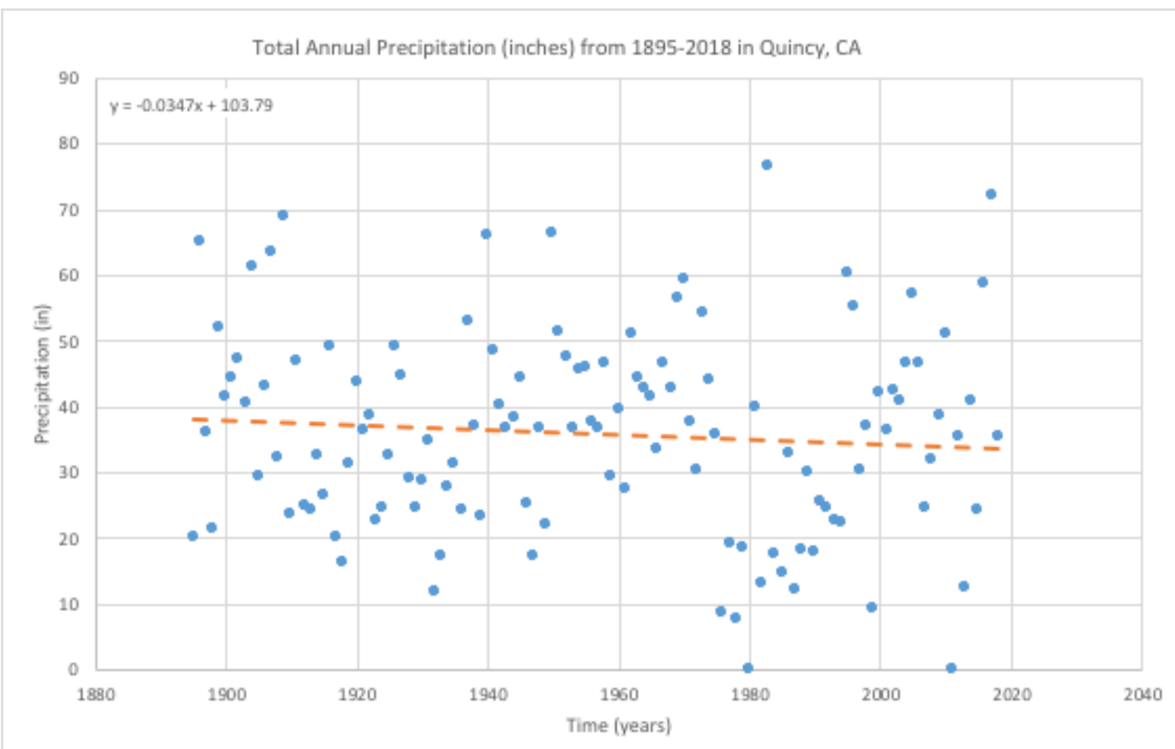




Teacher's Supplement 3.1b

Students' trendline added to the scatterplots with the full data set (1895-2019) should resemble to following:

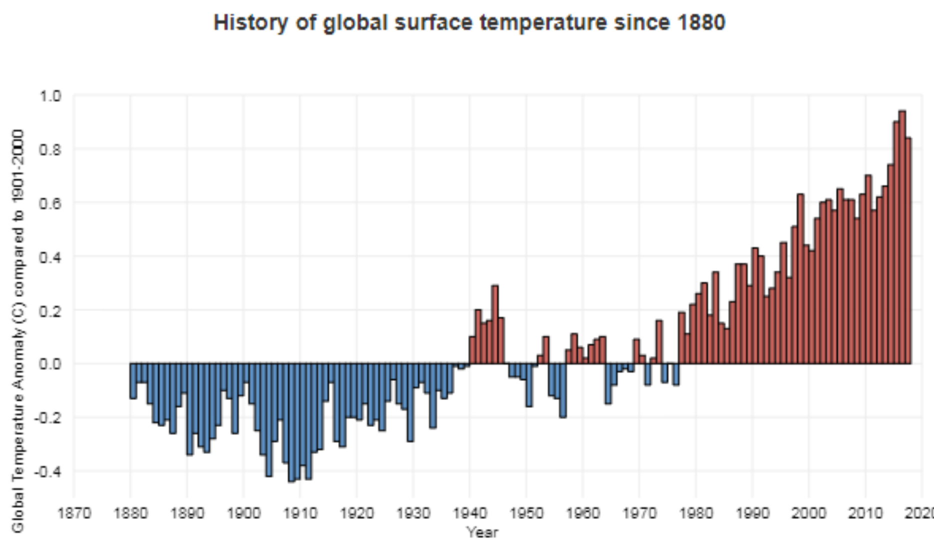




Teacher's Supplement 3.1c

GLOBAL CLIMATE

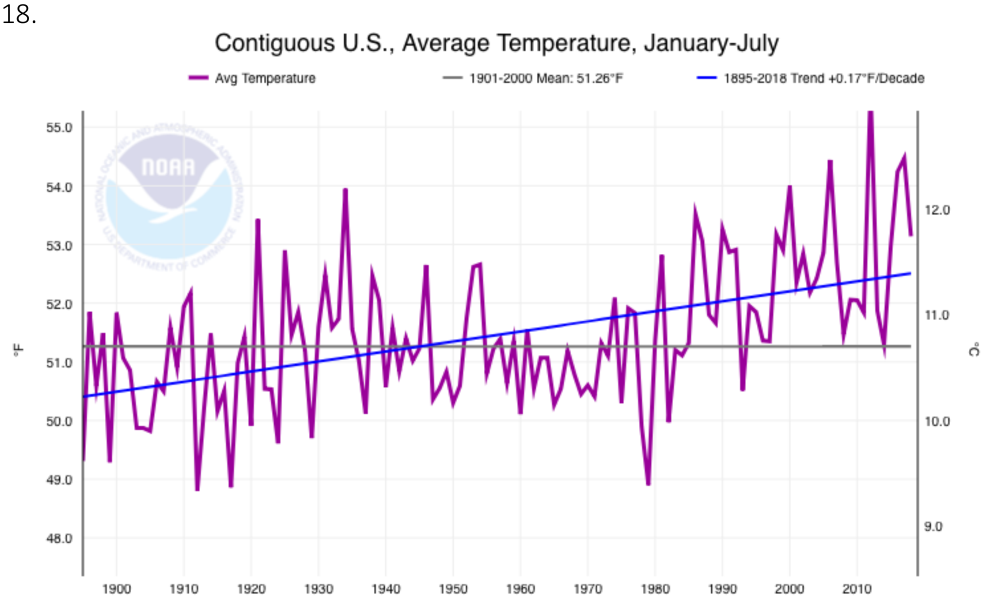
Climatologists are observing a change in the global climate: Earth's average temperature is increasing. While not all places on Earth are experiencing a warming trend, the upward march of the global average is stark. This rise in average temperature is attributed to the increase in greenhouse gases in Earth's atmosphere due to human activity. The chart below shows how annual average temperatures have changed worldwide since 1880, using data from land and sea surface measurements.



The graph shows average annual global temperatures since 1880 (source data) compared to the long-term average (1901-2000). The zero line represents the long-term average temperature for the whole planet; blue and red bars show the difference above or below average for each year.
Data Source: NOAA, 2018: https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

REGIONAL CLIMATE

The United States is a broad region also experiencing warming. The graph below shows the upward trend in average temperature recorded in the United States (contiguous) for a 6-month period from the year 1895 to 2018.



Graph from National Oceanic and Atmospheric Association. Obtained Aug. 14, 2018.
https://www.ncdc.noaa.gov/cag/national/time-series/110/tavg/7/7/1895-2018?base_prd=true&begbaseyear=1901&endbaseyear=2000&trend=true&trend_base=10&begtrendyear=1895&endtrendyear=2018

Plumas Audubon Society

UNIT 3: KNOWLEDGE
Climate Change: The Basics

Lesson 3.2

Lesson Objectives:
- Conduct an experiment to learn about Earth's natural greenhouse effect
- Understand the effects of human activities on Earth's systems.
- Practice the scientific method of testing a hypothesis, observing and recording data, and forming conclusions based on data

NGSS:
Middle School

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

High School

HS-ESS2-2.Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS3-6.Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Time: *60 minutes*

Materials:
See next page

Educator Tips:
- Background information is provided for students in Reading 3.2.
- Refer to the **Teacher's Supplement 3.2** which provides example answers for Results and Conclusion sections.

The Greenhouse Effect: A CO_2 Experiment

Summary:
Students will demonstrates the heat-trapping abilities of carbon using bottles and seltzer tablets that release carbon dioxide. Students will compare the temperature of the bottle and compare to a control.

Background:
The earth and atmosphere are like a greenhouse. A greenhouse allows the sun's light to enter through the glass, and that energy remains trapped as heat inside the enclosure. The light and heat trapped inside enable plants to grow in a warmer temperature than outside of the greenhouse.

How is Earth like a greenhouse? Light from the sun radiates through space and enters Earth's atmosphere. When that energy hits the earth's surface, some of it is absorbed, and some of it bounces back outwards into space. If all of that energy bounced back out to space, Earth would be much colder than its average temperature of 15°C (59°F). In fact, it would probably be a barren, frozen wasteland.

In 1827, French mathematician and physicist, Joseph Fourier, wondered how Earth's average temperature stayed at approximately 15°C (59°F) instead of −18°C (0°F). Fourier predicted there must be something happening in Earth's atmosphere that kept the Earth warmer than 0°F— a process similar to what happens in a greenhouse.

The process that keeps Earth warm is called the **greenhouse effect**. The sun's energy bounces off Earth's surface, heads back out into space, but is trapped by gases in Earth's atmosphere. These gases, water vapor, carbon dioxide, methane, and other trace gases, are called greenhouse gases. Greenhouse gases reemit the trapped heat. Some of that heat leaves the atmosphere and some returns to Earth's surface. This natural process, the greenhouse effect, warms Earth to an average global temperature of 15°C (59°F), allowing life to flourish.

What happens when more greenhouse gases are added in to the atmosphere? How does this affect Earth's average global temperature?

Some scientists foresaw climate change and global warming as humans started burning fossil fuels in the Industrial Revolution. In the 1860s, physicist John Tyndall observed the Earth's natural greenhouse effect and predicted that changes in the atmosphere could influence and alter the climate. In 1896, Swedish scientist Svante Arrhenius surmised that changes in concentrations of carbon dioxide in the atmosphere would affect the natural greenhouse effect

Check it out:
To convert temperature between degrees Celsius and Fahrenheit use:
T(°F)=T(°C) x 9/5 – 32

Every degree change in Fahrenheit is 1.8 (or 9/5) times the degree change in Celsius.

Materials:
- 2 empty 2-liter bottles (per group)
- 2 small candy thermometers (per group)
- 16 seltzer tablets (per group)
- Water
- Clay
- Plastic wrap
- Light source (direct sun, halogen or other high-wattage lamp, 100W+)
- Reading 3.2
- Handout 3.2a and 3.2b

and significantly increase Earth's surface temperature.

In fact, ice core samples taken from Greenland, Antarctica, and mountain glaciers in the tropics show historical shifts in Earth's climate with changes in greenhouse gas levels. According to these ice samples and other paleological evidence such as tree rings, sedimentary rock, and ancient coral reefs, the Earth is warming at a rate ten times faster than the temperature rise after the ice age!

Since the Industrial Revolution of the late 19th century, Earth's average surface temperature has risen at least 1°C (1.8°F) due to carbon emissions in the atmosphere from human activity. Moreover, the most drastic warming occurred in the last 35 years.

Activity:
CO_2 EXPERIMENTS
In these two experiments, students will construct two models: one modeling the natural greenhouse effect (the "control" model), and another modeling an amplified greenhouse effect (the "experimental" or "treatment" model) to answer the following questions:

1. Does carbon dioxide, a greenhouse gas, really trap heat?
2. Does the concentration of carbon dioxide affect the air temperature in a closed environment?

Have students read the background information reprinted in Reading 3.2, provided in the supplemental materials following this lesson.

Pass out Handout 3.2a (two pages) and 3.2b. Students will use Handout 3.2a to read through the methods for two experiments and to write their hypotheses, record their results, and graph their data.

On the back of Handout 3.2b or in a journal or lab book, students will write up a summary of their results and answer the concluding questions on Handout 3.2b, using the graph provided of the Monthly Average Carbon Dioxide Concentration from the Mauna Loa Observatory. The write-up of results and conclusions can be an in-class assignment or homework to be reviewed in the following class period. Refer to Teacher's Supplement 3.2 for sample answers for the Results and Conclusion sections.

Conclusion:
If all went well, your class should have discovered through these experiments that CO_2 does indeed trap heat and that greater concentrations of CO_2 trap more heat. If your results did not turn out this way, use this as opportunity to think critically about what may have caused your results to turn out differently (for example, consider whether your experiment set the bottles up at the same distance from and angle to the light, or whether another heat source or heat sink was nearby, etc).

Extension:

GREENHOUSE EFFECT

Remind your class that these experiments modeled the "greenhouse effect". Explain that carbon dioxide is a greenhouse gas that is both naturally occurring in the atmosphere and added to the atmosphere by humans, primarily by burning fossil fuels.

Compare and contrast the model you created in this experiment to Earth's greenhouse effect. What happens to the temperature on Earth when more carbon dioxide is added into the atmosphere?

As a class or as homework visit NASA's Global Climate Change: Vital Signs of the Planet, Carbon Dioxide Facts page online (https://climate.nasa.gov/vital-signs/carbon-dioxide/) and answer the following referring to the two graphs on that page:

- What is the current level of CO_2 in the atmosphere (latest measurement)?
- In the past 400,000 years, when were the levels of CO_2 equal to what they are today?
- In the past 400,000 years, approximately what was the highest level of CO_2 in the atmosphere?
    - Compare that level to today's level.
    - What do you think that means for Earth's temperature when comparing today's temperatures to any time in the past 400 thousand years?

Educator Tip:
To help put the large and difficult to grasp time period of 400,000 years into perspective, consider that anatomically modern humans (ie. Homo sapiens) emerged in the fossil record about 200,000 years ago and evolved during a time when Earth's climate has been relatively very stable—until most recently.

Lesson adapted from NASA, Climate Science Investigations: www.ces.fau.edu/nasa/content/teacher-materials/greenhouse-effect.docx

NASA, Global Climate Change: Vital Signs of the Planet, Facts/Evidence: https://climate.nasa.gov/evidence/

C. D. Keeling, S. C. Piper, R. B. Bacastow, M. Wahlen, T. P. Whorf, M. Heimann, and H. A. Meijer, Exchanges of atmospheric CO2 and 13CO2 with the terrestrial biosphere and oceans from 1978 to 2000. I. Global aspects, SIO Reference Series, No. 01-06, Scripps Institution of Oceanography, San Diego, 88 pages, 2001.

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Reading 3.2
The Greenhouse Effect

The earth and atmosphere are like a greenhouse. A greenhouse allows the sun's light to enter through the glass, and that energy remains trapped as heat inside the enclosure. The light and heat trapped inside enable plants to grow in a warmer temperature than outside of the greenhouse.

How is Earth like a greenhouse? Light from the sun radiates through space and enters Earth's atmosphere. When that energy hits the earth's surface, some of it is absorbed, and some of it bounces back outwards into space. If all of that energy bounced back out to space, Earth would be much colder than its average temperature of 15°C (59°F). In fact, it would probably be a barren, frozen wasteland.

In 1827, French mathematician and physicist, Joseph Fourier, wondered how Earth's average temperature stayed at approximately 15°C (59°F) instead of −18°C (0°F). Fourier predicted there must be something happening in Earth's atmosphere that kept the Earth warmer than 0°F— a process similar to what happens in a greenhouse.

The process that keeps Earth warm is called the **greenhouse effect**. The sun's energy bounces off Earth's surface, heads back out into space, but is trapped by gases in Earth's atmosphere. These gases, water vapor, carbon dioxide, methane, and other trace gases, are called greenhouse gases. Greenhouse gases reemit the trapped heat. Some of that heat leaves the atmosphere and some returns to Earth's surface. This natural process, the greenhouse effect, warms Earth to an average global temperature of 15°C (59°F), allowing life to flourish.

What happens when more greenhouse gases are added in to the atmosphere? How does this affect Earth's average global temperature?

Some scientists foresaw climate change and global warming as humans started burning fossil fuels in the Industrial Revolution. In the 1860s, physicist John Tyndall observed the Earth's natural greenhouse effect and predicted that changes in the atmosphere could influence and alter the climate. In 1896, Swedish scientist Svante Arrhenius surmised that changes in concentrations of carbon dioxide in the atmosphere would affect the natural greenhouse effect and significantly increase Earth's surface temperature.

In fact, ice core samples taken from Greenland, Antarctica, and mountain glaciers in the tropics show historical shifts in Earth's climate with changes in greenhouse gas levels. According to these ice samples and other paleological evidence such as tree rings, sedimentary rock, and ancient coral reefs, the Earth is warming at a rate ten times faster than the temperature rise after the ice age!

Since the Industrial Revolution of the late 19th century, Earth's average surface temperature has risen at least 1°C (1.8°F) due to carbon emissions in the atmosphere from human activity. Moreover, the most drastic warming occurred in the last 35 years.

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Handout 3.2a
Does the concentration of carbon dioxide affect the air temperature in a closed environment?

Hypothesis
After reading through the methods section below, write a hypothesis in the space provided for each experiment (ie. two in total) that include the independent and dependent variables in the experiment. (*Hint: The independent variable is what you change; the dependent variable is what happens because of the change*.) Your hypotheses should address the following questions:

1. Does carbon dioxide, a greenhouse gas, really trap heat?
2. Does the concentration of carbon dioxide affect the air temperature in a closed environment?

Experiment #1 hypothesis:

Experiment #2 hypothesis:

EXPERIMENT #1 Methods:
1. Fill each bottle with 100 mL of water.
2. Label one bottle "Control" and the other "Experimental" or "CO_2 added" (The bottle labeled as CO_2 will have four Alka-Seltzer tablets in the water. When seltzer tablets dissolve in water they release CO_2).
3. Cover the openings of the bottles with a lump of clay to create an airtight seal. Insert a thermometer into each bottle through the seal. Make sure the thermometer is hanging in the air above the water.
4. Tear two sheets of plastic wrap and set aside.
5. Carefully removing the seal with the thermometer on the bottle labeled "CO_2". Drop four Alka-Seltzer tablets into the water bottle and quickly reseal, ensuring once again that the thermometer is suspended in the air inside the bottle.
6. Immediately cover the top of each bottle (including the thermometer inserted in the clay) loosely with the plastic wrap. Use a rubber band to secure the plastic wrap around the top of the bottle.
7. Then immediately record the temperature in each bottle to eliminate the possible misconception that the seltzer tablet itself adds heat somehow (0:00A minutes).
8. Next, place the bottles directly under or next to your light source (either direct sun or a high-wattage lamp) ensuring that the light is shining evenly, directly, and the same distance from both bottles.
9. Record an initial temperature reading for each (0:00B minutes). Start a stopwatch or monitor a wall clock recording temperatures of both bottles every two (2) minutes for 10-20 minutes. You can stop the experiment when you notice the temperature is no longer increasing, but do not stop before the 10 minute mark.

EXPERIMENT #2 Methods:
Clean the bottles out and perform the experiment again following similar methodology as above, but with the following changes:

- In step 2, label one bottle "CO_2 added" and the other "Double CO_2".
- In step 5, as before, add 4 Alka-Seltzer tablets to the "CO_2 added" bottle *and* add 8 Alka-Seltzer tablets to the "Double CO_2" bottle. If limited by seltzer tablets, you can use other amounts, but retain the proportion ratio of 1:2.

Record your data in a second table, titled appropriately to distinguish it from the first results table.

Results

Record the air temperature (˚C or ˚F, but be consistent and fill in the table below) in each bottle at 2-minute intervals for 10 to 20 minutes in the table below. Title your tables.

Experiment #1:

Time (minutes)	Temp. (˚__) of control bottle	Temp. (˚__) of CO_2 bottle
0:00A		
0:00B		
2:00		
4:00		
6:00		
8:00		
10:00		
12:00		
14:00		
16:00		
18:00		
20:00		

Experiment #2:

Time (minutes)	Temp. (˚__) of control bottle	Temp. (˚__) of CO_2 bottle
0:00A		
0:00B		
2:00		
4:00		
6:00		
8:00		
10:00		
12:00		
14:00		
16:00		
18:00		
20:00		

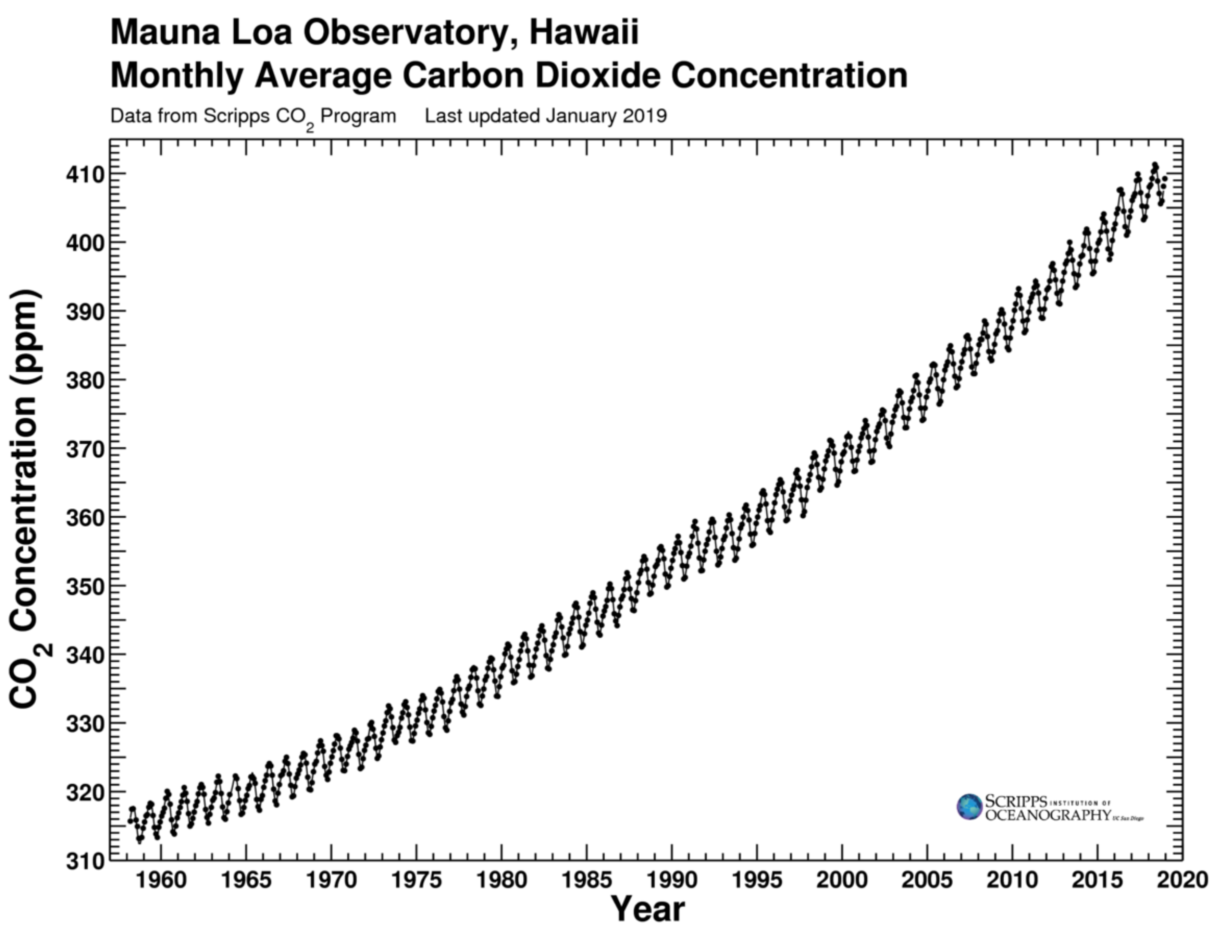
Graph Your Data

Construct a line graph for each experiment in the space provided that summarizes your results. Include a title and a legend for each graph and label the axes.

Handout 3.2b

Write a summary of your results and answer the following questions:

1. Were your hypotheses correct? If yes, cite data to support it. If no, how was your hypothesis incorrect? Cite data that disproves it.
2. Explain your results and discuss any flaws in the experiment.
3. How could you improve the experiment for further study?
4. How did this experiment model the greenhouse effect on Earth? Compare and contrast what you observed in the experiment to how the greenhouse effect occurs on Earth.
5. What if Earth's greenhouse effect was amplified? What do you predict will happen to the global temperature of Earth as more CO_2 is added to the atmosphere?
6. What is the current concentration of CO_2 in parts per million (ppm) in Earth's atmosphere? Approximate from the graph below or see http://scrippsco2.ucsd.edu/data/atmospheric_co2/primary_mlo_co2_record for updates.
7. What was the concentration of CO_2 the year that you were born? Approximate from the graph below:



This graph shows the measured monthly average concentration of carbon dioxide (in parts per million) in the atmosphere from the year 1958 to present. The graph shows a steady increase in the amount of carbon dioxide in the atmosphere. See http://scrippsco2.ucsd.edu/research/atmospheric_co2 for details on this study.

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Teacher's Supplement 3.2

Summary of Results

Write a summary of your results.

Answers will vary. Students should observe that the temperature of the air inside the "control" (bottle without Alka-Seltzer tablets) increased slightly by 1 or 2˚C. Students should have observed an increase of more than 2˚C for the air temperature in the bottle with the 4 Alka-Seltzer tablets.

Conclusions: Developing Explanations from Evidence

1. Were your hypotheses correct and supported by the data or evidence?

   Answers will vary. The data should support the hypothesis that the air temperature in the bottle with the Alka-Seltzer tablets increased more than that in the control and that the air temperature in the "Doubled CO_2" bottle increased more than that in the "CO_2 added" bottle. If students did not obtain these results, they may need to conduct the experiment longer or conduct repeated trials.

2. Explain your results and discuss any flaws in the experiment.

   The amount of Alka-Seltzer tablets influences the amount of CO_2 that is released into the bottle's environment, which affects the overall temperature in each environment. The bottle without the tablets has a smaller temperature increase than the bottle with the Alka-Seltzer tablets. This rise in temperature is caused by the absorption and re-emission of heat by the CO_2 gas molecules in the air.

   Flaws may include problems with the seal, other heat sources or sinks nearby, uneven light/heat treatment to the two bottles, or others.

3. How could you improve the experiment for further study?

   Answers will vary and there is no "right" answer. Student may recommend conducting the experiment over a longer period of time or conducting repeated trials.

4. Compare and contrast the model of the greenhouse effect to Earth's greenhouse effect.

   The model of the greenhouse effect without Alka-seltzer tablets represents Earth's natural greenhouse effect. This bottle contained water vapor and some small amount of CO_2 naturally present in the air, so it is similar to Earth's natural greenhouse effect. The bottle with the 4 Alka-Seltzer tablets represents an environment with an increased concentration of CO_2 (or an amplified greenhouse effect). The simple models constructed in this experiment are different from Earth's actual greenhouse effect because they have the physical barrier of the clay and plastic cover, which also prevents warmer air from flowing out of the bottle. (This is also how a greenhouse functions to keep plants warmer during winter months.)

5. What if Earth's greenhouse effect was amplified? What do you predict will happen to the global temperature of Earth as more CO_2 is added to the atmosphere?

   An increased concentration of atmospheric CO_2 will cause more infrared radiation to be absorbed and re-emitted, resulting in a warming atmosphere.

6. What is the current concentration (parts per million) of CO_2 in Earth's atmosphere? ____

7. What was the concentration of CO_2 the year that you were born?

   Answers will vary. Students should see the increase in CO_2 concentration over the past decades.

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Plumas Audubon Society

UNIT 3: KNOWLEDGE
Climate Change: The Basics

Lesson 3.3

Lesson Objectives:
- Learn what greenhouse gases are and how the greenhouse effect regulates Earth's atmosphere.
- Study the natural movement of carbon on Earth by diagramming the carbon cycle.
- Learn about the impact of human activity on the carbon cycle and its effect on Earth's climate.

NGSS:

Middle School
MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
MS-ESS3-3.* Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

High School
HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

The Carbon Cycle and Greenhouse Gases

Summary:
Through reading (Reading 3.3), class discussion, and diagramming the carbon cycle, students will learn about the natural flow of carbon between reservoirs, living things and the atmosphere over time. They will also read about greenhouse gases and analyze pie charts that represent global emissions and emissions sources (Handout 3.3). Students will learn how human activity increases the flow of carbon from reservoir to the atmosphere at a rate faster than natural processes can return carbon to its stores. Students must develop an understanding of how carbon moves through the environment in order to appreciate the complexity of developing solutions to address problems associated with climate change.

Background:
Carbon is the backbone of life on Earth-- it regulates the temperature of the planet, it makes the food we need to survive, it powers our cars, and heats our homes. The natural carbon cycle is essential to our daily life and to the success of all life on our planet. Human carbon use, primarily the burning of carbon-containing substances, however, is creating an imbalance in the natural cycle of carbon and contributing to global climate change.

Global warming and climate change can be attributed to an increased amount of heat-trapping gases called **greenhouse gases** in the atmosphere. The term "global warming" is often used interchangeably with the term "climate change," however, global warming is one aspect of global climate change that describes the recent rise in the average temperature at the earth's surface. This rise in average temperature is attributed to the increase in greenhouse gases in Earth's atmosphere due to human activity. Figure 1 on the following page shows how annual average temperatures have changed worldwide since 1880, using data from land and sea surface measurements.

In general, greenhouse gases are a good thing: they regulate the temperature of Earth by trapping warmth from the sun in earth's atmosphere. Without greenhouse gases, Earth would be a frozen wasteland, too cold to support life. Most greenhouse gases occur naturally, but human activities are increasing the amount of greenhouse gases in the atmosphere at a rate faster than can be regulated by Earth's natural processes.

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS3-4.* Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-6.Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

* Indicates standard fulfilled in "Extensions" section.

Time: *60 minutes*

Materials:

- Drawing materials
- Reading 3.3
- Handout 3.3
- Internet access to complete backside of Handout 3.3

Learn more:
For more about each of the greenhouse gases, visit https://climatekids.nasa.gov/greenhouse-cards/ which provides kid-friendly descriptions of the greenhouse gases and how they occur naturally and/or how humans have increased their presence in Earth's atmosphere.

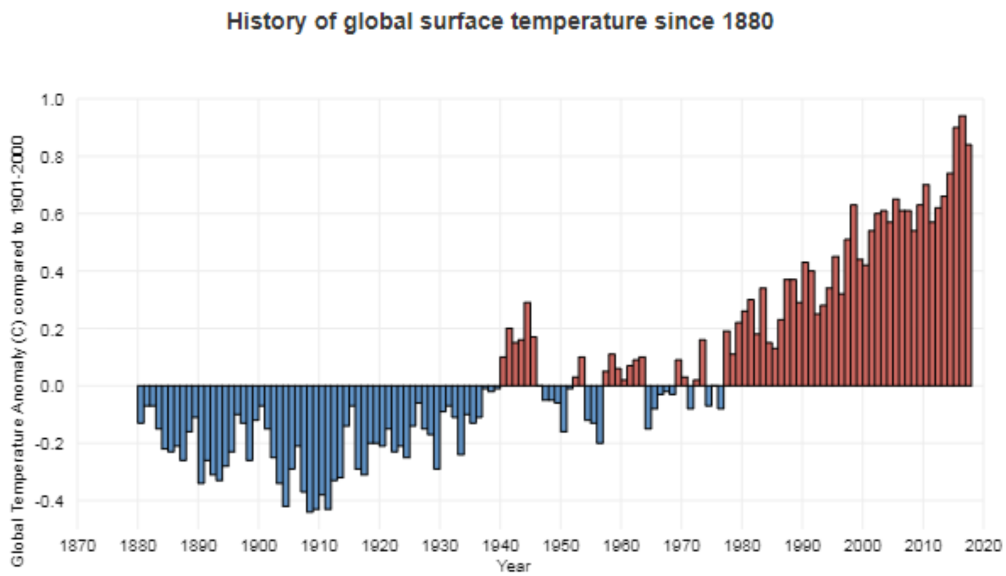

Figure 1. The graph shows average annual global temperatures since 1880 (source data) compared to the long-term average (1901-2000). The zero line represents the long-term average temperature for the whole planet; blue and red bars show the difference above or below average for each year. Data Source: NOAA, 2018 https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

GREENHOUSE GASES

- carbon dioxide
- methane
- water vapor
- ozone
- nitrous oxide
- fluorinated gases (Not a naturally occurring greenhouse gas)

Why does it matter if the average temperature on Earth increases?

Temperature has wide-ranging effects on human, animal, and plant life. Annual and seasonal temperature patterns determine the types of plants and animals that can survive in a particular place. Changes in temperature can disrupt natural processes, particularly when these changes occur faster than animal and plant life can adapt. Highly temperature-sensitive systems, such as the polar regions, high mountains and the tropics, low-lying coastal regions, and underwater coral reefs are experiencing significant changes already and life in these regions is at the forefront of bearing the brunt of climate disruption impacts. A seemingly small global temperature increase corresponds to enormous changes in the environment with real and alarming implications for biological, social, and political systems the world over.

Since the Industrial Revolution, the earth has experienced at least at least 1°C (1.8°F) of warming and the upward trend continues. One degree increase or even four may not sound like much, but consider that Earth's temperatures were only 2.7-5°C (5-9°F) degrees cooler around the end of the last ice age.

Global warming is like a rising fever: Just half a degree Celsius (0.9°F) increase moves the body's temperature out of the normal range to a fever. An additional 2°C (3.6°F) is cause for concern if the fever lasts longer than 48 hours, while a 3°C (5.4°F) increase would send a person to the hospital as the fever hits dangerous levels.

Although 2°C of global warming has been a politically agreed upon upper limit (The Paris Agreement, UNFCCC 2015), the UNFCCC expert group considers it "inadequate" as a safe limit. Three degrees of warming will leave much of the planet uninhabitable.

Did you know:
The UNFCCC is the United Nations Framework Convention on Climate Change. Formed in 1992, it is an international environmental treaty that aims to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

The Paris Agreement is an international agreement created in 2015 within the UNFCCC that addresses greenhouse gas emissions mitigation, adaptation, and finance.

Questioning Prompts:

- What is carbon?
- Why do we often hear about carbon when we hear about climate change?
- Does carbon occur naturally in our atmosphere?
- What is the carbon cycle?
- How are humans affecting the natural carbon cycle?

Activity:

Provide students with Reading 3.3. They may read in class or take it home to read as homework before class discussion and diagramming the carbon cycle.

After everyone has read Reading 3.3, discuss as a class the following questions and these key points about the carbon cycle. Refer to Teacher's Supplement 3.3a for sample answers to the questions and discussion guidance.

- What is carbon?
- Where can carbon be found on Earth?
- What are the processes that move carbon around in the carbon cycle?
- What are the human impacts on the carbon cycle?
- What are greenhouse gases?
- What is the greenhouse effect?
- What is global warming?
- Why do we focus on carbon dioxide as the primary driver of global warming?
- Why is a warmer Earth concerning?

Check it out:
In addition to reviewing Reading 3.3 assigned to students, teachers may benefit from reading the following NASA article that provides a more in-depth overview of the carbon cycle: https://earthobservatory.nasa.gov/Features/CarbonCycle/printall.php

Educator Tip:
The **Teacher's Supplement 3.3a** provides sample answers for all discussion questions in this activity. **Teacher's Supplement 3.3b** provides the answer key to Handout 3.3.

CARBON CYCLE

Have each student diagram the carbon cycle with drawing materials in the space provided on Handout 3.3. They may reference the diagrams provided in Reading 3.3, but their diagrams will be more detailed. They must include the following elements in their diagram:

SLOW CARBON CYCLE

- Chemical weathering and erosion
- Air-sea gas exchange
- Marine life, shells, and coral
- Limestone/sedimentary rock
- Fossil fuels (oil, coal)
- Volcanic activity

FAST CARBON CYCLE

- Photosynthesis (plants and phytoplankton)
- Respiration (plants and animals)
- Decomposition
- Excretion
- Natural combustion (forest fires)

HUMAN IMPACT

- Burning fossil fuels (coal, oil, and natural gas)
- Clearing land/deforestation
- Making concrete

<u>EMISSIONS</u>

The backside of Handout 3.3 has two fill-in-the-blank pie charts. The first shows the types of greenhouse gases emitted by human activity as percentages. As carbon dioxide is by far the most plentiful of the greenhouse gases, the second chart shows global carbon emissions by economic sector. Have your students complete the pie charts using the EPA's website: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data. See Teacher's Supplement 3.3b for the answer key to this activity.

Review the carbon cycle as a class and/or check students' diagrams for accuracy. As a class, identify and discuss where in the carbon cycle humans have the ability to influence carbon emission or absorption. The following points may help direct the discussion. Refer to Teacher's Supplement 3.3a for sample answers to discussion questions.

- How might we change industrial practices?
- How might we change agricultural practices?
- What small steps could we take to reduce the carbon footprint of our daily lives?

Extensions:

- Show this short video to the class about the greenhouse effect, which highlights why adding more carbon to the atmosphere causes the planet to warm.
    - https://tpt.pbslearningmedia.org/resource/phy03.sci.phys.matter.greenhouse2/global-warming-the-physics-of-the-greenhouse-effect/?#.WoYPpZM-eRs

- After this lesson, it may be helpful to discuss some ways we can begin to change the human impacts on the carbon cycle. Here is an example of a project in Marin County that addresses the influence of agricultural practices on the carbon cycle. The Marin Agricultural Land Trust (MALT) encourages local farmers and ranchers to conform to "carbon farming" practices which improve their land's ability to remove carbon from the air and store it in the soil. Read about carbon farming and the Marine Carbon Project here:
    - http://malt.org/protected-lands/carbon-farming?gclid=EAIaIQobChMIpribyvPO2QIVBJ7ACh205AbHEAAYASAAEgKWWvD_BwE
    - http://www.marincarbonproject.org/carbon-farming
- There are many ways to reduce your own carbon footprint, from choosing to eat a plant-based diet to avoiding air travel and reducing car travel to unplugging electronic devices and turning off lights to simply buying less stuff.

  As a class check out CoolClimate Network's Carbon Footprint Calculator (https://coolclimate.berkeley.edu/calculator) and try to calculate an average household's carbon footprint.

  Review the bar graphs to get an idea of where the most carbon emissions come from and then review the list of things you can do to reduce your impact under the Take Action tab (Note: sort the columns by "Upfront Cost" to see the things most people can do at the top of the list). Then, take a pledge to commit to at least one of those actions.

  Throughout the year, do quick, regular check-ins to see how well the class is holding to those commitments. Check-ins should not focus on anyone's failure to commit or follow-through, but rather focus on successful and lasting changes and offer both a reminder and an opportunity to recommit to a climate action.

NASA's Climate Kids Greenhouse Gases page: https://climatekids.nasa.gov/greenhouse-cards/

NASA's Climate Kids Carbon page: https://climatekids.nasa.gov/carbon/

NOAA's Carbon Cycle page: http://www.noaa.gov/resource-collections/carbon-cycle

EPA's Climate Change Indicators page: https://19january2017snapshot.epa.gov/climate-indicators/climate-change-indicators-us-and-global-temperature_.html

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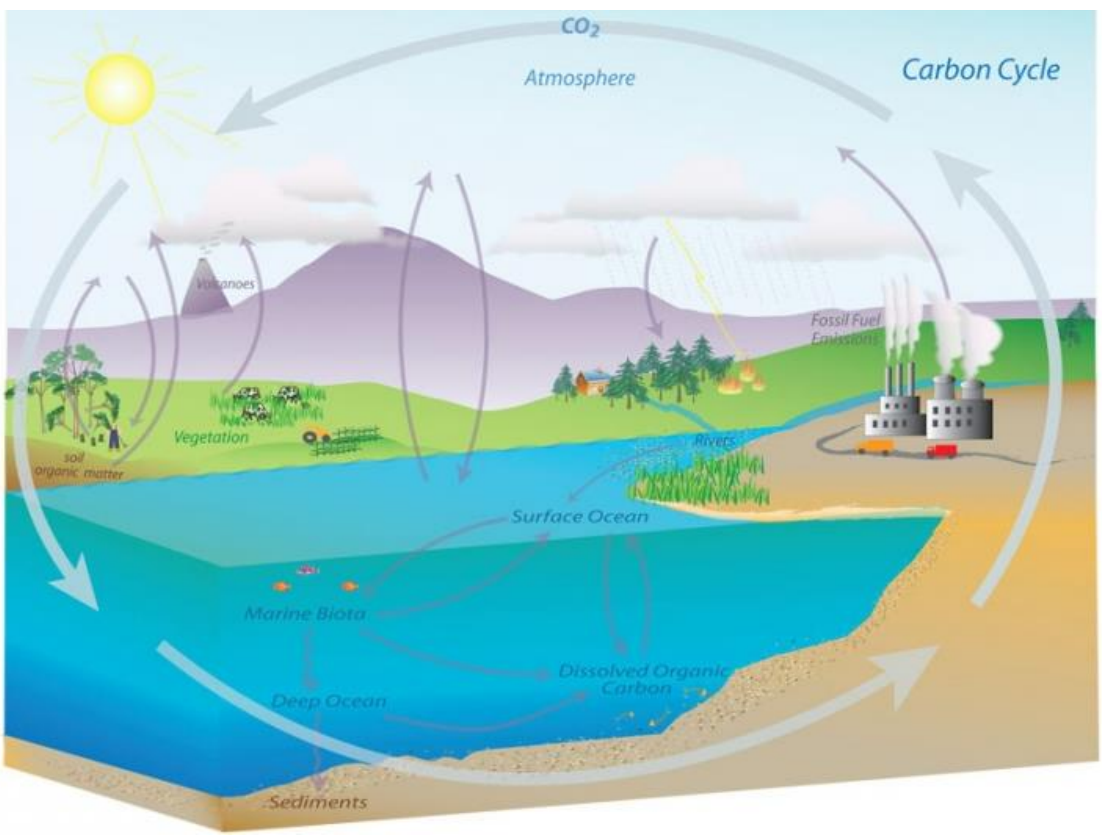
Reading 3.3
The Carbon Cycle

Take a bite of dinner, a breath, or a drive in a car — you are part of the carbon cycle.

Carbon is the chemical backbone of life on Earth and a key element in many important processes. Carbon compounds help to regulate the Earth's temperature, make up the food that sustains us, and provide a major source of the energy to fuel our global economy. Since carbon seems to be connected to everything that matters to us—our climate, our bodies, our ecosystems, the health of our planet—it makes sense for us, scientists and non-scientists alike, to learn about the carbon cycle and how we are changing it. Only then can we make sensible "carbon decisions" that will impact our future.

Carbon storage and exchange

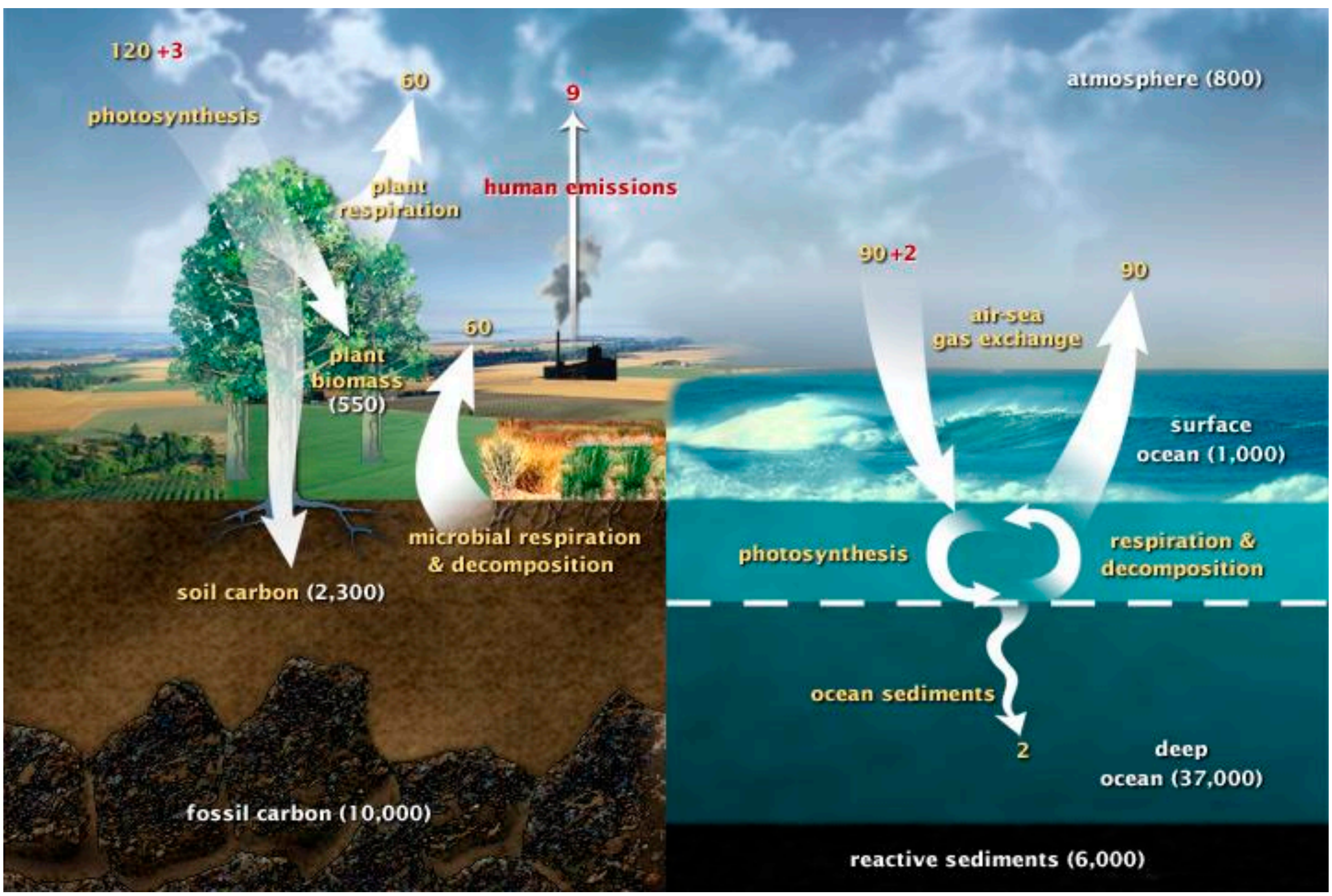
Most of Earth's carbon is stored in **rocks and sediments**, while the rest is located in the **ocean**, **atmosphere**, and in **living organisms**. These are the reservoirs through which carbon cycles.



Carbon moves from one storage reservoir to another through a variety of mechanisms. One example is the movement of carbon through the food chain. **Plants** move carbon from the atmosphere into the biosphere through **photosynthesis**: they take in carbon dioxide and use energy from the sun to chemically combine it with hydrogen and oxygen to create sugar molecules. **Animals** that eat the plant can digest the sugar molecules to get energy for their bodies. **Respiration**, **excretion**, and **decomposition** release the carbon back into the **atmosphere** or **soil** continuing the cycle.

The **ocean** plays a critical role in the storage of carbon, as it holds about 50 times more carbon than the atmosphere. Two-way carbon exchange can occur quickly between the **ocean's surface** waters and the atmosphere, but carbon may also be stored for centuries at the deepest **ocean depths**.

Rocks such as **limestone** and **fossil fuels** such as coal and oil are storage reservoirs that contain carbon from plants and animals that lived millions of years ago. When these organisms died, slow geologic processes trapped their carbon and transformed it into these natural resources. Processes such as **erosion** release this carbon back into the atmosphere very slowly while **volcanic activity** can release it very quickly. **Burning of fossil fuels** in cars or power plants is another way this carbon can be released into the atmospheric reservoir quickly.

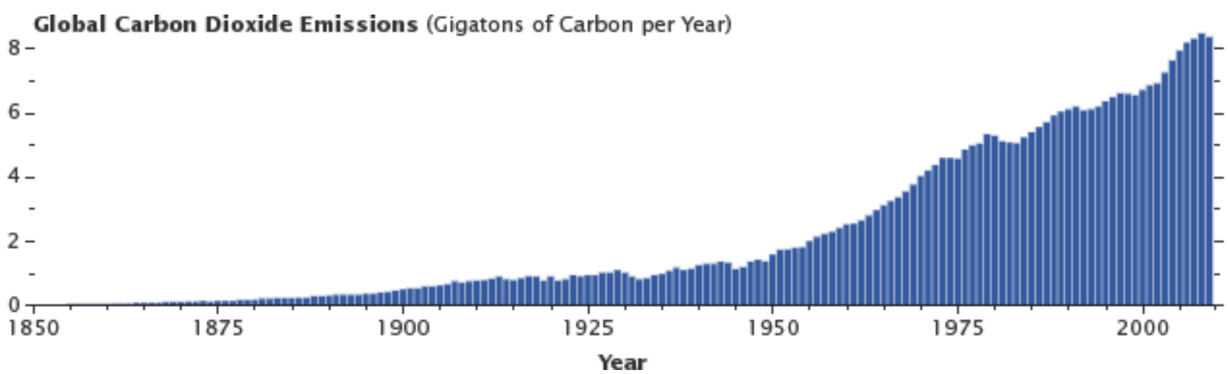


This diagram of the fast carbon cycle shows the movement of carbon between land, atmosphere, and oceans. Yellow numbers are natural fluxes, and red are human contributions in gigatons of carbon per year. White numbers indicate stored carbon. (Diagram adapted from U.S. DOE, Biological and Environmental Research Information System.)

Changes to the carbon cycle

The carbon cycle plays a key role in regulating Earth's global temperature and climate by controlling the amount of carbon dioxide in the atmosphere. However, the increasing human population and their activities have a tremendous impact on the carbon cycle. The amount of CO2 in the atmosphere has been increasing globally since the onset of the industrial revolution. **Burning of fossil fuels** (coal, oil, and natural gas), **changes in land use** (eg. clear cutting), and the **use of limestone to make concrete** all transfer significant quantities of carbon into the atmosphere. As a result the amount of carbon dioxide (CO_2) in the atmosphere is rapidly rising and accelerating and is already significantly greater than at any time in the last 800,000 years.

Increased levels of CO_2 in the atmosphere is affecting climate and ocean chemistry, subsequently influencing both marine and terrestrial ecosystems. The warming effects of increasing CO_2 and other greenhouse gases impinge on agriculture, natural systems, and a host of environmental variables. Increasing CO_2 in the atmosphere also directly translates to increasing acidity of the oceans. The ocean absorbs much of the CO_2 that is released from burning fossil fuels. Carbon dioxide dissolves in water to form carbonic acid, which is corrosive to the shells and skeletal material of many marine organisms (such as coral), some of which form the base of marine food chains (like the pteropod, or "sea butterfly", that feeds organisms ranging in size from krill to salmon to whales). Subsequent impacts on ecosystems are largely not understood.



Emissions of carbon dioxide by humanity (primarily from the burning of fossil fuels, with a contribution from cement production) have been growing steadily since the onset of the industrial revolution. About half of these emissions are removed by the fast carbon cycle each year, the rest remain in the atmosphere. (Graph by Robert Simmon, using data from the Carbon Dioxide Information Analysis Center and Global Carbon Project.)

http://www.noaa.gov/resource-collections/carbon-cycle
https://serc.carleton.edu/eslabs/carbon/index.html
https://www.esrl.noaa.gov/research/themes/carbon/
http://www.noaa.gov/resource-collections/ocean-acidification

Greenhouse Gases and the Greenhouse Effect

In general, greenhouse gases are a good thing: they regulate the temperature of Earth by trapping warmth from the sun in earth's atmosphere. Without greenhouse gases, Earth would be a frozen wasteland, too cold to support life. Most greenhouse gases occur naturally, but human activities are increasing the amount of greenhouse gases in the atmosphere at a rate faster than can be regulated by Earth's natural processes.

Greenhouse gases

- **Carbon dioxide:** Occurs naturally on Earth; moves through stores in the Earth, living things, and the atmosphere in the carbon cycle. Carbon dioxide is the biggest driver of climate change because humans put more carbon into the atmosphere than any other greenhouse gas, and it remains in the atmosphere for up to 50 years once emitted.
- **Methane:** Occurs naturally in wetlands and oceans; humans have increased the amount of methane in the atmosphere because it is a by-product of rice farming, raising cattle, landfills, and burning natural gas.
- **Water vapor:** Water in gas form; occurs naturally as water evaporates, forms clouds, and rains back down to Earth as a liquid.
- **Ozone:** Occurs naturally in the upper atmosphere, the ozone layer filters harmful UV rays from the sun. Closer to Earth's surface, ozone acts as a greenhouse gas and is produced by burning gas in cars and factories.
- **Nitrous oxide:** A natural part of the nitrogen cycle; produced by bacteria in the soil and ocean.
- **Fluorinated gases:** Not a naturally occurring molecule; F-gases were created by humans and used in aerosols, as refrigerants, and solvents.

Greenhouse gases are molecules in the atmosphere named after greenhouses, glass rooms that let in sunlight to create a warm enclosed space. Greenhouse gases trap energy in Earth's atmosphere to keep Earth warm much like a greenhouse. As solar radiation from the sun reaches Earth's surface, it is reflected back out to space. Some of that energy is absorbed and trapped in Earth's atmosphere by greenhouse gases and reflected back down to Earth's surface. The cycle repeats. Greenhouse gases slow the escape of heat and keep Earth warmer than it would be otherwise.

When the concentration of greenhouse gases in the atmosphere increases, the atmosphere is capable of absorbing more energy. As a result, the planet warms up —until it reaches the temperature at which it again radiates just enough energy to keep the temperature stable. The higher the concentration of greenhouse gases in the atmosphere, the warmer the planet becomes before it reaches the point at which it radiates all the energy it receives and the temperature again stabilizes. Consequently, an increase in greenhouse gas concentrations — whether as the result of natural causes or human activities— causes the average global temperature to rise.

Handout 3.3

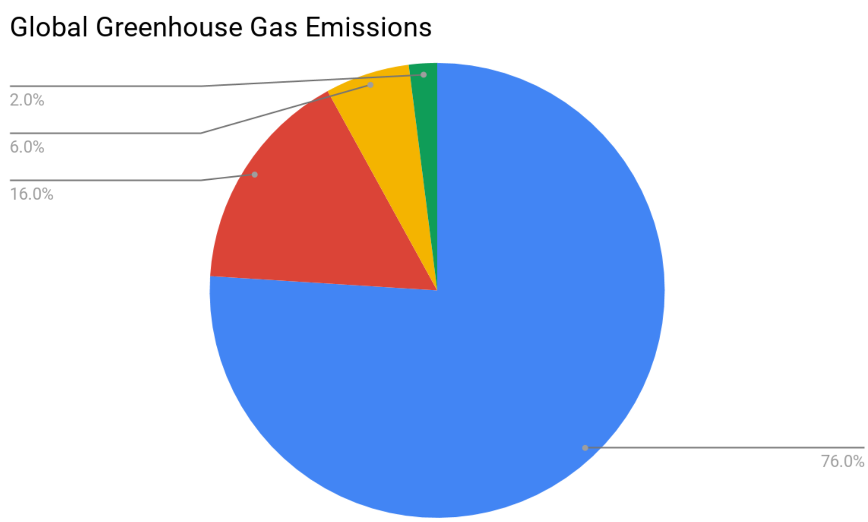
PART I: In the space provided, diagram the carbon cycle. You must include the following:

Slow carbon cycle
- Chemical weathering and erosion
- Air-sea gas exchange
- Marine life, shells, and coral
- Limestone/sedimentary rock
- Fossil fuels (oil, coal)
- Volcanic activity

Fast carbon cycle
- Photosynthesis (plants and phytoplankton)
- Respiration (plants and animals)
- Decomposition
- Excretion
- Natural combustion (forest fires)

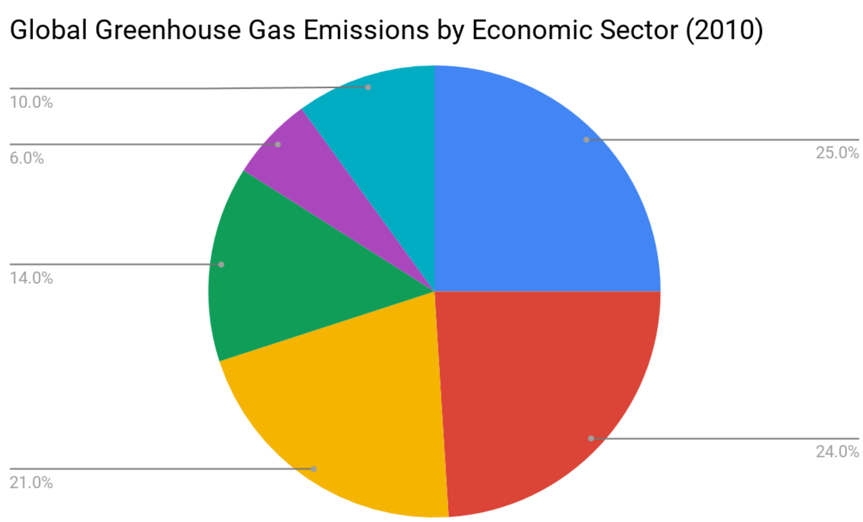
Human impact
- Burning fossil fuels (coal, oil, and natural gas)
- Clearing land/deforestation
- Making concrete

PART II: The pie chart below shows global greenhouse gas emissions. Use the list below and EPA's Greenhouse Gas Emissions webpage (https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data) to fill in the blanks indicating which greenhouse gas corresponds to each percentage of total global emissions.



- Carbon dioxide (fossil fuel consumption, industry, forestry, and land use)
- Methane
- Nitrous oxide
- Fluorinated gases

This pie chart shows the sources of carbon emissions in the U.S. Use the list below and the EPA's Greenhouse Gas Emissions webpage (https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data) to label each percentage with its corresponding source:



- Transportation
- Electricity and heat production
- Industry
- Buildings
- Agriculture, forestry, and other land use
- Other energy

Teacher's Supplement 3.3a

Discussion questions and key points to cover in class after Reading 3.3:

- **What is carbon?**
  Carbon is chemical element and fundamental building block in organic materials. It is very abundant on Earth and essential to all forms of life. Carbon also plays a crucial role in insulating and regulating the temperature of Earth's atmosphere.
- **Where can carbon be found on Earth?**
  Carbon is found in all living things on land and in the ocean. When plants and animals die and decompose, the carbon in their bodies/structures is released into the atmosphere or distributed in the soil. Carbon from organisms that lived millions of years ago is found deep underground where pressure and heat has compressed their decomposed matter over time to form stores of carbon-rich material we call "fossil fuels": crude oil, natural gas, and coal. Carbon is also found in abundance in the atmosphere as the gas carbon dioxide, formed when one carbon atom combines with two oxygen atoms (CO_2).
- **What are the processes that move carbon around in the carbon cycle?**
  - Physical processes
    - *Erosion*
      - Carbon in rock is released when rock erodes away. Rock sediments are carried to the ocean by rivers.
    - *Settling of sediments and particles to the ocean floor*
      - Ions and sediments carried to the ocean by rivers combine with carbon to make calcium bicarbonate used in shells of marine life. When marine organisms die they fall to the ocean floor and, over time, become carbon-storing rock such as limestone and sedimentary rock. Over millions of years, heat and pressure change this built up organic matter into fossilized carbon in the form of coal and oil, also known as "fossil fuels."
    - *Tectonic shifts and volcanic activity*
      - Tectonic plates shift and collide bringing molten rock up from the core through volcanoes. Volcanic eruptions vent carbon that had been stored below Earth's surface back into the atmosphere.
  - Chemical processes
    - *Chemical weathering*
      - Atmospheric carbon combines with rainwater to form carbonic acid, a weak acid that falls to Earth's surface and dissolves rock, releasing calcium ions which are carried to the ocean by rivers.
    - *Air-sea gas exchange*
      - Carbon in the air dissolves in water at the ocean's surface and ventilates back out into the atmosphere again (same reaction occurs when opening a can of soda).
    - *Combustion*

        - When forests burn, carbon stored in wood is released into the atmosphere. The same chemical process releases carbon into the atmosphere when fossil fuels are burned by humans.
  - Biological processes
    - *Photosynthesis*
      - Marine and land plants and phytoplankton make glucose using carbon dioxide from the atmosphere and from sunlight. The carbon absorbed in photosynthesis remains stored in plants until eaten by animals, burned in fires, or dies and decomposes.
    - *Respiration*
      - Plants and animals release carbon dioxide as a by-product in energy production (when you exhale).
    - *Excretion*
      - Animals excrete carbon in solid waste. They also excrete methane gas, another greenhouse gas!
    - *Decomposition*
      - Plants and animals die and decompose, releasing carbon back into soil.
- What are the human impacts on the carbon cycle?
  - Extracting and burning fossil fuels
  - Land use changes (clear cutting forests, intensive agricultural practices, increased livestock cultivation)
  - Use of limestone to make concrete
- What are greenhouse gases? What is the greenhouse effect?
  Greenhouse gases are gases found in Earth's atmosphere that insulate and regulate the temperature of Earth through the greenhouse effect. Just as a greenhouse traps sunlight to maintain a warm internal temperature, greenhouse gases trap the sun's energy when it is reflected off of Earth's surface. Without these gases in our atmosphere, the sun's heat would bounce off Earth's surface and return to space. Earth would be too cold to support life. While most greenhouse gases occur naturally, some are man-made and their presence in the atmosphere is increasing due to human activity.
- What is global warming? Why should we be concerned about adding carbon dioxide to the atmosphere?
  Global warming is the observed increase in Earth's global temperature. Since recorded observations began in 1880, global surface temperature has increased by 0.8 °C (1.5°F) and continues to rise. The preponderance of evidence points to human activities since the Industrial Revolution at the turn of the 20th century as the cause of this rapid warming. Burning fossil fuels, agricultural practices, and changes in land use by humans have contributed to an increase in greenhouse gases, especially carbon dioxide, in the atmosphere. Increased levels of greenhouse gases results in increased energy absorption in the atmosphere, amplifying the greenhouse effect. In other words, more greenhouse gases means more heat is trapped in Earth's atmosphere, causing the average temperature on earth to increase.

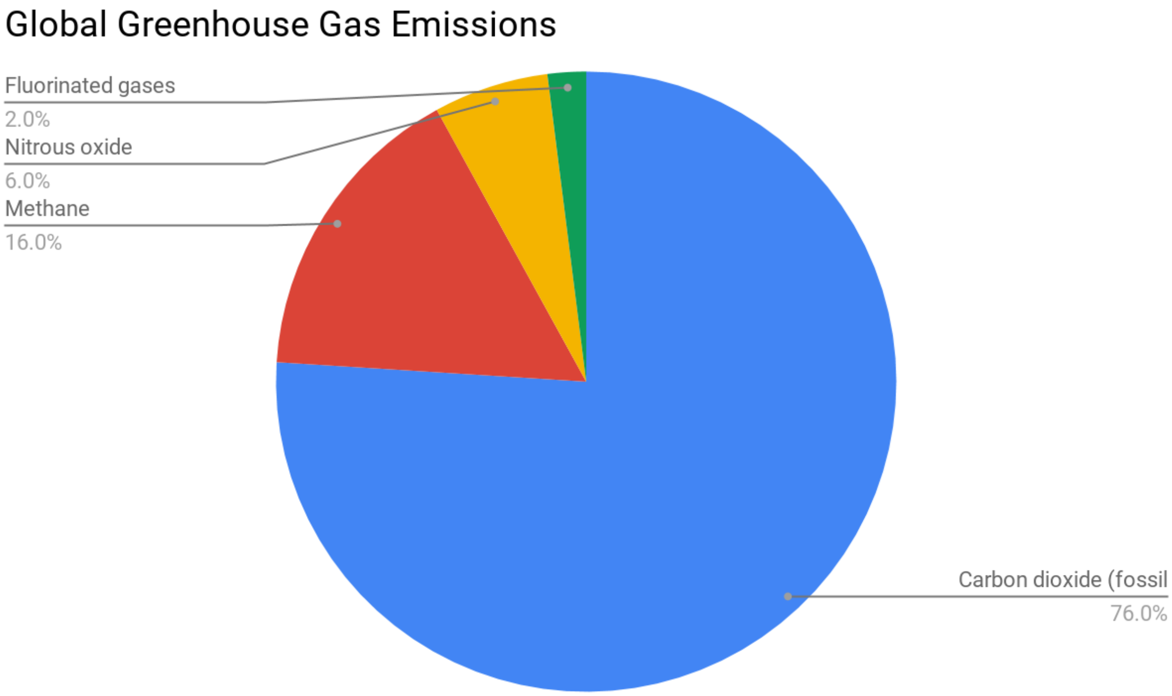
- **Why is a warmer Earth concerning?**
  While a single degree increase in outdoor temperature may seem insignificant to how you feel the temperature on your skin in your daily life, even a half of a degree increase on average globally has the potential to drastically change ecosystems, weather patterns, and even the shape of coastlines and the existence of freshwater reservoirs we depend on for crops and drinking water. To put it in perspective, the earth was only 4°C to 7°C cooler (7.2°F - 12.6°F), on average, during the last ice age when large parts of Europe and the United States were covered by glaciers. Consequences of a warmer earth include a longer growing season, rising sea-levels from melting of glaciers and polar ice caps, thawing permafrost, changing weather patterns and more severe, frequent, and prolonged extreme weather events such as hurricanes, floods, droughts, heat waves, wildfires, and severe storms. Globally, these changes threaten the lives of hundreds of thousands of people, endanger thousands of animal and plant species which rely on specific climatic conditions to survive and find food, and threaten crops grown to feed the world's human populations. For more details on how even a half-degree increase in average temperature could affect the earth, visit https://climate.nasa.gov/news/2458/why-a-half-degree-temperature-rise-is-a-big-deal/

Sample answers for discussion questions following Carbon Cycle diagraming:

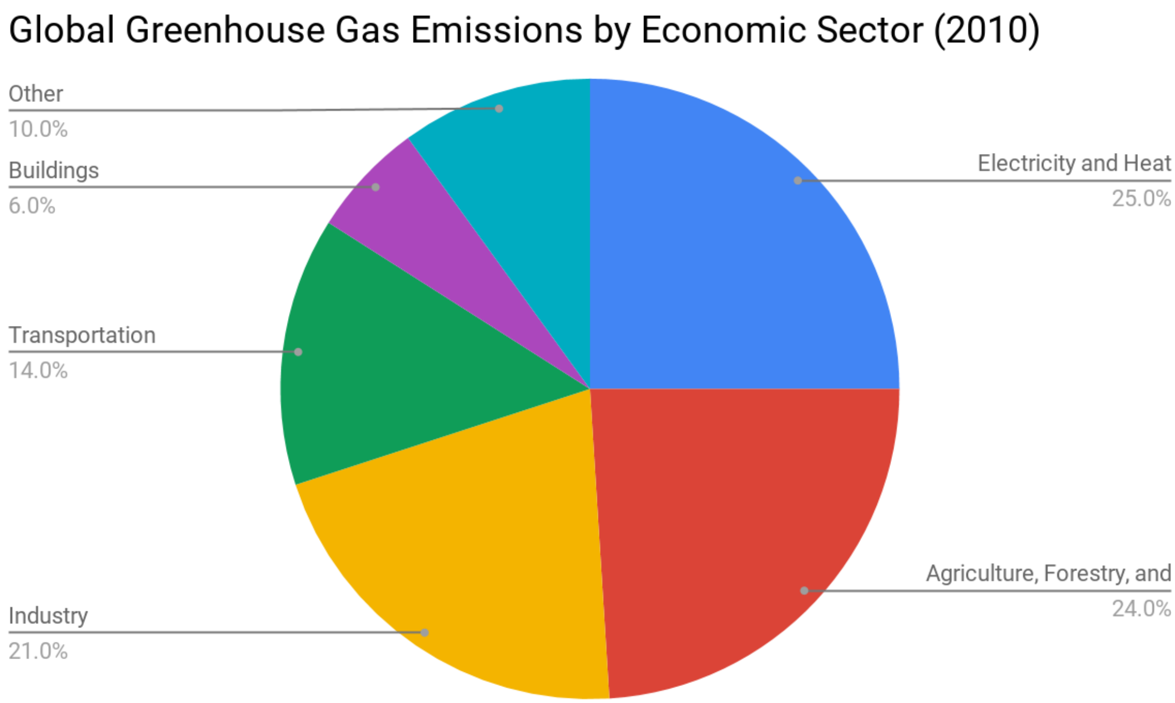
- **How might we change industrial practices?**
  - Use/create/search for alternative and renewable energy opportunities to replace fossil fuel consumption.
  - Evaluate current systems and buildings for efficiency, make structural and operational changes to reduce emissions/improve efficiency accordingly.
- **How might we change agricultural practices?**
  - No-till farming to reduce greenhouse gas emissions from otherwise tilled farmland that emits $CO2$ and $NO2$.
  - Spreading compost on rangeland to sequester carbon. (See Marin Carbon Project links below in the Extension section.)
- **What small steps could we take to reduce the carbon footprint of our daily lives?**
  - carpool, use public transportation, walk, or ride a bike for transportation to reduce gasoline consumption
  - turn of lights when you leave a room to reduce energy consumption
  - eat locally grown and raised produce and meat to reduce dependency on food transported from faraway places (reduces gasoline consumption)
  - recycle
  - drink filtered tap water instead of bottled water
  - plant trees and native species to absorb carbon dioxide in the air
  - What other ideas do students have?
  - Find more ideas at https://climatekids.nasa.gov/how-to-help/

Teacher's Supplement 3.3b

Answer key to backside of Handout 3.3



https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data



https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

"The world as we have created it is a process of our thinking.
It cannot be changed without changing our thinking."
— Albert Einstein[4]

Unit 4: RESPONSIBILITY

Effects of Climate Change: Our Earth, Our Actions

- Lesson 4.1: Best Place for A Bird: Why Range Matters
- Lesson 4.2: The Migration Game: Shifting Phenology
- Lesson 4.3: Climate Change Cause and Effect: Global and Local Impacts
- Lesson 4.4: Exploring the Alternatives
- Lesson 4.5: Be a Hummingbird: You Can Make a Difference!

[4] Einstein was a theoretical physicist, philosopher, and Nobel Prize in Physics laureate. He developed the theory of relativity and other groundbreaking theories that influence the philosophy of science.

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Plumas Audubon Society

UNIT 4: AWARENESS
The Effects of Climate Change: Our Earth, Our Actions

Lesson 4.1

Lesson Objectives:

- Define "range" in terms of suitable habitat for a given species.
- Understand how climate change affects a species' range.
- Consider the effects of shifting ranges on ecosystem function.

NGSS:

Middle School

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

High School

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may

Best Place for A Bird: Why Range Matters

Summary:

Students will learn about species' range and how climate change may or may not affect where birds live and thrive. Students will study different migratory bird species found in currently found in California. They will consider the effects climate change may have on a species' diet, migration path, mating and breeding behavior, and habitat, and the overall effects on an ecosystems function should an organism change or need to shift their range.

Background:

All plants and animals live in a geographic **range**—where the species is found. A species' range is determined by what it needs to survive; factors such as climate, the type and quantity of available food and water, and shelter. Some species are able to live in more varied territory or climate and have a relatively large range; others have a very small range due to very specific needs for survival. Some species migrate and have winter and summer ranges.

Birds are sensitive and adapted to particular climatic conditions (primarily temperature, precipitation, and seasonality), therefore, climate can play a large role in each species specific habitat requirements (some species are more tolerant and therefore can be found in a larger range of climates, while others need a very specific suite of conditions in order to survive) and, therefore, where they are found.

A change in climate may cause a species' range to move, expand, or shrink. If an area experiences a sustained change in temperature, precipitation, humidity, or any other climatic factor, the plants and animals living in that area will be affected. Some species will be able to adapt, others will have to move, and still others—unable to adapt or move—will be either be extirpated (local extinction) from the area or go extinct.

Climatic changes occur naturally on Earth over long periods of time. However, humans emitting greenhouse gases over the last century have created a warming effect, raising the temperature on Earth more rapidly than the natural processes would. This relatively fast-paced change in climate is causing range shifts for many species.

Many North American species affected by higher temperatures are moving northward or to higher elevations. Some species are already at their northern limits or highest habitable elevation and have nowhere else to go. Some cannot move due to physical barriers like mountain ranges or human settlement. Some face fierce competition for available resources in their new range. Other species are able to expand their ranges and live places that were previously too cool for result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Time: *40-50 minutes*

Materials:
- Computer with internet access (optional)
- Projector/media player (optional)
- Napa Solano Audubon's California Birds in a Changing Climate booklet
- Handout 4.1

Educator Tips:
Share with your class the following research from the National Audubon Society's Birds and Climate Change Report (2015):

Of the 588 North American bird species Audubon studied, more than half are likely to be in trouble due to climate change. Our models indicate that 314 species will lose more than 50 percent of their current climatic range by 2080.

Of the 314 species at risk from global warming, 126 of them are classified as climate endangered. These birds are projected to lose more than 50 percent of their current range by 2050. The other 188 species are classified as climate threatened and expected to lose more than 50 percent of their current range by 2080 if global warming continues at its current pace.

survival. In some cases, range shifts or an inability to establish a new range will bring about extinction for a species.

While some species will thrive and others will suffer due to climate change, a change in one population will inevitably affect other organisms within the same ecosystem. Organisms in an ecosystem are connected in a complex web of relationships and energy exchanges. One missing piece has the potential to offset or entirely dismantle the delicate balance of a functioning ecosystem.

Habitat ranges for plants and animals will continue to shift as the climate continues to be disrupted. It is difficult to predict what these new ranges will be, though scientists and researchers have created projected range shift maps using existing climate change data and estimates of how the climate will continue to change at the current rate and amount of greenhouse gas emission. Harder still to predict is how these range shifts will affect ecological functions and human economies that depend on resources from ecosystems all over the world.

Questioning Prompts:
- How do birds adapt to find resources?
- Do all birds need the same resources? Why or why not?
- How might a species' range change over time?
- What environmental factors cause habitats to change?

Activity:
Break students into four groups. Pass out *California Birds in a Changing Climate* booklets to each student. Assign each group one of the four different California bioregions defined in the booklet (Central Valley, Sierra Nevada, Mojave and Sonoran deserts, and California coasts). Have all students read pages 10-13 in the booklet, which summarizes its contents and explains how to interpret the data offered in the form of Venn diagrams and range maps.

Have each group select one species from their assigned bioregion to focus on. Each group will present their bioregion and selected bird species. Allow 10-20 minutes for each group to read their bioregion summary pages as well as their selected species pages, reminding them to refer to pages 12 and 13 as they work on data interpretation for help understanding how the data is presented.

Ask them to pay special attention to any descriptions about the opportunities or challenges for their species to find resources for food, water, cover, and space. Can this bird species find all four resources in one location all year-round? Species will move (if they can) to a different area if they cannot find enough of all the resources they need for survival.

Give each group a large printout of the outline of California (Handout 4.1) and ask them to use different colors to outline or color in the current ranges and

Educator Tips:
Watch again: National Audubon's "Climate Change and Birds" video from *Lesson 1.1 Why Birds Matter* to the class: https://www.youtube.com/watch?v=aN2-a82_3mg

the expected future ranges of their species using the species range maps in the booklet as guidance (or look up the species on climate.audubon.org to zoom in to California). Two copies of the state outline figure are provided for winter and summer ranges. Students should add a title and legend to each figure on the page to define the different colored ranges and time (ie. current ranges compared to projected future ranges).

After reading and discussing in their groups, each group should be ready to present the following to the class:

- Summary of bioregion and its expected climatic changes
- Bird name
- Brief description of their bird and what kind of habitat it lives in
- How are its habitat or resources expected to change?
- Status (climate threatened or climate endangered)
- Expected effect of climate change on the species summer and winter ranges
    - Students can refer to the Venn diagrams to explain how much range will be lost or shift to a new area.
    - Students should present the maps they colored to show where the climatic range of the species is expected to change.
- What does any loss of or shift in range mean for this species?

After each group presents, discuss as a class the implications of range changes. Some organisms will be able to track their climatic shifts and shift with them. This may work out for some of these species, but relationships with other organisms (eg. predator/prey) will be altered. How might such changes affect the way the ecosystem functions?

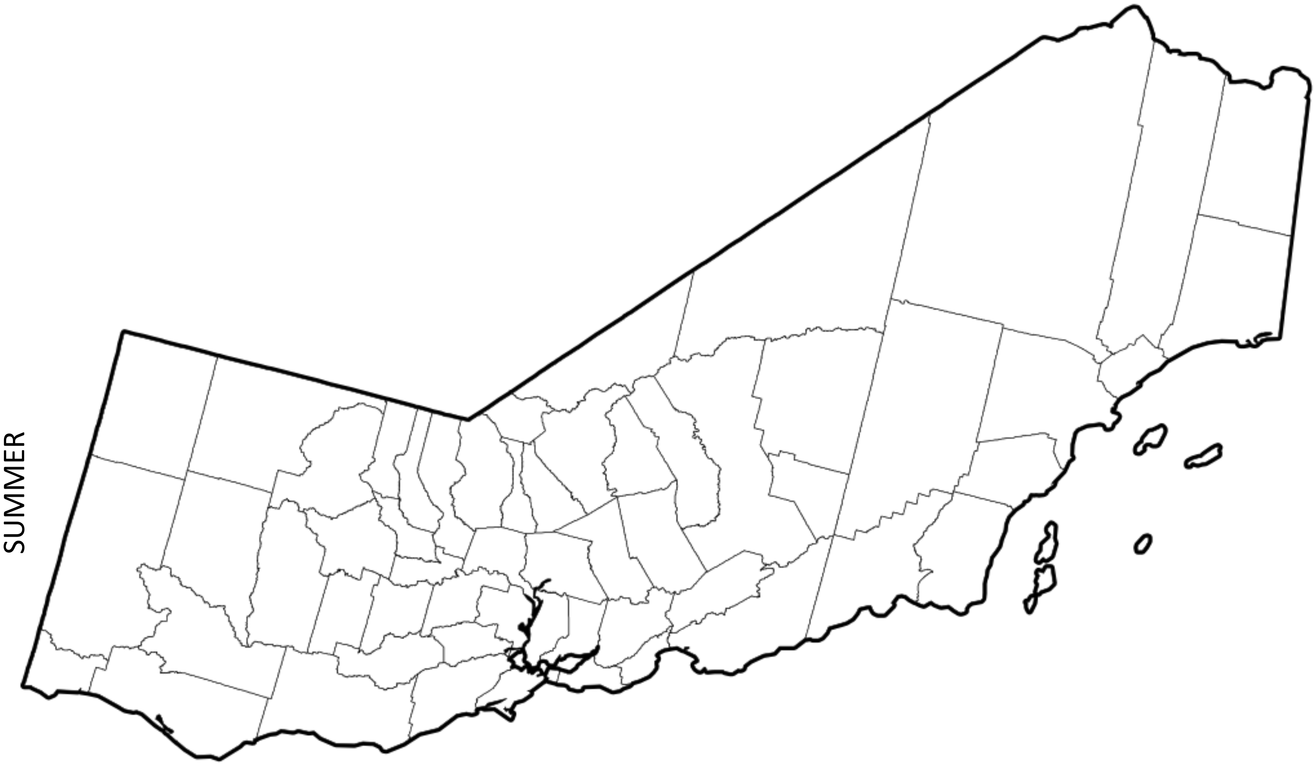
While some species may be able to adapt quickly enough, other organisms will not be able to shift in time. Others will run into barriers that prevent them from shifting their range (eg. impassable physical landscape features or human settlements). What might be the fate of such species?

Extension: Conservation Professional

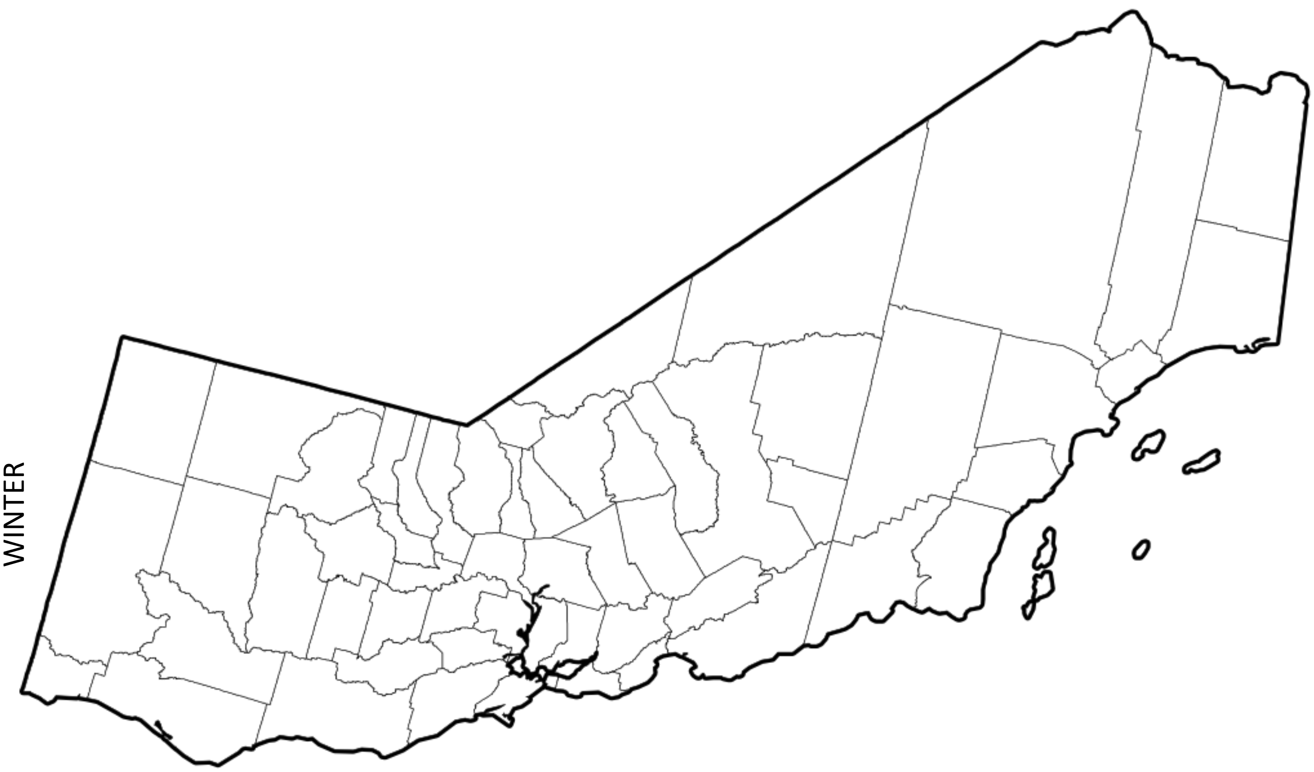
Ask students to imagine they work for an organization whose mission is to protect their bird species from extinction. Ask them to write a proposal to accomplish this goal. Should there be new laws or regulations? Should we do a habitat restoration project? Remind your students to think creatively: creativity can be key to imagining potential solutions no one has thought up before!

Handout 4.1

SUMMER



WINTER



Plumas Audubon Society

UNIT 4: AWARENESS
The Effects of Climate Change: Our Earth, Our Actions

Lesson 4.2

Lesson Objectives:

- Learn about challenges faced by birds during migration.
- Understand that migration is based on phenological cues.
- Consider how climate change affects the timing of phenological events, and therefore, affects migration and resources availability for species.

NGSS:

Middle School

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

High School

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-8. Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.
HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may

The Migration Game: Shifting Phenology

Summary:

This kinesthetic game models birds' migration and the challenges they face along the way in three rounds: The Competition Round, The Challenges Round, and The Climate Disruption Round. Students will observe that migration is challenging because of competition among and within species, outside threats like weather, habitat loss, human infrastructure, and predation. Now climate change is disrupting the timing of biological processes, posing yet another major threat to migration.

Background:

Migration is one of the most integral and fascinating parts of bird behavior. For many, the return of migratory bird species is an exciting indication of changing seasons. Generally, birds migrate south in winter towards a warmer climate and available food resources, and north in spring, to suitable nesting habitat and abundant food resources when the growing season begins. Along their migration between winter feeding grounds and summer breeding grounds, birds tend to follow predictable routes, including resting and refueling at **stopover sites**. Such routes are generally referred to as "**flyways,**" which usually occur along coastlines, major rivers, and mountain ranges. There are four major migratory flyways over the United States: 1) the Pacific Flyway along the Pacific coast and west of the Rocky Mountains; 2) the Central Flyway over the Great Plains and east of the Rocky Mountains; 3) the Mississippi Flyway along the Mississippi River; and 4) the Atlantic Flyway along the Atlantic coast.

The amount, health, and state of the resources found in habitats all along the migration route—including the winter, summer, and stopover site habitats—are critical for the survival of birds and entire populations. Such resources are always in a state of flux; however, human-driven climate change is altering many resources at a pace too fast and to an extent such that many species cannot efficiently respond or adapt to it. Although some species will be able to adapt their life cycles quickly enough to new conditions, others will have to move to different areas in order to survive and thrive. Others will risk extinction.

Many birds rely on environmental cues such as daylength and temperature to know when and where to migrate, when to find a mate, and when to breed. Climate disruption is altering the usual patterns of many birds. Because biological phenomena are related to seasonality, a changing climate may affect how and when these biological phenomena occur. We are already seeing earlier migrations, earlier egg-laying, and entire ranges shift and shrink. The behavioral changes just mentioned are examples of **phenological shifts**.

result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Time: *60 minutes*

Materials:
- Poker chips or other small colored items to represent resources to be gathered.

Phenology comes from the Greek word “phaino” meaning ‘to show or appear’. It is the study of recurring patterns of seasonal, rhythmic plant and animal life cycle stages such as migration, flowering maturity, insect hatches, or leafing, and how such events relate to climatic conditions and changes in climate. For example, you have most likely observed geese flying south as winter approaches, and you know spring is on the way when you see the geese return, flying north at winter’s end. Phenological events have been keenly observed by humans long before we had a word for it and have informed human behavior for thousands of generations. Nowadays we still collect and monitor phenological data to help us make predictions about plants, wildlife, weather patterns, and other natural occurrences.

Phenological events (leafing, budding, hatching, migration, etc.) are triggered by environmental cues such as daylength or temperature. Different phenological events do not all respond to the same environmental cues in the same ways or at the same time. Alterations in environmental cues due to changing climate, therefore, can throw off the choreography of various phenological events that have co-evolved over a very long time, potentially disrupting entire ecosystem functions. For example, if a change in temperature triggers a field of flowers to bloom before insects hatch, pollination of that field of flowers will not happen.

Migratory species face an especially difficult challenge in the face of climatic and phenological disruptions. A migrating animal cannot predict environmental changes in its destination based on the conditions of its current environment in an entirely different location. For example, a bird informed by environmental cues in southern Mexico, cannot predict a delayed insect hatch at its destination in the north. The bird migrates and finds that no insects have yet hatched. This bird now risks starvation.

Migration is risky business. Migratory species face many challenges along their way including competition, predation, habitat loss, human development (tall buildings, wind turbines, light pollution), and bad weather. Climate change is making it even riskier.

Activity:

Use the background information to guide a discussion with your students asking the following questions:

- What is migration?
- Why do many birds migrate?
- In general, where do migratory birds go in the fall? Why?
- In general, where do migratory birds go in the spring? Why?
- Some birds migrate in one long trip without stopping, but many need to stop at “stopover sites”. Why?

Now, head to a large open space (eg. an indoor gym or outdoor field) to play the Migration Game.

THE MIGRATION GAME

Students will play a game modeling different effects of changing phenology. The students will be birds trying to navigate a migration route and pick up enough resources along the way to survive. You will need a large space (indoors or outdoors) where students can run around.

For this activity you will need items of at least three different colors to represent different resources to be collected. Poker chips (blue, red, and white) work well for this activity. Start with enough to have approximately one of each color per student. The three colors represent food (red), water (blue), shelter/cover (white), the three resources that migratory birds need to find during their journey.

GOAL

Survive the journey of migration by collecting at least one of each resource (food, water, and shelter) while traveling from one end of the field to the other.

Round 1: The Competition Round

SET UP

Distribute the colored resources at different intervals along the field; these are "stopover sites". Spread resources out so that students are not all rushing to one location. You can mix the colors/resources or have only one resource per stopover.

To help encourage the understanding of why birds migrate at all, you can place the resources strategically in each migration direction to model the availability of resources and space. For example, to model fall migration north to south: scatter resources/position stopover sites across entire field, with few in the north across a wide swath and most in the south in a narrow swath. To model spring migration south to north: scatter resources/position stopover sites across the field again, but this time with a fair amount in a narrow swath in the south and a whole bunch in a wide swath in the north.

PLAY

Students will line up at one end of the field and, when directed, "migrate" across the field, stopping at "stopover sites" to gather resources along the way, and make it to the other side with enough resources in hand to have "survived". They need at least one of each color (resource) by the end of the journey in order to to have survived.

Students may only fly in a forward direction (sideways movement is allowed as long as it is not also backwards). That is, once a stopover site has been passed, they may not turn around and go back to a site to retrieve a needed resource.

Start the migration race by offering the students an environmental cue to trigger migration (eg. the days are getting shorter and the temperature is getting cooler, time to migrate south). Students should then "take off".

Each time the students run from one end of the field to the other it represents

Did you know…

Hummingbirds are the only birds that can fly backward. Some other species are known to be able to flutter backward a bit, but the hummingbird is the only kind that can truly fly backward for a length of time.

Educator Tip:
There is no rule about taking more than one of any given resource. Some students may take more than their share leaving others with none. This is an example of competition and can be used as a teaching moment for that concept.

Additionally, you can use this as an opportunity to review the concept of mutualism (introduced in Lesson 2.2) and encourage cooperation. How many more students survive when they attempt cooperation?

one migration "trip" (eg. north to south or vice versa). After each trip, collect the chips and redistribute them at the stopover sites. You can now start a new migration trip back the other way.

REST and DISCUSS
After two or three simple migration trips, stop to rest and discuss. Did every student get enough resources to survive the migration? Why or why not? Was there competition for resources? Were there other challenges experienced?

Round 2: The Challenges Round
SET UP
Set up the game as before, before you begin pose the following question to students:
What other challenges besides competition do birds face during migration?

Birds face a variety of challenges during migration. There are a few ways we can model that in this game. Select one student to play each of the following roles and discuss these roles out loud to the entire class:

- **Habitat loss:** Habitat loss is one of the primary drivers of biodiversity loss and poses a great challenge to birds. Select one student to play the role of "habitat loss". This student may move throughout the field and remove stopover points (and their resources).
- **Predation:** Select one student to be a roaming "predator". Anyone this student tags is out for that trip, meaning they did not survive migration.
- **Development:** Select one or two students to play the role of a "building" or "city". Have this student pick a spot in the field; this student must stay stationary (like a building or a city) but may tag other students if they come within reach. Tagged students are out.
- **Bad weather:** Select one student to play the role of "bad weather". This student may move around and tag individuals out.

Have the students playing these challenge roles set up as they choose within the playing field and migrating students line up again along one side of the field.

PLAY
Play the game as before, reminding students that if tagged by another student in the role of predator, development, or bad weather, that student is out and did not survive that migration trip. Those students tagged out can participate again in the next migration trip.

REST and DISCUSS
Discuss the outcome of Round 2. How many students survived migration this time? How did it compare with the previous round? What made this round harder?

Round 3: The Climate Disruption Round
Climate change has been causing some birds to begin migrating earlier in the

season, when resources along their migration path and at their destination may not yet be available. This round models what happens when environmental cues shift due to climate change, altering the phenologies of birds and of the organisms they depend on for survival.

SET UP
Set up the game similarly as before, keeping the challenges from the last round in place and adding one more:

- **Climate change:** Climate change poses the greatest threat to birds. Select one student to play the role of "climate change". Select one student to play the role of "climate change". This student may move resources around and scramble up the distribution of resources across the entire field of play. For example, "climate change" may cause "drought" in one area by removing all the water resources and "flooding" in another area.

Additionally, the instructor will **shift phenology** in this round. This time set out only *half* of the resources before you start the game. Wait until *after* the game has begun and the students are migrating to distribute the remaining resources at various stopover sites including ones that students have already passed and cannot return to. This action represents a phenological event such as an "insect hatch" and the timing of it represents a shift in the timing of such an event.

PLAY
Play the game as before, again reminding students that if tagged by another student in the role of predator, development, or bad weather, that student is out and did not survive that migration trip.

REST and DISCUSS
Discuss the outcome of Round 3. How many students survived migration this time? How did it compare with the previous two rounds? What made this round harder than the previous two?
Did students notice that more resources were made available *after* migration had already started? Why did that happen? Why might early or late migration affect a bird's survival? What effects do humans have on migratory birds? How does climate change make migration harder than it already is?

Conclusion:
Help students understand the concept of shifting phenologies and what happened in the last round of the game. Climate change is altering the phenologies of birds and the organisms they depend on for survival. Warmer climates have triggered earlier migration when resources along their migration path and at their destination may not yet be available (presence of seeds, hatching of insects, availability of water, etc.). Birds cannot predict these phenological changes or the availability of resources in a distant area before they begin migrating. Since they rely on environmental cues around them to know when to migrate, climatic changes and resulting phenological shifts across the globe are potentially devastating to migratory species.

Extension:

BIRDCAST

Explore migration maps online at the Cornell Lab of Ornithology's BirdCast (http://birdcast.info/). The Migration Forecast Maps are updated every day, showing where and how much bird migration you can expect across the U.S. over the next three days. The Live Migration Maps are updated every ten minutes every night, showing near-live migration maps animated from sunset to noon. Watch the animation cycle through a few times and ask students to notice when migration really ramps up each night (*hint: watch what follows the sunset which is depicted as a red line in the map*). Live Migration Maps: http://birdcast.info/live-migration-maps/

A BIRD'S EYE VIEW

Have your students write a story of migration from the perspective of a bird. Have them each choose a particular migratory species for which they will then research its migration pattern (eg. when it migrates, where it tends to winter and summer, whether it flies in long or short stretches) and habitat type to inform their story. Include in the story some mention of how climate change is affecting their habitats, migration, or other.

UNIT 4: AWARENESS
The Effects of Climate Change: Our Earth, Our Actions

Lesson 4.3

Lesson Objectives:

- Observe local impact by measuring local snow pack and comparing to historical data
- Learn about feedback loops and the positive feedback loops triggered by climate change.
- Consider the serious long-term implications of climate change if no action is taken to reduce anthropogenic causes.

NGSS:

Middle School

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

High School

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-4. Use a model to describe how variations in the

Climate Change Cause and Effect: Global and Local Impacts

Summary:

This lesson has two parts. Part I of this lesson will demonstrate a local impact on climate change by measuring Sierra Nevada snowpack and estimating snow water equivalent and looking historical data and trends. Students will think about how this local impact of climate change will soon have beyond-local consequences. Part II explores the anthropogenic (human) causes of climate change and its many interconnected effects on global and local communities, ecosystems, and Earth’s natural processes.

Background:

Climate change is happening and we are already experiencing its impacts on global and local levels. Many things that we value and depend on to survive are affected by climate change including water, food, energy, wildlife, ecosystems, the economy, human health, and the places we live.

Part I: LOCAL IMPACTS

How do you see climate change affecting you and the things around you? You will have noticed your community and communities around you in California and other western states are on high alert for wildfires. Rising average temperatures along with decreased snowpack and faster snowmelt have extended fire season and create dry conditions for the start and spread of wildfire. You may have also noticed milder winters with less snowfall and more rain. Not only has your ski and snowshoeing season gotten shorter, but the amount of water flowing downstream happens too fast and too early, threatening flooding and limiting water resources later in the year for all plants, wildlife, and people in California that are dependent on the gradual melt of the snowpack in the mountains. Have you or people you know been affected by flooding recently? Climate change is causing more intense rain events, filling our rivers and streams faster than we are used to or prepared for, causing damage to homes and infrastructure like roads and electrical systems. Severe rain events as well as tree mortality from drought and higher temperatures contribute to increased erosion resulting in mud and rock slides which can be hazardous.

We saw in *Lesson 3.2 The Greenhouse Effect* that increases in atmospheric CO2 (a greenhouse gas) traps more heat, resulting in increased temperatures in a closed environment (such as the sealed bottle or our earth with the surrounding atmosphere). Global anthropogenic emissions of CO2 have been rising since the industrial revolution and continue to rise today, despite the decades-long-held knowledge that our greenhouse gas emissions (primarily CO2 and methane) have been heating up the planet as a whole. Region to region this has been and will continue to alter climates in various ways.

flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.
HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Time:
Part I: 60 minutes
Part II: 30 minutes

Materials:
Part I:
- Snow gauge/yard stick/ruler
- Spring scale or other weighing device
- Can or other container with known or calculable volume
- Calculator
- Pencil
- Handout 4.3

Part II:
- Climate Change Cause and Effect cards
- Large piece of paper and writing utensil OR tape and whiteboard/chalkboard

Remember: climate is the long-term pattern (eg. 10 years or more) of weather conditions in a given area, while weather is the temperature/precipitation/ wind/sun/etc. conditions that vary on a day-to-day (or even hour-to-hour) basis.

Climate changes in the Sierra Nevada include warming trends, heat and precipitation extremes, declining snowpack, and earlier spring snowmelt. These changes impact important water resources for the vast majority of California. The Sierra Nevada mountains contain the headwaters for about 60% of the water that not only our local communities depend on, but also for the 23 million downstream users of this water! Water management, therefore, is extremely important as is monitoring and responding to any changes to our water resources.

Since much of the water in the west originates from our winter snowpack, the Natural Resources Conservation Service (NRCS) regularly monitors mountain snowpack and provides water supply forecasts which agriculture, industry, recreation, and government all rely on for water management plans. Snow Water Equivalent (SWE) is a common snowpack measurement. It is the amount of water contained within the snowpack. It can be thought of as the depth of water that would theoretically result from melting the entire snowpack. The NRCS measures SWE at many sites across the west --including Plumas-Eureka State Park, Bucks Lake, and other locations in the Upper Feather River Region-- and uses the data for streamflow forecasting.

We are going to practice estimating the Snow Water Equivalent in a way similar to how NRCS conducts their SWE measurements, reference historical data records, and discuss the variability as well as the patterns and trends in the data.

Activity 1:
MEASURING SNOWPACK AT EUREKA LAKE

To determine SWE we need to know the snow depth and the density of the snow (SWE= snow depth * snow density). Students will use Handout 4.3a to record their measurements and calculate an estimate of SWE.

1. Use a snow gauge, yardstick, ruler, or other measuring device to determine the **snow depth, *d***. Insert the device as deep into the snow as possible, record depth, and check for soil on the end of the device upon removal to ensure that the full depth was reached.
2. Estimate **snow density, *p*** (mass/volume). The density of new snowfall is generally lower than settled, packed, and melted and recrystallized snow. So the density of snow at the surface is likely going to be different than that closest to the soil. For that reason, scientists use a long aluminum tube to gather core samples of snow all the way to the soil surface to accurately calculate its density. Today, however, we'll make our snow density estimates with a smaller sub-sample snow core using a

Did you know…
The Natural Resources Conservation Service (NRCS) is a federal agency under the Department of Agriculture that provides products and services to help conserve soil, water, air, and other natural resources on non-federal land.

can.

3. Calculate and record the **volume, *V*,** of the can by first measuring its dimensions ($V = \pi * r^2 * h$, where r is the can's radius and h is the can's height).
4. Weigh and record the **mass** of the **empty can, *m1*,** using a spring scale or other device.
5. Take a snow core sample by sticking the open end of the can into the snow and pressing the can down until the bottom of the can is flush with the surface of the snow. Weigh and record the **mass** of the **snow-filled can, *m2***.
6. Calculate the **snow mass, *M*,** as the difference between the masses of the filled and empty can.
7. Calculate the **Snow Water Equivalent** (SWE) by multiplying the snow depth by the snow density.

DISCUSSION for Activity 1
Use the background information and Handouts 4.3a and 4.3b to guide a discussion, addressing the following questions:

1. Discuss what would make this SWE estimate more accurate. [*eg. full depth snow core sample, averaging SWE estimates from multiple samples]*
2. Why is having water available in the form of snow important for humans, plants, and animals?
3. What would happen if the majority of precipitation fell as rain instead of snow?
4. What are the trend lines showing in the historical data?
5. What effects are increasing temperatures over the long-term due to unnaturally high levels of CO_2 and other greenhouse gases in the atmosphere likely having on Sierra Nevada snowpack? *[Show the trend line graphs of historical SWE data trend lines from February, March, April, and May acknowledging the great variability from year-to-year, but noting the overall trends of late winter and spring snow water equivalent in Handout 4.3b]*
6. What are the implications of this for our local communities and the plants and animals in our watershed that depend on the water contained in the snowpack?
7. How does this "local" impact have beyond-local consequences? Think about what a decreased snowpack means for the millions of people downstream that depend on this water.

Part II: GLOBAL IMPACTS

The global impacts of climate change are numerous, diverse, complex, and often devastating. Higher global temperatures are melting snowpack, glaciers, and the polar ice caps. The melting of glaciers and the ice caps as well as the expansion of warmer ocean waters is causing global sea levels to rise. Rising sea levels will alter coastlines all over the world, destroying communities and homes and forcing people and animals to find new places to live. Human migration has many political, social, economic, and moral implications. Climate change is increasing the frequency and severity of extreme weather events, such as drought, flooding, heat waves, downpours and superstorms which present dangerous, even life-threatening situations for humans and put human health at risk, along with increased pollution and the spread of insect-borne diseases. More rainfall and less snowfall result in faster runoff and less water stored in reservoirs or replenishing groundwater, reducing the availability of water to plants and trees, wildlife, and humans. With limited water, global agricultural crop yields are reduced, pushing food prices upward and causing food insecurity.

Ecosystems and habitats are changing, being disrupted, and even destroyed, forcing plants and animals to adapt to new conditions, shift their ranges, or face extinction. Tree mortality is increasing due to insect infestations, stress from drought, and wildfires. The sea temperature is rising, causing coral bleaching (death of coral reefs) and destruction of underwater life, also affecting industries including fishing and tourism.

Examining the Cause and Effect Relationships of Climate Change

Earth's climate is regulated by a complex series of **feedback loops**. A feedback loop is a chain of cause and effect relationships that either enhance or regulate a specific outcome. A **positive feedback loop** amplifies the effect of the initial disturbance: event A causes event B, which then creates more of event A. The loop repeats and is amplified each time. A **negative feedback loop** restricts the effect of the initial disturbance: event A produces event B, which reduces the amount of A and the cycle repeats and balances itself. Positive feedback loops are known as "destabilizing" because the loop can spiral out of control, while negative feedback loops are known as "stabilizing" because the loop regulates the initial effect.

An example of a positive feedback loop exacerbated by climate change is the melting of the polar ice caps. As global temperatures rise due to greenhouse gas emissions, ice that has covered the poles for millions of years is melting. The ice melts and becomes water. The water, warmer than ice, surrounds the ice and melts it. The cycle continues. Both the Arctic and Antarctic are experiencing record lows of ice cover year after year.

Climate change is triggering a multitude of cause and effect relationships resulting in numerous feedback loops. While scientists work to understand the long-term effects of these feedback loops, we can examine the observable causes and effects of climate change and begin to make decisions and changes in behavior and policy to regulate feedback loops that seem to be spiraling out of control.

Educator Tip:
Laminate copies of the cause and effect cards for multiple uses.

Activity 2:

CLIMATE CHANGE CAUSE-AND-EFFECT EXERCISE

1. Prep: Print and cut out the climate change cause-and-effect cards (Teacher's Supplement 4.3). This activity can be done as a class or in small groups. Each group should have a set of cards.
2. Give each group a large piece of paper and a set of cause-and-effect cards. If you are doing the activity as a class, you can use tape to stick the cards on a chalk or whiteboard.
3. The goal of the activity is to show the causes and effects of climate change. Students should lay out cards on top of the large piece of paper in an order they think logical and draw arrows on the paper between cards they think are connected or have a direct cause-effect relationship.
   a) Many causes and effects are interrelated or overlapping and cyclical. For example, the card "DEFORESTATION" can lead to several cards, including (but not limited to) "FEWER TREES TO STORE CARBON," "CARBON RELEASED INTO THE ATMOSPHERE," and "HABITAT DESTRUCTION."
   b) Offer to students that they likely will find more connections than a simple, linear cause-and-effect chain; they might find even feedback loops.
4. Students should include the six "WE CAN HELP!" cards, placing them anywhere on their diagrams where they know of or can imagine an opportunity exists for our actions to help solve the climate crisis.
5. Share and discuss the ordering and connections of the web of cards. Ask students to explain why one cause would lead to several specific effects. Students should also explain their ideas for ways to help.

DISCUSSION for Activity 2

Use the background information and student created cause and effect diagrams to guide a discussion, addressing the following questions:

1. After playing with the cause and effect cards, can you identify any feedback loops? Walk through a feedback loop as a class using the cards to model the loop. What are the implications of these?
2. The sheer number and potential severity of the effects of climate change can feel incredibly overwhelming. Discuss some ideas for how individuals and groups can help address the causes and effects of climate change. This can be as simple as eating a plant-based diet, riding a bike, carpooling, or simply buying less to reduce greenhouse gas emissions or as large as getting involved in local and national government to create legislation regulating the drivers of climate change or preparing for the effects of climate change.

NASA, Global Climate Change: Vital Signs of the Planet: https://climate.nasa.gov/
Union of Concerned Scientists, Global Warming Impacts: https://www.ucsusa.org/our-work/global-warming/science-and-impacts/global-warming-impacts#.WwbRJVMvyRs
USDA NRCS, National Water and Climate Center snow survey report for Eureka Lake, CA: https://wcc.sc.egov.usda.gov/reportGenerator/view/customWaterYearGroupByMonthReport/monthly/start_of_period/EUR:CA:SNOW%7Cid=%22%22%7Cname/POR_BEGIN,POR_END:M%7C1,M%7C2,M%7C3,M%7C4,M%7C5,M%7C12/WTEQ::collectionDate,SNWD::value,WTEQ::value

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Handout 4.3a:

Estimating Snow Water Equivalent (SWE)

To determine snow water equivalent (SWE) we need to know the snow depth and the density:

SWE = snow depth * snow density

Measuring snow depth

First, use a snow gauge, yardstick, ruler, or other measuring device to determine snow depth (d). Insert the device as deep into the snow as possible, record the depth measurement, and check for soil on the end of the device upon removal to ensure that the full depth was reached.

Calculate snow density

Next, estimate snow density (ρ = mass/volume). The density of new snowfall is generally lower than settled, packed, and melted and recrystallized snow. So the density of snow at the surface is likely going to be different than that closest to the soil. For that reason, scientists use a long aluminum tube to gather core samples of snow all the way to the soil surface to accurately calculate its density. Today, however, we'll make our snow density estimates with a smaller sub-sample snow core using a can.

- Calculate and record the volume of the can by first measuring its dimensions (V= π * r^2 * h, where *r* is the can's radius and *h* is the can's height).
- Weigh and record the mass of the empty can using a spring scale or other weighing device.
- Take a snow core sample by sticking the open end of the can into the snow and pressing the can down until the bottom of the can is flush with the surface of the snow. Weigh and record the mass of the snow-filled can.
- Calculate the snow mass as the difference between the weights of the filled and empty can.

Calculate SWE

Calculate the snow water equivalent (SWE) by multiplying the snow depth (d) by the snow density (ρ).

Record

Record your measurements and calculations below, including units:

Snow depth (d) = ________

Snow density:

Radius (r) of can = _________

Height (h) of can = _________

Volume (V) of can = π * r^2 * h = _________

Mass (m1) of can = _________

Mass (m2) of can with snow core sample = ________

Snow mass (m) = m2 - m1 = ________

Snow density (ρ) = m/V = ________

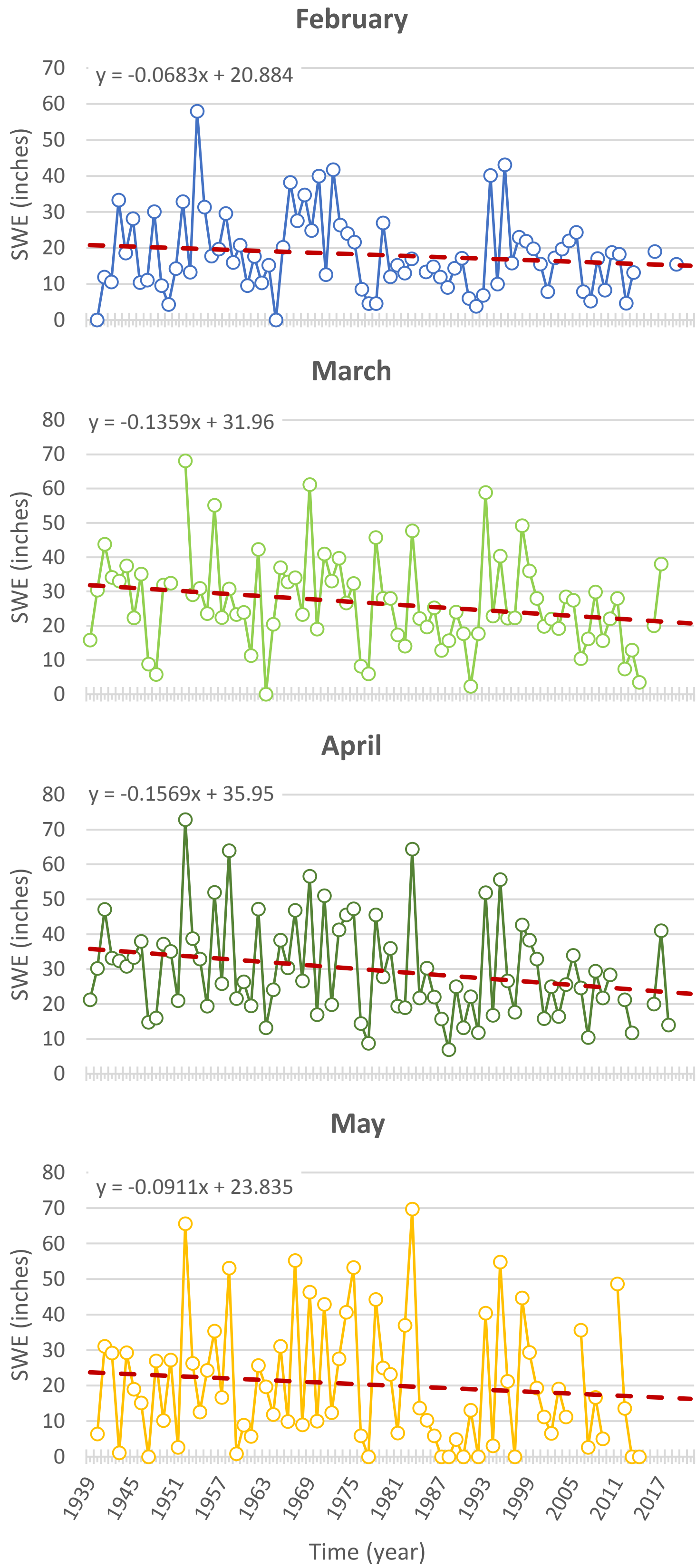
Snow Water Equivalent (SWE) = d * ρ = _________

What could make this SWE estimate more accurate? ____

____

Handout 4.3b:
Historical Snow Water Equivalent (SWE) data for Eureka Lake at Plumas-Eureka State Park

Historical Snow Water Equivalent (SWE) monthly data at Eureka Lake, Plumas-Eureka State Park, 1939-2018/9:



1. Why is having water available in the form of snow important for humans, plants, and animals?

2. What would happen if the majority of precipitation fell as rain instead of snow?

3. What are the trend lines showing in the historical data graphed to the left?

4. What effects are increased and increasing temperatures over the long-term due to unnaturally high levels of CO_2 and other greenhouse gases in the atmosphere likely having on Sierra Nevada snowpack?

5. What are the implications of this for our local communities and the plants and animals in our watershed that depend on the water contained in the snowpack?

6. How does this “local” impact have beyond-local consequences? Think about what a decreased snowpack means for the millions of people (as well as plants and animals) downstream that depend on this water.

Teacher's Supplement 4.3

Activity 2: Climate Change Cause-and-Effect Exercise

Cause-and-effect card set on the following four pages.

Print as many copies of the card set as number of groups.

Laminate cards for multiple uses.

LESS SNOWFALL, MORE RAIN

In a warmer climate, water is less likely to fall as snow. Snow usually stays on the ground and melts slowly, feeding lakes and rivers throughout the year. With less snow and more rain in our area, we may see more periods of intense flooding followed by periods of drought.

DECREASED SNOWPACK and EARLIER SPRING RUNOFF

Changes in our regional climate are resulting in less snow accumulating during the winter. Less snowpack and higher temperatures means snow melts faster and earlier in the spring. This can lead to flooding events. The faster snow melts the more directly it flows back into rivers, lakes, and oceans instead of replenishing important groundwater sources.

CHANGING HABITATS and ALTERED RESOURCES

Long term effects of drought and flooding may cause changes in landscape. Most plants and animals are adapted to live in specific environments with stable conditions. Some plants and animals may be able to adapt quickly enough to new conditions, others will have to relocate to find suitable habitats, while others will die off and risk extinction.

FEWER RESOURCES FOR EVERYONE

Decreased snowpack and earlier spring runoff leave plants, wildlife, and humans with less available water during the summer. With less water during the growing season, wildlife can struggle to find enough primary food sources and farmers struggle with food crop production.

MORE FREQUENT and SEVERE WILDFIRES

Wildfire season is getting longer as temperatures rise. Hotter, drier springs and summers and less water in the vegetation and ground due to faster and earlier melting snowpack create extremely dry conditions just right for large wildfires to start and spread quickly. Dry, dead trees killed by bark beetles fuel fires.

TREE MORTALITY

Drought, fire, and bark beetle infestations decimate trees and vegetation. Historically, large, high severity fires were less common than they are now because of overstocked forests and climatic changes.

FEWER TREES TO STORE CARBON

Trees and plants are natural carbon sinks. They remove CO_2 from the atmosphere and store it in their cells and release oxygen back to the atmosphere. When we deforest vast areas of land we lose large, important carbon sinks and habitat. Burning of trees in wildfires releases their stored carbon back into the atmosphere. Fewer trees to store carbon means more carbon in the atmosphere.

HABITAT LOSS

Animals need food, water, and shelter to survive. Natural disasters, wildfires, flooding events, deforestation, and land use change by humans for agriculture and development are all factors that destroy natural habitats and resource availability in an area.

BURNING FOSSIL FUELS

When we burn fossil fuels (coal, oil, and natural gas) for energy, we release carbon dioxide (CO_2) into the Earth's atmosphere. CO_2 acts like a blanket, trapping the Sun's heat in the atmosphere warming the Earth.

MORE CARBON RELEASED INTO ATMOSPHERE

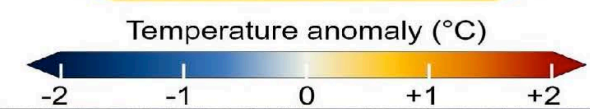
Carbon dioxide (CO_2) is the primary greenhouse gas released and controllable by humans. CO_2 in the atmosphere acts like an insulating "blanket" trapping heat from the sun and warming the Earth. When humans burn fossil fuels for all sorts of energy, cut down large swaths of natural forest, and make products such as cement and steel we release more CO_2 into the atmosphere than would naturally occur.

DEFORESTATION

Trees are natural carbon sinks: they take in atmospheric CO_2 and store the carbon in their structures, releasing oxygen back to the atmosphere. When we clear forests for timber or grazing land for cattle, we reduce the amount of CO_2 that can be removed from the atmosphere.

WARMER TEMPERATURES

CO_2 emissions from fossil fuel consumption accumulate in the atmosphere. CO_2 and other greenhouse gases trap heat from the sun; the more we put into the atmosphere the more we raise the global average temperature on Earth.



SNOW PACK and GLACIERS MELT FASTER

Increasing temperatures around the world cause glaciers, ice sheets, and snowpack to melt at an increased rate.

MORE EXTREME WEATHER EVENTS

Changes in extreme weather events are the primary way that most people experience climate change. The world—including the U.S—has seen more frequent and intense extreme weather events such as drought, flooding, downpours, heat waves, hurricanes, and superstorms. Climate change increases the number and strength of some of each of these events.

RISING SEA LEVELS

Sea levels are rising due to the expansion of water as it the oceans warm and to the addition of more water into the oceans as glaciers, ice sheets, and sea ice melt. Sea level rise means coastal flooding, shoreline erosion, and storms pushing further inland. Sea levels will continue to rise at a faster rate as the planet continues to warm.

MORE FREQUENT INTENSE FLOODING

Warmer temperatures cause water to evaporate at a faster rate. Warm air is able to hold more moisture than cold air. A warmer climate means more frequent and intense rain events. Additionally, less snow and faster snow melt create rapid and abundant runoff. The natural landscape and existing infrastructure in some places cannot cope with increased rain and runoff and hazardous flooding can result.

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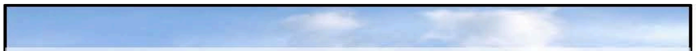
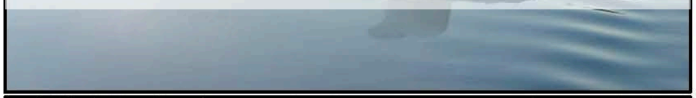
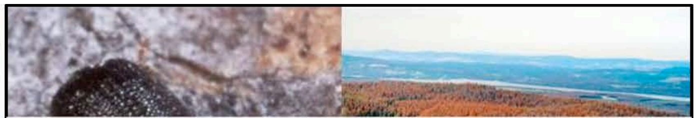


EXTINCTION and LOSS OF BIODIVERSITY

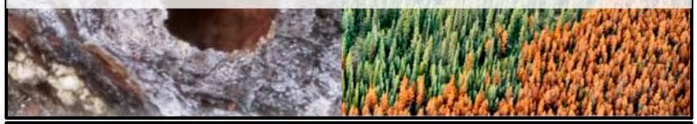
Plants and animals adapted to specific habitats and ecosystems over long periods of time. Human-induced climate change is altering ecosystems and habitats much more quickly than what would naturally occur. Because the climate and ecosystems are changing so rapidly, many plant and animal species are struggling to adapt fast enough to survive.

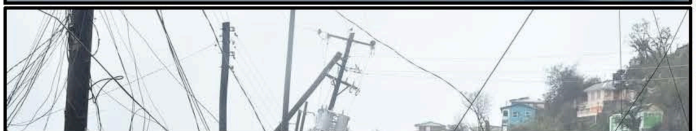




BARK BEETLES INFESTATIONS

Bark beetles live in and kill pine trees. Historically, they are dormant in the winter and get killed off with extended periods of very low temperatures. However, warmer temperatures make the beetles active year-round, killing trees at an unprecedented rate.





DESTRUCTION OF HUMAN INFRASTRUCTURE

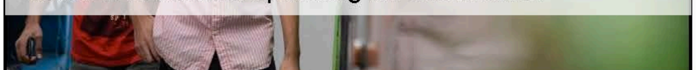
Homes, businesses, bridges, roads, power lines, etc. may be destroyed by flooding, fire, and extreme weather.

LOWER CROP YIELDS; HIGHER FOOD PRICES and FOOD INSECURITY

With less water available for agriculture, farmers may not be able to grow enough crops to meet demand, driving up food prices and impacting the ability of people to afford enough food to survive and thrive. Food insecurity can lead to social unrest, migration, and famine.

HUMAN HEALTH

Higher temperatures may lead to increased pollution causing respiratory conditions like asthma, a longer, more intense allergy season, and the spread of insect-borne diseases. Heatwaves and flooding may also cause illness and death. Increased health risks overall result in increased spending on healthcare.

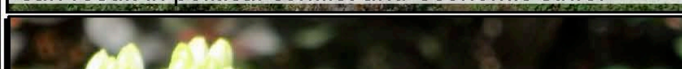


HUMAN MIGRATION

Low-lying and coastal communities risk repeat flooding or even complete disappearance as flood risks increase and coastlines change due to rising sea levels. People inhabiting these spaces will be forced to relocate. Additionally, resources like water and food may because less available in certain places, forcing migrations of thousands of people. Human migration can result in political conflict and economic strife.

DROUGHT

Higher temperatures mean increased evaporation and rapid drying of soils. Decreased snowpack and earlier snow melt lead to faster runoff and reduced groundwater and reservoir stores. This means water is less available for plants, wildlife, and humans.



SHIFTING PHENOLOGY

Phenological events (leafing, budding, hatching, migration, etc.) are triggered by environmental events like seasonal changes. Shorter winters and longer summers, for example, throw off the timing of biological processes organisms undergo to survive. For example, birds use phenological clues to know when to migrate. Increasing temperatures may cause them to migrate to their breeding grounds before food or water is available or accessible there.

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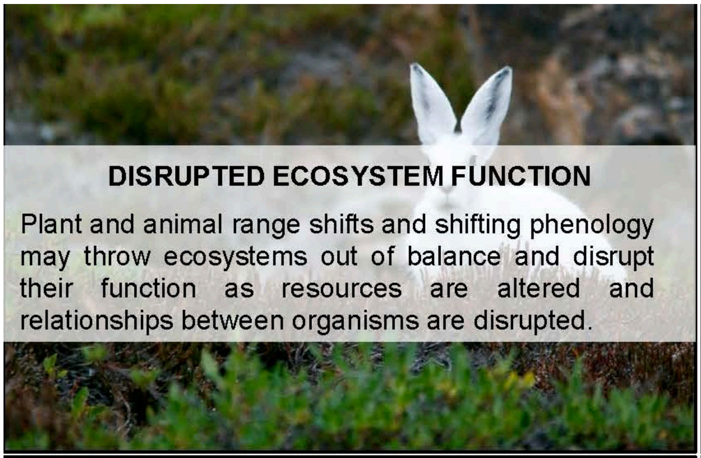
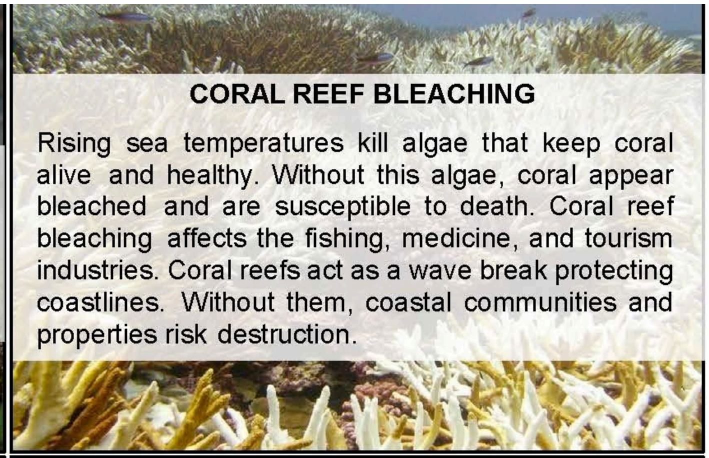

DISRUPTED ECOSYSTEM FUNCTION
Plant and animal range shifts and shifting phenology may throw ecosystems out of balance and disrupt their function as resources are altered and relationships between organisms are disrupted.


CORAL REEF BLEACHING
Rising sea temperatures kill algae that keep coral alive and healthy. Without this algae, coral appear bleached and are susceptible to death. Coral reef bleaching affects the fishing, medicine, and tourism industries. Coral reefs act as a wave break protecting coastlines. Without them, coastal communities and properties risk destruction.


WE CAN HELP!


WE CAN HELP!


WE CAN HELP!


LET THE YOUTH BE HEARD
THE ATMOSPHERE IS A PUBLIC TRUST
#YOUTHvGOV
WE CAN HELP!
WE DEMAND A CLIMATE RECOVERY PLAN
#YOUTHvGOV


IT'S TIME FOR ACTION
WE CAN HELP!
KIDS WANT CLIMATE JUSTICE


WE CAN HELP!
YOUR VOTE COUNTS

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Plumas Audubon Society

UNIT 4: AWARENESS
The Effects of Climate Change: Our Earth, Our Actions

Lesson 4.4

Lesson Objectives:

- Explain the reasoning behind and importance of finding an alternative to fossil fuels.
- Define renewable and non-renewable energies
- Discuss and consider the pros and cons of renewable energy sources
- Practice independent research and presentation skills.
- Evaluate pros and cons of renewable energies and propose a solution for energy use in their community

NGSS:

Middle School

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ESS3-4. Construct an argument supported by

Exploring the Alternatives

Summary:

This is a three-part lesson designed to be taught over the course of two to three, preferably consecutive, class periods. Part I consists of an overview of renewable and nonrenewable resources, reviewing the consequences of burning fossil fuels, and discussing our need for alternative and renewable resources. The basics of renewable resources will be discussed in class, then students will divide into groups and select or be assigned one energy source to research as homework. In Part II of this lesson, groups will present the environmental impacts and pros and cons of the energy source they researched to the class and answer questions. In Part III, the class will examine The Solutions Project and collectively choose on a proposed makeup of a 100% renewable energy mix for their community.

Background:

The burning of fossil fuels for energy is the largest contributor to global greenhouse gas emissions and, therefore, to global warming and the climate crisis. Fossil fuel (oil, coal, and natural gas) consumption accounts for about 80% of our energy consumption worldwide. At our current rate of consumption, some scientists estimate that reserves of all three fossil fuels will be gone by the year 2088. Recall from Lesson 3.3: *The Carbon Cycle* that it took millions of years to create and store carbon in the form of fossil fuels on Earth. Fossil fuels, therefore, are a finite and nonrenewable resource.

Despite this, fossil fuels continue to be sought out, even in increasingly sensitive and dangerous locations; new and even higher carbon-emitting extraction methods continue to be developed; and overall use of fossil fuels continues to increase. The longer we continue to use fossil fuels, the greater the effect of climate change on our planet, and the further we are to finding a solution to the problem. Simply put: it is not sustainable for humans to continue using fossil fuels.

In light of the threat climate disruption poses on our way of life and the entire biosphere, many people are advocating for the use of “clean” and “renewable” energy sources instead of fossil fuels. As seen and discussed in Lesson 3.2: *The Greenhouse Effect* and Lesson 3.3: *The Carbon Cycle*, rising carbon dioxide levels in the atmosphere is the greatest driver of climate change. Switching to low greenhouse gas-emitting energy sources is necessary to stabilize CO_2 emissions. These sources are often referred to as “clean energy” because of their low greenhouse gas emissions, and “renewable energy” because they naturally replenish themselves or cannot be used up (eg. solar, wind, hydroelectric). Renewable energies have a much smaller **carbon footprint** compared to that of fossil fuels.

evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

High School

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Time: *Part I: 60 minutes*
Part II: 30-60 minutes
Part III: 30 minutes

Materials:
- Handout 4.4
- Internet access

Did you know…

A carbon footprint of an energy source is the total GHG emissions (and global-warming potential) from all stages of its "life"--from raw material extraction through materials processing, manufacture, distribution, installation, use, repair and maintenance, and decommissioning.

There are also often **co-benefits** from the use of renewable energy. In addition to the direct benefit of stabilizing the climate, co-benefits of renewable energy such as reduced air pollution, added employment opportunities, fewer severe accidents, and improved energy access and security make the switch even more attractive.

Many types of renewable energy are already in use (though far less than fossil fuels) and technologies for use continue to improve. Although renewable energies pose substantially less harm and future threat to the planet than fossil fuels, they are not free of environmental impacts.

In this activity students will explore some of the environmental impacts and the pros and cons of different energy types to determine which might be best for their community.

Questioning Prompts:
- Why should we look for sources of energy other than fossil fuels?
- If humans continue using fossil fuels, what might the effects be?
- What are the pros and cons of each renewable resource?

Activity:
PART I

Define renewable and non-renewable energy with your class.
- **renewable energy**: energy harnessed from resources that are naturally replenished on a human timescale, such as sun, wind, waves
- **non-renewable energy:** energy harnessed from resources that are limited and cannot be naturally replenished on a human timescale

Next, ask students to come up with a list of energy sources that could be considered renewable (solar, wind, hydroelectric, hydrokinetic, geothermal, some forms of biomass). Ask if your students have used or seen these types of energy in action.

Alongside your renewable energy list, have students name the major non-renewable energies (coal, natural gas, oil, nuclear).

Break the class into six or more small groups. Assign each group one type of energy for which they will be responsible for researching and later presenting what they have learned to the class. Give each group their particular energy handout as well as the handouts containing the "Direct and lifecycle emissions" table and "US Energy Consumption" graphs from the Supplemental Materials (Handout 4.4). Each group should research their assigned form of energy, answer the questions provided on the handout, and prepare to share this information in a presentation of some form.

Did you know…
Co-benefits are the additional positive benefits related to reducing GHG emissions, above and beyond the direct benefits of a more stable climate.

Did you know…
Data from the table come from the 5th Assessment Report from the Intergovernmental Panel on Climate Change (IPCC). The IPCC is the United Nations body for assessing the science related to climate change and the world's foremost authority on the subject.

Data from the graphs come from the U.S. Energy Information Administration under the U.S. Department of Energy.

PART II
Each group should give a 5- to 10-minute presentation on their specific form of energy. Presentations may be given in any format(s) preferred by the instructor, but should address all the questions on the handout.

PART III
Individually or as a class, explore The Solutions Project (website: thesolutionsproject.org), an organization dedicated to reducing fossil fuel dependency and greenhouse gas emissions. Their website has details on their interactive clean energy map for the types of energy changes needed for most countries, each U.S. state, and many cities to switch to 100% renewable energy resources by 2050.

As a class, create a proposal for a 100% renewable energy mix for your community with The Solutions Project examples as a reference and considering what you learned about the different forms of energy in the group presentations.

In addition, consider some of the following as you work to come to an agreement on the makeup of your community's proposed energy mix:

- Where will we put these forms of energy supply?
- Will this impact wildlife?
- Will this impact a habitat?
- Will any people be affected?
- Will it alter the scenery?
- How much will this cost? *[Note that this question will require additional research, but calculating a rough estimate is possible.]*

Extension:

<u>TAKE IT TO THE SUPERVISORS!</u>
Have your class present their proposal to the Board of Supervisors. The Plumas County Board of Supervisors holds regular meetings at 10 am on the first three Tuesdays of every month on the third story of the Courthouse in Quincy. Contact the Clerk of the Board before the meeting to have your presentation included in the agenda.

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Handout 4.4

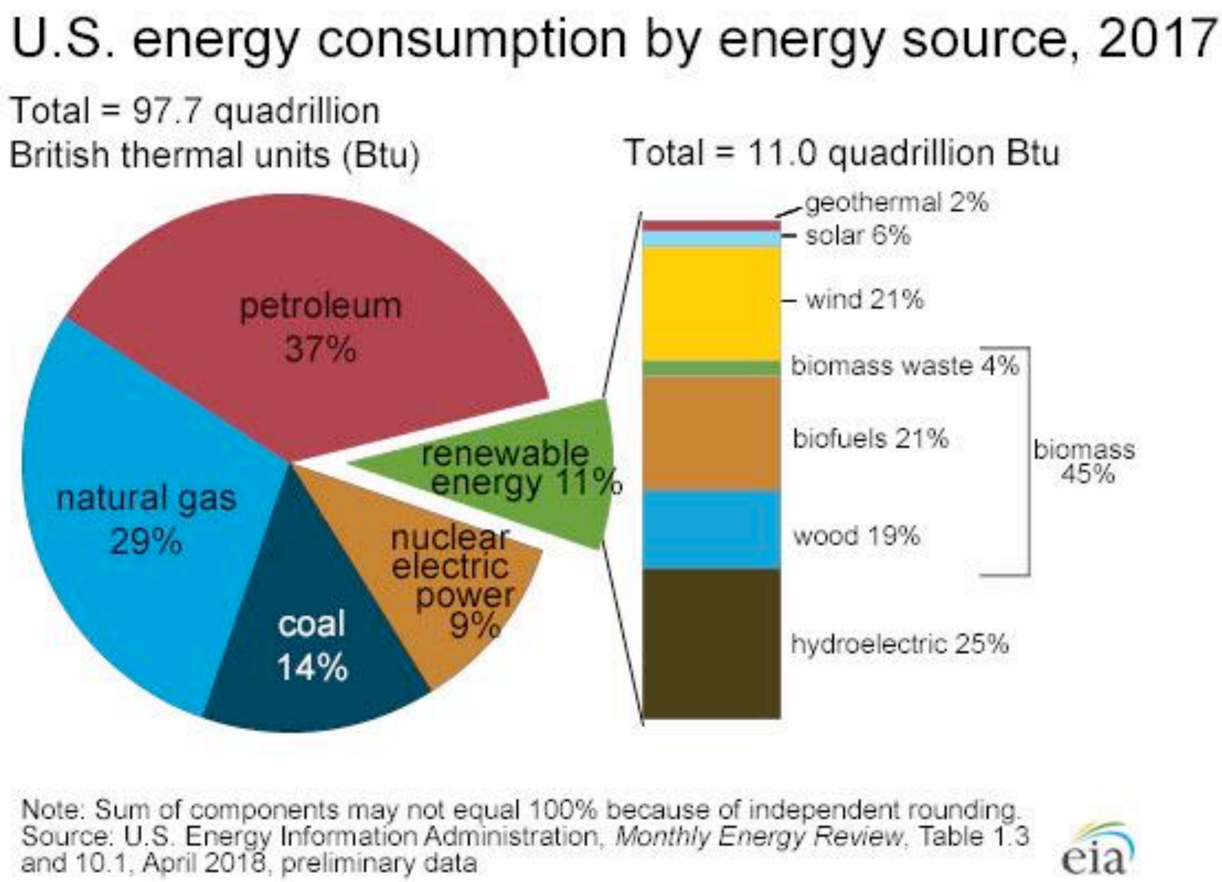
Direct and Lifecycle Emissions

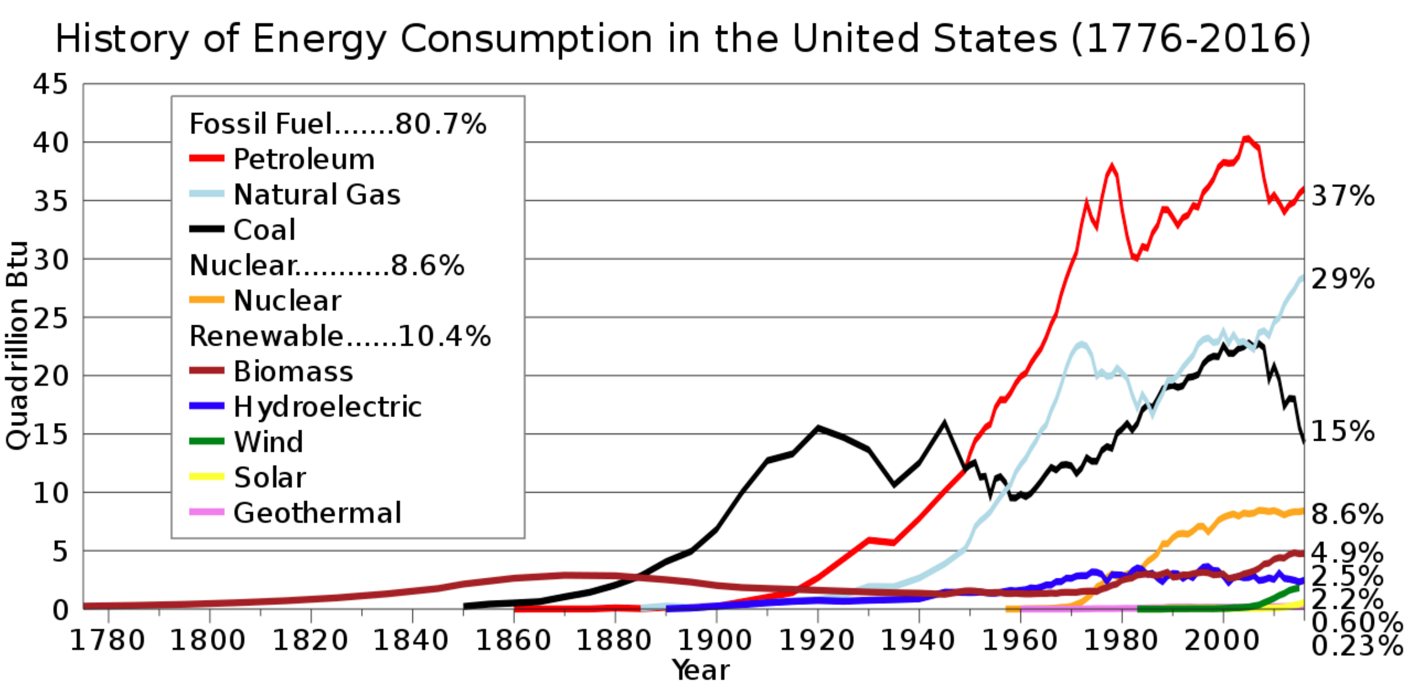
From IPCC's 5th Assessment Report, Working Group III – Mitigation of Climate Change, Annex III: Technology-specific Cost and Performance Parameters. https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf

Table A.III.2 | Emissions of selected electricity supply technologies (gCO_2eq/kWh)[i]

Options	Direct emissions	Infrastructure & supply chain emissions	Biogenic CO_2 emissions and albedo effect	Methane emissions	Lifecycle emissions (incl. albedo effect)
	Min/Median/Max	Typical values			Min/Median/Max
Currently Commercially Available Technologies					
Coal—PC	670/760/870	*9.6*	*0*	*47*	**740/820/910**
Gas—Combined Cycle	350/370/490	*1.6*	*0*	*91*	**410/490/650**
Biomass—cofiring	n.a. [ii]	–	–	–	**620/740/890**[iii]
Biomass—dedicated	n.a. [ii]	*210*	*27*	*0*	**130/230/420**[iv]
Geothermal	0	*45*	*0*	*0*	**6.0/38/79**
Hydropower	0	*19*	*0*	*88*	**1.0/24/2200**
Nuclear	0	*18*	*0*	*0*	**3.7/12/110**
Concentrated Solar Power	0	*29*	*0*	*0*	**8.8/27/63**
Solar PV—rooftop	0	*42*	*0*	*0*	**26/41/60**
Solar PV—utility	0	*66*	*0*	*0*	**18/48/180**
Wind onshore	0	*15*	*0*	*0*	**7.0/11/56**
Wind offshore	0	*17*	*0*	*0*	**8.0/12/35**
Pre-commercial Technologies					
CCS—Coal—Oxyfuel	14/76/110	*17*	*0*	*67*	**100/160/200**
CCS—Coal—PC	95/120/140	*28*	*0*	*68*	**190/220/250**
CCS—Coal—IGCC	100/120/150	*9.9*	*0*	*62*	**170/200/230**
CCS—Gas—Combined Cycle	30/57/98	*8.9*	*0*	*110*	**94/170/340**
Ocean	0	*17*	*0*	*0*	**5.6/17/28**

Life-cycle GHG emissions for an energy source are measured in units of global-warming potential per unit of electrical energy created by that source, gCO2e/kWh, where CO2e is the carbon dioxide equivalent, and kWh is one kilowatt hour.





Data from US DOE EIA AER and MER Table 1.3. Created by Delphi234.

WIND

Wind energy is harnessed with turbines: giant windmills that turn when the wind blows them. The wind turns two or three propeller-like blades around a rotor connected to the main shaft, which spins a generator to create electricity.

QUESTIONS

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

RESEARCH

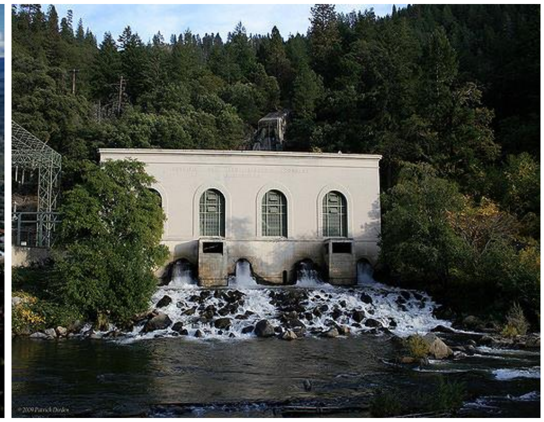
1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

HYDROELECTRIC

Hydroelectric energy comes in several forms. Commonly, dams are built across a river and flowing water turns turbines in the dam to generate electricity.

QUESTIONS

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

RESEARCH

1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

HYDROKINETIC

Hydrokinetic energy, or ocean energy, harnesses the kinetic energy in the movement of waves, tides, and currents and converts it into electricity. Buoys can harness the rise-and-fall, back-and-forth, and side-to-side movements of ocean waves. Other ocean-harnessing devices allow currents and tides to spin a turbine in multiple directions, generating electricity. This technology has yet to be used on a large-scale, but there is potential for future use and innovation.

QUESTIONS

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

RESEARCH

1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

GEOTHERMAL

Geothermal energy is the natural heat from molten rock underneath the Earth's surface. Geothermal heat is harnessed to make steam and generate electricity in a power plant, or used to heat buildings directly in a "closed loop" system where water is heated underground, pumped upward to heat the building, then, once cooled, cycled back underground to reheat. Some pumps can run in reverse in the summer to cool a building.

QUESTIONS

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

RESEARCH

1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

SOLAR

Energy from the sun is captured using photovoltaic cells to create useable energy for humans. Solar panels can cover huge stretches of land in solar farms and rooftops, or can be small enough to hold in your hand to power personal electronics.


QUESTIONS

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

RESEARCH

1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

BIOMASS

Biomass products (organic materials, most commonly plants, wood, and waste) are burned in the boiler to create steam and turn turbines, generating electricity. Some biomass products can also be converted into biofuels which are then burned in engines to power vehicles.

<u>QUESTIONS</u>

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

<u>RESEARCH</u>

1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

<u>CONSIDER</u>

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

COAL

Coal plants produce energy by burning coal, a carbon-dense sedimentary rock formed deep underground from dead plant matter transformed over hundreds of millions of years by intense heat and pressure. Coal is extracted from deep underground by mining. The coal is either burned to make steam, which then turns steam turbines to generate electricity, or it is burned and converted into a gas, which drives a combustion turbine to generate electricity. The heat from combustion is also used to make steam to run a steam turbine, generating additional electricity.

<u>QUESTIONS</u>

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

<u>RESEARCH</u>

1. What are the environmental impacts of this form of energy?
2. Create pros and cons list for this form of energy.
3. Is this form of energy being utilized where you live? If so, to what extent?

<u>CONSIDER</u>

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

OIL

Oil is a carbon-rich liquid formed from dead plant and animals transformed over hundreds of millions of years by intense heat and pressure. Oil is extracted from deep underground by drilling. Oil is primarily used to power transportation, although a small amount is used to produce electricity. For transportation, oil is first refined into various fuel products (eg. gasoline, kerosene, diesel, and jet fuels), which are then burned in engines to power vehicles. For electricity production, the oil is burned to make steam and turn a turbine, or it is burned and converted into a gas, which drives a combustion turbine to generate electricity. The heat from combustion is also used to make steam to run a steam turbine, generating additional electricity.

QUESTIONS

Refer to "Direct and Lifecycle Emissions" table and "U.S. Energy Consumption" graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
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RESEARCH

1. What are the environmental impacts of this form of energy?
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3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

NATURAL GAS

Natural gas, a product of decomposed organic materials transformed over hundreds of millions of years by intense heat and pressure, is burned to generate energy. Natural gas is extracted from deposits trapped underground by drilling. When burned the natural gas drives a combustion turbine to generate electricity. The heat from combustion is also used to make steam to run a steam turbine, generating additional electricity.

<u>QUESTIONS</u>

Refer to “Direct and Lifecycle Emissions” table and “U.S. Energy Consumption” graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
3. What is the median level of lifecycle emissions (aka carbon footprint) in CO_2e/kWh generated by this form of energy?
4. What percentage of U.S. energy consumption currently comes from this source?

<u>RESEARCH</u>

1. What are the environmental impacts of this form of energy?
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3. Is this form of energy being utilized where you live? If so, to what extent?

<u>CONSIDER</u>

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

NUCLEAR

Nuclear power plants are fueled by uranium, a naturally-occurring element. Uranium ore is mined from rocks in various places around the world. A particular uranium isotope is extracted and processed before being used to fuel a nuclear fission reaction (atoms are split apart). The fission reaction releases heat used to drive a steam turbine, generating electricity.

QUESTIONS

Refer to “Direct and Lifecycle Emissions” table and “U.S. Energy Consumption” graphs in Handout 4.4 to answer.

1. Is this a renewable or non-renewable form of energy?
2. What is amount of direct emissions measured in gCO_2e/kWh (units of global-warming potential measured in the carbon dioxide equivalent, CO_2e, per kilowatt hour, kWh)?
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4. What percentage of U.S. energy consumption currently comes from this source?

RESEARCH

1. What are the environmental impacts of this form of energy?
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3. Is this form of energy being utilized where you live? If so, to what extent?

CONSIDER

1. Should this form of energy represent a greater, lesser, or approximately the same percentage of U.S. energy consumption in the future? How far into the future would you recommend?
2. Should this form of energy be part of the mix of energy sources for your community? Why?

Plumas Audubon Society

UNIT 4: AWARENESS
The Effects of Climate Change: Our Earth, Our Actions

Lesson 4.5

Lesson Objectives:

- Combat overwhelm and consider the many ways, large and small, students can make a difference and contribute to a wider effort to solving climate change.

NGSS:

Middle School
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
High School
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Time: *30-60 minutes*

Materials:

- Computer with internet access (optional)

Learn more:

Wangari Maathai was the founder of the Green Belt Movement and the 2004 Nobel Peace Prize Laureate. She was the first woman in East and Central Africa to earn a doctorate degree and she was an activist for democracy, human rights, and environmental conservation.

The Greenbelt Movement is an environmental organization in Kenya that

Be A Hummingbird: You Can Make A Difference!

Summary:

Watch Wangari Maathai's telling of the story of the hummingbird and the wildfire, and select a few success stories to watch from the Young Voices for the Planet videos. Discuss the many ways you alone, in a small group, or as a class can commit to a plan however big or small that can contribute to solving climate change.

Background:

Climate change is a global problem with many impacts affecting life all over the world. When we think about climate change, it is easy to feel overwhelmed and depressed by the size and scale of the problem. While it's easy to get bogged down by the problem, don't be discouraged; we are not helpless! Instead rejoice that there are solutions and every action, no matter how small, counts. Every individual has the power to make a difference by doing their part.

Imagine if you committed to making one small change in your daily life to help the environment, and your friend committed to making one small change to help the environment, and your friend's friend committed to making one small change, and their friend's friend, and their friends' friend, and so on: that would be many individuals contributing in their own small way to help solve a problem larger than any one of them alone! Do your part, however big or small, and you can make a difference.

Activity:

You cannot solve climate change all by yourself. Even if an individual action by itself cannot save the environment, many individual actions can lead to big change. Listen (and watch) to Nobel Peace Prize Winner Wangari Maathai's telling of "I will be a hummingbird," in an excerpt from Dirt! The Movie.
http://www.greenbeltmovement.org/get-involved/be-a-hummingbird

Watch various success stories of young people taking positive action for a healthy world and brighter future in Youth Voices for the Planet.

- If your class has the time, watch the full hour-long video compilation of stories: https://vimeo.com/160802740?from=outro-embed
- If time is short, select one or a few to watch from the website film menu (approx. 4 - 12 min each):

  https://www.youngvoicesfortheplanet.com/youth-climate-videos/
  - Recommended videos from the list:
    - Plant for the Planet
    - Dreaming in Green
    - Olivia's Birds and the Oil Spill

empowers communities, particularly women, to conserve the environment and improve livelihoods.

Dirt! The Movie is a documentary featuring well-known environmentalists, exploring the relationship between humans and soil. http://www.dirtthemovie.org/

Did you know…
Climate drawdown is the point at which greenhouse gas concentrations in the atmosphere begin to decline on a year-to-year basis. Drawdown is a goal for reversing climate change, and eventually reducing global average temperatures.

- Green Ambassadors
- Longing for a Local Lunch

Journaling/Discussion Prompt:

- What does it mean to be like the hummingbird? How can you be a hummingbird in your own community?
- Make a list of some things you and your class or school could do to help solve the climate crisis. Consider putting ideas into a table with columns labeled individual, class, school, community (you can also add columns for state, country, and world if you want).

For information on Youth Action groups you can join (as seen in the films), go to: https://www.youngvoicesfortheplanet.com/for-kids/

Extension:

A CLASS FULL OF HUMMINGBIRDS

Individuals cannot solve the climate crisis alone; it will take the will of the masses pressuring the governments of the world to take serious and meaningful action to swiftly reach zero emissions and **climate drawdown** to reverse the current warming trend. While individual actions alone cannot change much, many individual actions add up to big change and many choices and voices demanding solutions creates a powerful call to action that governments the world over will have to listen to. So, be a hummingbird and encourage others to be one too!

- Help your class put into action one or more of the climate solution ideas your class came up with. Get support for your project by presenting your idea(s) as a class to the school administration. Provide regular time in class to do serious work on this project, encouraging students to monitor their own progress towards the goal.
- Show this short video (~4 min) to the class about how to talk to others about climate change: https://ourclimateourfuture.org/video/secret-talking-climate-change/. Then, challenge your students to practice the tips they learned from the video to engage someone they know and feel comfortable talking with in a conversation about climate change.

LIFT EACH OTHER UP AND BE THE INSPIRATION

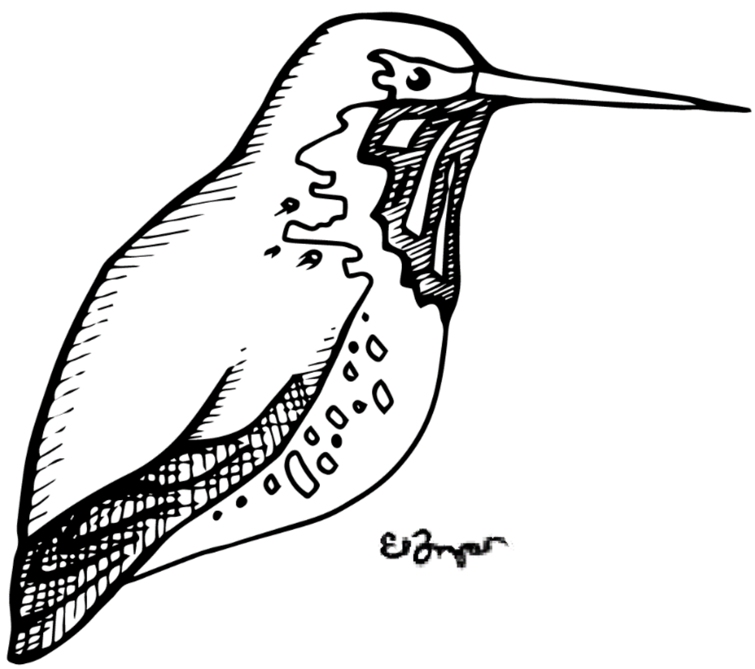
Lulls in action and motivation may occur, but don't give up! Re-motivate and reignite the class's desire to work towards your goals. This could be as simple as reviewing what you have already done and how far you've come, or watching another inspiring youth action video, or taking a walk outside, or taking a few moments of inner reflection to remind yourselves what you are doing it for and allow for sharing out loud some of that motivation!

"*There comes a time when humanity is called to shift to a new level of consciousness . . . that time is now.*"
— Wangari Maathai[5]

Unit 5: EMPOWERMENT & ACTION

Service Learning for Our Communities: Bird-Friendly and Climate-Wise Gardening

- Lesson 5.1: Survey Your Schoolyard
- Lesson 5.2: Planning and Design
- Lesson 5.3: Plant Propagation and Preparation
- Lesson 5.4: Get Your Hands Dirty! Dig In and Keep It Up!



[5] Maathai was an author, Nobel Peace Prize laureate, environmental and political activist, and founder of the Green Belt Movement. She was the first woman in East and Central Africa to earn a doctorate degree, she has assisted women in planting more than 20 million trees for the purposes of poverty reduction and environmental conservation, and is internationally recognized for her persistent struggle for democracy, human rights and environmental conservation.

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Plumas Audubon Society

UNIT 5: EMPOWERMENT AND ACTION
Service Learning and Community Science

Lesson 5.1

Lesson Objectives:
- Review key concepts in *Lesson 2.1: Ecosystems, Habitats, Resources, and Survival*
- Prepare and plan for creating a bird-friendly and climate-wise yardscape/garden

NGSS:

Middle School

MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

High School

HS-LS2-6. Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Time: *Variable.* Some groups may only want to spend a few hours, others may spend full days or more.

Materials:
- Binoculars (optional)
- Field Journals
- Writing utensils

Survey Your Schoolyard

Summary:
This guided exploration will help your class study what makes a healthy, functioning ecosystem and a bird-friendly habitat. Students will observe the conditions of their schoolyard or learning landscape in preparation for creating a “bird-friendly and climate-wise” garden.

Background:
Because of the water conservation, habitat, and biodiverse resources that native plants offer, creating a “bird-friendly and climate-wise” garden is a climate action that benefits wildlife and our communities. Creating bird-friendly and climate-wise habitats in your neighborhood can be as simple or complex as you feel like taking on. Birds will benefit from a variety of changes. Adding basic features to a yard, such as certain plants or a small brush pile, can alter the presence and abundance of bird visitors. To get ideas for the type of things birds need or are attracted to, we can observe and learn from birds in nature.

Questioning Prompts:
- What parts of this ecosystem are birds interacting with? How are birds using the habitat? What about this landscape is attractive to birds?
- What are the existing features of our schoolyard/learning landscape? How might we be able to mimic the natural landscape and habitats to create a bird-friendly and climate-wise area to serve birds and other wildlife as well as benefit the school and our community?

Activity:
1. Go back to *Lesson 2.1: Ecosystems, Habitats, Resources, and Survival.* Your class will observe the conditions of their schoolyard or learning landscape. If your class already visited another landscape(s) on a previous bird walk, compare the observations they made there to what they see in the schoolyard. Consider the natural type(s) of habitat the existing conditions in your schoolyard or learning landscape is most similar to or is surrounded by (refer to Lesson 2.1 for descriptions of these habitat types):
    - Forest or Woodland
    - Meadow
    - Wetland
    - Riparian

2. Be sure to do the extension activity at the end of Lesson 2.1 titled "Habitat Mapping." Students will draw out a map of the area you plan to work on, including its existing features, and observe how birds (if there are any present) already use the space.

3. Conduct an in-depth survey of the existing landscape you plan to enhance. It is a good idea to involve or consult with your school's groundskeeper or garden manager on this survey. You may want to invite this person to participate in the planning and implementation of the entire project to consult on growing conditions, feasibility of the project's elements, and future maintenance plans. You may want to survey the spot more than once, at different times of day, and in wet and dry conditions.

In your survey, consider the following:

Physical Characteristics

- Topography
  - Are there hills, pits, flats, etc.? Identify high and low spots.
- Winds
  - What is the direction of prevailing winds?
- Sun and Shade
  - Where is there shade? Consider how shade moves or remains at different times of day.
  - Where is there sunlight? Consider how light moves or remains at different times of day.
  - Designate spots as "full sun", "partial shade", and "full shade".
- Water
  - Where is there access to water?
  - Is there a natural source of water nearby?
  - Is there access to a hose?
  - Locate drainage spots and runoff directions.
  - Is there evidence of erosion?

Human-related Characteristics

- Structures
  - Depending on if and how this area is currently used, there may be benches, tables, play structures, light posts, etc.
- Accessibility
  - Identify formal and informal pathways.
  - Identify spots used by the public.
- Utility Features
  - Locate obvious utility lines above or below ground (school groundskeeper will be helpful here!)
  - Locate accessible spigots, sprinklers, irrigation lines.

Biological Characteristics

See next page.

Educator Tips:
Two good activities to review and prepare for surveying your plot of land can be found in Unit 1 and the Plumas Audubon field Birding Journal:

- Sound Mapping
- Field notes

Use the "Birding Basics" guide to help focus your students on birds in the ecosystem. The faster your students can get settled and the longer your students can sit quietly, the more likely birds will return to their normal behavior which is what we are trying to observe here.

Biological Characteristics

- Soil
  - What is the soil quality? Does it contain a lot of organic matter? Note whether it is sandy (rough, coarse particles), silty (smooth, small particles), clay-like (sticky or very smooth, very fine particles), or loamy (combination of the previous types)?
- Plants
  - Locate and identify trees, shrubs, and plants that provide food and shelter to wildlife.
- Wildlife
  - Are there signs of wildlife here?
- Groundcover
  - Is there grass, dirt, concrete, etc.?

Record as much of this information as you can as it will help inform which native plants will do well in your yard.

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Plumas Audubon Society

UNIT 5: EMPOWERMENT AND ACTION
Service Learning and Community Science

Lesson 5.2

Lesson Objectives:
- Define "native", "non-native", and "invasive" species
- Understand what makes a bird-friendly and climate wise landscape
- Consider design elements for a garden
- Research viable plant species for a bird-friendly and climate-wise garden

NGSS:

Middle School
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
High School
HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost,

Planning and Design

Summary:
Students will begin conceptualizing a design for their space and the impact it will have on the environment. Using your observations from Lesson 5.1, your students will brainstorm ideas, research viable plants, structures, and garden layouts, and create a master plan for their bird-friendly and climate-wise landscape.

Background:
Understanding what makes a bird-friendly and climate-wise habitat:
- **What are native plants?**
  Native plants have evolved naturally in the region. Having adapted to the local soil and climate conditions they usually require less frequent watering and fertilizing than non-native species. They tend to be more resistant to pests and disease, so they are less likely to need pesticides. Local birds and wildlife have adapted to and are dependent upon native species for food, cover, and rearing young.
- **What are non-native plants?**
  Non-native or introduced species have been moved from one locality to another and, as a result, grow outside their natural and historical range.
- **What are invasive species?**
  Invasive species reproduce rapidly and establish themselves over a large area, sometimes dominating and displacing existing native vegetation or wildlife.
- **Why do we care?**
  As non-native and invasive plants replace native ones, there are fewer and a lower diversity of native plants available to provide the necessities for existing wildlife. While some animals have a varied diet and can feed on a wide number of plant species, many are highly specialized and can only feed on specific plant species. Using native plants in your project will benefit the local wildlife and habitat issues in your area.

Design considerations:
Consider future maintenance when planning your design. A more formal garden will require more upkeep, while a more naturalized design will need less maintenance. Keep in mind that even if you chose to go with a naturalized design with native plants, the first year will require maintenance to allow the roots to establish!

Consider these basic formal concepts of landscape design in order to achieve an attractive design:
- **Balance:** Symmetry creates a formal look, while asymmetry creates a more natural-looking effect.

safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

Time: *Variable.* Some groups may only want to spend a few hours, others may spend full days or more.

Materials:
- Use a variety of tools! Drawings, models, or written items are all appropriate.
- Handout 5.2a
- Handout 5.2b

- **Repetition:** Repeating forms, textures, colors, planting, etc. gives a space unity and rhythm.
- **Contrast:** Contrast creates visual interest and variety. To create it, for example, place plants with different sized leaves or different colored flowers next to each other.
- **Color:** A great way to create visual impact, as well as attract pollinators and birds!
- **Shape:** Straight lines create a formal look, while curves mirror nature.

National Wildlife Federation Wildlife Habitat Certification qualifications:
See Handout 5.2a for the specific requirements of creating a certified wildlife habitat and use these elements as suggestions for what to include in your garden. Attaining certification is not necessary (though if your group wants to, go for it!), but this list of elements is useful as a guideline for things your garden could include and offer ideas for the future.

Activity

1. Brainstorm
   Hold a discussion of the observations made in the survey of your space. Brainstorm ideas for how to improve the space for birds and other wildlife, and how people can use the space, too. Pose the following questions:

   - What already exists here that attracts birds and wildlife?
   - What is missing? (i.e. Is there adequate shelter, food, water? Is there a place for students to observe wildlife?)
   - How can we enhance the space to attract wildlife or allow wildlife to thrive here?
   - What structures can we put in to enhance the space?
   - What types of plants can we put in to enhance the space?
   - How do we students hope to use the space? What will improve our use of the space?

2. Research viable plants for your landscape
   Have students research native plants to put into your landscape. The list in the Supplemental Materials (Handout 5.2b) is a great place to start! Divide the list amongst the class to research. Make sure to consider what species of birds and other wildlife each plant attracts, keeping in mind what plants will provide food and shelter/cover.

   The following are resources students may want to use to research native plants:

   - California Native Plant Society Database https://calscape.org/
   - Lady Bird Johnson Wildflower Center Native Plants Database https://www.wildflower.org/plants/

3. Draw out your master plan
   As a class, draw out a map of the chosen space using the students' habitat maps and observations from the activity and survey in Lesson 5.1. The map should include structures, trees, fields, water features, walkways and all the details obtained from your survey. This is the basis for your master plan.

   Create a plan for where and what you plan to plant, where you will place structures (like benches, nest boxes, feeders, a bird bath, picnic tables, pathways or a shade structure), where students can sit or stand to observe wildlife, or any other areas or aspects for how you plan to use the space as a learning landscape.

   Use the research gathered as a class to consider the space each plant will need (to accommodate vertical and horizontal growth), the quality of light (shade or full sun), rate of spread, what wildlife the plant will attract, and the educational value of each plant (eg. How has this plant been used historically or by Native Americans? If this plant produces seed pods, it may be used to study seed dispersal or germination. Different leaf shapes or vascular structures could be used to study plant biology, etc.).

   Get creative! Use a variety of materials to make your map, including collaged pictures, drawings, colored pencils, etc. You could even build a physical model of the layout design using different materials to represent plants in your garden.

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Handout 5.2a

National Wildlife Federation – Certified Wildlife Habitat

Certification requires a minimum number of elements from each of the following "habitat essentials": Food, Water, Cover, Place to Raise Young, Sustainable Practices

FOOD: Your habitat needs 3 of the following types of plants or supplemental feeders:

- ☐ Seeds from a plant
- ☐ Berries
- ☐ Nectar
- ☐ Foliage/twigs
- ☐ Nuts
- ☐ Fruits
- ☐ Sap
- ☐ Pollen
- ☐ Suet
- ☐ Bird feeder
- ☐ Squirrel feeder
- ☐ Hummingbird feeder
- ☐ Butterfly feeder

WATER: Your habitat needs 1 of the following sources to provide clean water for wildlife to drink and bathe:

- ☐ Birdbath
- ☐ Lake
- ☐ Stream
- ☐ Seasonal pool
- ☐ Ocean
- ☐ Water garden/pond
- ☐ River
- ☐ Butterfly puddling area
- ☐ Rain garden
- ☐ Spring

COVER: Wildlife need at least 2 places to find shelter from the weather and predators:

- ☐ Wooded area
- ☐ Bramble patch
- ☐ Ground cover
- ☐ Rock pile or wall
- ☐ Cave
- ☐ Roosting box
- ☐ Dense shrubs or thicket
- ☐ Evergreens
- ☐ Brush or log pile
- ☐ Burrow
- ☐ Meadow or prairie
- ☐ Water garden or pond

PLACE TO RAISE YOUNG: You need at least 2 places for wildlife to engage in courtship behavior, mate, and then bear and raise their young:

- ☐ Mature trees
- ☐ Meadow or prairie
- ☐ Nesting box
- ☐ Wetland
- ☐ Cave
- ☐ Host plants for caterpillars
- ☐ Dead trees or snags
- ☐ Dense shrubs or a thicket
- ☐ Water garden or pond
- ☐ Burrow

SUSTAINABLE GARDENING PRACTICES: You should be doing 2 things to help manage your habitat in a sustainable way.

Soil and Water Conservation:

- ☐ Riparian Buffer
- ☐ Capture rainwater from roof
- ☐ Xeriscape (water-wise landscaping)
- ☐ Drip or soaker hose for irrigation
- ☐ Limit water use
- ☐ Reduce erosion (i.e. ground cover, terraces)
- ☐ Use mulch
- ☐ Rain garden

Controlling Exotic Species:

- ☐ Practice integrated pest management
- ☐ Remove non-native plants and animals
- ☐ Use native plants
- ☐ Reduce lawn area

Organic Practices:

- ☐ Eliminate chemical pesticides
- ☐ Eliminate chemical fertilizers
- ☐ Compost

Handout 5.2b

Native Plants List

Botanical Name	**Common Name**
Acer macrophyllum	Big Leaf Maple
Achillea millefolium	Common/White Yarrow
Aesculus californica	California Buckeye
Allium campanulatum	Sierra Onion
Amelanchier alnifolia	Western Serviceberry
Aquilegia formosa	Western/Crimson Columbine
Arctostaphylos canescens	Manzanita
Asclepias speciosa	Showy Milkweed
Balsamorhiza sagittata	Arrowleaf Balsamroot
Calochortus coeruleus	Blue Star Tulip
Calycanthus occidentalis	Spice Bush
Castilleja miniata	Giant Red Paintbrush
Cercis occidentalis	Western Redbud
Cercocarpus betuloides	Mountain Mahogany
Chrysothamnus nauseosus	Rubber/Gray Rabbitbrush
Cornus nuttallii	Mountain Dogwood
Cornus sericea	Creekside Dogwood
Delphinium nudicaule	Red Larkspur
Epilobium canum	California Fuchsia
Eriodictyon californicum	Mt. Balm, Yerba Santa
Frangula californica	California Coffeeberry
Fraxinus dipetala	California Ash
Helianthus bolanderi	Bolander's Sunflower
Lonicera ciliosa	Orange Honeysuckle
Lupinus albicaulis	Sickle-keeled Lupine
Lupinus grayi	Sierra Lupine
Mahonia aquifolium	Oregon Grape
Monardella odoratissima	Pennyroyal, Mtn Coyote Mint
Penstemon newberryii	Mountain Pride
Penstemon speciosus	Royal/Showy Penstemon
Philadelphus lewisii	Mock Orange
Ribes aureum	Golden Currant
Ribes cereum	Wax Currant
Ribes nevadense	Sierra Currant
Ribes roezlii	Sierra Gooseberry
Rosa californica	California Wild Rose
Sambucus nigra or mexicana	Blue Elderberry
Spiraea douglasii	Spirea
Wyethia mollis	Mules Ears
Xerophyllum tenax	Bear Grass

Lesson 5.3

Lesson Objectives:
- Propagate from seed native plants for your garden
- Record observations of germination process
- Assess the relative success of germination
- Study plant biology by observing the germination process
- Learn basic gardening skills

NGSS:

Middle School
MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
High School
HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Time: *Variable.* This lesson covers several steps in preparing your garden including obtaining seeds, seed pretreatment, and seed germination and, therefore, will take days, weeks, or months. Please read the lesson and plan your time-frame accordingly.

Materials:
- seeds
- soil
- gardening tools
- flats or pots
- label-making materials (such as popsicle sticks or stickers for conatiners)

Plant Propagation and Preparation

Summary:
Now that students have identified native plants they would like to include in their garden, they will have the opportunity to germinate and propagate native plants from seeds. Option to keep a detailed record of observations during the germination process, including drawings.

Background:
GETTING YOUR PLANTS or SEEDS
Once you have a list of plants your class would like to grow, you'll need to get seeds or plants. Local native seeds can be ordered from Sierra Seed Supply (https://www.sierraseedsupply.com/) based out of Greenville, or from a variety of suppliers found online that sell California native seed. Native plants can be ordered from California Sister Nursery (http://featherriverhotsprings.com/nursery/) based out of Twain or from a variety of nurseries found online that sell California natives. Refer to the list of Potential Funding for Bird-friendly and Climate-wise Yards in the Supplemental Materials (Teacher's Supplement 5.3).

Your native seeds may be dormant. Before you sow indoor or outdoor, you may need to break their dormancy. Many native plant seeds have a dormancy mechanism that protects the seed from germination until the proper environmental conditions for growth occur. Most native species will not require pretreatment, but some seeds may need to be pretreated in a way that mimics the conditions they would experience in nature to break them out of dormancy.

SEED PRETREATMENT: BREAKING DORMANCY
Common simple treatments to break dormancy include:
- Scarification: chipping or scuffing the seed coat mechanically
- Cold stratification: temperature and moisture treatment to mimic winter conditions),
- Freezing and thawing
- Light exposure
- Hot water

Refer to the "Propagation" notes in the "Landscaping Information" section of each plant page on Calscape (https://calscape.org) to determine what, if any, pretreatment your seeds may need.

Be sure to consider the recommended length of pretreatment when planning the time-frame for your service-learning project. You will need to account for pretreatment, seed planting and transplanting to the garden. For example, cold stratification, common to many natives, may last a few days to several months, depending on the plant species.

Educator Tip:
Wondering how to cover the costs of your garden project? Teacher's Supplement 5.3 provides a list of possible funding sources.

Did you know…
Birds plant trees! Some seeds in the wild require moving through the digestive system of a bird to successfully germinate. Birds also help seed dispersal by dropping seeds further from the mother plant.

Did you know…
Simplest cold stratification method: All native seeds that require cold stratification can simply be sown and placed outdoors in the fall or winter.

Educator Tip:
There are many different container options and you can get creative with reusing various types of containers you can find for free, but be sure to thoroughly clean and make drainage holes in whichever type of container you choose.

<u>SEED SOWING: INDOORS or OUT?</u>
Native seeds are ideally suited to germinate outdoors and some species will germinate better outdoors than in a greenhouse. For outdoor propagation, seeds can simply be sown and placed outdoors in the fall or winter. Spring sowing can also be successful, but certain seeds may require artificial cold stratification using soaking and refrigeration to mimic winter conditions prior to planting.

You may be interested in sowing your seeds indoors so that your class can have a more "hands-on" approach and watch the development more closely. For indoor propagation, seeds can be sown in the spring. Be sure to check whether stratification or another pretreatment is necessary for the seeds.

You can also experiment with planting some seeds both indoors and outdoors to test which results in better germination and growing success.

Activity:
Have your students to maintain a journal with drawings of each stage of the plant's development, indoor or out.

<u>OUTDOOR PROPAGATION</u>
Native seeds can be propagated outdoors either directly on the ground or in flats, trays, or pots. Seeds can be sown in fall or early winter and will germinate when the outdoor conditions are optimum for each species.

DIRECT FIELD SOWING
If sowing directly on the ground, the soil should first be broken up, loosened, and leveled. Large seeds can then be lightly raked in, followed by light watering, and small seeds should be simply broadcast on top of moistened soil. It can be helpful to place labels in the ground with the sowing date to remind you which species were sown where. The area should be kept moist throughout the germination period.

FLATS and POTS

1. Native seeds can be sown in flats, trays, or pots at least 3" deep. Spread soil, soilless mix, or potting mix, spread evenly in containers (trays, flats, or pots at least and tamp to about ½" below rim.
2. Native seeds can be planted close together (⅛" to ¼" apart), but for more ease in later transplanting, space seeds at least ¼" apart in rows 1 or 2 inches apart and plan to pot-up or transplant seedlings while they are still small to avoid root entanglement between plants.
3. Take care not to plant seeds too deeply as they may germinate, but the shoot may die before reaching the light at the surface. Generally, plant medium to large seeds as deep as the seed is thick. Small seeds can be sown onto the soil surface and very lightly covered. Very fine seeds should be sown on the surface, gently patted down, and watered lightly with a spray bottle.

4. Label the plants and include sowing date.
5. Place the planted containers outside in a sheltered, shady spot until the plants germinate.
6. Keep the soil moist, lightly watering approximately every couple days to a week.

Note: Some seeds may not germinate the first year, but will the following year. If a flat of seeds fails to germinate, don't throw it out, be patient, and give it a second chance the following year.

INDOOR PROPAGATION

When propagating from seed indoors, you can have your students individually plant seeds and take individual responsibility for germination and seedling care, you can have a communal project with everyone working to care for all of the plants, or some combination of the two. Communal planting and caretaking allows the class to share not only the responsibility, but also both the germination and seedling successes and failures.

SOWING and GERMINATION

1. Follow the same initial sowing instructions #1-4 and #6 as in the "Flats and Pots" section of Outdoor Propagation described earlier.
2. Next, cover the container with clear plastic; this will create a greenhouse effect, which will help keep the soil and seeds moist and will trap some heat. Support the plastic covering with a frame or sticks and tuck the edges into the top of the pot or tray so condensed moisture can run back into the soil. Alternatively, you can pull the plastic taut with a rubber band around the container. Do not allow the covering to rest directly on top of the soil as seedlings could get stuck to the cover when they emerge. A single sheet of newspaper on top can help prevent too much heat build-up. Keep the container out of direct sunlight until germination.
3. Moisture and warmth are important for successful seed germination. Check the soil daily to ensure that seeds are kept consistently moist until they germinate (generally one to four weeks for most species). If the soil is drying out, water gently and avoid overwatering; do not allow the soil to stay too dry or too wet.
4. Once the seeds germinate, remove the newspaper and allow the seedlings to acclimate by poking a few more holes in the plastic each day for about a week before removing the plastic entirely. Take care that the plastic does not touch the leaves of the seedlings. Do not leave covered plants in strong sunlight or damage will occur.
5. Once uncovered, place seedling containers near a window in direct sunlight where possible. When choosing an indoor location for growing your plants consider the amount of light your plants receive on the windowsill. The amount will depend on the direction the window faces (southern- and western- facing windows receive the best light), any shade from trees or other buildings, and the time of year.

Did you know…

If using outdoor soil for propagation in a container, pasteurization by heating the soil to 140°F for 30 minutes can help prevent seedling loss to soil-borne disease or pests.

Educator Tip:

Fertilizer is not necessary as many California natives will not tolerate it. If you do choose to use fertilizer, however, go organic.

Educator Tip:

This is a good opportunity to review or connect back to the lessons and concepts of the greenhouse effect and global warming (Lessons 3.2 and 3.3).

MAINTENANCE

Water plants only when they need it; again being careful to not over- or under-water. Check the soil moisture regularly by sticking your finger about an inch into the soil.

Plants should not be left unattended for more than a few days. During periods of active growth, plants use water rapidly.

Journal and Discussion:

How successful was the class's germination rate (number of seeds that sprouted / number of seeds planted)? What factors may have affected this level of success?

Additional Resources:

- Poles. Tina M. *A Handful of Seeds: Seed Study and Seed Saving for Educators.* Occidental Arts and Ecology Center. Available at: https://oaec.org/wp-content/uploads/2014/10/A-Handful-of-Seeds.pdf
- Santa Barbara Botanical Garden. *Seed Propagation of Native California Plants*. Available at: https://calscape.org/seed_propagation.php
- Wild Seed Project. *How to Grow Natives from Seed.* Available at: https://wildseedproject.net/how-to-grow-natives-from-seed/

Teacher's Supplement 5.3

Possible Funding Sources for Your "Bird-Friendly and Climate-Wise" Garden:

Cornell Lab of Ornithology BirdSleuth K-12 Garden Grants
$500-$2,000 grant, gardening supplies, and BirdSleuth's ***Habitat Connections*** kit. Funds can support a new garden or the revitalization of an existing one. In addition to funding food/veggie gardens, preference will be given to bird, pollinator, native habitat, rain, and other natural projects. Read more and find out how to apply at http://www.birdsleuth.org/garden-grants/

Captain Planet Foundation Grants
The mission of the Captain Planet Foundation is to promote and support high-quality educational programs that enable children and youth to understand and appreciate the world through active, hands-on projects designed to improve the environment in their schools and communities. The foundation intends its grants to serve as catalysts for getting environment-based education into schools and inspire youth and communities to participate in community service through environmental stewardship. Requests for funding less than $500 will be given preference and occasionally grants of up to $2,500 will be considered. Schools and organizations with operating budgets of less than $3 million are eligible to apply. Read more and apply at https://captainplanetfoundation.org/grants/

The Nature Conservancy Nature Works Everywhere Grants
$2,000 awarded to 50 schools for projects that implement green infrastructure to address environmental problems. Find out more and how to apply, as well as peruse many garden building resources at https://www.natureworkseverywhere.org/grants/

Kids Gardening Youth Garden Grants
Supports school and youth educational garden projects that enhance the quality of life for students and their communities with cash grants and/or gardening supplies. Learn more and apply at https://kidsgardening.org/2019-youth-garden-grant/

Wild Ones Seeds for Education Grants
$100-$500 grants awarded to naturally landscaped garden projects where youth participate in planning and planting using native plants and seeds. Learn more and and find out how to apply at https://wildones.org/seeds-for-education/

National Environmental Education Foundation Grants
Several funding opportunities of varying amounts. Find out more, check the current list of funding opportunities and apply at https://www.neefusa.org/grants

Project Learning Tree Greenworks Grants
Up to $1,000 in funding for environmental service-learning projects, including establishing a school garden. Applicants must complete a PLT training (in-person workshops or online training), project must have at least one community partner (Plumas Audubon Society!), and at least 50% matched funding (in-kind acceptable). Learn more and find out how to apply at https://www.plt.org/resources/greenworks-grants/

The Pollination Project Grants
Small starter grants of up to $5,000 to a wide variety of projects that spread good and compassion. Read about the wide range of projects they have funded since 2013 and how to apply at https://thepollinationproject.org/

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Plumas Audubon Society

UNIT 5: EMPOWERMENT AND ACTION
Service Learning and Community Science

Lesson 5.4

Lesson Objectives:
- Learn the basics of planting
- Plant and landscape the garden!
- Create labels for plants that include scientific and common names, what birds, insects, and other wildlife the plant may attract, and the plants' ethno-botanical uses.

NGSS:
Middle School

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

High School

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Get Your Hands Dirty! Dig In and Keep It Up!

Summary:
It's time to get your hands dirty and put all your careful planning and preparation into action! This lesson provides resources for basic planting skills and instruction.

Activity:
BASIC PLANTING GUIDELINES

1. Remove unwanted existing plants or grass around the area you plan to plant.
   a. Weeding is important both before planting and during the growing season as other vegetation around your native plants will try to compete for water and nutrients in the soil.
2. If you are building raised beds, install them.
3. Prepare soil beds.
   a. Remove large rocks and separate hard clumps of dirt with a rake.
   b. Your groundskeeper or school gardener should be able to advise whether or not your planting area will need soil amendments like compost, fish emulsion, or organic fertilizer (most native plants, however, do not require fertilizer). Consult with them to determine what is needed and how much.
4. Stage plants according to your design.
   a. For older students, you may use colored flags or stakes to delineate areas where specific plants will go. With younger students, you may want to physically place plants in their temporary pots where plants will be put into the ground. You can use stakes and string to create guide lines.
   b. If you are planting an area that is open on all sides, start in the middle and work your way out. If you are planting up against a barrier like a wall or a fence, begin nearest the barrier and work your way outward.
   c. Before staging, water the plants one last time if possible.
   d. If you have multiple seedlings in trays, the trays can be cut during staging. Keep all plants in their plastic pots/trays until a hole is dug and the plant is ready to be put in the ground.
   e. Make sure each plant has a enough room for growth. Check the backs of seed packets, refer to your students' research, or check the labels that came with the plants from the nursery for guidance.
5. Transplant seedlings or purchased plants.

Time: *Variable.* This will depend on the size of your space, the amount of help you have, and careful planning, you should be able to put your garden in in one day!

Materials:

- gardening gloves
- trowels
- hoes
- shovels
- soil
- compost
- seedlings
- other garden features you want to put in your space
- many helping hands!

Educator Tip:
The Plumas County Fire Safe chipping program may be able to provide mulch for free. The program only operates for a few weeks twice per year (in late spring and late summer), and may not be able to provide chip delivery. Please contact PlumasFireSafe@plumascorporation.org for inquiries and coordination.

a. Do a demonstration for students. Depending on age and experience level, you may want to do a classroom demonstration before the planting day, as well as a demonstration on site on the planting day.
b. Dig a hole deep enough and wide enough so that the plant in its existing pot soil will fit evenly with the ground soil. Do not set plants so deep that you bury the stem or so shallow that the existing soil from the pot sticks out of the ground.
c. Remove the plant from its temporary plastic pot by gently squeezing the sides of the pot to loosen dirt and roots. Gently pull at the base of the stem to free plant from pot.
d. Sometimes the roots will be "root-bound" and growing in circles inside the temporary pot. In this case, gently break apart tangled up roots at the base (just a bit, do not overdo this!). This will give the roots air and room to grow.
e. Place the plant in the hole and push soil around plant to fill gaps and pat to secure.
f. Students may need volunteer supervision or a double-check when they are finished to ensure planting was done correctly.
g. Water the plant into the ground with a watering can or lightly flowing hose. If soil sinks around it, add a bit more soil.

6. Add mulch if desired.
   a. Mulch will create a uniform look, prevent weeds from growing, hold moisture in the soil longer, and contribute nutrients to the soil as it breaks down.
   b. You can use dried leaves, wood chips, grass clippings, or hay as mulch.
7. The plants will need extra attention and care when they are newly transplanted. Make sure to check on them in the next few days and water as needed.

BASIC "DIG DAY" TIPS

- Create a work plan for the planting day. Divide the number of plants by number of students; one student should be able to plant up to 10 quart-sized plants in an hour. Determine how many adult volunteers will be needed to help students. More students may be around and willing to work than there is work to do, so come up with an activity for students to do while they are not planting. Students will be most interested in planting, however, so make sure you have divided the plants so that each students has an opportunity to plant.
- It's best to do your transplanting on a cloudy or cool day to reduce the stress on the young plants.
- Native plants do not require as much water attention as non-natives, but care is still needed, especially in their first year while their roots establish in the ground. Water deeply but infrequently to encourage

plant roots to spread far and wide, and help them find their own sources of water in the drier months. Drought tolerant plants evolved to rest during the hot summer months, therefore, too frequent of direct watering can kill the plant.

LABELS AND INTERPRETIVE GARDEN SIGNS

Making labels for your plants is important for educating students and visitors to the garden, as well as informative for student gardeners who will care for the plants in the future. Label-making is a fun, creative project that will beautify the garden and help create an inviting space. Sign should be easy to read, long-lasting, and weatherproof. Consider the following types of signs for your garden:

- **Inviting signs:** welcome people into the space.
- **Informative signs:** can be general garden signs and/or specific to each plant
    - What kind of garden is it?
    - Who built it and why?
    - What are the plants growing here? Be sure to include scientific names and common names.
    - What wildlife might you see in the garden?
    - What benefits do they bring to wildlife and the environment?
    - How have these plants historically been used or enjoyed by people?
    - What groups of people used these plants? What time in history?
- **Inspiring signs:** get people excited to spend time in the garden and come back.

Educator Tip:
Las Pilitas Nursery provides a useful table on their Bird Garden page that describes which birds use which native plants, for what, and when! The website also has information on other pollinator wildlife. https://www.laspilitas.com/bird.htm

There are tons of ways to make signs and labels. Get creative! Here are some ideas to get you started:

- Crayons, colored pencils, or markers on thick paper followed by lamination; staple or clip to a stick;
- Permanent marker or paint on paint mixing sticks or popsicle sticks;
- Paint or paint marker on stones;
- Stamped clay (sculpey/polymer clay or ceramic);
- Plywood and paint.

CELEBRATE YOUR BIRD-FRIENDLY AND CLIMATE-WISE GARDEN!

When your space is complete, organize a Grand Opening Celebration. Invite the whole school, the community, and the local press. The more people know about the garden, the more people are going to want to spend time there and maybe help with future upkeep and planting.

Additional Resources:

- USFWS's *Schoolyard Habitat Project Guide*: https://www.fws.gov/external-affairs/marketing-communications/printing-and-publishing/publications/3012-Schoolyard-Habitat-Guide.pdf

- California Native Plant Society. *Calscape Natural Gardening Tips.* Available at: https://calscape.org/planting-guide.php

- National Gardening Association. 2006. *GrowLab: A Complete Guide to Gardening in the Classroom*. South Burlington, VT: National Gardening Association.

Nature Works Everywhere by The Nature Conservancy provides resources for teaching and learning about science and nature. The organization's website has several Tip Sheets and videos about planning and building a garden. Here are some useful links:

- https://www.natureworkseverywhere.org/resources/?type=garden-tip-sheet
- https://www.natureworkseverywhere.org/resources/how-to-build-garden-in-a-day/

KidsGardening.Org has tons of resources to help your school create a garden. Here are some useful links:

- Soil preparation: https://kidsgardening.org/gardening-basics-preparing-the-soil/
- Transplanting: https://kidsgardening.org/gardening-basics-transplanting-and-direct-seeding/
- Bird-friendly specific tips: https://kidsgardening.org/gardening-basics-the-winter-bird-friendly-schoolyard/
- All gardening basics links: https://kidsgardening.org/gardening-basics/

“*The greatest threat to our planet is the belief that someone else will save it.*”
— Robert Swan[6]

Curriculum Conclusion: STEWARDSHIP
The Bird is the Word

- Conclusion: Reflections of Fledgling Stewards

[6] Swan is an author, explorer, and environmental activist. He was the first person to walk to both the North and South Poles.

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Plumas Audubon Society

CURRICULUM CONCLUSION: STEWARDSHIP
The Bird Is the Word

Conclusion

Lesson Objectives:

- Reflect on what students have learned throughout this curriculum
- Take their stewardship outside of the classroom and share with the community and the world.

Time: *Varies.* Depends on project idea.

Educator Tip:

Have your class take the PEEP Post-Survey. If your class took the Pre-Survey, a comparison of the two will offer insight into your students' development on the path to becoming environmental stewards. If not, the Post-Survey can still offer useful insights into your students' understanding of climate change and its effects.

Reflections of Fledgling Stewards

Summary:

If your class did any lessons from the curriculum, this is an opportunity to have students reflect on what they learned, how their perspective may have developed or changed, if they feel a new or deeper sense of responsibility to care for the environment, and if they feel they have become empowered stewards of the environment.

Background:

Recall that the purpose of the "Birds and Climate Change" curriculum is to cultivate stewardship in students by opening an AWARENESS of climate change and its effects on the natural environment, wildlife, and society; building a RELATIONSHIP with the land, its resources, and the organisms who depend on such, including human communities; developing a sense of RESPONSIBILITY and CAPACITY to address climate issues; and EMPOWERING students to take ACTION to make positive change as stewards of the earth.

When creating your reflection activity or project, think of ways you can incorporate one or more of the four concepts in relation to one or various lessons your students completed from this curriculum:

1. **Open an AWARENESS:** Why should we care about birds? What is climate change?
2. **Build a RELATIONSHIP:** What kind of natural resources do birds and humans depend on? How are our lives connected to our environment? Why is the conservation of biodiversity important?
3. **Develop a sense of RESPONSIBILITY:** What is the main cause of climate change? What are the effects of climate change? How does it affect birds? How does it affect humans? How does it affect you and your community right now?
4. **Foster a feeling of EMPOWERMENT and call to ACT:** There is hope for change as we already know of a vast array of solutions for mitigating, adapting to, and solving the climate challenge and its effects. What small, medium, and large things can we do to help solve climate change? How can we help birds and wildlife? What will you do in your everyday life to make a difference? What can we do, collectively as communities, to make a difference?

Activity:

This activity can focus on individual student reflections of their experience with the curriculum, or you can take it a large step further by asking the students to now become the teachers and take what they have learned and spread the word out into the school, community, county, or even further! It is open to interpretation and imagination.

Here are a few activity or project ideas:

- Write a reflective journal entry or essay assignment.
- Design a bulletin board, posters, or flyers to display at school or around the community.
- Creative writing: write a story or a poem about your experience. For those willing/interested, consider submitting such pieces to local newspapers for publication.
- Do an art project such as a collage, painting, or drawing to hang or display publicly.
- Create a group presentation or play to present to the school or community.
- Create a podcast, video, or photo series and share with other classes, post online, and/or send to a public representative or the local radio station.
- Write a letter (narrative, descriptive, expository, persuasive, or a combination) to your County Supervisor, State Senators and Assembly members, U.S. Senators and Representative.

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Plumas Environmental Education Program
Birds and Climate Change Curriculum