HOLDEN FORESTS & GARDENS

Lesson Plans: Climate Change and Solution Strategies

Description: Students will watch a movie to understand what climate change is, why it is happening, why it is a problem, and some hints of possible solutions to it. Making a model of The Greenhouse Effect will help reinforce the main causes of climate change that were introduced in the movie. The movie touches on some impacts of climate change, but a less obvious impact being explored by scientists is Phenological Asynchrony that the students can start to understand with an analysis of data from a study exploring the topic. Finally, a card sort activity can then explore even more possible solutions and have them think about whether the solutions are going to reduce the rate of climate change or help us deal with its effects.

Learning Goals

- Students will recognize the causes and effects of climate change.
- Students will model the role of greenhouse gases (GHGs) in the greenhouse effect that can result in climate change.
- Students will analyze data to recognize the effects of climate change on the phenology of seasonal behaviors of different organisms that can result in phenological asynchrony.
- Students will become familiar with possible solutions to climate change.
- Students will be able to differentiate between mitigation and adaptation solution strategies.

Activity 1 – Our Climate Our Future Video on Climate Change (1-2 class periods)

Materials: Our Climate, Our Future video, Our Climate Our Future video question handouts (long or short versions)

Preparation: Print handouts for students. Recommended viewing of video before showing students.

Directions: Before watching the video, the instructor may want to have a discussion where the students can share what they already know about climate change. While showing the video chapters, the instructor should pause at points to give students an opportunity to write down their answers (or have different students share what they would put for different answers to ensure understanding). Instructors may want to consider having a discussion after the video about a particular question or important takeaways.

The full video is 40 minutes long, but they have broken it down into 11 chapters that range from 2-7 minutes. Some chapters are not as informative and could be skipped, if necessary. There are two versions of the video questions for students to fill out while watching. The longer version has questions for each chapter (except the last), while the shorter version has removed questions from less important chapters to keep the worksheet one page (front and back). Chapters removed from the shorter version have lighter heading fonts on the longer version. All chapters can still be viewed if using the shorter version and the instructor may want to ask questions for students to answer directly for the chapters that are not included on the question worksheet.

Activity 2 – Modeling the Greenhouse Effect (1-2 class periods)

Materials: Greenhouse Effect Model Information handout, blank paper (larger sizes preferred), colored pencils/markers/crayons, websites (given below), Peer Review of Greenhouse Effect Models handout

Preparation: Review the video and website to become familiar with the information provided. Provide students with the instruction sheet and the links to websites needed (NASA page that has the video and the NOAA page that gives more information).

Directions: Tell students that you'll be doing an activity to further explore The Greenhouse Effect that was mentioned in the video they watched earlier. The instructor could ask whether anyone remembers what The Greenhouse Effect is before showing a quick video that explains it (from the NASA page). The instructor should pause on occasion to emphasize key points. Tell them that they are going to draw a model of the process and explain the model in words around the drawing, including information about the different gases in the atmosphere. The models should show and describe something like the following (included on the Peer Review handout):

> **Solar radiation** coming from the sun comes into the Earth's atmosphere, some of which is **reflected** off **clouds (water vapor)** or **Earth's surface** and can go back out into space, but some is **absorbed** by the atmosphere or Earth's surface. When absorbed energy is released from things like the Earth's surface, it is called **infrared radiation (heat)**. Some infrared radiation (heat) goes out to space, but some gets trapped in the atmosphere by **greenhouse gases (GHGs)**. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), and water vapor in the form of **clouds**. These GHGs have a very large effect despite their *relatively low concentration* (< 0.5%) compared to other atmospheric gases like nitrogen, oxygen, and argon that make up more than 99.5% of the gases in the Earth's atmosphere. The trapped infrared radiation warms the planet, which is good to a certain extent, but continued rise in GHG concentrations are warming the planet too much.

If time allows, the instructor should allow the students to peer review a couple models that were not their own the day after creating the models. Have the different models hanging up around the classroom, where students can view it easily while completing the Peer Review handout. Tell students that reviewing other models can help them understand what is needed to have the most descriptive and accurate model. They should review at least two different models (front and back of the Peer Review handout). Ask them to look at the other models as well if time allows. Ideally, the instructor should end with having the class share what they thought was described well in most models vs what was left out of most models. Emphasize the importance of knowing that GHGs trap heat (like the glass on a greenhouse) and higher GHG levels increase the temperature on Earth.

Activity 3 – Understanding Phenological Asynchrony (1 class period)

Materials: Understanding Phenological Asynchrony handout, Research paper (for instructor only)

Preparation: Review the handout with figure to become familiar with the assignment. You may also want to review the paper from which the figure was obtained to understand key messages from the study. Print at least one handout per student.

Directions: Tell students that the video about climate change described some obvious effects of climate change, but that there is another possible effect that is being explored by many scientists now, called phenological asynchrony, where the peak timing of events associated with one organism are moving away from the peak timing of events of other organisms that provide them important resources. Explain that they will explore the data of one such study to understand how the phenology change differences between migrating birds and the plants in their breeding grounds could affect bird breeding performance. Have students read the background (perhaps even as a group). Allow students to read the description of the figure and make notes on it based on the information provided to help them answer questions about the data. Bring the class together towards the end of class to ensure that everyone understands the figure/information. Ask whether they have any questions that can be clarified and see if other students can help answer them. Answers to the handout questions are provided below.

1. Identify three dependent variables: *change in bird arrival, change in green-up, change in phenological interval (arrival – green-up)*
2. Identify two independent variables: *bird species, breeding range habitat (location)*
3. **Circle** any data points that show a trend of birds arriving at their breeding grounds AFTER green-up has occurred. *Birds on the left of the figure fall in this category (any point in panel B that falls below the zero line, especially those that don't have error bars overlapping the zero line if you want to stress this point).* How many birds fall into this category? *10-20 (depending upon whether they include those with overlapping error bars)* Name a bird species in this category. *(Any bird species to the left that satisfies the criteria discussed.)*
4. **Box** any data points that show a trend of birds arriving at their breeding grounds BEFORE green-up has occurred. *Birds on the right of the figure fall in this category (any point in panel B that falls above the zero line, especially those that don't have error bars overlapping the zero line if you want to stress this point).* How many birds fall into this category? *11-24 (depending upon whether they include those with overlapping error bars)* Name a bird species in this category. *(Any bird species to the right that satisfies the criteria discussed.)*
5. What **habitat locations** tend to be associated with birds that are arriving at their breeding grounds BEFORE green-up has occurred?
    - *Mostly Eastern Temperate Forests*
6. What **habitat locations** tend to be associated with birds that are arriving at their breeding grounds AFTER green-up has occurred?
    - *Mostly Western Forests*
7. Explain why you think bird breeding performance can be affected by arriving before or after green-up and indicate which you think could be more detrimental for the birds.
    - *Arriving before green-up could mean that the birds may have difficulty finding food since there is no/little vegetation to support the insects that they feed on. Arriving too late after green-up could result in missing out on peak abundances of insects that could help them obtain food more efficiently. Having no food when arriving before green-up is likely to have a greater negative affect on breeding performance.*

Activity 4 – Climate Change Solution Strategies Card Sort (1 class period)

Materials: card pages, Post-its, Infographic (if needed, possible links given below)

Preparation: Print one set of card pages for each group you plan to have in a class (recommended groups of 2-3 students). Cut out the cards and bundle them into their set (cards could be laminated to extend life). More cards could be made with more solutions, if desired. Some cards may also be left out to reduce the number of cards the students need to manage.

Directions:
Explain to students that you'll be focusing on possible solutions to reduce the risk of climate change. Remind them that they learned about different ways climate change can impact us. The instructor can either try to get students to recall different effects that can be written on the board or just project an infographic with some of the expected impacts of climate change (like this one from King County Washington). If the instructor would like to explain the goal of the IPCC (Intergovernmental Panel on Climate Change) to keep global warming below a 2°C increase, with reduced impacts if kept below 1.5°C, this infographic from WWF shows the degree of impact for the 1.5°C and 2°C scenarios that they would see if they further explore the Project Drawdown website.

The instructor should ask the students (individually or with their group) to come up with a few possible solutions to climate change or its impacts. Students should write one solution per Post-it, but they should have 2-3 Solution Post-its for a group/individual (depending upon time, too many Solution Post-its can lengthen the time to categorize them).

Introduce the terms "Mitigation" and "Adaptation" by writing them on the board. The instructor could ask if anyone can share what they may know about these terms to help define them in relation to climate change. The instructor should add definitions below the terms: Mitigation – taking action to slow/stop climate change, Adaptation – making changes to reduce our vulnerability to (how likely we will be harmed by) the harmful effects of climate change (like the heat waves, rising sea levels, increased fires, etc.).

The instructor may want to clarify what kinds of solutions would slow/stop climate change by asking students to recall what is causing the current climate change. Students will likely come up with using fossil fuels' but try to lead them towards recognizing how climate change is due to the increased levels of GHGs' due to using fossil fuels, among other things. This will allow for the clarification that if a solution strategy **lowers GHG emissions** somehow, it would be a mitigation strategy. Add that some solution strategies may be able to fall into both Mitigation and Adaptation.

The instructor should then allow students to evaluate whether each Solution Post-it they made should go under the category "Mitigation," "Adaptation," or both (add an extra space on the board to place those that might fall under both categories). Students can place each Post-it on the board below the appropriate category so that each solution can be seen (don't cover others).

The instructor should then introduce the Solution Strategy Cards, giving one set to each group of students. Tell the students that there are probably many more possible solutions than the ones they came up with, so they will have an activity to explore other possibilities and categorize them into "Mitigation" or "Adaptation" (they can write down the headings on their table or on pieces of paper to label each category, though it is not necessary). Tell them that some strategies may fall under both categories, so they could have a separate "Both" category or just place the card under the category that they feel aligns with the most. Students should be discussing with their group WHY they think it belongs in a category and HOW it reduces the risks associated with climate change.

The instructor should move around the room to help guide students in identifying useful information from the cards that can help them categorize the Solution cards. Question them whether the strategy can lower GHG. If they do, ask which category is most aligned with reducing GHGs. If they don't, ask which category is most aligned with reducing how much we are affected by the harmful impacts of climate change.

The instructor can have students review their own Solution Post-its. Ask them if they would recategorize any after gaining knowledge from the card sort activity. Ask what they notice about the numbers of solutions within each category from the class and from the cards. Do they think there is a reason why there are more in one category vs the other? Explain that both types of solution strategies will be needed, and some may be more important for certain communities.

If time allows, students can identify other aspects related to the solutions on the cards, like which would be easier for individuals to do vs communities, corporations, or governments (can be ranked or divided, this is explored further in the Regeneration pages). Another aspect to identify could be their relevance to their communities (those most important to their communities can be moved to the top of their solution groupings).

The instructor should end with an Exit Ticket that has students identify a mitigation and adaptation strategy (perhaps ones they feel could be especially relevant to their community), where they explain WHY they think it belongs in the identified category and HOW it reduces the risks associated with climate change.

Possible extensions: Have students explore and compare the economic impact of a couple different solutions on the Project Drawdown site or explore the different types of actions that can be taken at different levels (e.g., by individuals, groups, companies, governments) for each solution strategy on the Regeneration site. Individual solution entries will need to be selected from the provided websites. See explanations of the sites below.

Information for the Climate Change Solution Strategy Cards

The cards provided represent some examples of solution strategies that can be implemented by individuals, groups, companies, or governments to either mitigate climate change, adapt to the effects caused by climate change, or both. Most of these solutions can be found on the Project Drawdown Solutions Library and/or the Regeneration Nexus page. These pages hold important information on how to implement each strategy, as well as the impact each strategy can have on carbon emissions and other environmental aspects. Project Drawdown has a table of solutions that can be sorted into sector categories or ranked by their impact on reducing GHG emissions. Each entry discusses how they determined the potential GHG reduction, along with how much money would need to be spent and potential profit. Regeneration has a cascade of solutions that is beautifully illustrated and interactive, but there are more solutions on the Nexus page that are not included in the illustrated solutions page. Nexus solution entries include ratings of how well the solution will impact carbon, biodiversity, women, culture, and social justice, along with actions that can be taken at different levels (e.g., by individuals, groups, companies, governments). It is recommended to have students explore these pages to delve deeper into the solutions.

Most of the solutions included are related to plants, though some additional solutions were added to include key solutions students may be more familiar with. Project Drawdown and Regeneration both focus on mitigation strategies (first 4 pages of cards). Each solution strategy below (entry is bold if it is found in both Project Drawdown and Regeneration) lists the sources (with the name of source entry if it differs from the one provided) and links for photos if they came from different

sources than Project Drawdown or Regeneration. Alternative sources provided most of the adaptation strategies (last page of cards) and links are included.

- **Reduce Food Waste**: Project Drawdown, Regeneration (Wasting Nothing), photo
- Plant-Rich Diets: Project Drawdown
- **System of Rice Intensification (SRI)**: Project Drawdown, Regeneration
- **Silvopasture**: Project Drawdown, Regeneration
- **Forest Protection (Proforestation):** Project Drawdown (Forest Protection), Regeneration (Proforestation), photo
- **Protect and Restore Tropical Forests**: Project Drawdown (Tropical Forest Restoration), Regeneration (Tropical Forests), photo
- **Protect and Restore Coastal Wetlands**: Project Drawdown (Coastal Wetland Protection), Regeneration (Wetlands)
- **Protect and Restore Peatlands**: Project Drawdown (Peatland Protection and Rewetting), Regeneration (Peatlands), photo
- **Protect and Restore Grasslands**: Project Drawdown (Grassland Protection), Regeneration (Grasslands)
- **Composting**: Project Drawdown, Regeneration
- **Grow More Perennial Crops**: Project Drawdown (Perennial Staple Crops), Regeneration (Perennial Crops), photo
- **Seaweed Farming**: Project Drawdown, Regeneration
- **Responsible Bamboo Production**: Project Drawdown (Bamboo Production), Regeneration (Bamboo)
- **Biochar Production**: Project Drawdown, Regeneration (Biochar)
- **Regenerative Agriculture**: Project Drawdown (Regenerative Annual Cropping), Regeneration
- Bioplastics: Project Drawdown
- **Green Roofs and Nature in Cities**: Project Drawdown (Green and Cool Roofs), Regeneration (Nature of Cities), photo
- **Restore Degraded Land (Abandoned Farmland)**: Project Drawdown (Abandoned Farmland Restoration, Tree Plantations on Degraded Land), Regeneration (Degraded Land Restoration), photo
- **Nutrient Management**: Project Drawdown
- Biomass Power: Project Drawdown, photo
- Recycling: Project Drawdown
- **Wind Turbines**: Project Drawdown (Onshore/Offshore/Micro Wind Turbines), Regeneration (Wind)
- **Solar Energy**: Project Drawdown (Utility-Scale/Distributed Solar Photovoltaics, Concentrated Solar Power), Regeneration (Solar)
- **Improved Cattle Feed (Asparagopsis)**: Project Drawdown (Improved Cattle Feed), Regeneration (Asparagopsis)

Mostly adaptation aligned (though reasoning can be given for some to be both)

- Drought-resistant crops: AgWeb, photo
- Rain Gardens: book chapter, photo
- Fire Ecology: Regeneration, photo
- Flood Protection of Infrastructure: EPA, photo
- Rainwater Harvesting: Climate Action Accelerator, photo
- Relocation: Institute for Ecological Civilization