

Carbon Footprint

Bioenergy Education Initiative

Levels:

Grades 6-12

Content Areas:

Earth Science, Chemistry

Lesson Time:

Two, 50 minute classes

Next Generation Science Standards:

ESS3.D

ETS1.B

MS-ESS3-5

HS-ESS3-4

Outcomes:

- Students will be able to explain what is a carbon footprint.
- Students will be able to compare how different lifestyle choices and activities affect their carbon footprints.
- Students will be able to formulate plans to lower individual, family, or community carbon footprints.

Contact:

BioEnergy Education Initiative

agsci.oregonstate.edu/bioenergy-k-12

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Description & Objectives:

In this lesson, students will learn what a carbon footprint is and how increases in greenhouse gases affect climate change. Students will think critically about their lifestyle choices, identify ways to reduce their carbon footprint and create a plan to decrease it.

Using This Lesson:

This lesson is a mixture of group discussion and individual work. Advanced student questions and activities are included. The background information can serve as reading material for students.

Additionally, leading questions are included to promote discussion and critical thinking. Listed on the Resource page are links to a series of five exceptional videos on carbon and climate change produced by National Public Radio, as well as other carbon footprint calculators.

Carbon Footprint



Fossil fuels are a key component in powering our industrial society. Burning fossil fuels for energy, however, produces a number of pollutants, including carbon dioxide (CO₂). This means that everyone has a CO₂ or carbon “footprint”. A carbon footprint is the amount of CO₂ each person is directly or indirectly responsible for producing. The size of your footprint depends on lifestyle choices, such as transportation, diet and purchases.

The increasing levels of CO₂ in the atmosphere are a result of human activities and are intensifying climate change. Understanding the consequences of everyday consumption, and learning how to reduce the size of our collective carbon footprint, are vital to reducing CO₂ emissions and slowing down human caused climate change.

Carbon Footprint

Directions:

1. Begin this lesson by giving an introductory lecture based on the background information provided. It describes the natural greenhouse effect on Earth and how human activity affects that process.
2. Then have students watch *It's All About Carbon*, a series of short videos produced by National Public Radio. These videos explain how carbon atoms form bonds, break apart, and create the conditions that can lead to global warming. Each video is about three minutes long. Links to these free, online videos are in the Resources page.
3. Review/discuss with students the two questions below:
 - a. In your own words, define these terms: global warming, greenhouse effect, and mitigation.
 - b. What is the difference between natural greenhouse effect and human caused greenhouse effect? Give examples based on the videos.
4. Provide each student with the *Carbon Footprint* worksheets, *Parts 1-4*. At the beginning of the *Part 1: Carbon Footprint* worksheet, students are asked to hypothesize about which daily activities in their lives have the largest carbon footprint and record their thoughts on their worksheet. Students need to do this step **BEFORE** beginning the survey that follows this question.
5. Students then fill out the remainder of the *Part 1* worksheet and calculate their personal carbon footprint. The worksheet gives students a better idea of their impact on climate change. It provides an approximate level of greenhouse gas saved, or emitted, due to choices they make. Information from CO₂ calculators used to determine the values listed on the worksheet was created by Teach Engineering Curriculum. (See Resources: *What Kind of Footprint? Carbon Footprint*).
6. Record students' calculations from *Part 1* on the board. Discuss and compare their calculations. Ask students what surprised them about the calculations. Ask if they see any trends. Have students brainstorm lifestyle changes they and their families can make to lower their carbon footprints.
7. As homework, have students complete *Part 2: Personal Carbon Footprint Plan* and create a plan for how they can change their lifestyle habits to reduce their carbon footprint. For one week, students should follow this plan and keep daily notes on their success and struggles to make lifestyle changes.
8. Have students complete *Part 3: Household Carbon Calculators* using the [CoolClimate Network calculator](#). This worksheet asks a series of questions that demonstrate how different lifestyles, geographic locations, and incomes can affect a household's carbon

Materials: Per Group

- Student Worksheets (Attached)
- [Online Cool Climate Carbon Calculator](#) (See Resources)
- Series of five online [videos on carbon and climate](#). (See Resources)

The term **carbon footprint** refers to the amount of carbon dioxide (CO₂) we emit individually in any one-year period. CO₂ is produced from many sources and is the primary gas responsible for global warming and the resulting alarming changes in our climate.



48.5 tons CO₂/year

This is the footprint of the average household in the United States. It is based on the average size and income of U.S. households.

footprint. The CoolClimate Network is a collaboration between university, government, businesses and non-governmental organizations. Its goal is to reduce greenhouse emissions by increasing the adoption of low carbon technologies and practices. Their CoolClimate calculator is one of the tools they provide for making smarter, better informed decisions. (Invite students to share this calculator with their families, and evaluate their household's carbon footprint.)

9. Have students complete *Part 4: Reflections* and reflect on the activities in this lesson. Discuss how it has, or has not, affected their personal behavior and their families' behavior.

Experiment Questions:

Below are basic and advanced level questions and observations students should make from the experiment.

BASIC LEVEL

1. In your own words, define these terms: global warming, greenhouse effect, mitigation, and standard of living.
2. What is the difference between natural greenhouse effect and human caused greenhouse effect?
3. How can we minimize our carbon footprint while keeping our standard of living?
4. What activities in your daily life have the largest carbon footprint?
5. What daily activities or behaviors in your life have the greatest impact on climate change? Which activities have the smallest impact?
6. What alternatives are available to mitigate our carbon footprint in the community?
7. Compared the lifestyles of someone from a large city to someone from a rural town. Who would have a harder time changing their life style to reduce their carbon footprint? Why?
8. How could climate effect your carbon footprint?
9. Do you think your friends and family are aware of actions they can take to reduce climate change? What do you think you can do to inform them?
10. Did this assignment change how you feel about the issue of climate change?

ADVANCED LEVEL

1. Watch the interactive *Climate Time Machine* visualizations. Write about how higher sea levels and temperatures could present problems for life on Earth. (<http://climate.nasa.gov/interactives/climate-time-machine>)
2. Discuss how the energy demands of a rural community might differ from those of a larger city. What might be the differences in the primary uses of energy? Watch the video [No Impact Man](https://www.youtube.com/watch?v=Z9Ctt7FGFBo). The trailer is on YouTube at <https://www.youtube.com/watch?v=Z9Ctt7FGFBo>. Is it possible to have zero impact?
3. How do you think the U.S. compares to other countries in carbon emissions and energy use? What are the possible causes? Research the energy use of the U.S. and other countries and report on your findings.
4. Calculate the carbon footprint of a school lunch. Estimate the carbon footprint if everyone at your school ate that lunch every day, for a year. Then, calculate the footprint of that lunch if it was switched to a vegetarian option. What do you think you can do to influence what the school offers students?
5. What are carbon credits? How could carbon credits help mitigate an individual's carbon footprint? Do you think this is an effective method of combating global warming?

Part 1: Carbon Footprint Worksheet

Directions:

BEFORE you fill out the worksheet below, think about the daily activities in your life and write down which ones you think have the largest carbon footprint. Record your answer here.

Answer the questions below and fill in the corresponding values on the far right. Tally the values to find your carbon footprint. Only fill in one value for each question, unless otherwise stated.

1. How do you get to school? _____
 - a. walk (0)
 - b. bike (0)
 - c. car (1115)
 - d. bus (131)
 - e. carpool (459)

2. Do you eat mostly... _____
 - a. fast food (4818)
 - b. home-cooked food (629)

3. Do you eat mostly... _____
 - a. vegetables/fruits (153)
 - b. meat (644)
 - c. bread, rice, pasta, potatoes (364)

4. Do you turn off lights when you leave a room? _____
 - a. yes (133)
 - b. no (268)

5. Do you unplug appliances/chargers when not in use? _____
 - a. yes (9)
 - b. no (18)

6. How do you dry clothes? _____
 - a. hang to dry (0)
 - b. dryer (750)
 - c. both (375)

7. Do you turn off the water when brushing your teeth? _____
 - a. yes (34)
 - b. no (274)

Subtotal _____

8. Do you turn off the TV when you're not watching it? _____
a. yes (47)
b. no (140)

9. Do you turn off your video game system when you're not using it? _____
a. yes (29)
b. no (90)
c. don't have/use one (0)

10. Do you recycle? (select all that apply) _____
a. magazines (-15)
b. newspaper (-90)
c. glass (-7)
d. plastic (-19)
e. aluminum and steel cans (-89)

Add Subtotal from page 1 _____

TOTAL

This total is an **estimate** of your carbon footprint and shows the number of **pounds of carbon dioxide** you produce annually.

The lower the number, the fewer greenhouse gasses emitted into the atmosphere.

Part 2: Personal Carbon Footprint Plan

Directions:

Review your choices in the *Part 1: Carbon Footprint*. What changes can you make in your life to reduce your carbon footprint? Use the space below to engineer a plan to reduce your carbon footprint. Over the next week, try to enact the changes in your plan. Keep a daily log of how easy, or hard, it is to make these changes happen.

What things I will turn off:

How I will get to school:

What I will eat:

How much I will use electronics:

What I will recycle:

Other things I will do:

Part 3: Household Carbon Footprints

Directions:

Use the CoolClimate Network online carbon calculator at <http://coolclimate.berkeley.edu/calculator> to answer the questions below.

- Using your zip code, what is the average household carbon footprint in your area?
 - Now look at your state's average household carbon footprint. Is it higher or lower than your local zip code ranking?
 - Is your county average carbon footprint higher or lower?
 - Is your city average carbon footprint higher or lower?
 - What do you think is the cause of these differences?
- Using this same zip code, what is a family of four's carbon footprint based on an income of:
 - \$20,000-\$29,000
 - \$50,000 to \$59,000
 - \$100,000-\$119,000
- What changes in consumption do you observe in the calculator when the income levels are different?
- Create a household family profile that is in your zip code, has five or more people in the home, and has a gross income of \$60,000-\$79,999.
 - What is the total CO₂/year listed?
 - What is the top source of CO₂/year?
- Using this same family's base data, go to the *Travel* portion of the calculator. Review the different ways this family travels.
 - How could they reduce their travel carbon footprint?
 - What is their total travel carbon footprint with three cars, vs. two cars?
 - Is it more effective to reduce the number of cars to two, or cut all air travel?
- Using the same household profile, go to the *Housing* calculator page and choose the *Advanced Audit* option.
 - What is the result if the house was built in 1950 vs. 2000? Why do you think there is a difference?
 - Create a profile for your home that includes five people, living in a house built in 1972. Record the initial CO₂/year ranking. Then, review the options in this section and identify home improvements that would improve the home's ranking until its score is 10 CO₂/year or better. What improvements did you need to make? Which had the greatest impact?
- Now go to the *Food* section of the calculator. What is your base rating?
 - What adjustments to diet have the greatest impact on carbon footprint?
 - Why do you think these diet changes reduce the carbon footprint?

8. Go to the *Shopping* section of the calculator. What is your base rating? Using the *Advanced* option, look at the expenses for *Goods and Services*.
 - a. What has the greatest carbon footprint?
 - b. What costs the most?
 - c. What changes could you make to bring your rating in this section to 10 CO₂/year and have the least impact on your family? Explain/support your choices.
9. The calculator offers ways to improve your carbon footprint under the *Take Action* section. Using the example of a family of five with an income of \$60,000–\$79,999, identify five ways to reduce the carbon footprint to under 50 tons CO₂/year, by spending less than \$100.
10. Based on what you learned exploring this carbon calculator:
 - a. How would you adjust your personal plan to reduce your carbon footprint?
 - b. What actions would have the greatest impact on reducing your carbon footprint?

Part 3: Household Carbon Footprints

Directions:

Use the CoolClimate Network online carbon calculator at <http://coolclimate.berkeley.edu/calculator> to answer the questions below.

For the example below, Corvallis, Oregon 97330 was used.

1. Using your zip code, what is the average household carbon footprint in your area? *(Corvallis=41.9 tons CO₂/yr)*
 - a. Now look at your state's average household carbon footprint. Is it higher or lower than your local zip code ranking? *(higher; state 45.2 tons CO₂/year)*
 - b. Is your county average carbon footprint higher or lower? *(higher; county 45.2 tons CO₂/year)*
 - c. Is your city average carbon footprint higher or lower? *(slightly lower; 41.8 tons CO₂/year)*
 - d. What do you think is the cause of these differences? *(free public bus transportation in Corvallis)*

2. Using this same zip code, what is a family of four's carbon footprint based on an income of:
 - a. \$20,000-\$29,000 *(38.7 tons CO₂/yr)*
 - b. \$50,000 to \$59,000 *(51.7 tons CO₂/yr)*
 - c. \$100,000-\$119,000 *(65.5 tons CO₂/yr)*

3. What changes in consumption do you observe in the calculator when the incomes are different? *(Consumption goes up, especially travel, with higher income.)*

4. Create a household family profile that is in your zip code, has five or more people in the home, and has a gross income of \$60,000-\$79,999.
 - a. What is the total CO₂/year listed? *(57 tons CO₂/yr)*
 - b. What is the top source of CO₂/year? *(Travel; almost 20 tons CO₂/yr)*

5. Using this same family's base data, go to the *Travel* portion of the calculator. Review the different ways this family travels.
 - a. How could they improve their travel carbon footprint? *(Fewer cars, more fuel-efficient vehicles, use public transit, walk/bike).*
 - b. What is their total travel carbon footprint with three cars, vs. two cars? *(19.6 tons CO₂/yr vs. 15.6 tons CO₂/yr)*
 - c. Is it more effective to reduce the number of cars to two, or cut all air travel? *(cars to 2)*

6. Using the same household profile, go to the *Housing* calculator page and choose the *Advanced Audit* option.
 - a. What is the result if the house was built in 1950 vs. 2000? Why do you think this is? *(1950 = 14.4 tons CO₂/yr; 2000 = 12.3 tons CO₂/yr)*
 - b. Create a profile for your home that includes five people, living in a house built in 1972. Record the initial CO₂/year ranking. Then, review the options in this section and identify home improvements that would improve the home's ranking until its score is 10 CO₂/year

or better. What improvements did you need to make? Which had the greatest impact? (**windows, insulation, water heater and heater upgrade**) **Insulation made biggest impact**)

7. Now go to the *Food* section of the calculator. What is your base rating? (**11.9 tons CO₂/yr**)
 - a. What adjustments to diet have the greatest impact on carbon footprint? (**Reducing meat and snack foods.**)
 - b. Why do you think this is? (**Takes a lot of resources to raise animals for meat and energy to produce, package and ship snack foods**)
8. Go to the *Shopping* section of the calculator. What is your base rating? (**13.6 tons CO₂/yr**) Using the *Advanced* option, look at the expenses for *Goods and Services*.
 - a. What has the greatest carbon footprint? (**car travel**)
 - b. What costs the most? (**health care**)
 - c. What changes could you make to bring your rating in this section to 10 CO₂/year and have the least impact on your family? (**optional**) Explain/support your choices.
9. The calculator offers ways to improve your carbon footprint under the *Take Action* section. Using the example of a family of five with an income of \$\$60,000-\$79,999, identify five ways to reduce the carbon footprint to under 50 CO₂/year, by spending less than \$100. (**Purchasing green electricity, eat low carbon diet, carpool, turn down thermostat in winter, ride bike**)
10. Based on what you learned exploring this carbon calculator:
 - a. How would you adjust your personal plan to reduce your carbon footprint?
 - b. What actions would have the greatest impact on reducing your carbon footprint?

Part 4: Reflection on Your Carbon Footprint Plan

Were you able to follow the lifestyle changes in your carbon footprint plan for the whole week? What was the most challenging thing about making changes?

How did it feel to make those changes? Did it significantly change your daily routine?

What kind of difference do you think it would make if everyone followed the changes you made for a week?

Repeat the calculations for determining your carbon footprint in *Part 1* of this worksheet. This time, however, adjust it to include the changes you made in your plan. Did your changes make a significant difference on your carbon footprint?

Could you follow your plan for a longer period of time, like a month, or even a year? What would stop you from doing this? Would it be worth it? Why or why not?

Carbon footprint and Greenhouse Gases

What is Carbon & Carbon Dioxide?

Carbon is an element found in every living thing. When carbon and oxygen bind together, they form a colorless, odorless gas called carbon dioxide (CO₂). CO₂ is a heat-trapping greenhouse gas (GHG). When we burn fossil fuels (coal, oil, and natural gas) to do things like drive cars, create electricity or manufacture products, we are producing CO₂.

Carbon is stored in many places throughout our planet including the atmosphere, oceans, plants, soil, and in deposits of coal, oil, and natural gas deep underground. Carbon naturally moves from one part of the Earth to another through the carbon cycle. All living organisms have a role in the carbon cycle. The carbon cycle is the process where carbon moves from the atmosphere, into organisms and the Earth, and then back again.¹

By burning fossil fuels that were stored deep underground, humans are adding carbon to the atmosphere (in the form of carbon dioxide) faster than natural processes (like oceans, soil, and plants) can remove it. As a result, the amount of carbon dioxide in the atmosphere is increasing, warming the planet, and causing global climate change.²

What is a Carbon Footprint?

Everyone has a carbon footprint. A carbon footprint is the amount of carbon dioxide and other greenhouse gases released into the environment because of the direct and indirect consumption of fossil fuels by an individual, group or activity. The size of individuals' carbon footprints varies greatly, depending on lifestyle choices such as transportation, diet, purchases, how much trash thrown away, reused or recycled.

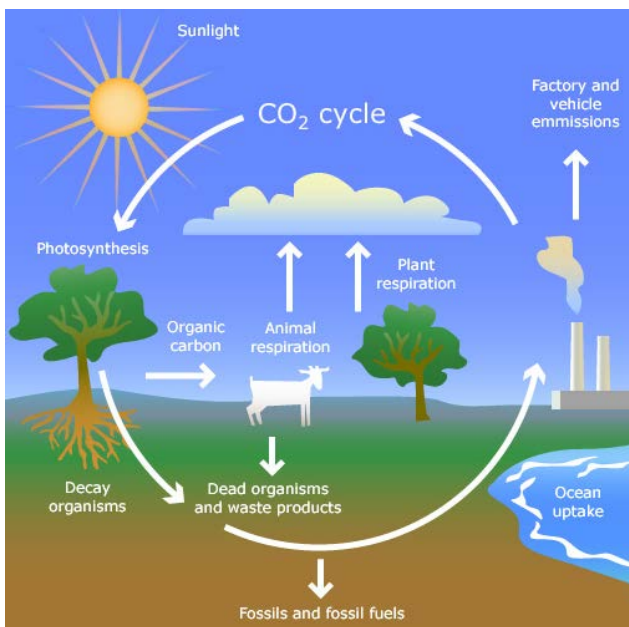


48.5 tons CO₂/year

This is the footprint of the average household in the United States. It is based on the average size and income of U.S. households.

Greenhouse Gases

When light from the sun hits the Earth, the Earth radiates some of this energy back out as heat. Greenhouse gases (GHG) in the atmosphere naturally capture some of this heat, instead of letting it all be released back into space. While carbon dioxide is the primary GHG, these gases also include water vapor, methane, nitrous oxide and ozone. At natural levels, these gases help regulate the Earth's temperature and maintain life on our planet. High GHG levels, however, trap solar heat on Earth and result in an increased in the number of extreme climate events.



Carbon Cycle

Carbon moves between the atmosphere and different parts of the earth. This is known as the carbon cycle.

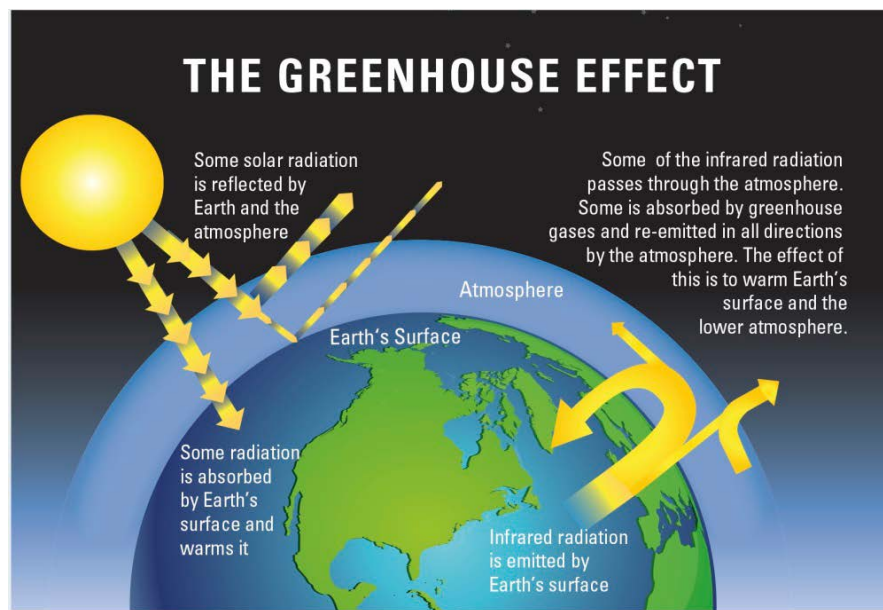
Source: U.S. EPA, Massachusetts Water Resources Authority

Human activities are changing the Earth's natural greenhouse balance. The natural processes for absorbing carbon dioxide (oceans, plants, soil) are not keeping up with the increased amount of GHGs produced by human consumption of fossil fuels.

Humans Affect the Natural Greenhouse Process

Virtually all climate scientists agree that Earth's temperatures are rising and that humans are the main cause of global warming. Observations and measurements from all over the world provide strong evidence that the climate has already changed.

While the consequences of changing the natural atmospheric greenhouse are hard to predict, certain consequences like higher temperatures, warmer oceans, and increased ocean acidity are already happening.



Source: *The Basics of Climate Change*; The Royal Society³

The following is a list of effects we are already seeing due to climate change.

- Higher Temperatures
- Changing Rain and Snow Patterns
- More Droughts
- Warmer Oceans
- Rising Sea Level
- Wilder Weather
- Increased Ocean Acidity
- Shrinking Sea Ice
- Melting Glaciers
- Less Snowpack
- Thawing Permafrost
- Loss of wildlife habitats

References:

¹ *What is the Carbon Cycle? Diagram, Process & Definition*; retrieved from Study.com; <http://study.com/academy/lesson/what-is-the-carbon-cycle-diagram-process-definition.html>.

² *Student's Guide to Global Climate Change*; retrieved from EPA Climate Change for Kids; <https://www3.epa.gov/climatechange/kids/basics/today/carbon-dioxide.html>.

³ *Greenhouse Effect: The Basics of Climate Change*; (image) retrieved from The Royal Society, <https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/basics-of-climate-change/>.

Next Generation Science Standards

DISCIPLINARY CORE IDEAS:

ESS3.D: Global Climate Change

ETS1.B: Developing Possible Solutions

PERFORMANCE EXPECTATIONS:

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

HS-ESS3-4: Evaluate or refine a technology solution that reduces impacts of human activities on natural systems.

PRACTICES:

- Asking questions/defining problems
- Construction explanations/design/solutions

CROSSCUTTING CONCEPTS

- Cause and effect: Mechanism/explanation

Video Resource

[View Episodes 1-5 of the All Things Considered series on Carbon and Climate Change.](#)

GRANT SUPPORT

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Resources:

[A Blanket Around the Earth](#), NASA Global Climate Change Project: Vital Signs of the Planet. Retrieved from <http://climate.nasa.gov/causes/>. October 5, 2016

[Cool Climate Network](#), online carbon calculator. Retrieve from <http://coolclimate.berkeley.edu/calculator>.

[Episode 1: It's All About Carbon](#), National Public Radio: All Things Considered Podcast. May 1, 2007. Retrieve from <http://www.npr.org/2007/05/01/9943298/episode-1-its-all-about-carbon>.

[Episode 2: Carbon's Special Knack for Bonding](#), National Public Radio: All Things Considered Podcast. June 14, 2007. Retrieve from <http://www.npr.org/2007/06/14/11027169/episode-2-carbons-special-knack-for-bonding>.

[Episode 3: Break a Carbon Bond and - Presto! - Civilization](#), National Public Radio: All Things Considered Podcast. June 25, 2007. Retrieve from <http://www.npr.org/2007/06/25/11366031/break-a-carbon-bond-and-presto-civilization>.

[Episode 4: When Carbon Falls in Love, the World Heats Up](#), National Public Radio: All Things Considered Podcast. July 3, 2007. Retrieve from <http://www.npr.org/2007/07/03/11662978/when-carbon-falls-in-love-the-world-heats-up>.

[Episode 5: What We Can Do About Global Warming](#), National Public Radio: All Things Considered Podcast. July 19, 2007. Retrieve from <http://www.npr.org/2007/07/19/12099564/what-we-can-do-about-global-warming>.