Climate Geopardy
Slide by Slide Explanation

Sections colored red are rough

Sections colored blue need a final revision

Sections colored green are finished

Table of Contents (Where #. is the Slide Number)

1. Title Card: Climate Geopardy

During the slide show, this slide begins with just a point to click. Before the click, explain that the game requires teams, that they should divide into 4 groups (or more if there are more than ~28 students), decide on a team name and pick a number from 150-300. Explain that the number they must guess is the number of corporations that agreed to be 100% renewable by 2050, as part of the RE100 project. Among them include many major corporations like Ikea, Apple, General Motors etc.

While the students are making these decisions, click the cursor icon in the middle of the screen which starts the Jeopardy music and a title sequence. After the sequence is done, they may need a bit more time to finalize their team name and number choice. Write their choices on the board, leaving space to count their points under their team name once the game begins. The order on the board of team names is important to the functioning of the game.

The answer to the 150-300 guessing game is 204 companies. The team with the guess closest to 204 begins. The order of the team names on the board is the order followed for turns.

Now, click the screen twice to move on to the scoreboard to explain the rules.

General Facts

Defining Climate

Climate refers to statistics of the atmosphere over a period of time, usually decades.

According to Mark Twain:
Climate is what you expect, weather is what you get.

According the the American Meteorological Society
Climate: The slowly varying aspects of the atmosphere-hydrosphere-land surface system. It is typically characterized in terms of suitable averages of the climate system over periods of a month or more, taking into consideration the variability in time of averaged quantities.

Carbon Emissions by Sector

World Wide
https://www.visualcapitalist.com/a-global-breakdown-of-greenhouse-gas-emissions-by-sector/

Agriculture Forestry and Land Used 18.4%
Transport Energy 16.2%
Industry Energy 24.2%
Waste 3.2%
Industrial Processes 5.2%
Energy use in Buildings 17.5%
Other Energy 15.3%
https://www.visualcapitalist.com/a-global-breakdown-of-greenhouse-gas-emissions-by-sector/

Canada

Agriculture and Forestry 10%
Transport Energy 25%
Industry Energy (Oil and Gas 26%) 37%
Waste 5.8%
Industrial Processes 7%
Energy Use in Buildings 13%

https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/reduce-emissions.html

Agriculture and Forestry 10%
Transport Energy 23%

Industry Energy (Oil and Gas 25%) 37%
Waste 7%
Industrial Processes 11%
Energy Use in Buildings 12%

Fossil Fuels in Canada
Extracting about 3.6 million barrels of oil daily, Canada is the largest foreign petroleum exporter to the United States and the world's seventh largest producer, according to the U.S. Energy Information Administration.
Partially due to its oil industry, Canada is one of the highest per-capita greenhouse gas emitters among the wealthy countries in the Organisation for Economic Co-operation and Development.

-Alberta produces 80% of Canada's oil
Source:https://www.huffingtonpost.ca/entry/albertas-oil-workers-are-shifting-to-renewable-energy-jobs_ca_5cd4f472e4b07bc729737788

2017 Oil Statistics in Canada
Oil Imports in: 0.6 MMb/d) 65% USA, 18% Saudi Arabia, 5% Azerbaijan. 3% Norway, 2% Nigeria
Oil production in Canada: 4.6 MMb/d
Oil Canada Exports: 3.7MMb/d
They also have this confusing stat: Crude oil shipped to domestic refineries: 1.7 MMb/d. Not sure how to include it. I am assuming it's a subset value of the the 3 previous ones

Based on the above numbers, we consume 1.5mmb/d in Canada, so 60% is from Canada, 40% is imported. So 9.2% of Canadas oil comes from place with with poor human rights Saudi Arabia,Azerbaijan and Nigeria
Source:
https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/crude-oil-facts/20064#L2
Image Sources:
Starry sky image: By Gemma Stiles from Sydney, Australia - Starry Sky, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=42074934

2. Question Board with 5 Categories

GEO-PARDY PLAYING INSTRUCTIONS & RULES
Instructions
This PowerPoint works best if the mouse is used exclusively to move through the game. Make sure to use Presenter View mode so that the computer in front of you has the notes and the next slide visible, while the projector displays just the current slide. If ever you accidentally end

up at an unintended slide, right click, hover the mouse over ‘By Title’ and click on ‘Slide 2’ to return to the Question Board.

This slide the Question Board. It is separated into 5 subjects related to the climate crisis, and each section has 5 questions with an associated point value based on the difficulty of the question. On a team’s turn, they choose a subject and a point value. As the presenter, click on the number to be led to the question slide. At the question slide, you must read out the question, and the multiple choices if any. Now you must start the 30 second timer and the Jeopardy music. To do this, click twice on the yellow bar above the question. The first click starts the music, the second click starts the timer bar. After 30 seconds, the Jeopardy music will end. Before it ends, all teams should discuss their answer because if the current team guesses wrong, the question moves on to the next team, for half the point value, and so on until all the teams have tried (unless it is multiple choice, and only one possible answer remains, which results in no points given out this turn). When the timer is up, the current team tries their answer.
Once the right answer is given, or if no group gets the right answer, click on the question mark symbol to move to the answer slide. After reading out the answer, and dealing with any questions, click the small grid outline icon on the bottom right to get back to the Question Board. The question just passed will now be in black rather than white on the question board. In some cases, another symbol at the bottom of the answer slide will lead you to an extra slide with a bonus question or an extra information slide.

Once at the Question Board, the next time in line takes their turn.

Keep in Mind:
Being strict about the answer seems to work best, otherwise the students tend to get rowdy and think the game is unfair.
This game can be played and modified however the facilitator desires. The following rules are those we have found to be most fair and organized.
Notes under each slide (like you are reading now) will help you expand on a question to facilitate a discussion if desired.

*For multiple choice questions, Team A has the first chance to pick the correct answer after which Team B will have one chance.
** BONUS QUESTION points are awarded to the team that answers it correctly first.

Climate Science (CS)

3. CS 100 Question: Two main human sources of GHGs?

Name one of the two main human sources of greenhouse gases?

CS 100 What are greenhouse gases (GHGs)?

The Short Answer

Our atmosphere is made up of many gases, mostly nitrogen (~78%) and oxygen (~21%). Greenhouse gases make up much less of the atmosphere (less than 1%), but they have a strong effect on the world because they absorb and trap heat(Dessler 2016). This is known as the "greenhouse effect". Notable GHGs are carbon dioxide, methane and nitrous oxide. We can talk about where they come from later.

Most GHG's exist naturally in Earth's atmosphere and have allowed our planet to be warm enough for life. But concentrations of many greenhouse gases are increasing due to human activity much faster than they can be naturally absorbed by the Earth, disrupting the delicate balance of gases in the atmosphere, warming the atmosphere and making many earth systems vulnerable to change.

Back to the question! What do you think one of the main human sources of greenhouse gases is?

Background

Greenhouse effect: Our atmosphere is mostly transparent to visible light coming from the sun, but not to infrared radiation coming from Earth (Dessler 2015). When the sun's visible light hits the surface of the planet, it is converted to infrared heat and re-emmitted into the atmosphere. The atmosphere is more opaque to infrared part of the electromagnetic spectrum because of the molecular shape of GHGs so the heat is retained and the atmosphere warms. (Dessler 2015)

Water Vapour is the most abundant greenhouse gas but is almost all natural in origin. It mainly originates from evaporation of the world's oceans. Humans affect the amount of water vapour only indirectly through methane emissions, so we do not focus on reducing water vapour directly(Dessler 2015).

Carbon Dioxide (CO_2) is emitted primarily through the burning of fossil fuels. It makes up 0.04% of the atmosphere and is the majority of human GHG emissions (Dessler 2015). However we must still seriously consider the other GHGs because they retain significantly more heat per molecule than CO_2.

Methane (CH_4) is emitted primarily by agriculture and burning fossil fuels. Ruminant animals like cattle release methane from digestion. The gas is 2.5 times more abundant in the atmosphere than before industrial times (Montzka et al. 2011) and is 20 times more effective as a GHG than CO_2 (Dessler 2015). The gas is released naturally through wildfires, permafrost melting (due to global warming), wetlands), anthropods (termites), oceans, rivers, estuaries and lakes. The last four are from microbes in the water and sediments. An important release is through leaks in natural gas extraction for the energy industry and rice agriculture.

Nitrous Oxide (N_2O) is a naturally occurring gas in the atmosphere. Its also known as "laughing gas" used by dentists for operations (Desseler 2015). Over 60% of annual emissions are natural, emitted by microorganisms in the ground/water and released into the atmosphere. Water-related emissions can be considered partially human-caused because they are related to agricultural pollution (Mann and Kump 2015).

Humans account for 40% of N_2O emmissions from the application artificial soil fertilizers, industrial processes and fossil fuel combustion (Dessler 2015; EPA, 2010).

Ozone (O_3) is a GHG that occurs naturally at high levels in the upper atmosphere, where protects Earth from the sun's powerful ultraviolet radiation. Near the Earth's surface, it is an important component of smog as a result of fossil fuel burning (Dessler 2015).

Halocarbons are synthetic greenhouse gases used in refrigeration, also known as chlorofluorocarbons and hydrochlorofluorocarbons. Their abundance is low compared to CO_2 but per molecule, they are thousands of times more effective as a GHG than CO_2 (Dessler 2015). Many halocarbons are also destructive to the ozone layer that protects us from the sun.

Sources

Dessler, Andrew. *Introduction to modern climate change*. Cambridge University Press, 2015.

Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015.

Montzka, S., Dlugokencky, E. & Butler, J. Non-CO_2 greenhouse gases and climate change. *Nature* 476, 43–50 (2011). https://doi.org/10.1038/nature10322

Pachauri, Rajendra K., and Andy Reisinger. "IPCC fourth assessment report." *IPCC, Geneva* 2007 (2007).

United States Environmental Protection Agency. *Methane and Nitrous Oxide Emissions From Natural Sources*. (2010).

4. CS 100 Answer

A: Fossil fuels and land use changes

The Short Answer

The two main ways that we emit greenhouse gases are through the burning of fossil fuels and land use changes (such as deforestation and agriculture). We release these gases into the atmosphere at a faster rate than can be removed through natural processes, such as

photosynthesis, and this leads to more radiation trapped in our atmosphere and the warming of our planet.

Background

Fossil fuels are petroleum, coal and natural gas, which are burned mostly for electricity, heat and transportation. They release three important greenhouse gases: carbon dioxide (CO_2) methane (CH_4) and nitrous oxide (NO_2)
Approximately 85% of the world's energy consumption comes from burning fossil fuels (EIA, 2017). The rest comes from cleaner sources like hydro, solar, wind and nuclear power.

Agricultural practices and Deforestation:
For hundreds of years weve been intensely cutting trees down and often replacing the forest with farmland. In 1750, about 7% of the planet was for agriculture, compared to more than 33% in 1990 (Dessler 2015). The result is that the land can hold less CO2 and more is released into the atmosphere. Trees and soil breath and store carbon dioxide. A wooded forest holds more carbon per area than a plowed agricultural field. And intensive agriculture releases greenhouse gases through damaging the soil, the use of inorganic fertilizers and that was previously stored in the soil and cows and lambs adds a lot of methane into the atmosphere through their burps. If cattle were their own nation, they would be the world's third-largest emitter of greenhouse gases (Mann and Kump 2015).

These two sources account for 93% of greenhouse gas emissions: ~67% from fossil fuel burning and 26% from land use changes (~14% agriculture and ~12% forest loss) (CBO, 2005). The remaining is from industrials practices like creating cement and waste management (landfills).

Further Reading

(Animation of the carboncCycle to see other releases and uptakes of CO2 and how this cycle has changed over the last 150 years….
https://www.youtube.com/watch?v=dwVsD9CiokY&fbclid=IwAR0-LxKUVu4vkFK8IuEl3xsPiBB-iCYRRdtXr31VLsqEQUuCk-Fed8bRkAU)

(See animation of Carbon Cycle to see other releases and uptakes of CO2 and how this cycle has changed over the last 150 years….
https://www.youtube.com/watch?v=dwVsD9CiokY&fbclid=IwAR0-LxKUVu4vkFK8IuEl3xsPiBB-iCYRRdtXr31VLsqEQUuCk-Fed8bRkAU)

Sources

Congressional Budget Office based on data from World Resources Institute, World Greenhouse Gas Emissions: 2005. Washington, D.C.: WRI, December 2005

Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015

Montzka, S., Dlugokencky, E. & Butler, J. Non-CO_2 greenhouse gases and climate change. *Nature* **476,** 43–50 (2011). https://doi.org/10.1038/nature10322

5. CS 100 Bonus Question: What GHG not found in nature?

What greenhouse gas do we emit that is not found in nature?

6. CS 100 Bonus Answer

Answer: Refrigerants

The Short Answer

GET READY FOR SOME BIG NAMES!

Chlorofluorocarbons, Hydrochlorofluorocarbons and hydrofluorocarbons (CFCs, HCFCs, HFCs)

These are chemicals used as coolants in air conditioners and refrigerators. Per molecule, these gases can be over two thousand times worse for global warming than carbon dioxide (Hodnebrog et al. 2020), They are gases that cool surrounding air as there are compressed and decompressed in the back of your fridge. They get released in industrial production and storage of the chemical and when pipes containing them are broken, usually when appliances are thrown in the landfill. Most municipalities have a service you can call to safely retrieve and dispose of these appliances. Properly disposing of appliances containing these gases is considered one of the least costly and most effective ways to reduce GHGs (see project Drawdown).

Background

CFCs and HCFCs are also the cause of the infamous hole in the upper atmosphere protects earth from harmful radiation: the ozone layer. International meetings in Montreal led to the ban of these gases and they were replaced (under the *Montreal Protocol*). These new chemicals don't destroy the ozone layer, but they warm the atmosphere up to 9000 times faster than CO2 (Mann and Kump, 2015). Manufacturers are phasing outto replace these chemicals with something that doesn't affect the climate, which they are in the process of changing now.

Does the ozone hole increase global warming?

The simple answer is no. The hole is not directly affecting climate change but it is indirectly it through affecting atmospheric circulation. It makes the stratosphere colder and creates faster winds near the poles (Personal communication, Dr. Damon Matthews, Concordia University)

Sources

Hodnebrog, Ø., Aamaas, B., Fuglestvedt, J. S., Marston, G., Myhre, G., & Nielsen, C. J., et al. (2020). Updated global warming potentials and radiative efficiencies of halocarbons and other weak atmospheric absorbers. *Reviews of Geophysics*, 58, e2019RG000691. https://doi-org.lib-ezproxy.concordia.ca/10.1029/2019RG000691

Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015

Project Drawdown: https://www.drawdown.org/solutions/table-of-solutions

7. CS 200 Question: Why care that the ice sheets are melting?

Name one reason why we care that the ice sheets are melting…

Background

A glacier is a “large, perennial accumulation of ice, snow, rock sediment and liquid water that originates on land” (USGS).The planet has glaciers all over the world. The two biggest are at the ice sheets at the north and south poles, so Antarctica and Greenland. There are also glaciers in the northern sea and on the highest mountain peaks around the world. The arctic is warming on average twice as fast as the globe (Jeffries et al. 2014) . The Greenland ice sheet and the west side of Antarctic sheet are melting quickly. Antarctica makes up 91% of the worlds glaciers, Greenland is 8% and the remaining are mountain glaciers around the world (USGS).

Further Reading

https://www.usgs.gov/faqs/what-a-glacier?qt-news_science_products=0#qt-news_science_products

Sources

M. O. Jeffries, J. Richter-Menge, and J. E. Overland, Eds., 2014: Arctic Report Card 2014, http://www.arctic.noaa.gov/reportcard.

USGS. What is a glacier? https://www.usgs.gov/faqs/what-a-glacier?qt-news_science_products=0#qt-news_science_products. Accessed December 2020.

8. CS 200 Answer

Sea level rise and/or albedo

The Short Answer

Glaciers are sensitive indicators of climate change; when they significantly melt it is an early sign that big changes may be coming. Besides being a sort of climate alarm, there are two main factors the ice sheets melting are cause for major concern:

Reason 1: Sea level rise

If just the Greenland ice sheet melted, the ocean would rise 7.2 meters (IPCC 2001). This is not even including the much larger glacier of Antarctica which is melting at rates similar to Greenland. If Antarctica melted, it would add 61 metres to the ocean (Dessler 2015). In the worst case scenario, this would happen over hundreds of years. What we do this century will affect the planet for the foreseeable future.

Background

The Greenland ice sheet is melting at record rates, with a new record set in 2019 (Sagen et al. 2020). This massive glacier is up to three kilometres high in some places and is three times the size of Texas! Since 1993 this ice sheets have lost over 3000 billions tons of ice. So far the ocean has risen by 20 cm since 1900, and more than 7 cm just since 1993 (Church and White 2011).

By 2100, the expected sea level rise is at worst 1.2 metre if we do nothing about climate change, but only 30 cm if we do our best to stop climate change (Kopp et al. 2014). But even in the best case scenario the sheets will continue to melt and sea level will rise for several hundred years (Kopp et al. 2014).

The arctic is warming on average twice as fast as the globe (Pithen and Moritsen 2014). Most of the world's largest cities are along the coast and will be affected, and it will likely affect over a billion people's lives in the next century (Neuman et al. 2015). This would include places close to home like New York City.

In worst case scenario, the huge amounts of freshwater released into the ocean from the glaciers can change the circulation of the ocean which would significantly affect the climate around the globe (Mann and Kamp, 2015).

How does it melt?

Warming of the ocean melts nearby land ice and this heat slowly spreads inland and further melts the land ice.

Why skeptics say the Antarctic sheet is actually growing?
The argument that Antarctic ice is actually increasing is sourced to one paper, and the author admitted that the results will likely be distorted and used by climate change deniers. The lead author believes long term, the melting of the Antarctic is a serious issue. The majority of other studies including NASA studies find a net loss in Antarctic ice, even though east Antarctica may be having some gains inland, the West is losing more ice.

See: https://skepticalscience.com/antarctica-gaining-ice-intermediate.htm.
https://www.mediamatters.org/rush-limbaugh/nasa-scientist-warned-deniers-would-distort-his-antarctic-ice-study-thats-exactly

Reason 2: Albedo - Reflecting Heat

The Short Answer

The white surface of the massive ice sheets reflects large amounts of energy from the sun back into space. When the darker surface of the ocean or the land is exposed because of ice melting, these surface absorb and release more heat than the ice would have, further increasing warming (Dessler 2015, p.25, 26, 103).

This is especially important in the Northern Hemisphere, because other than Greenland, most ice is sea ice, so it doesn't affect sea level rise (just as a full glass of water with an ice cube will not overflow when the ice melts) but it does affect the amount of energy reflected back into space.

Other possible answers for reasons ice sheets melting matters include: inuit livelihoods / polar bears / seal populations, particularily in relation to sea ice, not land ice such as Greenland and antartica.

Sources

Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp. [1], *"Archived copy". Archived from the original on 2006-02-10. Retrieved 2006-02-10.*, and [2].

Church, J. A., and N. J. White, 2011:Sea-level rise from the late 19th to the early 21st century. *Surveys in Geophysics* **32** (4–5), 585–602 doi:10.1007/s10712-011-9119-1.

Kopp, R.E., Horton, R.M., Little, C.M., Mitrovica, J.X., Oppenheimer, M., Rasmussen, D.J., Strauss, B.H. and Tebaldi, C. (2014), Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth's Future, 2: 383-406. https://doi.org/10.1002/2014EF000239

Neumann B, Vafeidis AT, Zimmermann J, Nicholls RJ (2015) Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment. PLOS ONE 10(3): e0118571. https://doi.org/10.1371/journal.pone.0118571

Sasgen, I., Wouters, B., Gardner, A.S. *et al.* Return to rapid ice loss in Greenland and record loss in 2019 detected by the GRACE-FO satellites. *Commun Earth Environ* **1,** 8 (2020). https://doi.org/10.1038/s43247-020-0010-1

Stone, E. J., Lunt, D. J., Annan, J. D. & Hargreaves, J. C. Quantification of the Greenland ice sheet contribution to Last Interglacial sea level rise. *Clim. Past* **9**, 621–639 (2013)

Pithan, F. & Mauritsen, T. Arctic amplification dominated by temperature feedbacks in contemporary climate models. *Nat. Geosci.* **7**, 181–184 (2014).

9. CS 200: What are feedback loops?

Feedback loops: An Important Issue in Climate Change

Feedback loops are when an event happens, it amplifies itself and continues happening more intensely over time.

The most relatable example is probably what you have heard happen with microphones on a stage. When a microphone picks up a sound, its volume is increased by an amplifier and then spit out of a speaker. If the microphone is too close to the speaker, then it picks up its own sound it will loop through the system and make that screeching sound.

Ice feedback is a good example of this process in the natural world. As ice and snow melt more near the poles from increasing heat due to global warming, the darker surface of the exposed ground or water absorbs more heat than the ice/snow would have thereby further increasing warming and melting and on and on

This is why, we need have strong climate change action now. There is a lot of uncertainty with climate feedback loops, but it is possible that changes in climate may lead to intense feedback loops, so once changes happen they start happening quicker.

More examples

As warming increases because of CO2, more water evaporates from the surface of the earth and causes more warming, because water vapour holds heat[3]

But also important negative feedback loops that can mitigate global warming.
Many plants like more heat and CO2 increases, and so as CO2 increases that absorb more GHGs,

and have a general cooling affect. But this isn't strong enough to stop human caused global warming

Remember! A great positive feedback loop you can be part of is through positive actions, they encourage others to do the same. For example, Greta Thunberg leads pushes other into action and those she influenced push others and so on.

Further Reading

https://politicalclimate.wordpress.com/tag/negative-feedback-loop/

10. CS 300 Question: Understand the climate of the past?

What natural phenomenon allows us to understand the climate of the past?

11. CS 300 Answer

E. All of the Above

The Short(ish) Answer

Nature provides plenty of time capsules that allow scientists to understand climate far back into the past. We call these natural records of past climate: **"climate proxies"**.

Ice Cores:
Annually layered ice in ice sheets have trapped air bubbles and other characteristics (dust) that show us what the atmosphere was like thousands of years ago.
Greenland ice core that is over 2 miles long has shown us what the climate was like for the past 110, 000 years.
Antarctic ice core records go back even further to 750,000 years ago.

Further reading:https://earthobservatory.nasa.gov/features/Paleoclimatology_IceCores

Tree Rings:
Tree rings can be used to reconstruct past climate because the ring width of a trees new growth is affected for each growing season's climate. Warmth and abundant rainfall create larger tree rings while cold and drought conditions inhibit growth leaving thinner rings.

Further reading:
https://www.climate.gov/news-features/blogs/beyond-data/how-tree-rings-tell-time-and-climate-history

Coral Reefs:

Simply put, the annual growth of corals is affected by the temperature of the water- ie. years where the ocean is very cold can make a thin layer of coral.
A diamond-tipped drill is used to gather cores from corals

Further reading:
https://earthobservatory.nasa.gov/features/Paleoclimatology_CloseUp/paleoclimatology_closeup_2.php

Lake sediments:
Mud at the bottom of lakes contains layers of pollen from the surrounding trees and plants which is dispersed every year. These pollen records can provide information about past species distribution of vegetation and the climate that was conducive for the vegetation.

Further reading:
http://mitrie.badc.rl.ac.uk/documents/mitrie_sediment_lake.pdf

12. CS 300: Safe Zone Graph : Long Term Global Temperature

Here is a graph of global temperatures from today going back to 22,000BC using data from natural climate archives. The line going through the graph is temperature and the pink bar going across is considered the safe zone, the temperature rang in which human civilisation has survived in. We are currently slightly above the safe zone and are risking going way beyond that with business as usual global warming!

“Significant civilizations” are thought to have started with the Sumerians in about 3700BC.
The goal of climate agreements is for the global temperature to rise no more than 2 degrees Celsius. Even this limit is beyond the temperatures human civilization has experienced.

Source
Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015.

13. CS 400 Question: How much CO_2 in atmosphere?

How much CO_2 have we put into the atmosphere since the year 1870? (units of measurement are elephants)

Background
Note that 1870 is important because this is the earliest period for which we have reliable measurements of global temperature, and is a common threshold for pre-industrial

temperatures used in scientific analyses and policy discussions. The year 1700 is often used as the pre-industrial threshold as well (Pierre Friedlingstein et al. 2019).
We are using elephants here to give measurements a real world connection, attempting to make measurements like 10 million gigatons less abstract.

14. CS 400 Answer

D. Over 135 billion elephants

The Short Answer

As of the end of 2020, humans have released approximately 2.384 trillion tonnes of CO2 into the atmosphere (Climate Clock, 2020). This comparison to elephants helps us understand how much carbon we have taken out of the Earth and have added to our atmosphere. Putting that much stuff in the atmosphere is bound to changes things…

Now what does that many elephants look like?
(Click on the arrow that pops up at the bottom right of the slide)

Background

1 gigaton is 1 billion tonnes

In 2020, we have about 1.5x the amount of CO2 in the atmosphere than we did in 1800.

In 1800, the CO2 concentration in the atmosphere was 282 parts per million atmosphere

In 2020, the CO2 concentration in the atmosphere was 417 parts per million atmosphere
(Source

Last time CO2 levels were this high was 3.5 million years ago, and in the past 2.5 millions years the global average temperature is unlikely to have surpassed 2C warmer than pre industrial temperatures.

To have a more precise comparison to elephant weight, we convert the CO2 emissions weight to the value that exclusively represents the weight of the carbon emitted, removing the weight of oxygen. This value is a better representation of the mass we have taken from the earth's crust and released in to the atmosphere. The weight of oxygen here is not really relevant because the oxygen molecules are typically from reaction with combustion, thus were already in the atmosphere in a different form. To do this weight conversion, we divide the CO2 weight by 3.67 (Source 1).

Calculations:

2.384 trillion tonnes of CO2 / 3.67 =
~650 billion tonnes of carbon (Friedlingstein, P. et al., 2020).
An elephant is on average 4.75 tonnes.
650 billion tonnes of carbon / 4.75 = 136.842 billion elephants
Over 135 billion elephants

Last time CO2 levels were this high was 3.5 million years ago

We can safely release 335 gigatons more to stay within 2 Celsius global temperature rise

This 2.384 trillion value used in the calculations is the total accumulated CO2 emissions from fossil fuel burning, cement manufacture and land-use change since 1870, based on the most recent data from the Global Carbon Project, through the Climate Clock website. The value was taken in December 2020.

CO2 we put in the atmosphere is different from natural causes**.** We know the carbon in the atmosphere is from fossil fuels because at a molecular and atomic level, carbon from fossil fuels looks different than carbon from non-fossil fuel sources. They weigh lighter and are more radioactive

There are some uncertainties about parts of global warming, but we know enough to know that we need to make changes and act quickly.

Further Reading

https://keelingcurve.ucsd.edu/

https://www.globalcarbonproject.org/carbonbudget/index.htm

https://informationisbeautiful.net/visualizations/how-many-gigatons-of-co2/
(information is beautiful seems to have made a mistake with their gigatons of CO2 but the rest of the infographic is interesting appears to be accurate)

Sources

Lyndon, G., Hanania, J., Pomerantz, C., Donev , J.(2018). Energy Education - C vs CO2 [Online]. Available: https://energyeducation.ca/encyclopedia/C_vs_CO2.

The Keeling Curve. Retreived from the University of California San Diego website: https://keelingcurve.ucsd.edu/

CO2 levels 3.5 million years ago and temperature:
Willeit, M., Ganopolski, A., Calov, R., & Brovkin, V. (2019). Mid-Pleistocene transition in glacial

cycles explained by declining CO_2 and regolith removal. *Science Advances*, *5*(4), eaav7337. https://doi.org/10.1126/sciadv.aav7337

Press release for Willeit et al 2019 :
https://www.eurekalert.org/pub_releases/2019-04/pifc-mct040319.php

Friedlingstein, P. et al. (2020). Global Carbon Budget 2020, Earth Syst. Sci. Data, 12, 3269–3340, https://doi.org/10.5194/essd-12-3269-2020.

15. CS 500 Question: Snow storms more intense?

Why can snow storms be more intense in Canada because of global warming?

16. CS 500 Answer

The Short Answer

Higher temperature air air can hold more moisture more potential for snow

Global warming means the air will be warming during winter in general. The hot air can hold more moisture than cold (i.e. relative humidity). It's a law of physics.
To visualize this, you can think of molecules as a group of humans: when its hot they want to spread out away from each other, when its cold they huddle together. If there is more space between them, water vapour can fill that space.

We can see this change in moisture holding capacity of air as dew on the grass that accumulates at night. The air gets colder so it releases water which ends up on grass as dew.

So hotter air has more moisture and more moisture during the winter tends to result in more snow. And when the temperature is near zero, we have the perfect balance capacity for moisture in the air while also having a temperature cold enough to create snow rather than rain.

As our winters get warmer, the temperature will be near 0 degrees more often. Depending on what region we look at , intense snow storms can be more likely, but the snow will often melt faster too (Barnett et al 2005).

Snow accumulations have generally declined every year, but we have a higher chance of intense snowfalls (Akerlof et al., 2013)

Further Reading

https://www.livescience.com/48874-warming-climate-produces-more-snow-storms.html

https://www.climate.gov/news-features/climate-qa/are-record-snowstorms-proof-global-warming-isn%E2%80%99t-happening

Sources

Barnett, T., Adam, J. & Lettenmaier, D. Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* **438,** 303–309 (2005). https://doi.org/10.1038/nature04141

Walsh, K.J., McBride, J.L., Klotzbach, P.J., Balachandran, S., Camargo, S.J., Holland, G., Knutson, T.R., Kossin, J.P., Lee, T.-c., Sobel, A. and Sugi, M. (2016), Tropical cyclones and climate change. WIREs Clim Change, 7: 65-89. doi:10.1002/wcc.371

Akerlof, K., Maibach, E.W., Fitzgerald, D., Cedeno A.Y., Neuman A. (2013). Do people "personally experience" global warming, and if so how, and does it matter? Global Environmental Change,23 (1), 81-91, https://doi.org/10.1016/j.gloenvcha.2012.07.006.

Impacts on Nature (IN)

17. IN 100 Question: How many species predicted to go extinct?

How many species in the world are predicted to go extinct due to climate change alone?

A. 1% **B. 3%** **C. 8%** **D. 20%**

18. IN 100 Answer

The Short Answer

It is predicted that 8% of species in the world will go extinct due to climate change alone, for a global temperature increase between 2°C and 3°C since pre-industrial times (Urban, 2015). As global temperatures rise, the extinction risk not only increases but accelerates with every degree of warming (Urban, 2015). For example, if we change our ways and limit global temperature rise to 2°C then approximately 5.2% of species will face extinction (Urban, 2015).

However, if we continue business as usual, this number increases to a 16% extinction risk, which is every 1 in 6 species (Urban, 2015).

Keep in mind, extinction risk is the just how animals are affected at the extreme, the total number of species influenced by climate change is much larger (Urban, 2015). Biodiversity (the variety and variability of life forms) is bound to be negatively affected by climate change in most places in the world.

Background

This 8% value was calculated from a meta-analysis of 131 different studies (Urban, 2015). A meta-analysis is when the author takes all of the research that has been done on a particular subject and compiles it in order to find bigger patterns or trends. This calculation is in agreement with another meta-analysis which explored extinction risk up to year 2100 based on predictions (7%) but found extinction **risk to be 15%** if based on observations (Maclean & Wilson, 2011). The 8% extinction prediction is smaller than many other studies on extinction risk, since they are more specific to certain areas or animals. For instance, research based in Mexico has found that in 35 years since 1975 about 12% of the local lizard species have gone extinct (Sinervo et al., 2010). Using this information, they estimate that 39% of lizard species in the world could go extinct by 2080 (Sinervo et al., 2010). Another reason for the prediction uncertainty, is due to the uncertainty level of future climate change

Keep in mind that this is only the extinction risk from climate change **and does not take into consideration other circumstances that affect animal populations** such as habitat destruction, pollution, over-exploitation, spread of invasive species and diseases, and hunting. From a detailed analysis documenting 177 mammal species, it was found that **40% have experienced extreme population decline**, and all of them have lost 30% or more of their habitat ranges (Ceballos, Ehrlich & Dirzo, 2017). According to the Living Planet Index, the estimated population abundance, so that would be the **actual numbers, of mammals, birds, reptiles, amphibians and fish has decreased by about 60%** since 1970 (LPI, 2018). This does not even include insects and other invertebrates. Although not as well studied, it has been found that insects are also being lost at alarming rates. In a 27-year study in Germany, they have found a 76% decline in flying insects (Hallmann et al., 2017). In a 36-year period in Puerto Rico, they found an astounding 98% decline in ground dwelling insects (Lister & Garcia, 2018). Although not all animals' extinctions and loses are due to climate change, it will most likely make matters worse.

Inability to migrate anywhere except upwards is then feared to lead to progressively decreasing ranges and eventual mountaintop extinction (Colwellet al.,2008; Dullingeret al., 2012; Gottfriedet al., 2012).

Extinction risk in different areas (Urban, 2015)
North America 5%
Europe 6%

South America with 23%,
Australia and New Zealand 14%,
There are limited studies on Asia

So even if a species is not predicted to go extinct, this does not mean that their population sizes, habitat area and how they interact with their environments and us will not change.

For more information and current statistics on the extinction risk of different animals, see the International Union for Conservation of Nature (IUCN) Red List of threatened species (IUCN, 2020)

Sources

Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(30), E6089–E6096. https://doi.org/10.1073/pnas.1704949114

Hallmann, C. A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörren, T., Goulson, D., & Kroon, H. de. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLOS ONE*, *12*(10), e0185809. https://doi.org/10.1371/journal.pone.0185809

Lister, B. C., & Garcia, A. (2018). Climate-driven declines in arthropod abundance restructure a rainforest food web. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(44), E10397–E10406. https://doi.org/10.1073/pnas.1722477115

LPI 2018. Living Planet Index database. 2016. < www.livingplanetindex.org/>. Downloaded on 21 May 2020

Maclean, I. M. D., & Wilson, R. J. (2011). Recent ecological responses to climate change support predictions of high extinction risk. *Proceedings of the National Academy of Sciences*, *108*(30), 12337–12342. https://doi.org/10.1073/pnas.1017352108

Sinervo, B., Méndez-de-la-Cruz, F., Miles, D. B., Heulin, B., Bastiaans, E., Cruz, M. V.-S., Lara-Resendiz, R., Martínez-Méndez, N., Calderón-Espinosa, M. L., Meza-Lázaro, R. N., Gadsden, H., Avila, L. J., Morando, M., Riva, I. J. D. la, Sepulveda, P. V., Rocha, C. F. D., Ibargüengoytía, N., Puntriano, C. A., Massot, M., … Sites, J. W. (2010). Erosion of Lizard Diversity by Climate Change and Altered Thermal Niches. *Science*, *328*(5980), 894–899. https://doi.org/10.1126/science.1184695

Urban, M. C. (2015). Accelerating extinction risk from climate change. *Science*, *348*(6234), 571–573. https://doi.org/10.1126/science.aaa4984

19. IN 100: Why care about biodiversity?

The Short Answer

There are many reasons why biodiversity is important. The long term availability of clean air, clean water, food and medicine all ultimately depend on healthy ecosystems and biodiversity. Most of the world's most amazing animals depend on a healthy biodiversity to survive. From a more human-centric perspective, about half of all medicines currently in use were discovered in natural products (Bruckner, 2002).

Background

An ecosystem depends on a variety of plants and animals in order to stay healthy and provide different ecosystem services, such as clean air and water, fertile soil, carbon sequestration and flood mitigation (ECCC, 2019). For example, it has been shown that a loss in biodiversity changes the forest composition and can lead to a reduction in the overall carbon storage (Hinsley et al., 2014). There has also been an association found between altering forest ecosystems and a rise in human disease (Fornace et al., 2016). Furthermore, biodiversity is a large contributor to the global economy (Balmford et al., 2002), and many plants and animals hold high importance in different cultures (ECCC, 2019). There are also still many undiscovered species that could be beneficial to people, for instance…

In 2011, a group of students at Yale University discovered that a rare mushroom from the Ecuadorian Amazon (*Pestalotiopsis microspore*) is capable of breaking down a plastic that is widely used in manufacturing textiles, called polyester polyurethane (Russell et al., 2011). The fungus can use this type of plastic as it's only energy source and is able live without oxygen (Russell et al., 2011), which suggests that it could potentially exist at the bottom of landfills. More research is needed in order to identify possible other species of fungus that could degrade different types of plastic, such as PET.

Viruses are a large contributor to bee mortality (Stamets et al., 2018). In 2018, a study found that honeybees that fed on extracts of polypore mushroom mycelia were shown to have a 45,000-fold reduction in virus infection (Stamets et al., 2018). Honeybees are not only extremely important for wild plant communities but contribute over 15 billion dollars to the US economy through the pollination of food products (U.S. Office of the Press Secretary, 2014).

For more information on Canada's goals and targets to conserve biodiversity, see the Summary of Canada's 6th National Report to the Convention on Biological Diversity (ECCC, 2019).

Sources

Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R. E., Jenkins, M., Jefferiss, P., Jessamy, V., Madden, J., Munro, K., Myers, N., Naeem, S., Paavola, J., Rayment, M., Rosendo, S., Roughgarden, J., Trumper, K., & Turner, R. K. (2002). Economic Reasons for Conserving Wild Nature. *Science*, *297*(5583), 950–953. https://doi.org/10.1126/science.1073947

Bruckner, A.W. (2002) Life-Saving Products from Coral Reefs. *Issues in Science and Technology* ,18, (3). https://issues.org/p_bruckner/

Environment and Climate Change Canada. 2019. *Summary of Canada's 6th National Report to the Convention on Biological Diversity.* Gatineau, QC: Government of Canada.

Fornace, K. M., Abidin, T. R., Alexander, N., Brock, P., Grigg, M. J., Murphy, A., William, T., Menon, J., Drakeley, C. J., & Cox, J. (n.d.). *Association between Landscape Factors and Spatial Patterns of Plasmodium knowlesi Infections in Sabah, Malaysia—Volume 22, Number 2—February 2016—Emerging Infectious Diseases journal—CDC*. https://doi.org/10.3201/eid2202.150656

Hinsley, A., Entwistle, A., & Pio, D. V. (2015). Does the long-term success of REDD+ also depend on biodiversity? *Oryx*, *49*(2), 216–221. https://doi.org/10.1017/S0030605314000507

Russell, J. R., Huang, J., Anand, P., Kucera, K., Sandoval, A. G., Dantzler, K. W., Hickman, D., Jee, J., Kimovec, F. M., Koppstein, D., Marks, D. H., Mittermiller, P. A., Núñez, S. J., Santiago, M., Townes, M. A., Vishnevetsky, M., Williams, N. E., Vargas, M. P. N., Boulanger, L.-A., … Strobel, S. A. (2011). Biodegradation of Polyester Polyurethane by Endophytic Fungi▽. *Applied and Environmental Microbiology*, *77*(17), 6076–6084. https://doi.org/10.1128/AEM.00521-11

Stamets, P. E., Naeger, N. L., Evans, J. D., Han, J. O., Hopkins, B. K., Lopez, D., Moershel, H. M., Nally, R., Sumerlin, D., Taylor, A. W., Carris, L. M., & Sheppard, W. S. (2018). Extracts of Polypore Mushroom Mycelia Reduce Viruses in Honey Bees. *Scientific Reports*, *8*(1), 13936. https://doi.org/10.1038/s41598-018-32194-8

U.S. Office of the Press Secretary (Producer). June 20, 2014. *Fact Sheet: The Economic Challenge Posed by Declining Pollinator Populations*. Retrieved from https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/fact-sheet-economic-challenge-posed-declining-pollinator-populations

Image Left: By Eric Steinert - photo taken by Eric Steinert at Paussac, France, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=452328

Image Right: By MSchink - Mushroom Observer, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=39925853

20. IN 200 Question: Why will disease spread?

Why will more diseases spread to Canada because of climate change?

21. IN 200 Answer

The Short Answer

The climate directly effects fluctuations of different kinds of infectious diseases. Temperature affects the reproduction and distribution of disease spreading insects like mosquitoes and ticks. By the end of the 21st century its expected that a billion more people will be exposed to mosquito spread disease than today. Ticks carrying Lyme's disease are increasingly found in northern areas that they were not in before.

(Click on red X mark on tick icon)
Always check your body for ticks when you go off trails in the wilderness! You have at least 24 hours before a tick transmits its disease to you, so check your body and shower after an adventurous hike in tick prone areas.

Background

It has been shown that variation in the climate directly effects fluctuations of different kinds of infectious diseases, including vector-borne diseases (McIntyre et al., 2017). If a disease is vector-borne, this means that it is spread by an organism, for instance a mosquito or tick, to other organisms. For example, Dengue fever is considered the most serious mosquito spread disease globally, and research has shown that climate variations are strongly correlated to cases (Hopp & Foley, 2003). This makes logical sense since temperature plays a big role in mosquito egg-laying, their growth and survival (Hopp & Foley, 2003). It has even been suggested that yearly climate forecasts can also predict dengue fever caseloads (Hopp & Foley, 2003). Different diseases are specific to different vectors. There are several species of mosquito that carry viruses such as dengue, malaria and Zika, that we do not yet find in Canada. These species have optimal transmission temperatures and are not cold adapted (See Ryan et al. 2019 for more references and information). Global modelling studies have shown many mosquito diseases (such as chikungunya, dengue and Zika) as projected to expand their limits for transmission to higher latitudes and elevations, specifically in Europe, eastern Africa, northern Andes, the United States and Canada (Ryan et al., 2019). It is estimated that by 2080, approximately a billion more people will be exposed to mosquito spread disease than at present (Ryan et al., 2019).

The warmer temperatures have increased the geographic range in which disease carrying insects and animals can live. For instance, research has shown that tick expansion northwards are due to winters having warmer temperatures, especially in higher latitudes (Lindgren et al., 2000). In more southern latitudes, the combination of the milder winters, the earlier spring and later fall seasons contribute to the increasing tick populations (Lindgren et al., 2000). This would mean a longer breeding season for these disease carrying arthropods because they are active for longer. Ticks are limited by colder temperatures and propagate in warmer

temperatures (Lindgren et al., 2000). In Canada, ticks can carry Lyme disease. If left untreated, Lyme disease can cause severe symptoms including facial paralysis, heart disorders, neurological disorders and even death in some cases (Public Health Agency of Canada & Health Canada, 2019).

There are also risks with diseases being spread to vegetation and being distributed further. For example, whiteflies spread hundreds of plant diseases and cause serious damage to human crops. Depending on the species of whiteflies, some populations will be reduced due to the environmental change, however, the better adapted species are projected to experience an increase in population sizes and geographic distribution (Aregbesola et al., 2018). Furthermore, the mountain pine beetle (which kills forest trees in North America) has begun its flight season one month earlier and has been reported to now breed twice throughout the year, instead of just once, due to warmer temperatures (Mitton & Ferrengerg, 2012).

Although many disease carrying arthropods are increasing in abundance, this does not mean that all insects will be experiencing increases in population sizes and be able to adapt to environmental changes. This is illustrated by many studies on butterflies showing that their populations are already greatly affected by climate change impacts (Warren et al., 2001). For a thorough review on climate change and vector-borne diseases see Caminade et al. (2019).

Will also accept answer **A. Heat Waves, but only if they can make a solid case for the heat as affecting food poisoning. For instance, it was found that hotter temperatures (specifically 1 week in some countries) before food consumption increased cases of salmonella poisoning (Kovats et al., 2004). The reasons for which may be direct effects of temperature on the food, inappropriate storage or preparation, or insufficient cooking or through altered eating habits during hotter weather, such as a BBQ (Kovats et al., 2004).

For more information on how climate change will affect human health, see Patz et al. (2005).

This graphic might be cool for slide:
https://www.npr.org/sections/goatsandsoda/2019/03/28/707604928/chart-where-disease-carrying-mosquitoes-will-go-in-the-future

Sources

Aregbesola, O. Z., Legg, J. P., Sigsgaard, L., Lund, O. S., & Rapisarda, C. (2019). Potential impact of climate change on whiteflies and implications for the spread of vectored viruses. *Journal of Pest Science*, *92*(2), 381–392. https://doi.org/10.1007/s10340-018-1059-9

Caminade, C., McIntyre, K. M., & Jones, A. E. (2019). Impact of recent and future climate change on vector-borne diseases. *Annals of the New York Academy of Sciences*, *1436*(1), 157–173. https://doi.org/10.1111/nyas.13950

Hopp, M. J., & Foley, J. A. (2003). Worldwide fluctuations in dengue fever cases related to climate variability. *Climate Research*, *25*(1), 85–94. https://doi.org/10.3354/cr025085

Kovats, R. S., Edwards, S. J., Hajat, S., Armstrong, B. G., Ebi, K. L., & Menne, B. (2004). The effect of temperature on food poisoning: A time-series analysis of salmonellosis in ten European countries. *Epidemiology & Infection*, *132*(3), 443–453. https://doi.org/10.1017/S0950268804001992

Lindgren, E., Tälleklint, L., & Polfeldt, T. (2000). Impact of climatic change on the northern latitude limit and population density of the disease-transmitting European tick Ixodes ricinus. *Environmental Health Perspectives*, *108*(2), 119–123. https://doi.org/10.1289/ehp.00108119

McIntyre, K. M., Setzkorn, C., Hepworth, P. J., Morand, S., Morse, A. P., & Baylis, M. (2017). Systematic Assessment of the Climate Sensitivity of Important Human and Domestic Animals Pathogens in Europe. *Scientific Reports*, *7*(1), 7134. https://doi.org/10.1038/s41598-017-06948-9

Mitton, J. B., Ferrenberg, S. M., & Benkman, N. H. E. C. W. (2012). Mountain Pine Beetle Develops an Unprecedented Summer Generation in Response to Climate Warming. *The American Naturalist*, *179*(5), E163–E171. JSTOR. https://doi.org/10.1086/665007

Patz, J. A., Campbell-Lendrum, D., Holloway, T., & Foley, J. A. (2005). Impact of regional climate change on human health. *Nature*, *438*(7066), 310–317. https://doi.org/10.1038/nature04188

Public Health Agency of Canada & Health Canada. (2019). *Lyme disease.* Retrieved from https://www.canada.ca/en/public-health/services/diseases/lyme-disease.html

Ryan, S. J., Carlson, C. J., Mordecai, E. A., & Johnson, L. R. (2019). Global expansion and redistribution of Aedes-borne virus transmission risk with climate change. *PLOS Neglected Tropical Diseases*, *13*(3), e0007213. https://doi.org/10.1371/journal.pntd.0007213

Warren, M. S., Hill, J. K., Thomas, J. A., Asher, J., Fox, R., Huntley, B., Roy, D. B., Telfer, M. G., Jeffcoate, S., Harding, P., Jeffcoate, G., Willis, S. G., Greatorex-Davies, J. N., Moss, D., & Thomas, C. D. (2001). Rapid responses of British butterflies to opposing forces of climate and habitat change. *Nature*, *414*(6859), 65–69. https://doi.org/10.1038/35102054

22. IN 300 Question: How will plants react?

Over time, how will plants in North America react as the climate warms up?

What is a repercussion of this vegetation shifting for animals?

23. IN 300 Answer

*Need to change the answer slide so that is also says “North America” instead of “Canada”.

The Short Answer

Generally, vegetation will move northwards and up mountains. Of course, plants cant get up and move, were talking about vegetation moving over time by seeds succeeding in places they could not have before. Over time this will disrupt many ecosystems. Plants can move to new areas quickly because of wind spreading seeds. Animals, other than birds, tend to have harder time adapting because they are often blocked by highways and other man-made systems. Some vegetation that animals once depended on will no longer exist in the same areas as they used to.

In this image of a mountain top, we can see how an ecosystem can disappear locally. As the temperature warms the trees will grow past the limit of tree line we see here, overtaking the tree-less top of this mountain. While this mountain top may look like a barren landscape, these tundra type hilltops are habitat to rare plants and insects and are important habitat for endangered species like caribou (Rowland et al. 2016)!

Background

As the climate changes, plants are going to grow in different areas then they used to in order to stay in their preferred climate. This will mean that vegetation that used to grow in the south will be seen growing further north. Vegetation is able to disperse across human infrastructure and roads by wind seed dispersal, whereas animals cannot as easily cross these barriers. Animals cannot disperse by wind like plants can (birds are an exception); therefore, vegetation can change its location much quicker than land animals. This leaves the animal at a disadvantage if it needs a specific tree to live in, or if its food no longer grows in the area that it has always lived in. Some species of animals are often very adaptable and resilient, but others are not. And with pressure on animal populations from multiple sources (habitat loss, pollution, habitat fragmentation, climate change), the risks of vegetation changes from climate change are an additional stress.

When going up a mountain, there is different vegetation at different heights. With climate change, the ecosystems on mountains will shift upwards and change. Animals that can only live in the high up alpine ecosystem at the top have the mountain will have problems if their habitat disappears. There will be no alpine habitat left at the top, and the animals will have nowhere to go.

This is also the case for island habitat. If animals that live on islands are used to the type of vegetation that is on it, but then the climate changes and the plants that used to live on the island can no longer because it is dryer or wetter or hotter, then the animals will have nowhere to go. Most animals are not as easily adaptable as humans, so they need a specific habitat. If the

vegetation changes so that the animal's food source is no longer available, they will no longer be able to sustain themselves

But its important to acknowledge that interactions between climate and vegetation can be complex and are a results of many other factors than just climate and the direct effects of climate are faced with many uncertainties (Peterson et al. 2020). What is important to note is that climate change is adding an extra stress to plants and animals.

Try to get kids to think of why this happens and how there are boundaries for animals to move with their preferred habitats. Some animals can more easily adapt to changes in their habitat than others, can you think of any? (Racoons, rats, etc.) Many animals are specialists and cannot adapt to a changing ecosystem. There are some hummingbirds that only drink nectar from one specific type of flower. If that flower disappears from that area, so does the hummingbird.

Further Reading

https://thenarwhal.ca/worlds-longest-border-moving/

Sources

Corlett, R. T., & Westcott, D. A. (2013). Will plant movements keep up with climate change? *Trends in Ecology & Evolution*, *28*(8), 482–488. https://doi.org/10.1016/j.tree.2013.04.003

Freeman, B. G., Lee-Yaw, J. A., Sunday, J. M., & Hargreaves, A. L. (2018). Expanding, shifting and shrinking: The impact of global warming on species' elevational distributions. *Global Ecology and Biogeography*, *27*(11), 1268–1276. https://doi.org/10.1111/geb.12774

Parmesan, C. (2006). Ecological and Evolutionary Responses to Recent Climate Change. *Annual Review of Ecology, Evolution, and Systematics*, *37*(1), 637–669. https://doi.org/10.1146/annurev.ecolsys.37.091305.110100

Peterson, M. L., Bailes, G., Hendricks, L. B., Pfeifer-Meister, L., Reed, P. B., Bridgham, S. D., … Morris, W. F. (2020). Latitudinal gradients in population growth do not reflect demographic responses to climate. *Ecological Applications : A Publication of the Ecological Society of America*, *E2242*, 2242. https://doi.org/10.1002/eap.2242

McKenney, D. W., Pedlar, J. H., Lawrence, K., Campbell, K., & Hutchinson, M. F. (2007). Potential Impacts of Climate Change on the Distribution of North American Trees. *BioScience*, *57*(11), 939–948. https://doi.org/10.1641/B571106

Root, T. L., Price, J. T., Hall, K. R., Schneider, S. H., Rosenzweig, C., & Pounds, J. A. (2003). Fingerprints of global warming on wild animals and plants. *Nature*, *421*(6918), 57–60. https://doi.org/10.1038/nature01333

Rowland, E. L., Fresco, N., Reid, D., & Cooke, H. A. (2016). Examining climate-biome ("cliome") shifts for yukon and its protected areas. *Global Ecology and Conservation*, *8*, 1–17. https://doi.org/10.1016/j.gecco.2016.07.006

24. IN 400 Question: How is climate change causing coral reefs to bleach and to die? There are 2 answers, worth 200 points each

25. IN 400 Answer

The Short Answer
Corals are threatened by a **warmer and more acidic** ocean.

The planet's oceans absorb 90% of the heat from global warming (IPCC, 2007) and 25% of the carbon dioxide released by human activities. Warming oceans are the main cause of coral reefs bleaching and degrading.

Bleaching happens because of the symbiotic relationship between algae and coral; they help each other survive. Microscopic algae live inside of the coral for protection, and in return the algae's photosynthesis feeds the coral. When the ocean becomes too warm, the algae can't function so they leave the coral to cooler areas. Once this occurs, the coral can no longer get the nutrients it needs so it will bleach and will become more vulnerable to disease (NOAA, 2020). Oceans' becoming more acidic affects coral reefs in a different way. Corals use the calcium carbonate in the ocean to build their "skeletons". When the water becomes more acidic they no longer have the important chemical building blocks that they need to grow and form.

We need to care about coral reefs for several reasons:
-Tens of millions of people depend directly on food from coral reefs
-Coral reefs cover less than 1% of the ocean floor, but support 25% of the ocean's fish, and 1/3 of all ocean species (Reaka-Kudla, 2001).
- Important medication continues to be discovered from coral reef organisms.
- Barrier reefs protect coastal communities from storms.
- Over a third of the oceans life is supported by coral reefs.

Background
Beginning when CO2 concentration in the atmosphere exceeded ~320 ppm in the 1960s, coral reefs have been deteriorating, mostly during years of warm ocean currents (El Nino events)

(Veron et al. 2009). It takes approximately 10 years for the ocean to absorb heat from the atmosphere, so we won't see the damage of this year's emissions for a long time (Veron et al. 2009). Warming is increasing in conjunction with ocean acidification, ocean pollution. The domino effect of degrading coral reefs on the rest of the ocean ecosystem is expected to be an important contribution to the sixth mass extinction event in Earth's history (Veron et al. 2009).

Coral reefs are important because they protect shores from the impact of waves and from storms. They provide food and medicine to humans, and provide economic benefits to local communities through tourism. Coral reefs cover less than 1% of the ocean floor, but support 25% of the ocean's fish, and 1/3 of all ocean species (Reaka-Kudla, 2001). Tens of millions of people depend directly on protein and other services from coral reefs (Costanza et al., 1997). Coral reefs harbor many medically active compounds that have proven beneficial to humans (e.g. antiviral and anti-cancer medicine), and many remain to be discovered (Bruckner, 2002)

There is a window of time after a bleaching event caused by warm ocean currents, in which the coral can regain their relationship with the algae and keep living, however the length of this is still uncertain. There has been a study showing that even if the coral survive a bleaching event, it can take 10 years to fully recover. So if another bleaching event were to happen, the coral would most likely die.

Although the increasing temperature of the ocean is the leading cause of coral bleaching, it can also be caused from pollution, overexposure to sunlight, and extreme tides. Coral is very susceptible to change.

Further Reading

https://www.worldatlas.com/articles/what-is-the-conservation-status-of-the-world-s-reef-building-corals.html

https://oceanservice.noaa.gov/facts/coral_bleach.html

Sources

Bruckner, A., 2007. Life Saving Products from Coral Reefs. https://issues.org/p_bruckner/

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assess-ment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A.(eds.)]. IPCC, Geneva, Switzerland, 104 pp
For a related summary read:
https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch5s5-2-2-3.html

NOAA, 2020. What is coral bleaching? National Ocean Service website, https://oceanservice.noaa.gov/facts/coral_bleach.html
Watson, A. J., Schuster, U., Shutler, J. D., Holding, T., Ashton, I. G., Landschützer, P., ... & Goddijn-Murphy, L. (2020). Revised estimates of ocean-atmosphere CO2 flux are consistent with ocean carbon inventory. *Nature communications*, *11*(1), 1-6.

26. IN 500 Question: Problems of season-change timing?

The timing of seasons are changing at a rapid rate, some plants are blooming two weeks earlier than in the past...

How can these changing times be a problem for plants and animals?

27. IN 500 Answer

The Short Answer

As patterns of seasons, rain and temperature change, the **schedules of plants and animals will no longer align disrupting food chains.** Think of a flower opening like a bus. If you miss your bus, your out of luck, your chance is gone. This could result in not as many plants being pollinated, and therefore fewer flowers, fruits and vegetables. This can cause major disruptions along food chains.

The timing of activities of plants and animals are strongly tied to the changing of seasons. As a result of climate change, springtime has arrived up to 15 days earlier in some areas since the 1970s (Pachauri et al., 2007). In Canada, many species flower 9 days earlier than before, some trees species (e.g. Trembling Aspen) bloom 14 days earlier than in the past (Beaubien et al., 2011). Changes tied to autumn are also occurring later (Piao et al., 2019).

We are already seeing that many different plants and animals are adapting in different ways (Root et al., 2003). Some animals will struggle to adapt their schedules to coincide with these seasonal changes, which can have significant ecological consequences for many plants and animals (Walther et al., 2002; Piao et al., 2019). It may lead to some local and total extinctions (Root et al., 2003).

An example of this chain are the interaction of oak trees, caterpillars and song birds. In the spring, if the oak tree starts growing leaves earlier, caterpillars that depend on eating young leaves may hatch too late, so their numbers will drop, and when the migratory songbirds arrive

to feed on the caterpillars which are the main source of food for their growing young, they will suffer from a loss of food. (based on Piao et al., 2019)

Plants and animals are a complex web of systems interacting with the climate. The lower amount of food will affect the animals higher up on the food chain.

Background

The study of patterns of development in plant and animal behaviors is called phenology. Many of these patterns are seasonal and related to the climate. Many species have evolved to be at the right place and time for peak resource availability. In general, spring activities of plants and animals have occurred progressively earlier since the 1960s (Waltger et al 2002).

Many of these interacting plant, animal and climate systems are more complex than we are able to fully model and understand, so when we combine all their interactions there are high levels of uncertainty (Piao et al., 2019). In this uncertainty it is wisest to follow the precautionary principle and avoid as much climate change as possible, especially given that we are already observing significant changes in plant and animal populations and we have reduced many species capacity to adapt because of habitat destruction and fragmentation (Menendez et al., 2006).

Further Reading

https://www.treehugger.com/spring-phenology-and-global-climate-change-1203890

https://www.usgs.gov/centers/casc-sc/science/impacts-climate-change-phenology-a-synthesis-and-path-forward-adaptive?qt-science_center_objects=0#qt-science_center_objects

Sources

Beaubien, E., & Hamann, A. (2011). Spring flowering response to climate change between 1936 and 2006 in Alberta, Canada. *BioScience*, *61*(7), 514-524.

Menéndez, R., Megías, A. G., Hill, J. K., Braschler, B., Willis, S. G., Collingham, Y., ... & Thomas, C. D. (2006). Species richness changes lag behind climate change. *Proceedings of the Royal Society B: Biological Sciences*, *273*(1593), 1465-1470.

Pachauri, Rajendra K., and Reisinger, A. (2007)"IPCC fourth assessment report." *IPCC, Geneva* 2007.

Piao, S., Liu, Q., Chen, A., Janssens, I. A., Fu, Y., Dai, J., … Zhu, X. (2019). Plant phenology and global climate change: current progresses and challenges. *Global Change Biology*, *25*(6), 1922–1940. https://doi.org/10.1111/gcb.14619

Tang, J., Körner, C., Muraoka, H., Piao, S., Shen, M., Thackeray, S. J., & Yang, X. (2016). Emerging opportunities and challenges in phenology: a review. *Ecosphere*, *7*(8).

Impacts on Humans (IH)

28. IH 100 Question: Effects felt evenly across the world?

In most cases, who will suffer the most from the consequences of climate change?

29. IH 100 Answer

The effects of climate change are disproportionately felt by already disadvantaged groups (people with less income, poorer nations) leading to even more inequality! The Climate Justice movement addresses this important aspect of climate change.

An example of how this can play out is Hurricane Katrina in 2006 and Hurricane Sandy in 2012. Extreme weather events like hurricanes are expected to increase in intensity (Stott, 2016). Both hurricanes most effected poorer communities because they lived in lower lying areas and had less income to recover from the disaster.

This inequality is one of the reasons many climate justice advocates urge the richest countries of the world to help the poorest, because the richest contributed the most to climate change in the past but the poorer nations will experience the effects the most.

The planets poorest communites are closer to the equator, the region that will experience more changes, fore example the Democratic Republic of Congo is one of the porest nations in the world and is expected to expreinces the greatest changes in local temperature (King and Harrington 2018)

Climate change is an ethical issue, because poorer communities within countries like Canada, and poorer countries in the world, will often feel the worse effects from climate change and will not have the resources to rebuild, replant, adapt etc. As a more developed country we have an ethical responsibility to reduce the harm we do to other countries through climate change.

For example, people who have the money and resources to move away from places experiencing sea level rise or intense drought

This map shows how different the effects are just in North America. Eastern USA and Mexico will be highly affected by sea level rise. The west of the continent by wild fire and drought while the east and norther will get more rain, more flooding and Animals everywhere will be affected..

There is what's been called a reinforced vicious cycle between inequality and climate change.

Due to climate change, water availability is becoming less predictable in many places and increased floods threaten to destroy water access point, sanitations facilities leading to contaminated water sources.

Higher temperatures and more extreme, less predictable, weather conditions are projected to affect availability and distribution of rainfall, snowmelt, river flows and groundwater, and further deteriorate water quality.

Low-income communities, who are already the most vulnerable to any threats to water supply are likely to be worst affected.

More floods and severe droughts are predicted. Changes in water availability will also impact health and food security and have already proven to trigger refugee dynamics and political instability. (UNwater.org)

Lack of economic diversity, limited access to the internet, and relatively limited infrastructure, resources, and political clout further detract from the adaptive capacity of rural communities.[226,227,228.]

This is dubbed the climate gap. "Further, low-income and minority communities could be more seriously harmed by the economic shocks associated with climate change both in price increases for basic necessities (i.e., water, energy, and food) and by threats of job loss due to economic and climatic shifts that affect industries such as agriculture and tourism (Stern 2006)." (Morello-Frosch et al., 2009)

https://skepticalscience.com/

https://youtu.be/Evb0Vav5kpc

Map from: https://environmentalmigration.iom.int/maps

Further Reading

https://e360.yale.edu/features/unequal-impact-the-deep-links-between-inequality-and-climate-change

Sources

Stott, P. (2016). How climate change affects extreme weather events. *Science*, *352*(6293), 1517-1518.

King, A. D., & Harrington, L. J. (2018). The inequality of climate change from 1.5 to 2 C of global warming. *Geophysical Research Letters*, *45*(10), 5030-5033.

Morello-Frosch, R., M. Pastor, J. Sadd, and S.B. Shonkoff, 2009: The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap. University of California, Berkeley, and USC Program for Environmental & Regional Equity.
http://dornsife.usc.edu/assets/sites/242/docs/The_Climate_Gap_Full_Report_FINAL.pd

https://www.nature.com/articles/nature15725

https://www.tandfonline.com/doi/abs/10.1080/08941920118490?casa_token=d--aY2TzlQQAAAAA:whn1L56xPmqfJ67L_2fJ_BE61HB-lNBxyZ0mK-BRQAYoYOoExt_sfIXh4cu8j6w2p_7xVB9Skad3Ww

30. IH 200 Question: What is a climate refugee?

What does it mean to be a climate refugee?

31. IH 200 Answer

Climate Refugee:
someone who is **forced to flee** their home due to sudden or gradual **changes in the natural environment** related to at least one of three **impacts of climate change**: sea-level rise, desertification and loss of ecosystem services such as water supply and food production.

Climate refugee (also known as environmental migrants more broadly) remains a contested term because it is often difficult to directly associate climate change to refugees today, and effects such as water scarcity and crop failures often aggravate pre-existing social, political and economic issues that together force people to flee (Kraemer 2020). As sea-level rise and desertification increase, refugees as a direct result of climate change will be more obvious.

Climate refugees as of yet, do not yet receive any legal protections in the same way that other refugees do (McCarney and Kent, 2020). More and more, there are pushes by leaders in human rights and climate justice to create international frameworks to deal with this ever-growing issue.

Background

“More people, less water, less food”
– Micheal Mann, from the book Dire Predictions

In 1990, the Intergovernmental Panel on Climate Change predicted that forced human migration could be the single greatest effect of climate change (McCarney and Kent, 2020). Since 2008, an average of 24 million people globally have been displaced by catastrophic weather disasters each year (Randall, *Climate Refugees*). Many of these catastrophes cannot be directly linked to climate change, but as the planet warms, we expect extreme weather events will be more frequent and more intense. Climate impacts such as desert expansion and sea level rise play a large role in forcing people to permanentely leave their homes.

Policy changes must be made to accommodate this to prevent huge migration crises in the future. The United Nations International Organization for Migration forecasts 25 million to 1 billion environmental migrants for the year 2050 (Kraemer, 2017). Environmental migrant is a broader term relating to and environmental cause of migration, but we can be certain that an increasing amount of these migrants will be related to climate change and will be permanent rather than temporary. **Compared to most refugees, who need temporary support from a political disaster much of climate related migration will be permanent leaving populations trapped with no home to return to and no new place to call home (Findlay, 2011).** A large problem that remains is that “climate refugees” lack protection under international law (unlike refugees fleeing persecution, violence or war)... this leaves climate refugees vulnerable when fleeing disasters as it’s harder for them to find sanction in other countries.

Climate refugee remains a contested term because, in many cases, clearly delineating a climate refugee from political refugees is difficult. Many of the circumstances that drive people to migrate are an interaction of political and environmental (climate and non-climate related) factors. Regardless, environmental degradation aggravates pre-existing political and economical issues, further making the world unstable and driving refugee crises (Kraemer 2017). The current frameworks for international policy coordination are not prepared to accommodate climate-related refugees and there is no institution officially responsible for addressing this issue, “a blind spot in international governance” (Kraemer, 2017). Climate mobility must become a recurring item on agendas of international meetings (Kraemer, 2017). Recent global meetings have begun to consider and address these issues (McCarney and Kent, 2020).
Still, efforts to address climate refugees are in their infancy.

Long term solutions include migration with dignity programs, which reate openings in labour markets for refugees in wealthy countries, international aid for investments in preventative measures such as seawalls, and funding for research and developments in drought resistant crops in area prone water scarcity (McCarney and Kent, 2020). We need to have a long term perspective to counter anti-immigrant sentiment in culture to highlight the positive economic, cultural aspects of accepting immigrants (Kraemer, 2017).

Further Reading

Climate refugees: how many are there? How many will there be? – Climate Migration Coalition
http://climatemigration.org.uk/climate-refugees-how-many/

Can we define a climate refugee? – Climate Migration Coalition
http://climatemigration.org.uk/climate-refugees-definition/

The Refugees The World Barely Pays Attention To
https://www.npr.org/sections/goatsandsoda/2018/06/20/621782275/the-refugees-that-the-world-barely-pays-attention-to

Migration, Environment and Climate - International Organization for Migration
https://www.iom.int/migration-and-climate-change#estimates

Climate change will create the world's biggest refugee crisis - The Guardian
www.theguardian.com/environment/2017/nov/02/climate-change-will-create-worlds-biggest-refugee-crisis

Sources

Global Governance Project. (2012). Forum on Climate Refugees.

Findlay, A.M. (2011). Migrant destinations in an era of environmental change. *Global Environmental Change 21*. 50-58, doi: http://dx.doi.org/10.1016/j.gloenvcha.2011.09.004.

Kraemer, R. A. (2017). *The g20 and building global governance for "climate refugees"* (Ser. Policy brief, 107). Centre for International Governance Innovation.

McCarney, R., & Kent, J. (2020). Forced displacement and climate change: time for global governance. *International Journal: Canada's Journal of Global Policy Analysis*, *75*(4), 652–661. https://doi.org/10.1177/0020702020968944

32. IH 300 Question: Extreme weather events are more likely because of climate change?

Name two extreme events that Canadians will experience more of because of climate change.

33. IH 300 Answer

Floods

Heat Waves
Hurricanes
Sea Level Rise
Drought

The Short Answer

The effects of climate change vary widely because of the complex relationship between climate and the landscape. We can expect extreme events related to water such as flooding and hurricane to occur with more intensity and frequency. This is because more heat in the atmosphere tends to mean more energy and moisture in the air (IPCC AR5). There has been an increase in hurricanes from the Atlantic ocean since the 1970s, and the scientific community has a medium level confidence that GHGs, air pollution and the warming ocean are partly responsible for this increase. (Walsh et al 2016).

The inevitable rise of temperatures worldwide has lead and will continue to lead to a rise in heat waves. Its likely that humans have more than doubled the probability of occurrence heat waves in some locations
Drought is another serious issue. Due to climate change, water availability is becoming less predictable in many places and increased floods threaten to destroy water access point, sanitations facilities leading to contaminated water sources. Over 80% of the world's population already experiences a serious threat to their water security (IPCC, ch.3). Higher temperatures and more extreme, less predictable, weather conditions are projected to affect availability and distribution of rainfall, snowmelt, river flows and groundwater, and further deteriorate water quality. Low-income communities, who are already the most vulnerable to any threats to water supply are likely to be worst affected. Changes in water availability will also impact health and food security and have already proven to trigger refugee dynamics and political instability. (UNwater.org)

Background

As recently as 10 years ago scientists were unable to confidently connect extreme weather events and climate change, but advancements in modeling have allowed us to make more attributions in recent years (Stott, 2016). This is a relatively new area of science called event attribution (NASEM, 2016). Some events like extreme precipitation in Western Europe in spring of 2013 can be excluded from a result of climate change, while others like the hottest summer in eastern China in 2013 can be attributed to have been much more likely because of climate change (Stott, 2016). Extreem rainfall events are more difficult to model and blame on climate change (Stott, 2016).

It us likely that in the early 21st century we will feel increases in warm days and nights, more heavy precipitation events and increased sea level rise. By the late 21st century, its is virtually certain that warmer days will be more frequent, cold days less frequent, very likely to have increased heavy precipitation events, likely increases in intensity and duration of drought, more likely than not that tropical cyclones (hurricanes will increase in intensity) (IPCC AR5).

Since the 1980s, extreme one day precipitatione vents have significantly increased (Gouda et al., 2018)

When it comes to tornadoes, hail and thunderstorms, models have difficulties in predicting changes with such regional storm events.

Further Reading

Explaining Extreme Events from a Climate Perspective
https://www.ametsoc.org/index.cfm/ams/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-from-a-climate-perspective/

On this website, you can see what the climate of major cities in USA and Canada will be like in 70 years if emissions rates remain the same.
https://fitzlab.shinyapps.io/cityapp/

Sources

Gowda, P., J.L. Steiner, C. Olson, M. Boggess, T. Farrigan, and M.A. Grusak, 2018: Agriculture and Rural Communities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. doi: 10.7930/NCA4.2018.CH10

National Academies of Sciences, Engineering, and Medicine. (2016). *Attribution of extreme weather events in the context of climate change*. National Academies Press.

Stott, P. (2016). How climate change affects extreme weather events. *Science*, *352*(6293), 1517-1518.

Walsh, K.J., McBride, J.L., Klotzbach, P.J., Balachandran, S., Camargo, S.J., Holland, G., Knutson, T.R., Kossin, J.P., Lee, T.-c., Sobel, A. and Sugi, M. (2016), Tropical cyclones and climate change. WIREs Clim Change, 7: 65-89. doi:10.1002/wcc.371

34. IH 400 Question: How will climate change affect food in Canada?

Which of the following is false concerning how climate change will likely affect food in Canada?

A. The Crop yields of farms will increase in Canada
B. Cows will produce more milk
C. Fruits and veggies will have less nutritional value
D. Exotic fruits will be less available

35. IH 400 Answer

B. Cows will NOT produce more milk

Cows are susceptible to heat stress and they produce less milk when temperatures are too high, leading to large economic losses for producers (Gowda et al., 2018)

Average yields of many commodity crops (rice, corn, soybean, wheat) decrease at certain temperature thresholds. However in some regions crops such as wheat will increase because of changes in precipitation and carbon fertilization. The timing change of pollinators and plants will also affect yields. Increased temperatures will also increase the competitiveness of weeds relative to crops (Gowda et al., 2018)

There are climate-smart agriculture systems with irrigation technology, developing stress-tolerant plant varieties and other farming practices (Gowda et al., 2018).

technological improvements have outweighed the aggregate negative impacts of climate to date, projected climate change indicates that U.S. agriculture TFP could drop to pre-1980s levels by 2050 (Ray et al. 2015)24

Novick et al. (2016)243 indicate that atmospheric vapor pressure deficits play a critical role in plant function and productivity and that it will become more important at higher temperatures as an independent factor, relative to available soil moisture. For instance, high temperature has been documented to decrease yields of major crops, including wheat, corn, rice, and soybean.92,113,120,244

For wheat, but less so for corn, impacts of exposure to extremely high temperatures would be partially offset by carbon dioxide fertilization effects. Tack et al. (2015)248

There is considerable uncertainty in what is expected for the frequency and severity of future droughts.260 The applied global cli-mate models project 50%–200% increases in agricultural drought frequency in this century, even under low forcing scenarios.
There is uncertainty about the interactive effects of carbon dioxide concentration, temperature, and water availability on plant physiological response

Soil carbon on agricultural lands is decreased due to land-use change and till-age,268,269 resulting in decreased hydrologic function.101

Rosenzweig et al. (2014)241 indicated strong negative effects of climate change on crop yields, particularly at higher levels of warming and lower latitudes.

Climate controls our food systems. As it changes so will our agriculture. Agriculture will be affected by changes in rain patterns, high frequency of heat waves and drought, and changing insect populations. Several areas in the North will have an increase in their food production if global temperatures rise slightly (1-3C) because of increased livestock productivity, favorable rainfall and longer growing season (Dire Predictions). But most of the world will have less food as populations grow and temperatures rise, food systems will be disrupted and we will be forced to adapt.

Northern nations import much of their food from agriculture closer to the equator, so we will all be affected.

and those sources will be threatened changes in average temperatures, rainfall, most drastic in desertification, already affecting a lot of agricultural zones around the world as well as climate extremes (e.g., heat waves) changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods; changes in sea level

Positively managing soils in an organic way that's less industrial can actually absorb carbon in the atmosphere. SO by supporting organic farming you are helping change the way farming is done for the better.

Background

In bread basket areas of the world like California, South Asia, Australia Brazil and South east asia, will be threatened by substantial crop losses. Places that depend on glacial water around the Andes mountains in SOtuh America and Himalays in Asia will suffer water shortages once the glaciers melt. In parts of the USA, corn yields are expected to drop by up to 25%

A longer growing season and projected increases in CO_2 may enhance crop yields in northern growing areas. Major factors in these scenarios analyzes are increased drought tendencies and more extreme weather events, both of which are detrimental to agriculture. (Motha and Baier, 2005)

Cow milk production is expected to decrease by over 3% by 2030 in parts of the southern US, and will continue to decline

This slide and explanation is mainly from the map paper on this slide. There is also a paper online (if you can't find it, let me know and I'll see what I can do) that talks about how Canada will produce LESS food because the Canadian prairies have so much farm land and they are predicted to become way drier. So then when I gave the presentation, I would talk about the uncertainty of climate change and although since in this paper (on the slide) Canada is "green" that's not 100%. There are many sources on heat stress of cattle and producing less, I've seen them in IPCC reports and online. There's a good one done in Jamaica. Also, plants having less nutritional value has some controversial sources. See what you can find! It's a fascinating topic and from what I've seen, there is at least one experiment that's shown it.*

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0217148
https://cpree.princeton.edu/news/land-use-critical-food-security-warming-planet
https://www.globalagriculture.org/report-topics/adaptation-to-climate-change.html?key=0
file:///C:/Users/Linda/AppData/Local/Temp/Motha-Baier2005_Article_ImpactsOfPresentAndFutureClima.pdf
https://link.springer.com/article/10.1007/s10584-005-5940-1

Source

Mann, M. E., and Kump, L. R. (2015). *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House

Gowda, P., J.L. Steiner, C. Olson, M. Boggess, T. Farrigan, and M.A. Grusak, 2018: Agriculture and Rural Com-munities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. doi: 10.7930/NCA4.2018.CH10

Map:
https://www.globalagriculture.org/fileadmin/_processed_/csm_Yields2050withouttitle_7e049f4a02.jpg

Further Reading

How Climate Change Will Affect Dairy Cows and Milk Production
http://theconversation.com/how-climate-change-will-affect-dairy-cows-and-milk-production-in-the-uk-new-study-101843

Agriculture Adaptation to Climate Change
Ray DK, West PC, Clark M, Gerber JS, Prishchepov AV, Chatterjee S (2019) Climate change has likely already affected global food production. PLoS ONE 14(5): e0217148. https://doi.org/10.1371/journal.pone.0217148

36. IH 500 Question: How and why example feeling affects?

Describe how and why one of these places in Canada is feeling the effects of climate change? Yukon, Prince Edward Island, Alberta & BC, or Southern Quebec

37. IH 500 Answer

Lennox Island, Prince Edward Island
Lennox Island is expected to be one of the first Canadian communities requiring relocation due to climate change. The island is home to almost 500 people, but the rock that makes the island is weak. At the going rate, scientists estimate half the island could disappear in 50 years.
Lennox Island is a small Mi'kmaq reserve that approx. 470 people of the Lennox Island First Nation call home.
The geology of Lennox Island mainly consists of a distinctive red-colored sandstone which is an easily erodible bedrock (Coldwater Consulting Ltd., 2011). This erosive sandstone increases the islands vulnerability to environmental threats that are being exacerbated by climate change, such as saltwater intrusion (Charles et al. 2012).
Other environmental threats include **sea-level rise, erosion and storm intensification** (ParCa, 2016). Erosion is causing the islands coastline to recede, which is gradually encroaching inland towards the islands historic church, residential housing, traditional pow wow grounds, cemetery and archaeological sites (Majeed, 2015).

https://www.cbc.ca/radio/day6/facing-the-change-5-canadian-communities-threatened-by-climate-change-now-1.4447042

Brooks, Hariana S. 2018. "CLIMATE MIGRATION IN CANADA: A CASE STUDY OF LENNOX ISLAND, PEI," 57.

2. Old Crow, Yukon
Old Crow, is a small fly-in community in the northwest corner of the Yukon territory.
Earlier this April (2019) the community declared a state of emergency as the effects climate change is affecting the community's traditional ways of life.
Rapidly rising temperatures in the (twice the rate of increased temperature in southern Canada) is making it difficult for the community to safely build the winter roads they rely on for access to their traditional hunting and fishing grounds.

Recent studies have found that the northern coast of North America has experienced some of the most rapid climate changes on our planet and predominantly Indigenous communities in

the Arctic region are now dealing with the **melting of permafrost, coastal erosion, and unpredictable weather** (Lemmen et al. 2016).
(Box et al. 2019)

3. Sainte-Marie, Quebec (many more towns in the Pontiac, Rigaud ect…)

Flooding from the spring thaw and rain has affected more than 2,300 homes in Quebec just outside Montreal, and 1,500 residents have been evacuated, according to the latest numbers by Urgence Québec. The increase in extreme rainfall events was predicted over 30 years ago for this area.
Sudden waves of warm weather followed by quick drops in temperatures increase the risk of ice accumulating on the rivers in the winter, he said. The ice jams act as a dam, holding back water, and when the ice begins to melt and move, the dam bursts.
The Ottawa River causes this flooding and is managed by many dams and lack of coordination, intense rainfall events and ice jams increase risk of flooding
Flooding is going to be a major challenge for Canada due to climate change

https://www.theglobeandmail.com/news/national/anatomy-of-a-deluge-are-the-quebec-floods-a-sign-of-things-to-come/article34953478/

Forests across Canada

University of Alberta professor Mike Flannigan, said the extended wildfire season, which used to start April 1 and now officially starts on March 1, and that he and his colleagues "attribute that to human-caused climate change."[49] The *Calgary Herald* reported that because of climate change, in the coming years, the prairie provinces would "see a longer fire season, more frequent wildfires, heat and drought."[44]

*** This question is pretty straight forward, we will need good explanations on each place.***

Personal Solutions (PS)

IN this section, it is important for the educator to frame the solutions in a way that subverts feelings of guilt and apathy, emphasizing the importance of an individual in playing a role to push culture towards one more conscious and respectful of the natural world. The effects on greenhouse gases resulting from the pandemic showed that even if individuals radically changed their lifestyles, driving around and shopping significantly less, co2 emissions were reduced only by 4-7% for the whole year. Greater systemic changes are fundamentally needed. Regardless, a person can still significantly reduce their personal impact on the environment while maintaining their quality of life. In doing so, we can make people around us reflect on their role and push culture in the direction needed that may facilitate larger scale changes.

38. PS 100 Question: Which food is the biggest contributor?

Which of the following foods is the biggest contributor to climate change?

1. Beef/Lamb
2. Cheese
3. Poultry
4. Tuna
5. Eggs
6. Beans and Tofu

Get 20 Points per right answer

39. PS 100 Answer

The Short Answer

1. Beef/Lamb
2. Cheese
3. Poultry
4. Tuna
5. Eggs
6. Beans and Tofu

Reducing red meat from your diet and replacing it with proteins like beans, tofu, eggs and chicken is a great way to reduce your carbon footprint. For an average student, removing just red meat from your diet can reduce your personal carbon foot print by about 15% or even 36% in the UK (Pledge to Lead, 2021; Macdiarmid et al. 2012). A plant based diet, in which the vast majority of your protein comes from beans, tofu, nuts and grains would reduce your emissions even more. For perspective, eating a serving of red meat is like driving 21 km, eggs is like driving 3.5 km and beans and tofu are like driving less than half a km (Clean Metrics 2011).

There are two obvious ways to understand why eating less meat has a lower impact. Animal protein requires two steps: grow plant protein, then raise animals with that food. By eating plant protein we are skipping the whole second step which has high emissions associated to it. That's not to mention the water use, water pollution and ethical issues avoided with plant based proteins (Westhoek et al. 2014). The second reason is that red meat from cows and lambs have especially strong effect in global warming because of the methane emitted by their special digestive systems and the nitrous oxide in their manure (EWG 2011). Cheese has high emissions because of the large amounts of milk are needed for one block of cheese (1kg of cheese = ~9kg of milk) (EWG 2011).

Keep in mind eating locally has a significant impact on the emissions of products. Eating cheese from you region versus cheese imported from across the ocean can make a 50% difference in the emissions of that food (EWG 2011). As for fish, different fish have different emissions because of where they come from and how they are harvested and processed.

Food waste is a very important factor in emissions as well. A year of zero food waste in the United States would be as effective as removing 33 million cars off the road for the same year (Heller and Keoleian, 2015).

Background

Worldwide, industrial agriculture emits around 15% of greenhouse gas emissions, about 60% of which is from cattle (Gerber et al. 2015; Drewnowski et al. 2015). The emissions are lower in highly developed countries like Canada (10%) because of more efficient practices and technology in the industry (Canada site; Gill et al. 2010). Less-developed nations can improve their cattle's carbon emissions by certain feeding and breeding practices and better manure management (Gerber et al. 2015).

In a CBC interview, Professor Derek Gladwin of UBC stated that change in Canada may face challenges in converting to a more plant-based diet because "The meat industry is one of the largest sectors of the Canadian economy and it retains strong social influence on politics, marketing, media and education more generally." Despite this, it public surveys, market directions and even the Canada Food Guide is heading in this direction (see CBC article). We are heading in the right direction: meat consumption by Canadians has reduced by half in the past 40 years (TUAC 2010).

The impact of diet change on GHG emissions varies significantly by geography. In the best case scenarios, if everybody moved to healthy plant based diets we can reduce the GHGs of our food by 70% (as a result of using less land and animals) and will also reduce our water use in agriculture by 50% (Aleksandrowicz et al., 2016). In some regions, raising of livestock regions allows humans to derive nutritional benefit from non-arable land, or to utilize crop residues and food waste, avoiding the need to import large amounts of food and increase their emissions that way (Alesandrowicz et al 2016)

Remember that not to focus solely of the carbon footprint of diet. We must balance health, environment, personal needs and ethics. For example, a free range organic chicken egg may have slightly higher emissions than a confined chicken egg (EWG 2011), but in this case the organic egg is more nutritional -higher levels of omega 3 fatty acids, vitamin D and E- and more ethical (Karsten et al., 2010). Organic food is more carbon intensive in some cases (Venkat, 2012). Health has to be taken in to account, because one of the lowest footprint diets would be exclusively candy and pastries (Drenowski et al. 2015). Plant based proteins tend to be less energy dense, however even when we accommodate for this factor, they emit significantly less GHGs (Reynolds et al. 2015)

Local beef vs tropical fruit?
According to a study performed on food consumption in Sweden, the greenhouse gas emissions from eating tropical fruit flown overseas is 15% greater than eating domestic pork, it is 23% greater than eating domestic cod, 61% greater than eating domestic chicken, and 86% greater than eating domestic Herring (Carlsson-Kanyama & González 2009). This study concludes that the ultimate protein-diet in terms of the lowest GHG emissions is the mix of cereals, legumes and fish (Carlsson-Kanyama & González 2009).

Where Do the Emissions Come From?
Most of foods emission come from the production, not the transportation and storage, with exception to food flown by plane (Aleksandrowicz et al. 2016) The high emissions of meat and dairy products are produced through a variety of factors, including energy use (which often requires fossil fuels) and methane from the animals themselves. Grass eating animals are particularly resource heavy. While the water consumption needed to make a 1 hamburger over 1500 L of water to make, the water consumption for many plant based proteins like chickpeas and lentils are about the same so it is not the best argument to make Emissions from fertilizer and pesticide production are substantial because they are formed primarily using natural gas. Using organic fertilizers and regenerative agricultural practices can reduce emissions (EWG 2011). Enteric fermentation is the digestive process in cattle and goats that lead to high methane emissions

"Broadly, the livestock themselves result in emissions of methane (CH_4) and nitrous oxide (N_2O) from their manures, and further methane from digestion of ruminants (grass eating animals). Further GHGs associated with, but not directly emitted by, animal production include the loss of nitrous oxide from fertilizer application to grow their feed, carbon dioxide (CO_2) emissions from the conversion of land for pasture or feed production, and CO_2 emissions resulting from fossil fuel based energy generation, for example in tractor fuels or the manufacture of fertilizers (in addition to by-product CO_2 also formed in fertilizer production, Dawson and Hilton, 2011)."

Average Quebec Student Carbon Footprint (Pledge to Lead)
Red meat omnivore -> ~50%
Non Red meat omnivore- > ~35%
Vegetarian -> ~33%
Vegan -> ~31%

Facts
- A quarter of land worldwide is used for livestock grazing (FAO, 2008)
- A third of farm land is used to grow food for animals

• Nearly 40% of methane gas emissions comes from farm animals
• Methane is 70 times worse than carbon dioxide in global warming impact
• 50 billion animals are raised each year rather than the first estimate of 20 billion
• Further emissions from cooking, storage, waste disposal and packaging.

(http://www.worldwatch.org/files/pdf/Livestock%20and%20Climate%20Change.pdf)

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"Livestock production carries the greatest environmental burden and nutritionally it is disproportionately higher than for the amount of nutrients derived from other food commodities.

Intensive industrial systems can have a lower GHGE than extensive systems as the livestock are reared faster and slaughtered earlier, hence less methane is produced overall but they require more land to produce animal feed and there can be concerns about animal welfare. A holistic approach is needed rather than focusing on a single outcome. A recent study proposed that in the USA the demand for beef could not be met from a purely grass-fed system, as yields would be too low(14) Intensive industrial systems can have a lower GHGE than extensive systems as the livestock are reared faster and slaughtered earlier, hence less methane is produced overall but they require more land to produce animal feed and there can be concerns about animal welfare. A holistic approach is needed rather than focusing on a single outcome. A recent study proposed that in the USA the demand for beef could not be met from a purely grass-fed system, as yields would be too low(14)" (Macdiarmid and Whybrow 2018)

Further Reading
https://www.ewg.org/meateatersguide/a-meat-eaters-guide-to-climate-change-health-what-you-eat-matters/climate-and-environmental-impacts/

http://www.fao.org/news/story/en/item/197623/icode/

(French)
http://www.tuac.ca/index.php?option=com_content&view=article&id=2441:en-chiffres-le-secteur-de-lelevage-bovin-au-canada&catid=179:directions-1130&Itemid=6&lang=fr

https://cdn.theatlantic.com/static/mt/assets/food/brochure6a.png

https://www.cbc.ca/news/technology/what-on-earth-newsletter-e-waste-elizabeth-may-1.5104341?cmp=newsletter_What%20on%20Earth_2896_229486

https://www.agr.gc.ca/eng/agriculture-and-the-environment/agricultural-practices/climate-change-and-agriculture/greenhouse-gases-and-agriculture/?id=1329321969842

https://www.huffpost.com/entry/best-and-worst-proteins-health-environment_b_903613

Sources

Graphic : https://cdn.theatlantic.com/static/mt/assets/food/brochure6a.png

Aleksandrowicz, L., Green, R., Joy, E. J., Smith, P., & Haines, A. (2016). The impacts of dietary change on greenhouse gas emissions, land use, water use, and health: a systematic review. *Plos One*, *11*(11), 0165797. https://doi.org/10.1371/journal.pone.0165797

Annika Carlsson-Kanyama, Alejandro D González, Potential contributions of food consumption patterns to climate change, *The American Journal of Clinical Nutrition*, Volume 89, Issue 5, May 2009, Pages 1704S–1709S, https://doi.org/10.3945/ajcn.2009.26736AA

Drewnowski, A., Rehm, C. D., Martin, A., Verger, E. O., Voinnesson, M., & Imbert, P. (2015). Energy and nutrient density of foods in relation to their carbon footprint. *The American journal of clinical nutrition*, *101*(1), 184-191.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome

Karsten, H., Patterson, P., Stout, R., & Crews, G. (2010). Vitamins A, E and fatty acid composition of the eggs of caged hens and pastured hens. *Renewable Agriculture and Food Systems, 25*(1), 45-54. doi:10.1017/S174217050999021

Kebreab, E., Clark, K., Wagner-Riddle, C., & France, J. (2006). Methane and nitrous oxide emissions from Canadian animal agriculture: A review. *Canadian Journal of Animal Science*, *86*(2), 135-157.

Macdiarmid, J. I., Kyle, J., Horgan, G. W., Loe, J., Fyfe, C., Johnstone, A., & McNeill, G. (2012). Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by

eating a healthy diet? *The American Journal of Clinical Nutrition*, *96*(3), 632–9. https://doi.org/10.3945/ajcn.112.038729

Macdiarmid, J. I., & Whybrow, S. (2019). Nutrition from a climate change perspective. *Proceedings of the Nutrition Society*.

Reynolds, C., Macdiarmid, J., Whybrow, S., Horgan, G., & Kyle, J. (2015). Greenhouse gas emissions associated with sustainable diets in relation to climate change and health. *Proceedings of the Nutrition Society, 74*(OCE5), E351. doi:10.1017/S0029665115003985

Venkat, K. (2012) Comparison of Twelve Organic and Conventional FarmingSystems: A Life Cycle Greenhouse Gas Emissions Perspective, *Journal of Sustainable Agriculture*, 36:6,620-649

Westhoek H, Lesschen JP, Rood T, Wagner S, De Marco A, Murphy-Bokern D, et al. 2014Food choices, health and environment: Effects of cutting Europe's meat and dairy intake. Global Environmental Change.;26(1):196–205.

40. PS 200 Question: Electric vehicles emit more?

What is the only situation where electric vehicles emit more greenhouse gas emission than a gas-powered vehicle?

41. PS 200 Answer

Electric cars are always better than gasoline cars except when the electricity for charging is produced by burning **the dirtiest fossil fuels.**

This graphic shows that manufacturing of the car battery causes Electric car manufacturing to emit almost as twice GHG as a gasoline car, at the day of purchase. However over its lifetime, an EV in the majority of locations, will emit much less CO2 than even the equivalent gasoline cars (2). If its powered by renewables it emits about a third of a gas cars emissions. Even in a powergrid powered 80% by fossil fuels, it emits about 15% less.

This is just another reason to convert to renewable energy more quickly. Additionally, EVs reduce urban pollution and the associated health problems.

But its important to remember that the best mode of transportation for environmental impact is always active transportation (walking, cycling) or public transit.

Background:
The calculation gets bit more complicated with hybrids (4): In places that rely heavily on coal power plants like the American midwest, hybrids emit less than an EV. The increasing efficiency in EV manufacturing and EV battery recycling and the increasing proportion of renewable energy across the world means EVs will only keep getting cleaner with time (1).

Even though they don't have batteries, conventional automobiles can contain plenty of the same problematic rare metals that electric cars do. (3)

New car batteries are expected to last beyond the life of the car.
95% of the metals used in car batteries can be reclaimed and recycled
In Québec, with more than 99% renewable electricity, electric cars pollute about 3 times less than a gasoline car over their lifetime. In India, electric cars pollute more than gas cars because the electricity is produced with coal plants. In the Netherlands, even with an electricity grid powered by 82% fossil fuels (around 1/3 coal, 2/3 natural gas), an electric car is still emitting significantly less CO2 than a gasoline car (1).

SOURCES
1. Graphic
=https://thecorrespondent.com/7056/why-electric-cars-are-always-green-and-how-they-could-get-greener/741917761200-afaa6e5d
2.
https://www.ucsusa.org/clean-vehicles/electric-vehicles/life-cycle-ev-emissions#.Vv0_OhIrKRt
3. https://www.wired.com/2016/03/teslas-electric-cars-might-not-green-think/
4. https://www.scientificamerican.com/article/electric-cars-are-not-necessarily-clean/
https://www.nationalobserver.com/2019/12/05/analysis/tesla-cybertruck-carbon-crushes-ford-f-150

42. PS 300 Question: Effective way to reduce emissions?

What is the most effective way for an individual to reduce their personal carbon footprint?
A. Use less plastic

B. Stop Using A Car
C. Take one less atlantic flight a year
D. PLant based diet

43. PS 300 Answer

The Short Answer

Being mindful of transportation is key…
Car culture is not necessary
Using public transit, cycling and ground travel is by far the best way to reduce our carbon footprint. This means that living in a city allows much more opportunity for a smaller footprint because of access to good transportation infrastructure and proximity of destinations. The population of the world is becoming
Airplanes are big emitters. At any given moment there are somewhere between 8000 and 20000 airplanes in the sky. A single trip across the Atlantic can make up a large portion of your emissions for the year. Carbon offsets can be purchased, sometimes offered by airlines, where you can pay for trees to be planted to make up for your portion of the planes emissions. Its important to reflect on the necessity of your travel and whether you can vacation closer to home. Train is always better than airplane!

This is not to say you should never take an Atlantic flight or never take a car, or never eat meat. Be aware, and avoid them when you can. Climate change is a crisis of convenience. Its more convenient in the short term to abuse the planet… but we can only do that for so long.

Air travel is twice as polluting (CO2eq/km) as car travel.

Sources
https://www.theguardian.com/environment/blog/2010/sep/09/carbon-emissions-planes-shipping

Again this is according to one study, so you'd want to make that clear and bring in different studies. We left out the "having one less kid" part of this article because we are mostly presenting to younger kids and that's not really on their minds or a reasonable ask.

44. PS 400 Question: What can local governments do?

What can we pressure our local governments to do to address climate change?

45. PS 400 Answer

NEEDS WORK*

Green Renovation
Insolating attics and houses better for the winter in Canada

Large upfront costs so
Tax Incentives,, energy efficiency quotas, building codes. Improves air quality indoors and savings in heating/cooling costs
Impove Pubic Transport
Well thought out urban planning that facilitates bus routes, train routes.
More bike routes
Composting, recycling

Tree-planting and forest protection initiatives

Waste Management
https://archive.epa.gov/wastes/conserve/tools/payt/web/html/factfin.html

Really accentuate the fact that this is for LOCAL governments (so municipal). Try to give small description paragraphs and multiple references on each one. Want to add an aside to not talk about the electric car in different provinces or places yet (because of a different question in the game). There was a study that came out about how landfills release more methane than we originally thought because the food rotting in our garbage cannot biodegrade properly, I would add that study into that explanation! Talk about differences in public transport between cities and how younger people could incentivize their local governments.*

46. PS 500 Question: Action to reduce climate change?

How can we relate all these pictures to an important action to reduce climate change?

Image Sources: From left to right
https://commons.wikimedia.org/wiki/Category:Plastic_waste#/media/File:Plastic_Beach_-_geograph.org.uk_-_798998.jpg
https://www.flickr.com/photos/tabor-roeder/16735283478/in/photolist-cKaoWu-cpRWy7-5R2MpX-awUcoP-c57o9b-4K8FoG-oAJJDS-6FMThV-h11DWB-75vLXZ-ngfzfe-dYAEpa-4Xf2T-4Xf8k-4XfgL-6s1yae-5qcWT8-4tmF4z-4Xffi-9uJFxv-aNfzfz-4u2Mza-5qdqRX-57Mux3-FfARv-4Xfgd-4Xf6Q-9i9vTk-5APwSC-avCBnn-PxeQ3-NgVb7-7mK5K-6xukye-9nbQW7-4Xf5H-eh4Pd-4HBt7N-6k4wat-DrLTc-ruQGJj
https://commons.wikimedia.org/wiki/IPhone#/media/File:IPhone_8_plus_vector.svg
https://commons.wikimedia.org/wiki/File:Unicorn_Frappucino.jpeg
https://upload.wikimedia.org/wikipedia/commons/1/1b/Op%3DOp_Voordeelshop_shopping_bag_%282019%29_05.jpg

EWASTE
https://www.cbc.ca/news/technology/what-on-earth-newsletter-e-waste-elizabeth-may-1.5104341?cmp=newsletter_What%20on%20Earth_2896_229486

47. PS 500 Answer

Especially at a younger age, one of the best ways to control and reduce your carbon footprint, other than eating less meat, is to consume less products. Everything you buy has a trail of carbon behind it through the raw materials used, the method of production and the transportation involved to get it into your hands. Try to limit your purchases of things you know you don't need. Buy used when you can. Make your own plant-based food or bring re-usable containers when you don't.

The Myth of recycling…
In Canada, only about 9% of plastic is actually recycled. (1)
Avoid cheap products that are cheaply made and are bound to break. Do research and spend a bit more now on good quality products in order to save more in the long run and have less of an impact on the environment.

Clothing is a huge source of carbon emissions. The apparel industry accounts for 10% of global carbon emissions and remains the second largest industrial polluter, second only to oil.
When buying clothing, choose cotton. While it does use more land and water than plastic based clothing, it is more sustainable. Producing polyester (fossil fuel based clothing) releases two to three time more carbon emissions per kilogram than cotton, and washing polyester clothing results in microplastics in the water system eventually ending up in the ocean.

Resources:
1.https://publications.gc.ca/collections/collection_2019/eccc/En4-366-1-2019-eng.pdf
https://www.nationalobserver.com/2021/03/09/canada-drowning-plastic-waste-recycling-wont-save-us

https://www.wri.org/blog/2017/07/apparel-industrys-environmental-impact-6-graphics
https://www.unece.org/fileadmin/DAM/RCM_Website/RFSD_2018_Side_event_sustainable_fashion.pdf
https://www.forbes.com/sites/jamesconca/2015/12/03/making-climate-change-fashionable-the-garment-industry-takes-on-global-warming/#596521b879e4)
Check out the slow fashion movement
(https://www.npr.org/2015/04/24/401764329/slow-fashion-shows-consumers-what-its-made-of)

The production of electronics takes a lot of energy and minerals that can often come from mines that exploit workers. Take care of your electronics and keep them as long as possible.

Canadians emit 3 times the CO2 per person compared to the world other most developed countries, so we have work to do.

(https://www.theglobeandmail.com/canada/article-canada-found-to-produce-most-greenhouse-gas-emissions-per-person-among/)
Canadians produce 77kg of waste per person per year. Highest in the world.
Source of Infographic
https://www.ucsusa.org/global-warming/what-you-can-do/ten-personal-solutions-to.html

*** Maybe try to find a study in Canada if you can? This one is American, and if you can't that's ok. Just say that the American footprint is almost identical to the Canadian one. Want to talk about the supply chain, how mining things emits CO2, then driving those mined things to the factory emits CO2, then the factory process emits CO2, then the drive from the factory to the store emits CO2, then running the store does and you going to the store does, etc. So it really gets the person thinking about how everything they buy has this huge amount of CO2 attached to it.***

48. HIDDEN SLIDE
49. HIDDEN SLIDE
50. HIDDEN SLIDE

System Solutions (SS)

51. SS 100 Question: Predictor of individual carbon footprint?

What is the best predictor of an individual's carbon footprint?

The answer is income, people with more money have a bigger footprint. If living student lifestyle and no money, you're not so much of the problem. Rich people have the biggest carbon footprint.

52. SS 100 Answer

NEEDS WORK*

53. SS 200 Question: Time to cut global emissions in half?

According to the experts, how much time do we have to cut our global carbon emissions in half?

NEEDS ADDITIONAL INFO
Corporate accountability

***This question is confusing. Maybe it should say "According to the IPCC" instead of "experts"? This would give it more of a background of where the numbers are coming from. Or Maybe it should say something like "How much time do we have to cut our global carbon emissions in half before a potential point of no return?" I found that when I presented this question in classrooms that I really had to explain where the numbers were coming from. Also, it would make it better I think to have "C. Until 2050". I found people would guess 2030 cause it's an even decade number.

54. SS 200 Answer

NEEDS ADDITIONAL INFO

55. SS 300 Question: Most effective method of geoengineering?

Geoengineering means to use science to alter the environment.
What is currently the most effective way geoengineering can reduce climate change?

56. SS 300 Answer

Trees are a carbon sink. They breathe carbon dioxide, store it in their wood and leaves.

(also algae farms) (reforestation for previous forests; afforestation for previously non-forest).
We spend only 2% of climate change funding on natural solutions. We spend 1000x more on fossil fuel subsidies.
About 20% of global annual carbon emissions come from deforestation.
Forests absorb globally the equivalent of 30% of carbon emissions from fossil fuels.
Global potential of reforestation is about 5-10 years of current emissions (not peer reviewed study) (find better)

The average American emits 34 000 pounds per year… a person would need 500 trees a year to make up for all their carbon.

PROS: also contributes to biodiversity, air pollution reduction, economic activity if harvested
CONS: sequestration potential is limited to the forest reaching maturity (30ish years) if there is no harvesting. A constantly harvested forest is not equivalent to an old-growth forest in terms of ecological functions.

ECOSIA is a search engine, exactly like google. The difference is that the money from advertisements goes towards planting trees rather than into the pockets of one of the worlds largest companies. About every 45 searches, they are able to plant one tree.

For more info: https://www.youtube.com/watch?v=z1AVgbI_1r0
https://www.scientificamerican.com/article/massive-forest-restoration-could-greatly-slow-global-warming/

<u>The False Answers: (Source: Dire Predictions)</u>
Space mirrors: concept of deploying huge mirrors into orbit to reflect radiation from the sun before it hits earth. Has a very immediate effect on climate but how it will effect climate is unpredictable. Also, it does not help with ocean acidification and justifies the use of more fossil fuels.

Ocean fertilization : a huge carbon sink are plankton living on the top layer of the ocean. Their growth is limited by the amount of nutrients, especially iron, in the upper ocean layer. By adding iron in the ocean we can increase the amount of plankton and they will absorb more CO2. However, messing with complex ecosystems can cause unintended problems and we are unsure whether the carbon would fully be stored in the deep ocean as plankton die and sink or if the carbon will end up back in the atmosphere or upper ocean
https://en.wikipedia.org/wiki/List_of_climate_engineering_topics

Carbon capture and storage
Idea of capturing the carbon from burning fossil fuels before it escapes to the atmosphere, and injecting it back underground. We can also scrub the smokestacks of factories and do the same, Another method is to use artificial “trees” that suck carbon dioxide out of the atmosphere and transform it to be stored underground. This is all very expensive so far.

Half Earth Project
An important solution to many environmental and societal problems is to protect land and water. The famous environmentalist EO Wilson started a huge organization pushing the world to protect half of the planet's water and land from industrial development.
This helps with many issues including climate change, biodiversity loss, natural disasters, clean water and more.

https://www.half-earthproject.org/story/the-half-earth-project/

Video about natural solutions

http://newsletters.cbc.ca/c/11inOrF0bY8wy1hvBMUzd7xhsvk
http://newsletters.cbc.ca/c/11inOrQYe0qIAwbrQmvhoaIdiM7

57. SS 400 Answer

58. SS 400 Question: Subsidies to fossil fuel vs clean energy companies?

How much more money does the Canadian government give to help fossil fuel companies compared to clean energy companies?

A. 4x more
B. 9x more
C. About the same
D. 1.5x more

A. is correct.
The government does not say upfront what total subsidies are, but studies have shown that federal and provincial government collectively give well over 3 billion per year, based on a yearly average of subsidies from 2015-2018.

Imagine what we could do with all that money otherwise

Even with this unfair advantage given to fossil fuels, renewables like wind and solar are steadily growing in Canada and clean technology and clean energy sector already provides 1.5% of Canadas jobs, compared to oil and gas which only provide, while it is not clear, somewhere between 0.8% and 1.1% in direct jobs. (see energy factbook).

Renewable energy jobs are more bang for the governments buck too. For every billion dollars spent by the government in the fossil fuel industry, there are 4520 jobs, where as for renewable energy there are 10, 419 jobs per billion invested, and these jobs are more stable and clean.

Background:
There are no clear numbers on subsidies to renewables and cleantech either, but even if we go to the most fossil-fuel biased numbers, renewables are the better choice. According to a climate change denier website Friends of Science, with strong ties and funding from the fossil fuel industry, they found that from 2017 to 2021, the government will be spending about 800 million per year to subsidize renewable energy, so about the quarter of whats going to fossil fuels, and that is number that is likely exaggerated for their cause…

Also, clean tech companies are more locally owned, 86% of clean tech companies in Canada are owned by Canadians, whereas only 56% of fossil-fuel extraction related activities are Canada owned.

World wide, renewable enrgy employs more people than fossil fuels since 2016. So Canada is falling behind…|
Relative to our population size, the USA has created 2x more jobs in renewables
The demand for expensive alberta oil will reduce steadily as renewables are set to decrease in price by over 40% in the 20 years.

82% of electricity in Canada is from clean sources. The rest is coal and natural gas and oil.
This only includes electricity, our energy use in general is more dirty. (energy fact book page 86.)

"Every major industrial sector in Canada – from the aerospace industry to the oil sands – has gotten off the ground with support from the federal government. But in the clean-energy sector, the federal government is really missing in action.“
Source:
https://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/green-energy-sector-jobs-surpass-oil-sand-employment-total/article21859169/

Jobs in Oil
Canada-wide just over 1, 039, 000 fulltime jobs and will decline steadily in the future.
This is with 116.8 billion dollars in overall investment
That’s 8895.54 jobs per billion dollars
Alternatively, pro-fossil fuel site www.canadasoilsands.ca reports that there are 528,000 total indirect and direct jobs in fossil fuels in Canada… that’s 4520 jobs per billion invested.

Jobs in Clean Energy Sector
Over 298,000 full-time jobs in 2019, on track to employ over 559,000 by 2030
This is with 28.6 billion dollars in overall investment

That’s 10,419.58 jobs per billion dollars invested
AND
These jobs are more stable, secure, reduce pollution and better for our future,

While 50,000 jobs may be lost in fossil fuels, just over 160,000 will be created in clean energy—a net increase of 110,000 new jobs.
Also, 86% of clean tech companies in Canada are headquartered in Canada, where as only around 58% of oil related activities are owned by Canadians (page 21 and page 15 of Energy Fact book). So clean energy keeps more money in the Canadian economy.
The Clean Energy Canada report notes that much of the investment for Canada's clean-tech expansion currently comes outside the country. Of the five largest investors since 2009, just one, Manulife Financial Corp., is Canadian. Two Japanese companies are in that top-five list, along with two German banking groups.
Source:
https://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/green-energy-sector-jobs-surpass-oil-sand-employment-total/article21859169/

World wide, renewable enrgy employs more people than fossil fuels since 2016. So Canada is falling behind…|
Relative to our population size, the USA has created 2x more jobs in renewables
The demand for expensive alberta oil will reduce steadily as renewables are set to decrease in price by over 40% in the 20 years.
“If the world shifts to renewables without Canada in the game, the Great White North could find itself an importer of renewable energy technologies in the decades to come, even an importer of renewable energy itself — quite a shift for a country that not long ago aspired to “energy superpower” status.
According to BNEF, fossil fuels will attract US$2.1 trillion in investment between now and 2040. That's an impressive amount, until you see the forecast that renewables will see US$7.8 trillion in investment in that time — nearly four times as much.”
Source:
https://www.huffingtonpost.ca/2016/06/13/canada-oil-renewables-energy_n_10441636.html

Jobs section from:
https://cleanenergycanada.org/wp-content/uploads/2019/10/Report_TER2019_CleanJobsFuture_20191002_FINAL.pdf
https://www.canadasoilsands.ca/en/explore-topics/economic-contribution

Taxes from Fossil Fuels
Over the next 10 years, the oil sands industry is expected to pay an estimated $17 billion in provincial and federal taxes – including royalties (Canadian Oil Sands Supply Costs and Development Projects, 2019 - 2029, CERI).

Related links:
Renewable Subsidies in Canada:
https://blog.friendsofscience.org/2017/11/05/subsidies-to-solar-and-wind-energy-in-canada-an-inventory/

Fossil fuel subsidies in Canada:
https://www.iisd.org/faq/unpacking-canadas-fossil-fuel-subsidies/

Fossil fuel subsidies in the world:
https://www.theguardian.com/environment/2019/aug/01/fossil-fuel-subsidy-cash-pay-green-energy-transition
https://www.iisd.org/gsi/news-events/reforming-subsidies-could-help-pay-clean-energy-revolution-report

Federal Governments Energy Factbook:
https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/energy-factbook-oct2-2018%20(1).pdf
-seems purposely convoluted and confusing when trying to compare clean energy to fossil fuels

Friends of Science ties to fossil fuel industry: https://en.wikipedia.org/wiki/Friends_of_Science

Clean Jobs in Canada:
https://cleanenergycanada.org/wp-content/uploads/2019/10/Report_TER2019_CleanJobsFuture_20191002_FINAL.pdf

Clean Jobs Alberta:
https://www.cbc.ca/news/canada/calgary/alberta-renewables-wind-solar-jobs-energy-1.4385124
https://thenarwhal.ca/after-oil-and-gas-meet-alberta-workers-making-the-switch-to-solar/

Iron and Earth initiative: not for profit led by oilsand workers committed to incorportation more renewable energy projects into their work scope
“Canada’s energy industry stands at a crossroads. More than 100,000 workers have lost their jobs in the oil patch in the past three years1”
http://www.ironandearth.org/national_upskilling_initiative_petition

Energy Democracy:
https://www.tni.org/en/article/the-meaning-relevance-and-scope-of-energy-democracy

https://www.researchgate.net/publication/227421212_Local_impact_of_renewables_on_employment_Assessment_methodology_and_case_study

https://www.researchgate.net/publication/289844164_Analysis_on_Employment_Effects_of_the_Introduction_of_Renewable_Energy_Technologies_Using_an_Extended_Input-output_Table
https://www.researchgate.net/publication/316537826_Employment_effects_for_renewable_energy_industry_A_literature_review

Exxonmobil, the worlds biggest petro company invested 16 million dollars in fossil fuel denial groups a network of 43 advocacy organizations that seek to confuse the public on global warming science.
Many leading companies routinely market or brand themselves as being part of the climate solution, while actively working behind the scenes to undermine or limit the scope of climate policies and regulations—a tactic known as "greenwashing."
https://www.ucsusa.org/climate/disinformation

**** Would probably be beneficial to have a well-written definition of a subsidy.**

59. SS 500 Question: Sectors of the economy that have not reduced emissions?

What are the only parts of the Economy that have not reduced their carbon footprint in the last two decades?

A. Transportation, oil & gas, agriculture
B. Transportation, oil & gas
C. Transportation, oil & gas and waste
D. Waste & Heavy Industry

60. SS 500 Answer

The Short Answer

Fossil fuel related sectors are have not seen an improvement in the past 20 years, while most other sectors have significantly reduced emissions. Agriculture is an exception, with a slight increase in emissions.
Carbon Pricing is an important solution: big polluting companies pay more

Canada has implemented a price for carbon in 2019. Other nations outside of north america have carbon taxes way higher than in Canada and we have seen its effect on reducing emissions and pushing people to buy less gas guzzling cars and this had an effect on overall emissions of the country .1
Multiple academic studies show that carbon pricing *does* work, even at relatively low levels. Several of these studies have looked at the carbon tax in British Columbia, Canada, and shown

marked improvement in per capita fuel consumption and reduction in greenhouse gasses since the carbon price came in (Elgie and McClay [2013], Rivers and Schaufele [2012], Duke University [2015]). In addition, the performance of the province's economy has outpaced the Canadian average since the carbon price came in, further busting the myth of the "job-killing carbon tax." Facts are facts and the truth is that renewable energy is cheap and effective, and that carbon pricing is a smart way to control pollution and promote the shift to a strong, low-carbon economy.
Besides, saying we shouldn't implement a carbon tax just because it will only be a low rate and have a small *initial* impact is akin to saying "I have to train for a marathon, so there is no point in running a 5k." We have to start somewhere.

Background
"A carbon tax is just another tax on everything."
The misconception here is that a carbon tax will just make everything more expensive.
REALITY: The truth is that a carbon tax is a progressive tax, and an avoidable one at that. You can avoid or reduce paying a carbon price by driving less or buying a more fuel-efficient vehicle or keeping your thermostat at 19°C instead of 23°C.
In many jurisdictions, such as British Columbia and Alberta, residents have benefitted from associated tax rebates and reductions to the point that the average person actually pays *less* tax than they did before the carbon tax came into place, and, as mentioned above, they can now control how much they pay.
In British Columbia, the government lowered income tax rates to offset the impact of the carbon tax. You can avoid a carbon tax by buying less gasoline—you can't avoid paying your income tax. Finally, a carbon price also focuses on raising prices on things that are bad (pollution) and can make things that are good (income, jobs, renewable energy) more affordable, depending on how the revenue is spent.

Social cost of carbon: calculations show that we impose a cost to society every time we emmitt carbon that is not accounted for, which is why a carbon tax is important It forces big emitters to pay money for the damage they are doing by release CO2 into the atmosphere. So just like cigarettes have high taxes to offset the strain they put on the healthcare system by making people sick.

It will cost less for us to stop climate change from intensifying than it will to do very little now and adapt to the changes when they happen

"If the world shifts to renewables without Canada in the game, the Great White North could find itself an importer of renewable energy technologies in the decades to come, even an importer of renewable energy itself — quite a shift for a country that not long ago aspired to "energy superpower" status.
According to BNEF, fossil fuels will attract US$2.1 trillion in investment between now and 2040. That's an impressive amount, until you see the forecast that renewables will see US$7.8 trillion in investment in that time — nearly four times as much."

Source:
https://www.huffingtonpost.ca/2016/06/13/canada-oil-renewables-energy_n_10441636.html

“the energy-generating capacity of wind, solar, run-of-river hydro and biomass plants has expanded by 93 per cent since 2009, the report says.
The oil sands account for 11% of Canada’s total GHG emissions
https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/crude-oil-facts/20064#L2

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https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/crude-oil-facts/20064#L2

1.https://www.nationalobserver.com/2021/10/01/analysis/pricing-carbon-canadas-carbon-tax-vs-international-gas-taxes

61. HIDDEN SLIDE
62. HIDDEN SLIDE
63. HIDDEN SLIDE
64. HIDDEN SLIDE
65. HIDDEN SLIDE
66. HIDDEN SLIDE
67. HIDDEN SLIDE

68. The Climate Emergency Committee

Outro Based On these Vibes
https://www.youtube.com/watch?v=d9uTH0iprVQ

** Maybe talk about us a bit here**

VERSION FRANÇAISE ICI

1. Titre : Jeu Geopardy sur le climat

Durant la présentation du diaporama, les diapositives devraient d'abord avoir seulement un endroit sur lequel cliquer. Avant de cliquer, expliquer que le jeu requiert des équipes et que tout le monde doit former des groupes de quatre personnes (ou plus, s'il y a plus de 28 étudiants), choisir un nom et un numéro entre 150 et 300. Expliquez que le numéro qu'ils doivent deviner est le nombre d'entreprises qui ont accepté de faire la transition à l'énergie renouvelable à 100% d'ici 2050, dans le cadre du projet RE100. Parmi elles comptent notamment des multinationales telles que Ikea, Apple, General Motors, etc.

Pendant que les étudiants prennent leurs décisions, cliquer sur l'icône de curseur au milieu de l'écran, ce qui commencera la musique de Jeopardy et la (title sequence, vérifier le FR ici). Après le (title sequence[EB1]), les étudiants pourraient avoir besoin d'un peu plus de temps pour finaliser le nom de leur équipe et choisir leur numéro. Écrivez leur choix sur le tableau, en laissant de l'espace pour qu'ils puissent compter leurs points sous le nom de leur équipe une fois le jeu commencé. L'ordre des noms tel qu'il apparaît sur le tableau est important pour le fonctionnement du jeu.

La réponse à la question (le chiffre entre 150 et 300) est 204 entreprises. L'équipe qui a deviné le chiffre le plus proche de 204 commencera le jeu. L'ordre des équipes sur le tableau est celui qui sera utilisé pour déterminer le tour de chacun.

Ensuite, cliquez sur l'écran deux fois pour accéder au tableau des scores, et expliquez les règles.

Connaissances générales

Définir le climat

Le terme "climat" désigne les statistiques sur l'atmosphère couvrant une certaine période, généralement des décennies.

Selon Mark Twain :

« Climate is what you expect, weather is what you get. » (Le climat est ce que vous anticipez, les conditions météo ce que vous obtenez.)

Selon la American Meteorological Society

Le climat : Le climat désigne les changements progressifs du système atmosphérique, hydrosphérique, et géosphérique . Il est typiquement caractérisé en fonction de données qui s'appuient sur les tendances moyennes du système climatique sur une période d'un mois ou plus, en tenant compte de la variabilité des facteurs temporels.

Émissions de carbone par secteur

À l'échelle mondiale

https://www.visualcapitalist.com/a-global-breakdown-of-greenhouse-gas-emissions-by-sector/

L'agriculture, la foresterie et l'exploitation des terres 18,4 %

L'énergie liée aux transports 16,2 %

Industrie énergétique 24,2 %

Déchets 3,2 %

Procédés industriels 5,2%

Consommation d'énergie dans les bâtiments 17,5 %

Autre consommation d'énergie 15,3%

https://www.visualcapitalist.com/a-global-breakdown-of-greenhouse-gas-emissions-by-sector/

Canada

L'agriculture, la foresterie et l'exploitation des terres 10 %

L'énergie liée aux transports 23 %

Industrie énergétique 37 %

Déchets 7 %

Procédés industriels 11 %

Consommation d'énergie dans les bâtiments 12 %

Combustibles fossiles au Canada

Le Canada extrait environ 3,6 millions de barils de pétrole par jour, ce qui en fait le principal exporteur de pétrole des États-Unis et le septième plus grand producteur, d'après le U.S. Energy Information Administration.

L'industrie pétrolière du Canada contribue à en faire l'un des plus grands pays émetteurs de gaz à effet de serre par personne, parmi les pays riches de l'Organisation de coopération et de développement économiques.

- L'Alberta produit 80 % du pétrole canadien.

Source:https://www.huffingtonpost.ca/entry/albertas-oil-workers-are-shifting-to-renewable-energy-jobs_ca_5cd4f472e4b07bc729737788

Statistiques de 2017 sur l'industrie pétrolière au Canada

Les importations de pétrole : 0,6 millions de barils par jour) 65 % au États-Unis, 18 % en Arabie Saoudite, 5 % en Azerbaïjan, 3 % en Norvège, 2 % au Nigeria

Production pétrolière au Canada : 4,6 millions de barils par jour

Pétrole exporté du Canada : 3,7 millions de barils par jour

La statistique suivante porte à confusion : le pétrole brut livré aux raffineries canadiennes : 1,7 millions de barils par jour. Je ne sais pas trop comment inclure cette information, mais je pense qu'il s'agit d'une valeur appartenant à l'une des trois catégories précédentes.

D'après les statistiques ci-dessus, nous consommons 1,5 millions de barils par jour au Canada : 60 % est produit au Canada, 40 % est importé. De plus, 9,2 % du pétrole au Canada provient de pays dans lesquels les droits de la personne ne sont pas protégés, c'est-à-dire l'Arabie Saoudite, Azerbaïjan et le Nigeria.

Source:
https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/crude-oil-facts/20064#L2

Source de l'image :

Starry sky image: By Gemma Stiles from Sydney, Australia - Starry Sky, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=42074934

2. Tableau de questions – 5 catégories

INSTRUCTIONS ET RÈGLEMENTS DU JEU GEOPARDY

Instructions

Pour une utilisation optimale de ce PowerPoint, il est préférable d'utiliser la souris exclusivement pour progresser dans le jeu. Assurez-vous d'activer le mode Présentateur dans PowerPoint, afin que l'écran en face de vous affiche les notes et la prochaine diapositive, tandis que le projecteur n'affiche que la diapositive actuelle. Si vous ouvrez accidentellement la mauvaise diapositive, cliquez avec le bouton droit de la souris, déplacez la souris sur « By Title » et cliquez sur « diapositive 2 » ou « Slide 2 » pour revenir au tableau des questions.

Cette diapositive est le tableau des questions. Il est séparé en cinq sujets qui ont rapport avec la crise climatique, et chaque section a cinq questions avec une valeur de pointage en fonction du niveau de difficulté de la question. Lorsque c'est son tour, chaque équipe choisit un sujet et une valeur de pointage. En tant que présentateur, cliquez sur le nombre associé pour vous rendre à la diapositive qui contient la question. Quand la diapositive s'affiche, vous devez lire la question et les choix multiples, s'il y en a. Ensuite, démarrez le chronomètre de 30 secondes et jouez la musique de Jeopardy. Pour ce faire, cliquez deux fois sur la barre jaune en haut de la question. Le premier clic commence la musique, le deuxième clic commence la barre de chronométrage. Après 30 secondes, la musique de Jeopardy prendra fin. Avant que la musique s'interrompt, les équipes doivent discuter de leur réponse, car si l'équipe actuelle n'arrive pas à répondre correctement, la question sera posée à la prochaine équipe, pour la moitié des points, et ainsi de suite jusqu'à ce que toutes les équipes aient tenté leur chance (sauf si la question est à choix multiples, car dans ce cas, il ne restera qu'une seule réponse. Aucun point ne sera donné pour cette question). Quand le temps s'écoule, l'équipe actuelle donne sa réponse.

Lorsqu'une équipe donne une bonne réponse, ou qu'aucun groupe n'arrive à trouver la réponse, cliquez sur le point d'interrogation pour afficher la réponse. Après avoir lu la réponse et répondu aux questions des participants, cliquez sur l'icône de grille en bas à droite pour retourner au tableau des questions. Dans certains cas, un autre symbole sous la réponse vous mènera à une diapositive supplémentaire qui contient une question bonus ou une diapositive qui contient des renseignements supplémentaires.

Une fois que le tableau des questions s'affiche de nouveau, c'est le tour de la prochaine équipe.

N'oubliez pas :

Il est préférable d'être strict lorsqu'il s'agit d'accepter une réponse, sinon les étudiants deviennent frustrés et pensent que le jeu est injuste.

Le jeu peut être modifié et joué différemment selon les préférences de l'animateur. Les règles suivantes sont les plus organisées et celles qui fonctionnent le mieux d'après nos observations.

Les notes sous chaque diapositive (comme celle que vous lisez maintenant) vous aideront à expliquer une réponse pour animer une discussion, si vous le souhaitez.

*Pour les questions à choix multiples, l'équipe A a la première chance de choisir la bonne réponse, après quoi l'équipe B aura une deuxième chance.

**DES POINTS BONUS sont donnés à l'équipe qui répond correctement en premier.

Science climatique (SC)

3. SC 100 - Question : Quelles sont deux des principales sources de GES provenant de l'activité humaine?

Pouvez-vous nommer l'une des deux principales sources de GES provenant de l'activité humaine?

SC 100 - Quels sont les gaz à effet de serre (GES)?

La réponse courte

Notre atmosphère est composée de nombreux gaz, principalement le nitrogène (environ 78 %) et l'oxygène (environ 21 %). Les gaz à effet de serre constituent une quantité minime de l'atmosphère (moins de 1 %), mais ils ont un effet important sur la planète, car ils absorbent et captent la chaleur (Dessler 2016). On nomme ce phénomène « effet de serre ». On compte notamment les GES suivants : le dioxyde de carbone, le méthane et l'oxide nitreux. Nous parlerons plus tard de leur provenance.

La plupart des GES existent naturellement dans l'atmosphère terrestre, et ils ont fait en sorte que la planète soit assez chaude pour que la vie y soit possible. Cependant, à cause de l'activité humaine, la concentration de gaz à effets de serre augmente beaucoup plus vite qu'elle ne peut être absorbée par la planète, ce qui perturbe l'équilibre délicat des gaz dans l'atmosphère et la réchauffe et rend de nombreux écosystèmes vulnérables aux changements.

De retour à la question! Selon vous, quelle est l'une des principales sources de gaz à effet de serre?

Renseignements

L'effet de serre: Notre atmosphère est principalement transparente à la lumière émise par le soleil, mais pas à la radiation infrarouge qui provient de la Terre (Dessler, 2015). Lorsque les rayons visibles du soleil atteignent la surface de la planète, cette lumière est convertie en chaleur infrarouge, et est émise dans l'atmosphère. L'atmosphère est plus opaque aux infrarouges du spectre électromagnétique à cause de la forme moléculaire des GES. Conséquemment, la chaleur est absorbée et l'atmosphère se réchauffe

La vapeur d'eau est le gaz à effet de serre le plus abondant, mais presque entièrement d'origine naturelle. Elle provient principalement de l'évaporation des océans. Comme les êtres humains ont seulement une incidence indirecte sur la quantité de vapeur d'eau à cause des émissions de méthane, nos efforts ne sont pas orientés vers une réduction directe de la vapeur d'eau.

Le dioxyde de carbone (CO_2) est principalement émis lorsque l'on brûle des combustibles fossiles. Il constitue 0,04 % de notre atmosphère et la majorité des émissions de GES causées par les humains (Dessler 2015). Cependant, nous devons aussi sérieusement porter notre attention sur les autres GES parce qu'ils absorbent une quantité beaucoup plus élevée de chaleur que ne le fait le CO_2.

Le méthane (CH_4) est émis principalement par l'agriculture et la combustion des énergies fossiles. Le processus de digestion des animaux ruminants fait en sorte qu'ils libèrent du carbone dans l'atmosphère. Ce gaz est 2,5 fois plus abondant dans l'atmosphère qu'il ne l'était à l'époque préindustrielle (Montzka et coll. 2011) et les effets de ce GES sont 20 fois plus puissants que ceux du CO_2 (Dessler 2015). Ce gaz est émis naturellement par les feux de forêts, la fonte du pergélisol (à cause du réchauffement climatique), les zones humides, les anthropodes (termites), les océans, les rivières, les estuaires, et les lacs. Le gaz produit par les quatre derniers éléments mentionnés provient des microbes dans l'eau et des sédiments. On compte aussi une quantité importante de fuites de gaz causées par l'extraction de gaz naturel pour l'industrie de l'énergie et la riziculture.

L'oxide nitreux (N_2O) est un gaz produit naturellement dans l'atmosphère. On le désigne aussi sous le terme « gaz hilarant », utilisé par les dentistes pour les opérations (Desseler 2015). Plus de 60 % des émissions annuelles sont naturelles, émises par des microorganismes dans le sol et l'eau, et relâchées dans l'atmosphère. Les émissions causées par l'eau peuvent être considérées comme partiellement causées par les humains, car elles sont liées à la pollution produite par l'agriculture (Mann and Kump 2015).

L'ozone (O_3) est un GES qui se produit naturellement à de hauts niveaux dans l'atmosphère, où il protège la Terre contre les effets puissants des rayons ultraviolets du soleil. Proche de la surface de la Terre, c'est une composante importante du smog, en raison de la combustion des énergies fossiles (Dessler 2015)

Les halocarbures sont des gaz à effets de serre synthétiques utilisés pour la réfrigération, et sont aussi connus sous le nom de chlorofluorocarbones et hydrochlorofluorocarbones. Ils sont peu abondants comparativement au CO_2. Cependant, par molécule, leur effet est mille fois plus puissant que le CO_2. De nombreux halocarbures contribuent aussi à la destruction de la couche d'ozone qui nous protège du soleil.

Références

Dessler, Andrew. *Introduction to modern climate change*. Cambridge University Press, 2015.

Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015.

Montzka, S., Dlugokencky, E. & Butler, J. Non-CO_2 greenhouse gases and climate change. *Nature* 476, 43–50 (2011). https://doi.org/10.1038/nature10322

Pachauri, Rajendra K., and Andy Reisinger. "IPCC fourth assessment report." *IPCC, Geneva* 2007 (2007).

United States Environmental Protection Agency. *Methane and Nitrous Oxide Emissions From Natural Sources*. (2010).

4. SC 100 - Réponse:

A: Les combustibles fossiles et la transformation du sol

La réponse courte

Les deux principales façons dont nous émettons des gaz à effet de serre sont par la combustion des énergies fossiles et la transformation du sol (par exemple la déforestation et l'agriculture) Nous libérons ces gaz dans l'atmosphère tellement rapidement qu'ils ne peuvent pas tous être éliminés naturellement, par exemple par la photosynthèse, et cela mène à une quantité accrue de radiation dans l'atmosphère et au réchauffement de la planète.

Renseignements

Les combustibles fossiles sont le pétrole, le charbon et le gaz naturel, que l'on brûle principalement pour la production d'électricité et de chaleur, ainsi que pour le transport. Les combustibles fossiles libèrent trois importants gaz à effet de serre : le dioxyde de carbone (Co_2), le méthane (CH_4), et l'oxyde nitreux (NO_2).

Approximativement 85 % de la consommation d'énergie dans le monde provient de la combustion des énergies fossiles (EIA, 2017). Le reste provient de sources plus propres comme l'hydroélectricité, l'énergie solaire, l'énergie éolienne, et l'énergie nucléaire.

Pratiques agricoles et déforestation :

Pendant des centaines d'années, nous avons décimé les arbres, souvent pour remplacer les forêts par des terrains agricoles. En 1750, environ 7% de la planète était consacrée à l'agriculture, comparativement à plus de 33% en 1990 (Dessler 2015). Par conséquent, la capacité du sol à absorber le CO_2 a diminué, et une plus grande quantité de CO_2 est émise dans l'air. Les arbres et le sol absorbent et conservent le dioxyde de carbone. Une forêt qui a beaucoup d'arbres absorbe plus de carbone qu'un champ agricole. L'agriculture massive produit des émissions de gaz à effet de serre, car elle endommage le sol et entraîne l'utilisation d'engrais chimiques. De plus, les vaches et les moutons expulsent du méthane par leurs rots. Si le bétail formait une nation à lui seul, il serait le troisième plus important émetteur de gaz à effet de serre du monde (Mann et Kump 2015).

Ces deux sources sont responsables de 93 % des émissions de gaz à effet de serre : environ 67 % proviennent de la combustion des énergies fossiles et 26 % de la dégradation du sol (l'agriculture compte environ 14 %, et la destruction des forêts, 12 %) (CBO, 2005). Le montant restant provient de pratiques industrielles telles que la production du ciment et la gestion des déchets (lieux de décharge).

Références

Congressional Budget Office based on data from World Resources Institute, World Greenhouse Gas Emissions: 2005. Washington, D.C.: WRI, December 2005

Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015

Montzka, S., Dlugokencky, E. & Butler, J. Non-CO_2 greenhouse gases and climate change. *Nature* **476,** 43–50 (2011). https://doi.org/10.1038/nature10322

5. SC 100 - Question Bonus : Quels GES ne trouve-t-on pas dans la nature?

Quel est le gaz à effet de serre que nous émettons mais que l'on ne trouve pas dans la nature?

6. SC 100 – Réponse bonus

Réponse : le fluide frigorigène

7. SC 200 – Question : Pourquoi la fonte des glaciers est-elle importante?

Nommez une raison pour laquelle la fonte des glaciers est importante….

8. SC 200 – Réponse

L'élévation du niveau de la mer et/ou l'albédo

Réponse courte

Les glaciers sont des indicateurs importants des changements climatiques; le fait qu'ils fondent à une vitesse significative est un signal que de gros changements sont à prévoir. En plus de servir en quelque sorte de signal d'alarme, la fonte des glaciers nous rappelle deux facteurs très inquiétants :

Raison 1 : l'élévation du niveau de la mer

Si uniquement la couche de glace du Groenland fondait, le niveau de l'eau de l'océan monterait de 7,2 mètres (IPCC 2001). C'est sans compter le glacier de l'Antarctique, qui est beaucoup plus gros et qui est en train de fondre presque à la même vitesse que la couche de glace du Groenland. Si le glacier de l'Antarctique fondait, cela ajouterait 61 mètres au niveau de l'eau de l'océan (Dessler 2015). D'après le scénario le plus catastrophique, ce phénomène s'étendrait sur une période de 100 ans environ. Les actions que nous prendrons au cours de ce siècle auront des répercussions significatives sur la planète dans un avenir proche.

Raison 2 : L'albédo – La chaleur causée par la réflexion des rayons du soleil

La réponse courte

La surface blanche des immenses couches de glace reflète une grosse partie de l'énergie du soleil dans l'espace. Quand la glace fond, la surface sombre de l'océan et du sol sont exposées et elles absorbent et émettent plus de chaleur que ne l'aurait fait la glace, ce qui augmente le réchauffement (Dessler 2015, p.25, 26, 103).

Ce phénomène est d'une importance particulière dans l'hémisphère Nord, car à l'extérieur du Groenland, la plupart de la glace est de la glace marine, ce qui n'a pas d'incidence sur l'élévation du niveau de la mer (tout comme un verre plein d'eau avec un cube de glace ne déborde pas quand la glace fond), mais a une incidence sur la quantité d'énergie réfléchie vers l'espace.

Autres raisons possibles de l'importance de la fonte des couches de glace :

Conséquences sur le style de vie des Inuits, des ours polaires et des phoques, surtout en ce qui concerne la fonte de la glace marine (et non les glaces terrestres, telles que celles en Antarctique et au Groenland)

Références

Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp. [1], *"Archived copy"*. *Archived from the original on 2006-02-10. Retrieved 2006-02-10.*, and [2].

Church, J. A., and N. J. White, 2011:Sea-level rise from the late 19th to the early 21st century. *Surveys in Geophysics* **32** (4–5), 585–602 doi:10.1007/s10712-011-9119-1.

Kopp, R.E., Horton, R.M., Little, C.M., Mitrovica, J.X., Oppenheimer, M., Rasmussen, D.J., Strauss, B.H. and Tebaldi, C. (2014), Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. Earth's Future, 2: 383-406. https://doi.org/10.1002/2014EF000239

Neumann B, Vafeidis AT, Zimmermann J, Nicholls RJ (2015) Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment. PLOS ONE 10(3): e0118571. https://doi.org/10.1371/journal.pone.0118571

Sasgen, I., Wouters, B., Gardner, A.S. *et al.* Return to rapid ice loss in Greenland and record loss in 2019 detected by the GRACE-FO satellites. *Commun Earth Environ* **1,** 8 (2020). https://doi.org/10.1038/s43247-020-0010-1

Stone, E. J., Lunt, D. J., Annan, J. D. & Hargreaves, J. C. Quantification of the Greenland ice sheet contribution to Last Interglacial sea level rise. *Clim. Past* **9**, 621–639 (2013)

Pithan, F. & Mauritsen, T. Arctic amplification dominated by temperature feedbacks in contemporary climate models. *Nat. Geosci.* **7**, 181–184 (2014).

9. SC 200 – Question : Qu'est-ce que sont les rétroaction climatiques positives?

Les rétroactions climatiques positives : un enjeu climatique important

Lorsqu'un événement climatique se produit, il peut entraîner un changement qui l'amplifie, et il continuera alors de se produire de plus en plus violemment avec le temps. On appelle cela les rétroactions climatiques positives.

Le meilleur exemple pour illustrer ce phénomène est ce qui se produit avec les microphones sur la scène. Quand un microphone capte un son, le volume est augmenté par un amplificateur et émis par un haut-parleur. Si le microphone est trop proche du haut-parleur, il capte son propre son, ce qui provoquera une boucle de rétroaction et produira un son discordant.

La rétroaction glace-albédo est un exemple de ce processus que l'on trouve dans la nature. Lorsque la glace et la neige près des pôles fondent à cause du réchauffement climatique, la surface sombre qui est alors exposée absorbe plus de chaleur qu'avant, ce qui augmente le réchauffement et crée un cercle vicieux.

C'est pourquoi nous avons besoin d'agir immédiatement en ce qui concerne le climat. Il y a beaucoup d'incertitude au sujet des rétroactions climatiques positives, mais il est probable qu'elles seront fortement amplifiées par les changements climatiques, ce qui veut dire qu'une fois que des changements commencent à se produire, ils se reproduiront beaucoup plus rapidement.

Il existe aussi d'importantes rétroactions climatiques positives qui peuvent ralentir le processus du réchauffement climatique.

Beaucoup de plantes aiment la chaleur et les quantités de CO_2 plus élevées. Au fur et à mesure que le CO_2 augmente, ces plantes absorbent plus de GES, et ont un effet refroidissant. Cet effet n'est malheureusement pas assez puissant pour prévenir le réchauffement climatique causé par les êtres humains.

N'oubliez pas! Vous pouvez vous-même contribuer à une rétroaction climatique positive en prenant action, ce qui encouragera d'autres à vous suivre. Par exemple, le leadership de Greta Thunberg a poussé d'autres personnes à agir, et ces personnes ont elles-mêmes influencé d'autres, et ainsi de suite.

Lecture supplémentaire

https://politicalclimate.wordpress.com/tag/negative-feedback-loop/

10. SC 300 – Question : Quel phénomène naturel nous aide à comprendre le climat du passé?

Quel phénomène naturel nous aide à comprendre le climat du passé?

11. SC 300 – Réponse

E. Toutes ces réponses

La réponse courte

La nature nous offre une grande quantité de paléodonnées qui permettent aux scientifiques d'obtenir des renseignements sur le climat couvrant une longue période de l'histoire. Ces indicateurs climatiques portent le terme de **« proxies climatiques »**

Carottes glaciaires

Les carottes glaciaires, que l'on retrouve dans les calottes polaires composées de couches de glace successives formées année après année, contiennent des bulles d'airs et d'autres caractéristiques (poussière) qui nous permettent de rassembler des données sur le climat passé, il y a des milliers d'années. Une carotte de glace du Groenland, qui mesurait plus de 2 miles (1609 mètres) de long, a permis aux scientifiques de savoir quel était le climat dans les derniers 750 000 ans.

L'information obtenue des carottes de glace de l'Antarctique date d'il y a plus longtemps que 750 000 ans.

Pour en savoir plus (en anglais) :
https://earthobservatory.nasa.gov/features/Paleoclimatology_IceCores

Troncs d'arbres :

Les anneaux de croissance des troncs d'arbres permettent de retracer l'évolution du climat au fil du temps. Quand un arbre pousse, ses anneaux subissent les effets du climat pendant chaque saison. La pluie chaude et abondante crée des anneaux plus gros, alors que le froid et la sécheresse inhibent la croissance de l'arbre, produisant des anneaux plus étroits.

Pour en savoir plus :
https://www.climate.gov/news-features/blogs/beyond-data/how-tree-rings-tell-time-and-climate-history

Les récifs de coraux :

La température de l'eau a une incidence sur la croissance annuelle des coraux. Par exemple, le corail qui est formé pendant les années où l'eau est très froide sera moins volumineux. On utilise un outil à pointe en forme de diamant pour récolter les fragments de coraux.

Pour en savoir plus :
https://earthobservatory.nasa.gov/features/Paleoclimatology_CloseUp/paleoclimatology_closeup_2.php

Sédiments des lacs :

La boue dans le fond des lacs contient des couches de pollen qui se dispersent chaque année, provenant des plantes et des arbres environnants. Ces échantillons de pollen révèlent des renseignements à propos de la distribution de différentes espèces de plantes et le climat qui était favorable à cette végétation.

Pour en savoir plus : http://mitrie.badc.rl.ac.uk/documents/mitrie_sediment_lake.pdf

12. SC 300 : Graphique de la zone de température sécuritaire – température mondiale à long terme

Voici un graphique de la température à l'échelle mondiale, qui date d'aujourd'hui à 22,000 ans av. J.-C. Les données proviennent des archives sur le climat. La ligne qui traverse le graphique représente la température, et la barre rose est considérée comme la zone sécuritaire. Ce sont les températures auxquelles les êtres humains ont survécu. Notre température commence à dépasser légèrement la zone sécuritaire, et nous risquons de l'excéder bien plus si le réchauffement climatique continue comme il le fait actuellement.

On considère que l'une des premières « civilisations significatives » était celle des Sumériens, approximativement 3700 av. J.-C.

L'objectif des accords sur le climat est de s'assurer que la température mondiale ne dépasse pas 2 degrés Celsius. Même cette limite dépasse la température que les civilisations humaines ont connu dans le passé.

Références

Mann, Michael E., and Lee R. Kump. *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House, 2015.

13. SC 400 Question: Combien de CO_2 y a-t-il dans l'atmosphère?

Combien de CO_2 avons-nous mis dans l'atmosphère depuis 1870? (on utilise les éléphants comme unité de mesure)

14. SC 400 - Réponse :

D. Plus de 135 milliards d'éléphants

La réponse courte

En date de la fin de 2021, les êtres humains ont émis approximativement 2,384 billions de tonnes de CO_2 dans l'atmosphère (Climate Clock, 2020). Cette comparaison avec des éléphants nous aide à comprendre combien de carbone nous avons retiré de la Terre et émis dans l'atmosphère. Le fait d'émettre autant de carbone dans l'atmosphère entraînera forcément des changements….

Maintenant, à quoi ressemble cette quantité d'éléphants?

(Cliquer sur la flèche qui apparaît en bas à droite de la diapositive)

15. SC 500 – Question : Comment le réchauffement climatique peut-il rendre les tempêtes de neige plus violentes au Canada?

Comment le réchauffement climatique peut-il rendre les tempêtes de neige plus violentes au Canada?

16. SC 500 - Réponse

La réponse courte

L'air chaud contient plus d'humidité que l'air froid. Lorsque l'air se réchauffe, il y a une haute probabilité de neige.

Le réchauffement climatique fait en sorte que l'air se réchauffe durant l'hiver. L'air chaud contient plus d'humidité que l'air froid (c'est-à-dire l'humidité relative). C'est une loi de la physique.

Pour visualiser ce phénomène, imaginez les molécules comme un groupe de personnes : lorsqu'il fait chaud, elles gardent une distance physique entre elles, mais lorsqu'il fait froid, elles se blottissent les unes contre les autres pour se réchauffer. S'il y a plus d'espace entre ces personnes, la vapeur d'eau peut remplir cet espace.

En observant la rosée qui s'accumule sur les brins d'herbe la nuit, nous pouvons témoigner de ce changement de la capacité de l'air à préserver l'humidité. L'air devient plus froid, ce qui produit de l'eau sous forme de rosée.

L'air chaud contient beaucoup d'humidité en hiver, ce qui donne plus de neige qu'avant. Lorsque la température approche de zéro, l'air atteint alors la condition idéale pour accumuler de l'humidité, au même moment où il fait assez froid pour qu'il y ait de la neige plutôt que de la pluie.

Alors que les hivers se réchauffent, la température atteindra zéro degrés plus fréquemment qu'avant. Dans certaines régions, la possibilité de tempêtes de neige violentes peut être plus élevée qu'ailleurs, et la neige fond aussi plus rapidement (Barnett et al 2005).

En général, la neige s'accumule moins à chaque année, mais la probabilité de chutes de neige a augmenté (Akerlof et al, 2013).

Lecture supplémentaire

https://www.livescience.com/48874-warming-climate-produces-more-snow-storms.html

https://www.climate.gov/news-features/climate-qa/are-record-snowstorms-proof-global-warming-isn%E2%80%99t-happening

Références

Barnett, T., Adam, J. & Lettenmaier, D. Potential impacts of a warming climate on water availability in snow-dominated regions. *Nature* 438, 303–309 (2005). https://doi.org/10.1038/nature04141

Walsh, K.J., McBride, J.L., Klotzbach, P.J., Balachandran, S., Camargo, S.J., Holland, G., Knutson, T.R., Kossin, J.P., Lee, T.-c., Sobel, A. and Sugi, M. (2016), Tropical cyclones and climate change. WIREs Clim Change, 7: 65-89. doi:10.1002/wcc.371

Akerlof, K., Maibach, E.W., Fitzgerald, D., Cedeno A.Y., Neuman A. (2013). Do people "personally experience" global warming, and if so how, and does it matter? Global Environmental Change,23 (1), 81-91, https://doi.org/10.1016/j.gloenvcha.2012.07.006.

Incidence sur la nature (IN)

17. IN 100 – Question : Quel est le nombre estimé d'espèces en voie de disparition?

Quel est le nombre estimé d'espèces d'animaux qui disparaîtront à cause des changements climatiques?

1. **1%** **B. 3%** **C. 8%** **D. 20%**

18. IN 100 – Réponse

La réponse courte

On estime que 8 % des espèces dans le monde disparaîtront à cause des changements climatiques, car la température mondiale continue d'augmenter pour atteindre entre 2°C et 3°C depuis l'époque pré-industrielle (Urban, 2015). Au fur et à mesure que les températures mondiales deviennent plus chaudes, le risque d'extinction augmente également et s'accélère avec chaque degré (Urban, 2015).

Si nous faisions les changements nécessaires pour limiter la hausse de température à 2°C, approximativement 5,2 % des espèces seraient en voie de disparition (Urban, 2015). Cependant, si nous ne faisons pas de changements, le risque d'extinction sera de 16 %, ce qui représente 1 espèce sur 6 (Urban, 2015).

N'oubliez pas, les statistiques sur le risque d'extinction ne représentent que les espèces qui subissent les conséquences les plus graves. Cependant, le nombre total d'espèces qui subissent les effets du réchauffement climatique est beaucoup plus grand (Urban, 2015). La biodiversité (la variété et variabilité des êtres vivants) subira forcément les effets du réchauffement climatique dans la plupart des régions du monde.

19. IN 100: Pourquoi se préoccuper de la biodiversité?

La réponse courte

La biodiversité est importante pour plusieurs raisons. L'air, l'eau potable, la nourriture et la médecine existent grâce à un écosystème sain qui favorise la biodiversité. La plupart des animaux les plus impressionnants dépendent de la biodiversité pour leur survie. D'un point de vue plus anthropocentrique, il faut aussi considérer que la moitié des médicaments utilisés actuellement ont été découverts grâce aux produits naturels.

20. IN 200 - Question : De quelle façon le réchauffement climatique augmentera-t-il le risque de maladies au Canada?

De quelle façon le réchauffement climatique augmentera-t-il le risque de maladies au Canada?

21. IN 200 - Réponse

La réponse courte

Le climat exerce une influence directe sur les fluctuations de différentes maladies contagieuses, et la température a un effet sur la reproduction et la distribution d'insectes vecteurs de maladies comme les moustiques et les tiques. D'ici la fin du 21^{e} siècle, on s'attend à ce que le nombre de personnes exposées aux maladies transmises par les moustiques soit un milliard de plus qu'aujourd'hui. Au Canada, dans les régions au nord, on trouve de plus en plus de tiques qui sont des vecteurs de la maladie de Lyme.

(Cliquez sur le X rouge sur l'image de la tique)

Quand vous faites une randonnée dans la nature, assurez-vous toujours qu'il n'y a pas de tiques sur votre peau. Vous avez 24 heures avant qu'une tique ne vous transmette une maladie, alors inspectez toujours votre corps et prenez une douche après une randonnée dans un endroit où il risque d'y avoir des tiques.

22. IN 300 – Question : Quelle sera la réaction des plantes au réchauffement climatique en Amérique du Nord?

Au fil du temps, quelle sera la réaction des plantes au réchauffement climatique en Amérique du Nord?

Quelle sera l'une des répercussions de cette réaction sur les animaux?

23. IN 300 – Réponse

*Il faudra changer la diapositive pour qu'elle indique « Amérique du Nord » au lieu de « Canada ».

La réponse courte

En général, la végétation se propage au nord et au sommet des montagnes. Évidemment, les plantes ne peuvent pas se déplacer physiquement, mais elles peuvent se propager d'un endroit à l'autre au fil du temps, à cause des graines qui se déposent sur le sol dans différents environnements que la plante ne peut pas atteindre. Progressivement, cela perturbe les écosystèmes. Les plantes peuvent se propager rapidement dans de nouveaux environnements à cause du vent qui répand les graines. Les animaux, excepté les oiseaux, ont généralement plus de difficultés à s'adapter, car leur chemin est bloqué par les autoroutes et d'autres structures construites par les humains. Certains types de végétations essentiels à la survie de ces animaux n'existeront plus dans les régions où ceux-ci habitent.

Dans cette image représentant le sommet d'une montagne, nous voyons comment un écosystème peut disparaître à l'échelle locale. Au fur et à mesure que la température se réchauffe, les arbres vont commencer à pousser au-delà de la zone habituelle, envahissant le sommet de la montagne où il y avait peu d'arbres auparavant. Même si le sommet de la montagne a l'air d'une terre stérile, la toundra abrite des espèces rares de plantes et d'insectes, et ce type d'environnement est un habitat important pour les espèces en voie de disparition, comme le caribou (Rowland et al. 2016).

24. IN 400 - Question: pourquoi autant de récifs de coraux blanchissent et meurent?

Quelle est la raison pourquoi autant de récifs de coraux blanchissent et meurent?

La réponse courte

Le réchauffement et l'acidification de l'océan

Les océans absorbent 90 % de la chaleur excédentaire accumulée dans l'atmosphère en raison du réchauffement climatique (IPCC, 2007). Le réchauffement de l'océan est la raison principale pourquoi les récifs de coraux blanchissent et meurent. Ce phénomène se produit à cause de la relation symbiotique entre les algues et les coraux, qui sont dépendants l'un de l'autre pour survivre. Des algues de taille microscopique vivent à l'intérieur du corail pour se protéger, et en retour, elles nourrissent le corail grâce à la photosynthèse. Quand l'océan devient trop chaud, les algues migrent vers un environnement plus frais. Comme les coraux ne peuvent plus obtenir les nutriments dont ils ont besoin, ils blanchissent et deviennent vulnérables aux maladies (NOAA, 2020).

Bien que le réchauffement de la température de l'océan soit la cause principale du blanchissement des coraux, ce n'est pas la seule. La pollution, la surexposition aux rayons du soleil, et les raz de marées peuvent aussi en être la cause. Les coraux sont très vulnérables aux changements.

Nous devons prendre soin des récifs de coraux pour plusieurs raisons :

- Les récifs coralliens sont la source d'alimentation de dizaines de millions de personnes
- Les organismes qui vivent dans les récifs coralliens sont à l'origine de médicaments importants
- Les récifs-barrières protègent les communautés qui vivent sur la côte contre les tempêtes
- Plus d'un tier de la vie marine dépend des récifs de coraux

Lecture supplémentaire

https://www.worldatlas.com/articles/what-is-the-conservation-status-of-the-world-s-reef-building-corals.html

https://oceanservice.noaa.gov/facts/coral_bleach.html

Références

Bruckner, A., 2007. Life Saving Products from Coral Reefs. https://issues.org/p_bruckner/

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assess-ment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A.(eds.)]. IPCC, Geneva, Switzerland, 104 pp

For a related summary read:
https://archive.ipcc.ch/publications_and_data/ar4/wg1/en/ch5s5-2-2-3.html

NOAA, 2020. What is coral bleaching? National Ocean Service website, https://oceanservice.noaa.gov/facts/coral_bleach.html

25. IN 500 – Question : Quels sont les problèmes causés par la perturbation des saisons?

Les saisons subissent des changements à cause du réchauffement climatique, à un rythme plus rapide que jamais. Quelles seront les répercussions de ces changements sur les plantes et les animaux?

26. IN 500 – Réponse

La réponse courte

Les habitudes d'un grand nombre de plantes et d'animaux seront perturbées, et leur population risque de diminuer.

Les habitudes des plantes et des animaux sont étroitement liées au changement des saisons. À cause du réchauffement climatique, le printemps a commencé à se manifester jusqu'à 15 jours plus tôt dans certaines régions depuis les années 1970 (Pachauri et coll., 2007). L'automne se manifeste aussi plus tard qu'avant (Piao et coll., 2019). Nous constatons déjà que de nombreuses espèces de plantes et d'animaux s'adaptent de différentes façons (Root et coll., 2003). Si les animaux ne changent pas leurs habitudes pour s'adapter à ces perturbations saisonnières qui ont des effets dévastateurs au niveau écologique, ces espèces risquent de disparaître, localement ou même à l'échelle de la planète (Root et coll., 2003).

Nous pouvons observer un exemple de ce phénomène dans les interactions entre les chênes, les chenilles et les oiseaux chanteurs. Au printemps, les feuilles des chênes commencent à pousser plus tôt qu'avant. Comme les chenilles dépendent des jeunes feuilles pour leur alimentation, leur éclosion sera retardée, et elles seront par conséquent moins nombreuses

qu'avant. Les oiseaux chanteurs, qui migrent pour se nourrir des chenilles (la principale source de subsistance de leurs oisillons) manqueront alors de nourriture. Les plantes et les animaux constituent un écosystème complexe interrelié avec le climat. La quantité réduite de nourriture a une incidence sur les animaux qui sont situés au sommet de la chaîne alimentaire.

Lecture supplémentaire

https://www.treehugger.com/spring-phenology-and-global-climate-change-1203890

https://www.usgs.gov/centers/casc-sc/science/impacts-climate-change-phenology-a-synthesis-and-path-forward-adaptive?qt-science_center_objects=0#qt-science_center_objects

Sources

Menéndez, R., Megías, A. G., Hill, J. K., Braschler, B., Willis, S. G., Collingham, Y., ... & Thomas, C. D. (2006). Species richness changes lag behind climate change. *Proceedings of the Royal Society B: Biological Sciences*, *273*(1593), 1465-1470.

Pachauri, Rajendra K., and Reisinger, A. (2007)"IPCC fourth assessment report." *IPCC, Geneva* 2007.

Piao, S., Liu, Q., Chen, A., Janssens, I. A., Fu, Y., Dai, J., … Zhu, X. (2019). Plant phenology and global climate change: current progresses and challenges. *Global Change Biology*, *25*(6), 1922–1940. https://doi.org/10.1111/gcb.14619

Tang, J., Körner, C., Muraoka, H., Piao, S., Shen, M., Thackeray, S. J., & Yang, X. (2016). Emerging opportunities and challenges in phenology: a review. *Ecosphere*, *7*(8).

(EAH) Les effets sur l'activité humaine

28. EAH 100 - Question : les effets ressentis sur l'ensemble du globe ?

Dans la majorité des cas, qui sont les personnes prédisposées à subir les conséquences du changement climatique ?

29. EAH 100 - Réponse courte

Les effets du réchauffement climatique sont disproportionnellement imminents à l'égard de quelques groupes (les ménages à faible revenu et les pays émergents) ce qui augmente l'inégalité de la richesse. Le mouvement de la Justice climatique a constaté ce problème du réchauffement climatique.

Des exemples percutants sont l'ouragan Katrina survenu en 2006 et l'ouragan Sandy en 2012. Les conditions météorologiques extrêmes risquent de s'aggraver avec le temps (Scott, 2016). Les ouragans ont considérablement affecté les communautés pauvres aux alentours et situées en relief bas. Elles ne sont pas en mesure de se rebâtir avec leur faible revenu, et cela les rend vulnérables aux catastrophes naturelles.

L'inégalité des richesses est une des principales raisons pour lesquelles les activistes demandent aux pays riches d'envoyer de l'aide internationale aux pays émergents. Ceux-ci sont les principaux responsables depuis des années du changement climatique et les nations du tiers monde subissent présentement les conséquences voire à long terme.

Lecture supplémentaire

https://e360.yale.edu/features/unequal-impact-the-deep-links-between-inequality-and-climate-change

Références

Stott, P. (2016). How climate change affects extreme weather events. *Science*, *352*(6293), 1517-1518.

King, A. D., & Harrington, L. J. (2018). The inequality of climate change from 1.5 to 2 C of global warming. *Geophysical Research Letters*, *45*(10), 5030-5033.

Morello-Frosch, R., M. Pastor, J. Sadd, and S.B. Shonkoff, 2009: The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap. University of California, Berkeley, and USC Program for Environmental & Regional Equity. http://dornsife.usc.edu/assets/sites/242/docs/The_Climate_Gap_Full_Report_FINAL.pd

https://www.nature.com/articles/nature15725

https://www.tandfonline.com/doi/abs/10.1080/08941920118490?casa_token=d--aY2TzlQQAAAAA:whn1L56xPmqfJ67L_2fJ_BE61HB-lNBxyZ0mK-BRQAYoYOoExt_sfIXh4cu8j6w2p_7xVB9Skad3Ww

30. EAH 200 - Question : Qu'est-ce qu'un réfugié.e. climatique ?

Quelle est la définition d'un.e réfugié.e climatique ?

31. EAH 200 - Réponse courte

Un.e réfugié.e climatique est un.e individu.e forcé.e de se déplacer en à cause d'un changement graduel ou soudain de l'environnement naturel. Cela affecte les populations locales qui n'échappent pas à une des trois conséquences naturelles suivantes : l'élévation du niveau des océans, la déforestation ou la perte des installations sanitaires comme l'eau potable ou l'accès à la nourriture.

Les réfugiés sont aussi désignés sous le terme « migrants climatiques » à l'échelle internationale, ce qui engendre encore des débats parce qu'il est difficile d'associer les réfugié.es au réchauffement sans tenir compte de leur statut politique.

Lecture supplémentaire

Climate refugees: how many are there? How many will there be? – Climate Migration Coalition
http://climatemigration.org.uk/climate-refugees-how-many/

Can we define a climate refugee? – Climate Migration Coalition
http://climatemigration.org.uk/climate-refugees-definition/

The Refugees The World Barely Pays Attention To
https://www.npr.org/sections/goatsandsoda/2018/06/20/621782275/the-refugees-that-the-world-barely-pays-attention-to

Migration, Environment and Climate - International Organization for Migration
https://www.iom.int/migration-and-climate-change#estimates

Climate change will create the world's biggest refugee crisis - The Guardian
www.theguardian.com/environment/2017/nov/02/climate-change-will-create-worlds-biggest-refugee-crisis

Références

Global Governance Project. (2012). Forum on Climate Refugees.

Findlay, A.M. (2011). Migrant destinations in an era of environmental change. *Global Environmental Change 21*. 50-58, doi: http://dx.doi.org/10.1016/j.gloenvcha.2011.09.004.

Kraemer, R. A. (2017). *The g20 and building global governance for "climate refugees"* (Ser. Policy brief, 107). Centre for International Governance Innovation.

McCarney, R., & Kent, J. (2020). Forced displacement and climate change: time for global governance. *International Journal: Canada's Journal of Global Policy Analysis*, *75*(4), 652–661. https://doi.org/10.1177/0020702020968944

32. EAH 300 - Question : les phénomènes météorologiques extrêmes sont-ils de plus en plus fréquents à cause du changement climatique ?

Nommez deux phénomènes naturels auxquels les Canadiens seront possiblement exposés avec le changement de température ?

33. EAH 300 - Réponse

Inondations
Vagues de chaleur
Montée du niveau des océans
Ouragans
Sécheresse

Réponse

La relation complexe entre le climat et la nature perturbe les variations de température dans le monde. Nous pouvons nous attendre à ce que les phénomènes météorologiques tels que les inondations et les ouragans deviennent plus fréquents et intenses qu'avant. Ainsi, la hausse des températures dans l'atmosphère produit davantage d'énergie et d'humidité dans l'air ambiant ((IPCC AR5).

L'augmentation de la température rend inévitable la fréquence des vagues de chaleur à l'échelle planétaire. La probabilité de la hausse des vagues de chaleur a doublé parce que l'activité humaine bouleverse la température dans certaines régions du monde.

La sécheresse est une autre conséquence majeure. À cause des perturbations climatiques, l'accessibilité à l'eau se fait rare à plusieurs endroits, les inondations détruisent les sources d'eau et celles-ci se contaminent. À ce jour, plus de 80% de la population mondiale boivent une eau contaminée (IPCC, ch.3). La hausse des températures et les phénomènes météorologiques qui s'intensifient auront des répercussions sur la distribution de l'eau. Ces phénomènes affectent la qualité de l'eau douce issue de la pluie, de la neige, des nappes phréatiques et des rivières. Les communautés pauvres, déjà vulnérables au manque d'eau potable, seront

assurément les plus affectées. La contamination de l'eau vise aussi la santé et la sécurité alimentaire, car elle risque de compliquer la situation précaire des réfugiés et la stabilité politique des pays visés.

Historique

Depuis les dix dernières années, les scientifiques n'ont pas été en mesure de vérifier la relation entre les phénomènes météorologiques extrêmes et le réchauffement climatique, mais des progrès par la confection de scénarios pour prédire les phénomènes ont permis une avancée scientifique dans les récentes années (Stott, 2016). Cette nouvelle avenue se nomme accentuation des phénomènes naturels (NASEM, 2016). Néanmoins, les précipitations affluant dans l'ouest de l'Europe au printemps 2013 sont à exclure des conséquences du réchauffement planétaire. Bien que d'autres préfèrent les étés chauds, dans l'est de la Chine en 2013 par exemple, elles sont le résultat du changement climatique. L'intensification des précipitations reste difficile à prévoir et nous blâmons le réchauffement pour cette raison.

De ce que nous constatons depuis le début du 21e siècle, la fréquence des journées et nuits chaudes s'écourte. Quant aux précipitations et le niveau des océans, cela ne cesse d'augmenter. Vers la fin du siècle, la communauté scientifique estime que les journées chaudes seront plus fréquentes au détriment des froides ; probablement aussi l'intensité de la pluie.

Lecture supplémentaire

Explaining Extreme Events from a Climate Perspective
https://www.ametsoc.org/index.cfm/ams/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-from-a-climate-perspective/

On this website, you can see what the climate of major cities in USA and Canada will be like in 70 years if emissions rates remain the same.
https://fitzlab.shinyapps.io/cityapp/

Références

Gowda, P., J.L. Steiner, C. Olson, M. Boggess, T. Farrigan, and M.A. Grusak, 2018: Agriculture and Rural Communities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. doi: 10.7930/NCA4.2018.CH10

National Academies of Sciences, Engineering, and Medicine. (2016). *Attribution of extreme weather events in the context of climate change*. National Academies Press.

Stott, P. (2016). How climate change affects extreme weather events. *Science*, *352*(6293), 1517-1518.

Walsh, K.J., McBride, J.L., Klotzbach, P.J., Balachandran, S., Camargo, S.J., Holland, G., Knutson, T.R., Kossin, J.P., Lee, T.-c., Sobel, A. and Sugi, M. (2016), Tropical cyclones and climate change. WIREs Clim Change, 7: 65-89. doi:10.1002/wcc.371

34. EAH 400 - Question : De quelle façon le réchauffement du climat risque-t-il de nuire à la distribution globale de la nourriture au Canada?

Parmi les énoncés suivants, lequel n'affecte pas la distribution de la nourriture?

A.Le rendement agricole de l'industrie alimentaire augmentera au Canada.
B.Les vaches produisent plus de lait.
C.La valeur nutritive des fruits et des légumes décline.
D.La vente des fruits exotiques diminue graduellement.

35. EAH 400 - Réponse

B. Les vaches NE produisent PAS davantage de lait.

En effet, elles sont sensibles aux changements de température et cela perturbe la quantité de lait qu'elles peuvent créer. Ainsi, nous ne pouvons pas éviter la diminution du lait ce qui entraînera de lourdes pertes financières aux entreprises. (Gowda et al., 2018)

De même, nous estimons que le rendement agricole des semences telles que le blé, le soja, le maïs et le riz diminue sa croissance en raison de la mousson rare et due à la concentration de carbone dans l'atmosphère. Les variations du climat troublent les pollinisateurs et les plantes : on prévoit un changement des récoltes dans les années à venir. La hausse des températures compromet la récolte des semences et augmente la compétitivité entre les principaux producteurs. (Gowda et al., 2018)

Nous avons des systèmes agricoles adaptés au climat, avec l'aide de la technologie, qui assurent la résistance des variétés de plantes sous stress climatique et d'autres pratiques agricoles. (Gowda et al., 2018)

Les innovations technologiques ont radicalement changé l'importance des effets négatifs du climat à ce jour. Les projections des années précédentes anticipent que la superficie des terres agricoles des États-Unis va chuter comme dans les années 1980 d'ici 2050.

Novick et al. (2016) 243 indique qu'une baisse de pression de l'atmosphère joue un rôle critique dans le cycle des plantes et leur croissance. Cela insiste que la hausse de température chaude agit à titre de facteur indépendant quant à l'humidité du sol. Au fait, des études sur l'augmentation de la température ont prouvé que le rendement des fermes et des semences de soja, riz, maïs et blé diminue. 92, 113, 120, 244.

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0217148
https://cpree.princeton.edu/news/land-use-critical-food-security-warming-planet
https://www.globalagriculture.org/report-topics/adaptation-to-climate-change.html?key=0
file:///C:/Users/Linda/AppData/Local/Temp/Motha-Baier2005_Article_ImpactsOfPresentAndFutureClima.pdf
https://link.springer.com/article/10.1007/s10584-005-5940-1

Source

Mann, M. E., and Kump, L. R. (2015). *Dire Predictions: Understanding Climate Change*. 2nd ed. Penguin Random House

Gowda, P., J.L. Steiner, C. Olson, M. Boggess, T. Farrigan, and M.A. Grusak, 2018: Agriculture and Rural Com-munities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. doi: 10.7930/NCA4.2018.CH10

Map:
https://www.globalagriculture.org/fileadmin/_processed_/csm_Yields2050withouttitle_7e049f4a02.jpg

Lecture supplémentaire

How Climate Change Will Affect Dairy Cows and Milk Production
http://theconversation.com/how-climate-change-will-affect-dairy-cows-and-milk-production-in-the-uk-new-study-101843

Agriculture Adaptation to Climate Change
Ray DK, West PC, Clark M, Gerber JS, Prishchepov AV, Chatterjee S (2019) Climate change has likely already affected global food production. PLoS ONE 14(5): e0217148. https://doi.org/10.1371/journal.pone.0217148

36. EAH 500 - Question :

Décrivez de quelle façon et pour quelle raison cette région du Canada subit les effets du réchauffement climatique.

Le territoire du Yukon, l'Île-du-Prince-Édouard, l'Alberta, la Colombie-Britannique ou le sud du Québec ?

37. EAH 500 - Réponse

L'île Lennox, Île-du-Prince-Édouard

La communauté de Lennox sera l'une des communautés canadiennes obligées de migrer vers d'autres terres. L'île est habitée par 500 personnes, mais en raison de l'érosion par l'eau et le vent, sa superficie diminue d'années en années. À ce rythme, les scientifiques estiment que 50% de l'île sera engloutie dans les prochaines cinquante années.

L'île Lennox est le foyer de la réserve Micmacs des Première Nations où 470 personnes y habitent. En ce qui a trait à sa géologie, l'île est principalement composée de grès rouge, c'est-à-dire d'une roche de fond facilement friable (Coldwater Consulting Ltd., 2011). L'érosion de la roche accentue la fragilité de l'île. La menace plane sur les communautés environnantes, car leur conditions de vie sont atteintes par les effets du réchauffement climatique. En effet, l'effritement de la roche est dû par l'intrusion de l'eau salée dans la roche (Charles et al. 2012).

D'autres menaces environnementales incluent la montée du niveau des océans et des tempêtes violentes (ParCa, 2016). L'érosion des zones côtières est un autre phénomène observé. Elle rétrécit graduellement l'espace des zones résidentiels, de l'église, les terres réservés aux célébrations pow wow, aux cimetières et aux sites archéologiques (Majeed, 2015).

Sources
https://www.cbc.ca/radio/day6/facing-the-change-5-canadian-communities-threatened-by-climate-change-now-1.4447042

Brooks, Hariana S. 2018. "CLIMATE MIGRATION IN CANADA: A CASE STUDY OF LENNOX ISLAND, PEI," 57.

Old Crow, Yukon

Old Crow est une communauté accessible par avion au large de la côte nord-ouest du Yukon. Au début de l'année 2019, la communauté a déclaré l'état d'urgence, car les effets du réchauffement affectaient leur mode de vie traditionnel. La rapidité à laquelle la température grimpe (le double du taux d'élévation de la température au sud du Canada) compromet la

construction de chemins d'hiver desquels les communautés dépendent pour la chasse et la pêche.

De récentes études ont démontré que la côte nord américaine a subi une accélération accrue de la fonte des calottes glaciaires sur notre planète. Les communautés indigènes sont les premières à connaître présentement dans l'Arctique les effets de l'érosion côtière, du temps imprévisible et la fonte du pergélisol (Lemmen et al. 2016).

Sainte-Marie, Québec (d'autres villes comme Pontiac, Rigaud, etc…)

Selon les dernières statistiques d'Urgence Québec, 1500 résidents ont été évacués et 2300 maisons à l'extérieur de Montréal ont subi des dommages par les inondations et la pluie. La venue de pluies torrentielles dans cette zone a été prédit il y a trente ans. Les inondations sont un problème majeur pour le Canada. Les effets du réchauffement montre que plusieurs zones occupées seront inondées à cause d'une mauvaise gestion de l'aménagement du territoire.

Source
https://www.theglobeandmail.com/news/national/anatomy-of-a-deluge-are-the-quebec-floods-a-sign-of-things-to-come/article34953478/

(SS) Les solutions suggérées

38. SS 100 - Question : Quelle source de nourriture est principalement responsable de grandes émissions de carbone ?

Quelle source de nourriture émet le plus de gaz à effet de serre ?

Boeuf/Viande de chèvre
Fromage
Volaille
Thon
Oeufs
Haricots et le tofu

20 points par bonne réponse

39. SS 100 - Réponse courte

Boeuf et la viande de chèvre

Réduire votre consommation de viande rouge dans votre régime alimentaire et la remplacer par des protéines végétales comme le tofu, les haricots, les œufs et la volaille est une bonne manière de réduire votre empreinte de carbone. Pour la communauté étudiante, la diminution de viande rouge dans l'alimentation réduit votre empreinte de 15% ou de 36% si vous êtes au Royaume-Uni (Pledge to Lead, 2021; Macdiarmid et al. 2012).

Une alimentation à base de végétaux dans laquelle la majorité de vos protéines proviennent d'haricots, de tofu, de noix et de grains entiers baisse autant vos émissions de carbone. Dans une première perspective, le fait de se nourrir de viande rouge est équivalent à conduire sur une distance de 21 kilomètres. Dans une seconde, cela équivaut à conduire 3.5 kilomètres et en combinant les haricots et le tofu, le chiffre s'élève à moins d'un kilomètre (Clean Metrics 2011).

Nous avons deux manières pour réduire sa consommation de viande rouge afin de minimiser notre impact écologique. Il y a deux étapes pour nourrir les animaux : on cultive d'abord les aliments et par la suite, on nourrit le bétail. En choisissant les protéines végétales, nous évitons la deuxième étape ce qui empêche le rejet d'une grande quantité des émissions de gaz. Par conséquent, nous évitons également la contamination de l'eau et les enjeux éthiques par le choix d'une alimentation végétale (Westhoek et al. 2014). La deuxième façon, produire du bœuf et de la viande de chèvre ont une forte incidence sur le réchauffement planétaire à cause du méthane produit par leur système digestif. De plus, la forte présence de d'oxyde nitreux se dégage du fumier (EWG 2011). Le fromage est un autre aliment qui répand beaucoup de gaz dans l'air : une grande quantité de lait est requise pour former un bloc de fromage. (1kg de fromage équivaut à environ ~ 9kg de lait) (EWG 2011).

Gardez à l'esprit que manger localement à un effet significatif sur votre empreinte de carbone, alors que consommer des produits importés demande une plus grande source d'énergie. Manger du fromage de votre région en comparaison à celui importé d'un autre pays équivaut à 50% de la quantité de gaz rejetée par la nourriture (EWG 2011). La pêche de différentes espèces de poisson n'a pas la même quantité d'émissions, car la façon dont les poissons sont pêchés et préparés n'est pas la même.

Le gaspillage alimentaire à des répercussions sur les gaz à effet de serre. Notamment, une année sans gaspiller de la nourriture aux États-Unis enlève 33 millions de véhicules sur la route dans la même année. (Heller and Keoleian, 2015).

40. SS 200 - Question : Les automobiles électriques produisent-elles plus d'émissions de carbone ?

De quelle façon, les voitures électriques deviennent-elles les principales agentes de gaz à effet de serre ?

41. SS 200 - Réponse

Les automobiles électriques sont toujours une meilleure option que les véhicules à essence. Par contre, elles ne le sont pas si la source d'alimentation pour recharger leur batterie est issue des énergies fossiles.

42. SS 300 - Question :

Quelle est la manière la plus efficace de réduire notre empreinte carbone ?

A. **bannir le plastique**
B. **Cessez l'utilisation d'un véhicule**
C. **Voyager une fois par année**
D. **Une alimentation à base végétale**

43. SS 300 - Réponse

Le type de transport que vous utilisez a une forte

Dépendre de son automobile n'est pas la solution au problème.

Le transport public est de loin la

(SRSM) Solutions systémiques

54.SR 300 - Question : 54. Quelle est la méthode de géo-ingénierie la plus efficace?

La géo-ingénierie est une méthode qui utilise la science pour modifier l'environnement. Quelle est actuellement la méthode de géo-ingénierie la plus efficace pour réduire le réchauffement climatique?

55.SS 300 – Réponse

Les arbres sont des puits de carbone. Ils absorbent le dioxyde de carbone et le séquestrent dans leur écorce et leurs feuilles.

(Autres réponses : l'algoculture, la reforestation, et l'afforestation).

Seulement 2 % du financement accordé aux changements climatiques est investi dans les solutions naturelles. Nous investissons mille fois plus d'argent dans les subventions du secteur des énergies fossiles.

Environ 20 % des émissions de carbone annuelles à l'échelle mondiale proviennent de la déforestation. Dans leur totalité, les forêts absorbent l'équivalent de 30 % des émissions de carbone émises par les énergies fossiles. La reforestation a le potentiel d'absorber des émissions équivalentes à ce qui a été émis sur une période de 5 à 10 années. (besoin de trouver une meilleure source avec évaluation par les pairs).

Le citoyen américain produit des émissions annuelles de 34 000 livres de carbone; une personne aurait besoin de 500 arbres pour compenser.

Avantage : contribue à la biodiversité, à la diminution de la pollution de l'air et à l'activité économique

SR 300 - Réponse

SR 400 - Question : Subventions données aux entreprises du secteur des énergies fossiles comparativement aux entreprises d'énergie propre?

À quel point les subventions que le gouvernement donne aux entreprises du secteur des énergies fossiles sont-elles plus élevées que celles qu'elles donnent aux entreprises d'énergie propre?

A. 4 fois plus élevées

B. 9 fois plus élevées

C. Elles reçoivent une quantité égale de subventions

SR 400 - Réponse

La réponse correcte est A.

Le gouvernement ne déclare pas ouvertement quel est le montant des subventions, mais des études ont démontré que le gouvernement, au niveau fédéral et provincial, a accordé des subventions excédant 3 milliards de dollars par année, selon la moyenne annuelle des subventions de 2015 à 2018.

Imaginez ce qui pourrait être accompli avec des montants pareils.

Malgré cet avantage injuste donné aux industries du secteur des énergies fossiles, le secteur des énergies renouvelables, qui comprend notamment l'énergie éolienne et solaire, prend rapidement de l'ampleur au Canada. De plus, les secteurs de l'énergie et de la technologie propres constituent 1,5% des emplois au Canada, comparativement au pétrole et à l'essence qui ne constituent qu'environ 0,8% à 1,1% des emplois (voir le *Energy Factbook*).

Les emplois liés au secteur de l'énergie renouvelable sont plus profitables pour le gouvernement comparativement au secteur des énergies fossiles. Il y a 4520 emplois pour chaque milliard de dollars que le gouvernement investit dans le secteur énergies fossiles, alors qu'il y a 10,419 emplois par milliard dans le secteur des énergies renouvelables. Ce sont aussi des emplois plus stables et écologiques.

SR 500 - Question :

SR 500 - Réponse