TØWNGREEN 2025

Middle School Climate-Change Curriculum

Lesson 5

Carbon Cycles through Ecosystems

Unit Title: **Carbon Cycles through Ecosystems**	
Theme: **Ecosystems & Cycles**	Grade Level: **7**
# of sessions for the unit: **2**	Session #5: **How can we model the density of land and atmospheric carbon?**
Date created: **Summer 2017**	Author: **B. Allia, C. McWilliams**

CC Climate Change Curriculum

Unit Description

Focusing on systems and cycles, students use their understanding of climate-change and how carbon and thermal energy interact with Earth's land and atmosphere. Students practice skills such as argumentation and collecting and analyzing data. Students gain experience with the interactions of humans and Earth processes with ecosystem dynamics, and with developing solutions to complex climate-change issues. The lessons generally follow this order:

- Introduce unit and culminating event: climate-change's effect upon fauna
- analyze global temperature and carbon dioxide trends
- understand personal climate-change experiences, such as weather, matter and energy uses
- collect wetland and upland forest soil carbon-stores
- sample atmospheric carbon-store
- analyze land and atmospheric carbon-stores
- understand the carbon cycle, pre-human and human era
- describe personal experiences with solid forms of carbon changing into atmospheric carbon
- develop and present solutions to save a fauna from climate-change issues

Standard(s)

Based upon the 2016 MA Science & Technology/Engineering Curriculum Framework

MA LS2 Ecosystems: Interactions, Energy, and Dynamics

MA 7.MS-LS2-3 Develop a model to demonstrate how matter and energy are transferred among living and nonliving parts of an ecosystem and that both matter and energy are conserved through these processes

Unit Goals

1. Create an action plan to decrease carbon in the atmosphere, increase carbon stored by the land, and preserve natural carbon-stores in the ground
2. Build background knowledge of how carbon cycles within a local ecosystem
3. Understand relevant climate-change issues in order to make informed decisions
4. Identify authentic scientific processes, such as sampling, gathering, and analyzing land and atmospheric carbon-content data, in order to validate evidence regarding climate-change

Unit Objectives

Students will be able to

understand that:

1. Carbon cycles through the atmosphere and land
2. Human activities increases atmospheric carbon by burning fossil fuel
3. Atmospheric carbon is a “greenhouse gas”
4. Greenhouse gases increase global temperatures
5. Wetlands and uplands store different amounts of carbon above and below ground

and to:

1. Sample, collect, and analyze primary-source data
2. Collect and analyze secondary data as a means to validate causes of climate-change

Lesson Objectives

Students will

1. demonstrate that carbon cycles through the atmosphere and land
2. provide examples of where human activities increases atmospheric carbon by burning fossil fuel
3. illustrate that wetlands and uplands store different amounts of carbon above and below ground
4. analyze the amount of carbon in forest and wetland (above and below ground)
5. analyze amount of atmospheric carbon caused by the burning of fossil fuels

Note any potential barriers to the lesson — consider variability

Math-graphing barriers

- The handout provides visual scaffolding between the graph and its interpretation

Evaluation/Assessment

(directly linked to the goals, i.e., Formative/Ongoing Assessment or Summative/End of Lesson Assessment)

Formative Assessment

1. Accuracy of Density Dot Diagram
   - A. Reasonable carbon-dot ratio
   - B. Equal spacing between dots, showing understanding of the density unit-rate formula mass/volume (rise/run)
2. Aesthetics and Organization of Density Dot Diagram
   - A. Neatness
   - B. Captions/sketching within the diagram is neat and relevant

3. Completeness of Diagram
   A. Dots labeled as carbon within each soil type
   B. Sample location & date
   C. Diagram's completion visually depicts the different carbon content

Vocabulary

- Density
- Unit-rate formula
- Carbon dioxide
- Atmospheric carbon
- Wetlands
- Upland forest
- Fossil fuel
- Biomass
- Carbon content
- Biomass
- Organic

Differentiated Vocabulary Ideas

- word wall
- word splash
- common prefixes and suffixes
- content vocabulary roundtable
- flashcards

NOTE: Consider the UDL Guidelines in selecting methods and materials to ensure that you provide options for engagement, representation, and action and expression.

Methods

(e.g., Anticipatory Set, Introduce and Model New Knowledge, Provide Guided Practice, Provide Independent Practice)

1. Analyze data to support that carbon cycles through the atmosphere and land
   A. Review Atmospheric-Carbon CO_2 graph, emphasizing difference between carbon density in air before and after burning fossil-fuel
   B. Students analyze their primary-source carbon data
   C. Students write a caption on their density-dot diagram handout, to illustrate that burning gasoline (chemical change) cycles carbon from the land into the atmosphere
2. Provide examples of how human activities increases atmospheric carbon by burning fossil fuel
   A. While students draw their density-dot diagrams, discuss examples of how people increase atmospheric carbon
   B. Write down these examples and post in the classroom
3. Illustrate that wetlands and uplands store different amounts of carbon above and below ground
   A. When students convert data from a graph into a density-dot diagram, they analyze the different storage capacities above and below ground ofwetlands and upland forests (Visual Scaffolding)
   B. Students analyze their primary-source carbon data
   C. See Density-Dot Diagram handout below — Land-Based Carbon is on one side, while Atmospheric Carbon is on the other side
      1. Students decide how many carbon "dots" to assign to Wetlands above ground and Wetlands below ground, on a general-proportionate basis. For example, the Wetlands has an approximate 0.5:3 ratio - perhaps students choose 5 Above Ground carbon dots and 30 Below Ground carbon dots.
      2. Emphasize equal spacing between carbon dots, since the diagram visualizes the density unit-rate formula kilograms/meter

3. Encourage students to use “compactness,” “squished,” or “spread-out” as density descriptors as they internalize the difference between carbon-compactness above and below the ground

4. Illustrate amount of atmospheric carbon caused by burning fossil fuel
   - A. When students illustrate data from the graph in a density-dot diagram, they analyze the large amount of carbon that transfers into the atmosphere when humans burn fossil fuel (Visual Scaffolding)
   - B. Students analyze their primary-source atmospheric-carbon data
   - C. See Density-Dot Diagram handout below — Land-Based Carbon is on one side, with Atmospheric Carbon on the other side
     1. Students decide how many carbon “dots” to assign to Atmospheric Carbon, based on a general-proportionate basis. Because the ratio is too large and cumbersome to reflect accurately, students should focus on exaggerating just a few control carbon dots to crowded fossil-fuel carbon dots.
     2. Emphasize equal spacing between carbon dots, since the diagram visualizes the density unit-rate formula carbon-dioxide parts/million
     3. Encourage students to talk about “compactness,” “squished,” or “spread-out” density descriptors as they internalize the difference between the control sample and the human-made fossil-fuel sample

5. Homework
   - A. Text Passage Peer - Response
     1. Students read the Reforest the Tropics (RTT) July 2017 newsletter while completing the top 4 boxes labeled “reader”
     2. Next day in class, students switch papers with another student
     3. 2nd student completes the bottom 4 boxes labeled “responder,” while reviewing the article
     4. Next day in class, the reposder returns the paper to the first student to read the response
     5. Students ask teachers unanswered questions from the reader
     6. This graphic organizer is also included in Materials in Google Doc format
   - B. The teacher chooses a relevant current-events article about climate-change
     1. This suggested article is from Reforest the Tropics July 2017 newsletter, regarding carbon sequestration
     2. This article is also included in Materials in Google Doc format

3. The teacher can select different articles for students at different reading levels; the teacher can also provide audio-recordings of the articles

Text Passage Peer/Response

Carbon Cycles through Ecosystems

Reader – please complete this top chart

Name: Block: Date:

Facts	Feelings
List 3 interesting facts 1. 2. 3.	How did you feel as you read this? What made you feel this way? 1. 2. 3.
Questions	**How this applies to your life?**
List 3 questions you have about the reading 1. 2. 3.	List 3 connections that you thought about 1. 2. 3.

Responder – please complete this top chart

Name: Block: Date:

Facts	Feelings
List 3 interesting facts 1. 2. 3.	How did you feel as you read this? What made you feel this way? 1. 2. 3.
Questions	**How this applies to your life?**
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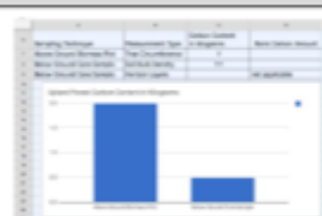
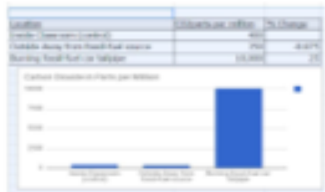
Carbon Data Density Dot-Diagram

Name: ______________________ Block: ______ Date: ____________

Wetlands Carbon Above and Below Ground		Upland Forest Carbon Above and Below Ground	
			
Wetland Carbon ABOVE Ground	Wetlands Carbon BELOW Ground	Forest Carbon ABOVE Ground	Forest Carbon BELOW Ground

Carbon Data Density Dot-Diagram

Name: ______________________________ Block: _____ Date: ____________

Atmospheric Carbon Carbon Gas CO_2 in the Air *People increase atmospheric carbon when we burn fossil fuel*	
	
Carbon in our Control Air Sample as CO_2	Carbon Car Exhaust as CO_2

Materials

1. Teacher photocopies and distributes the density dot worksheet to students
2. Students keep their density-dot diagram posters in their science binder, to refer to as unit progresses
3. Homework resource: Text Passage Peer — Response graphic organizer in Google doc format below
4. Homework resource: Reforesting the Tropics reading passage (July 2017 newsletter) included below (teacher might choose different articles, based on reading variability)

Text Passage Peer/Response

Reader – please complete this top chart

Carbon Cycles through Ecosystems

Name: Block: Date:

Facts	Feelings
List 3 interesting facts 1. 2. 3.	How did you feel as you read this? What made you feel this way? 1. 2. 3.
Questions	**How this applies to your life?**
List 3 questions you have about the reading 1. 2. 3.	List 3 connections that you thought about 1. 2. 3.

Responder – please complete this top chart

Name: Block: Date:

Facts	Feelings
List 3 interesting facts 1. 2. 3.	How did you feel as you read this? What made you feel this way? 1. 2. 3.
Questions	**How this applies to your life?**
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RTT
Reforest The Tropics
July, 2017
Reforest The Tropics is an United Nations approved, non-profit organization dedicated to environmental education and the capture and permanent storage of global carbon dioxide emissions in tropical farm forests

Impressive Carbon Capture Verified

For decades, Reforest The Tropics has been measuring the productivity of its forest plantations. In June 2017, for the first time, RTT contracted with an accredited third party, EARTH University, to verify its carbon claims under the protocols established by the International Organization of Standards.

The results are fantastic news for RTT and anyone with an interest in global sustainability. ***Verified forests are averaging 23.66 metric tons (MT) of CO2e capture per hectare, per year!*** To help put this into perspective, most literature on tropical reforestation demonstrates carbon capture of 10-15 MT of CO2e capture under favorable conditions. In other words, RTT is essentially doubling the carbon capacity of current, successful reforestation projects.

Measurements of a Klinkii tree are being taken for the carbon verification process.

One of RTT's longstanding research goals was to design a mixed-species forest that can capture and store an average of at least 20 MT of CO2e per hectare, per year. Internally, we recognized this target was ambitious, however we have maintained the belief that lofty goals are fundamental to fulfillment of our mission of 'making a tangible contribution to global sustainability.' Not only have we met this objective, but we are exceeding it.

The amazing carbon capture of RTT forests is only part of the story however. Two additional pieces distinguish the RTT approach:

1) RTT's mixed-species forests are more beneficial to the biome than ubiquitous single species monocultures, and

2) RTT forests are designed to generate perpetual income, which allows partnering landowners to participate in the project over the long-term.

Essentially, RTT is planting some of the worlds most productive forests...is doing so in more environmentally beneficial manner than typical reforestation models...and is working to ensure they will remain standing indefinitely.

RTT has focused on forestry research for many years. Dozens of different planting matrices and mixtures of species have been investigated in order to discover the optimal design to achieve RTT's three research goals:

1) Sequester 500 MT CO2e over the initial 25-year contract period,

2) Generate $500 income for the landowner per hectare per year, and

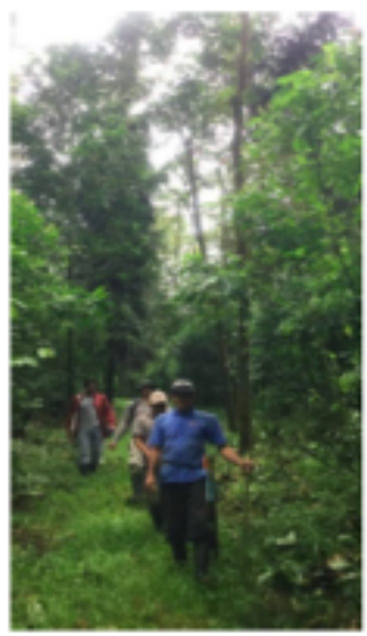
3) Create a 'permanent' (read 100+ year) farm forest.

The verification process certified carbon from 8 different designs. The most productive forest was able to capture a phenomenal 34.21 MT CO2e per hectare per year for the Mohegan Sun Casino. Conversely, the least productive design achieved a respectable 11.9 MT CO2e per hectare per year. This design is noteworthy, however because one of the species in this mixture succumbed to a disease and had to be removed. Despite the elimination of hundreds of trees, the 5-year old forest is still productive and will only improve in terms of carbon capture as it matures. This example highlights the importance of RTT's mixed species orthodoxy and offers a fair warning to advocates of a monoculture approach. Furthermore, if we remove this outlier from our analysis, verification results show that ***RTT forests are actually storing 25.38 MT CO2e per hectare per year.***

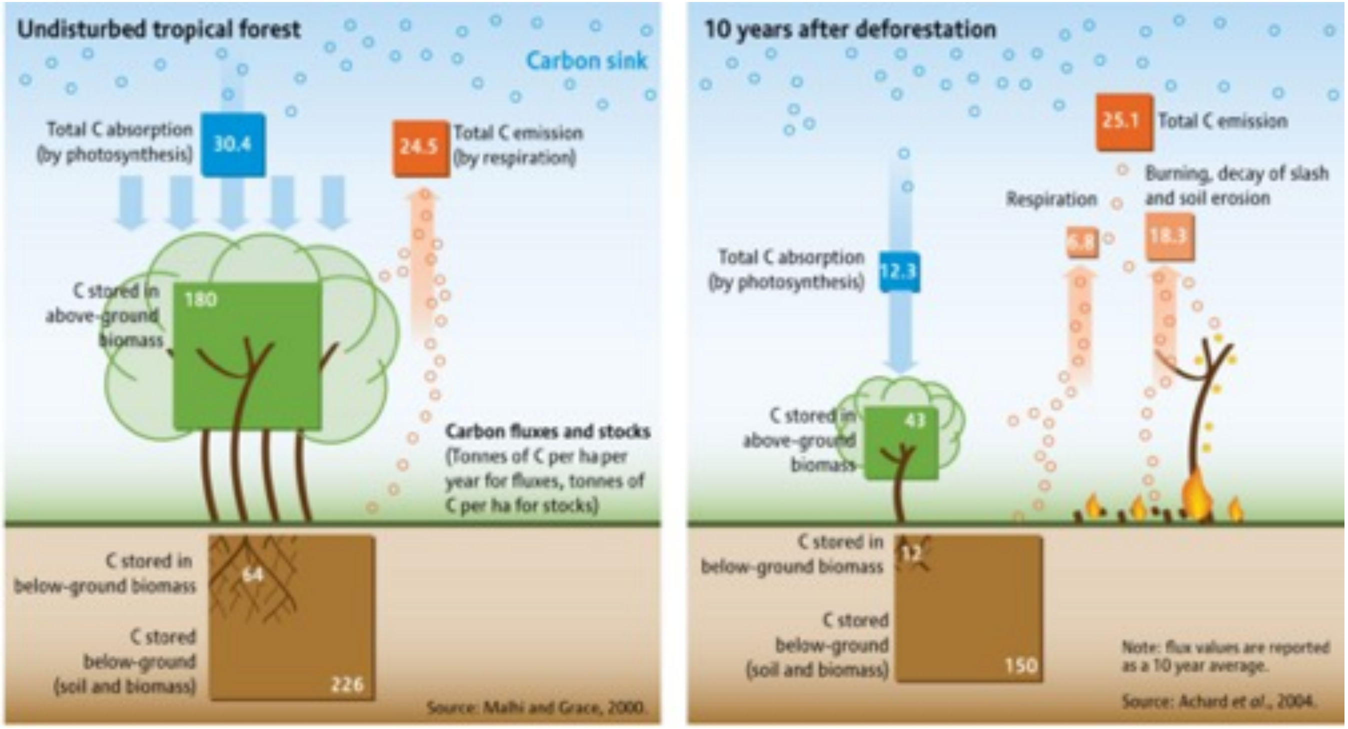
The Big Picture: If RTT can plant a forest that doubles or triples CO2 capture of the most common reforestation models per hectare, we only need half the land (or less) to extract a corresponding amount of CO2. We at RTT have long known this is possible and now we have official verification of the RTT model's potential.

We thank you for your support as we spread the word.

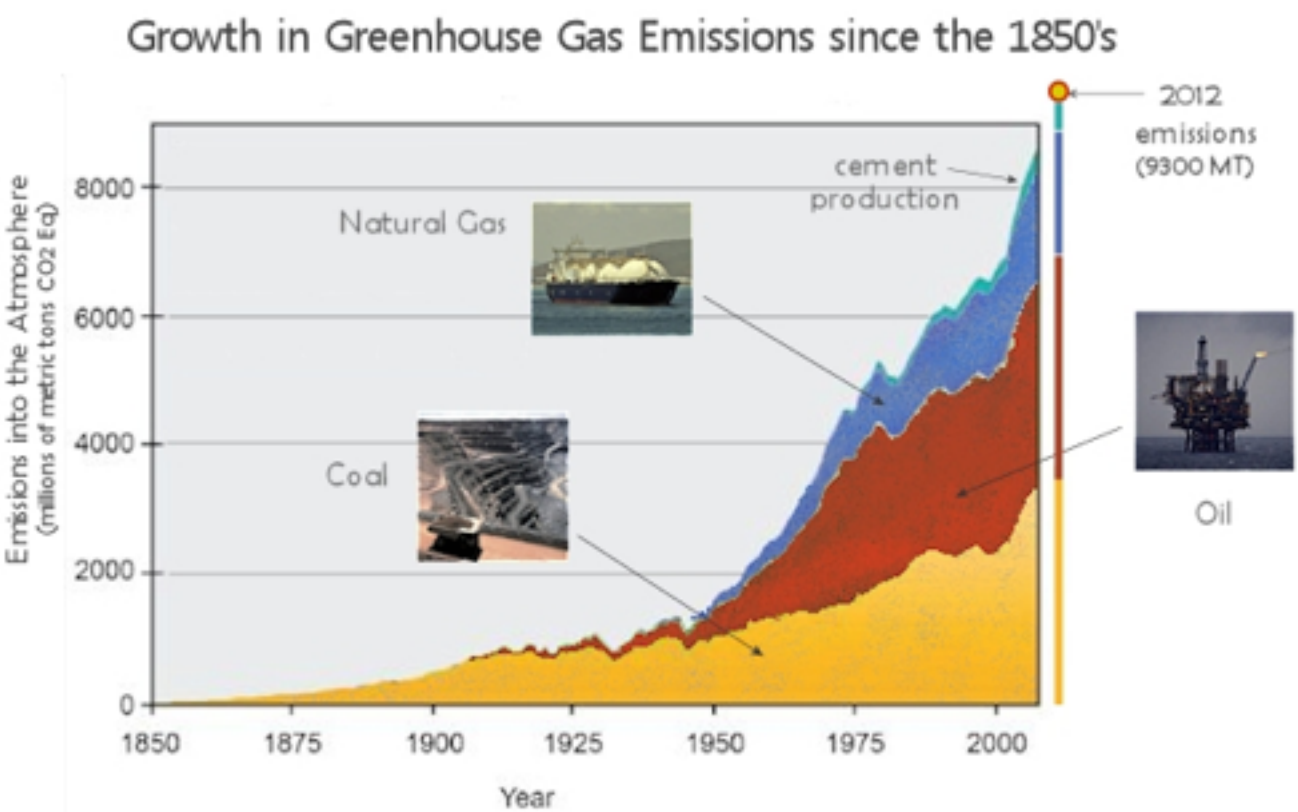
Greg Powell
Executive Director,
Reforest The Tropics



Carbon verification team from EARTH University joins RTT staff and farm personnel to conduct their field work.



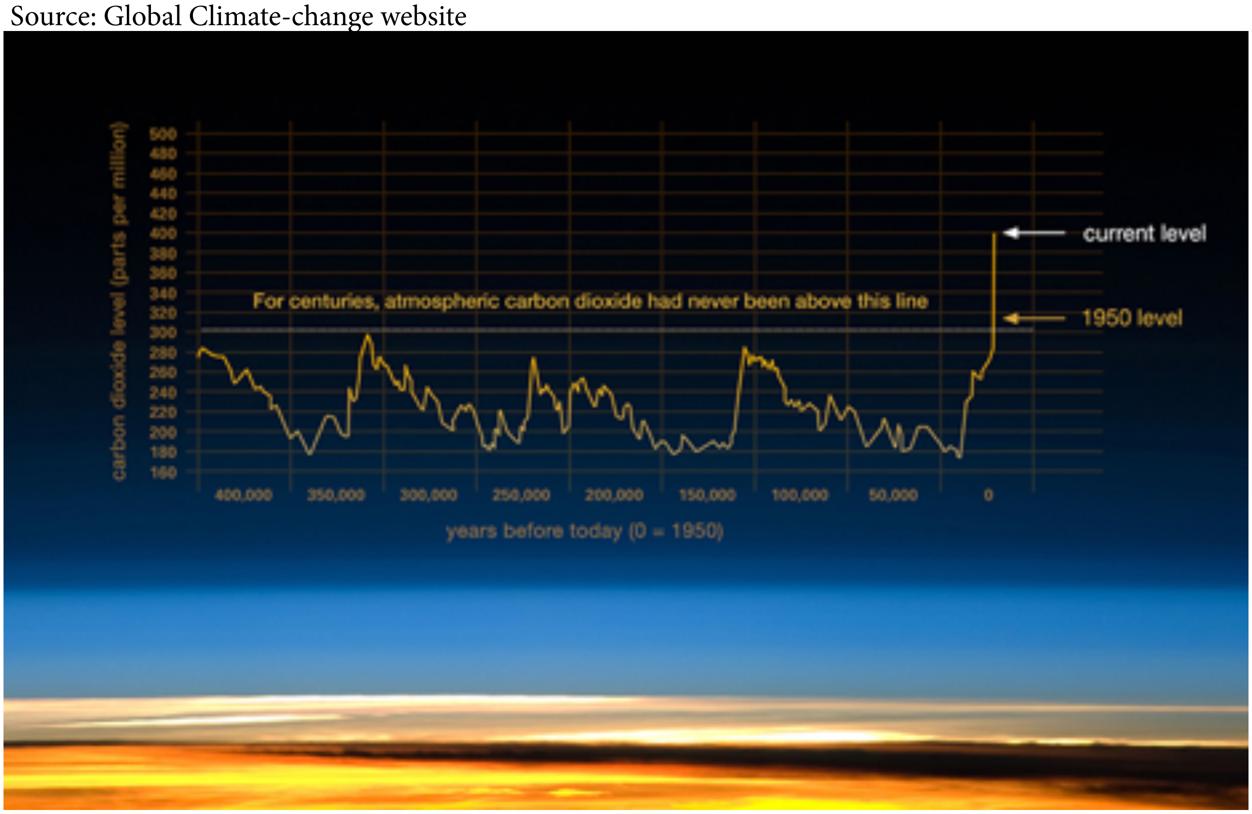
Undisturbed tropical forest
Carbon sink
Total C absorption (by photosynthesis)
30.4
24.5
Total C emission (by respiration)
C stored in above-ground biomass
180
Carbon fluxes and stocks (Tonnes of C per ha per year for fluxes, tonnes of C per ha for stocks)
C stored in below-ground biomass
64
C stored below-ground (soil and biomass)
226
Source: Malhi and Grace, 2000.
10 years after deforestation
25.1
Total C emission
Burning, decay of slash and soil erosion
Respiration
6.8
18.3
Total C absorption (by photosynthesis)
12.3
C stored in above-ground biomass
43
C stored in below-ground biomass
12
C stored below-ground (soil and biomass)
150
Note: flux values are reported as a 10 year average.
Source: Achard et al., 2004.



Growth in Greenhouse Gas Emissions since the 1850's
2012 emissions (9300 MT)
cement production
Natural Gas
Coal
Oil
Emissions into the Atmosphere (millions of metric tons CO2 Eq)
0
2000
4000
6000
8000
1850
1875
1900
1925
1950
1975
2000
Year

https://climate.nasa.gov/climate_resources/24/

Source: Global Climate-change website



Ancient air bubbles trapped in ice enable us to step back in time and see what Earth's atmosphere, and climate, were like in the distant past. They tell us that levels of carbon dioxide (CO_2) in the atmosphere are higher than they have been at any time in the past 400,000 years. During ice ages, CO_2 levels were around 200 parts per million (ppm), and during the warmer interglacial periods, they hovered around 280 ppm (see fluctuations in the graph). In 2013, CO_2 levels *surpassed 400 ppm* for the first time in recorded history. This *recent relentless rise* in CO_2 shows a remarkably constant relationship with fossil-fuel burning, and can be well accounted for based on the simple premise that about 60 percent of fossil-fuel emissions stay in the air.