Eco-Link
Linking Social, Economic, and Ecological Issues

# The Tree That Changed the World

The Tree of Life, © 2001 by John Perlin

Volume 12, Number 3

Astronomers for the longest time have regarded Venus as the planet most resembling Earth. Having almost the exact size as Earth and being almost as close to the sun has led many to even call it Earth's twin. The clouds always covering the Venusian landscape gave another compelling reason to believe in Venus' affinity to Earth. Pioneering astronomer Svante Arrhenius hypothesized great rains pouring from these clouds nurtured lush rain forests below.

But when various space probes penetrated the Venusian atmosphere they burst this belief. Astronomers found an inferno rather than a tropical paradise. Here they discovered the ultimate greenhouse effect: Although the carbon-dioxide laden atmosphere allowed sunlight to pass through, when the solar rays hit the surface of Venus and changed into heat waves, they could not escape the carbon-dioxide cover. So the heat had nowhere to go and therefore accumulated at the surface where temperatures exceed eight hundred degrees Fahrenheit.

Interestingly, Earth has as much carbon dioxide as Venus. But instead of the gas blanketing the sky as happened on Venus, much of the carbon dioxide on Earth has been locked up inside and on the surface. This has made all the difference in the story of the two planets—one, a heaven bountiful with life, the other a hellish place where nothing animate can survive.

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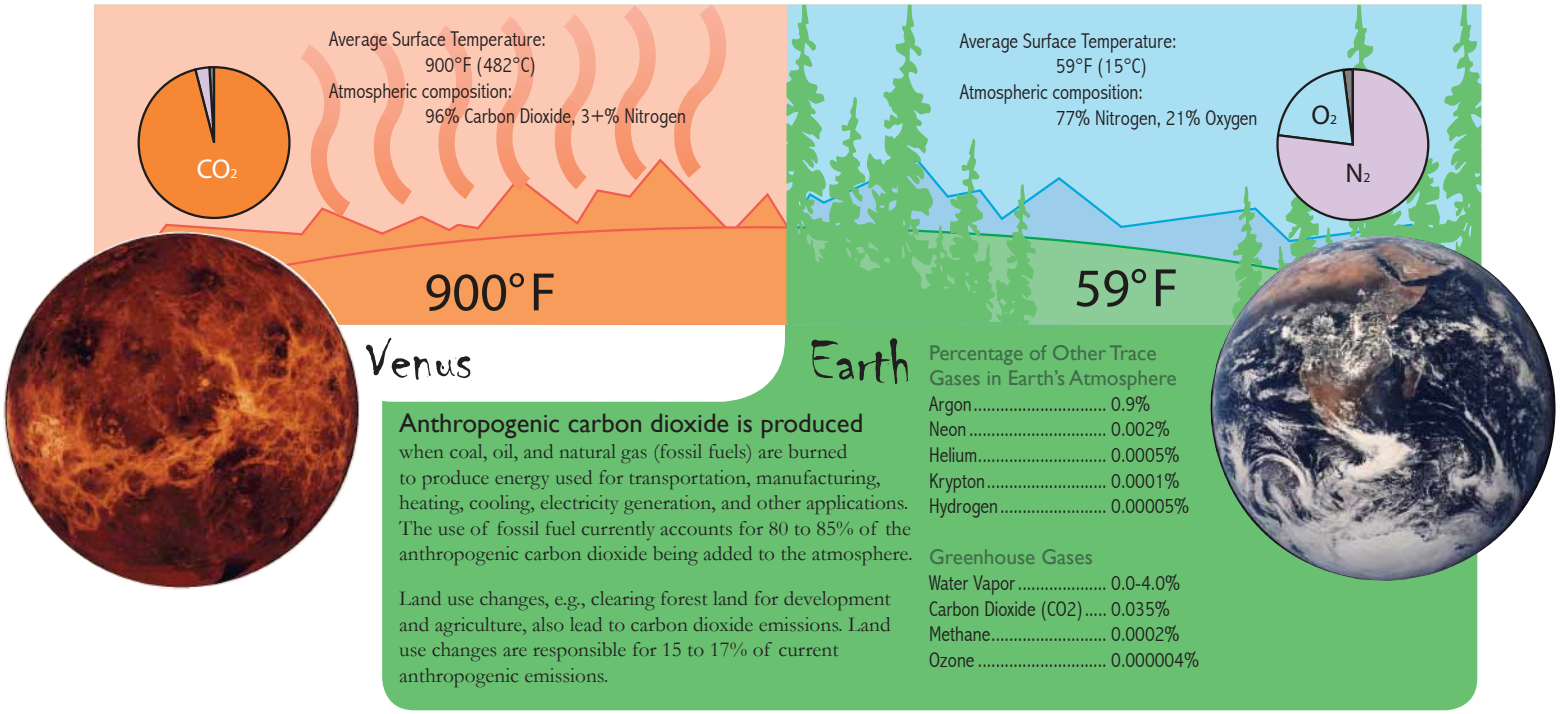



**Anthropogenic carbon dioxide is produced** when coal, oil, and natural gas (fossil fuels) are burned to produce energy used for transportation, manufacturing, heating, cooling, electricity generation, and other applications. The use of fossil fuel currently accounts for 80 to 85% of the anthropogenic carbon dioxide being added to the atmosphere.

Land use changes, e.g., clearing forest land for development and agriculture, also lead to carbon dioxide emissions. Land use changes are responsible for 15 to 17% of current anthropogenic emissions.

**Percentage of Other Trace Gases in Earth's Atmosphere**

| | |
|---|---|
| Argon | 0.9% |
| Neon | 0.002% |
| Helium | 0.0005% |
| Krypton | 0.0001% |
| Hydrogen | 0.00005% |

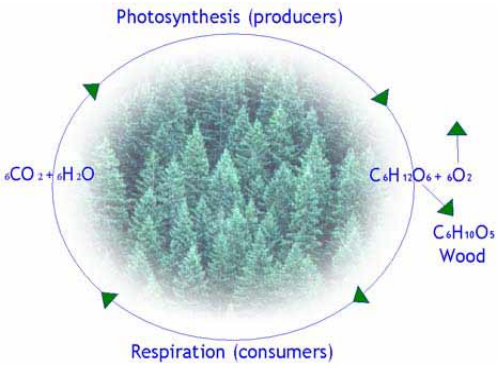
**Greenhouse Gases**

| | |
|---|---|
| Water Vapor | 0.0-4.0% |
| Carbon Dioxide (CO2) | 0.035% |
| Methane | 0.0002% |
| Ozone | 0.000004% |

Photos: Courtesy of National Aeronautics and Space Administration (NASA)

*Eco-Link* is a quarterly publication of the Temperate Forest Foundation

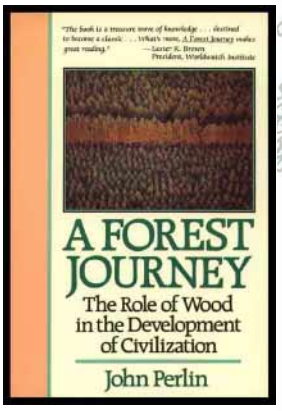
## Photosynthesis




**Photosynthesis is a chemical process occurring in plants where carbon dioxide ($CO_2$) and water ($H_2O$) are converted into glucose ($C_6H_{12}O_6$) and oxygen ($O_2$).** It is generally accepted that photosynthesis produces all of the oxygen in the Earth's atmosphere. Without plants this planet could not sustain life as we know it.

The carbon from the $CO_2$ is biochemically transformed into sugar compounds necessary for plant growth and structure. The fundamental task of photosynthesis is to make it possible for cells to convert carbon dioxide and water into carbohydrates with energy absorbed from the sun. In green plants, chlorophyll molecules collect light energy and funnel it to a reaction center.

The process of photosynthesis in trees is a contributor to the sequestration of carbon from the atmosphere—in the process of photosynthesis, carbon is stored in the wood and roots of the tree as well as being deposited into the soil.




*John Perlin is the author of* A Forest Journey: The Role of Wood in the Development of Civilization.

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**Credit much of this carbon dioxide transfer from the atmosphere to the land to the rapid global spread 400 million years ago of the first true tree, Archaeopteris.** Its dense canopy photosynthetically absorbed carbon dioxide. As the leaves shed, they would have given back the carbon dioxide to the air had not the tree's deep and powerful root system broken down rock through which it dug into soil where chemical reactions eventually locked up the carbon dioxide in sediment. Mud buried much of the remaining dead leaves, branches, twigs, trunks, and roots. With the passing of millions of years under great pressure deep in the bowels of the earth the plant material ended up as rich beds of fossils and coal. Once again, natural forces denied returning to the atmosphere what the trees had devoured.

Illustration of Archaeopteris (#2)
[from National Geographic, May 1999, *From Fins to Feet*]

**Archaeopteris prepared the soil for smaller plants to flourish and assisted in removing carbon dioxide from the air.** Archaeopteris' root system turned rock into rich, soft earth. Their leaves shielded the newly formed soil from erosive rain and wind and fertilized it as they fell and decomposed. Debris from the growing number of plants filled waterways, promoting plankton which also feeds on atmospheric carbon dioxide. Buried by sediments these consumers of carbon dioxide could not release this greenhouse gas to the air.

**The plunging carbon dioxide levels in the atmosphere caused temperatures on land to drop.** The change made it possible for large creatures to amble about the land without overheating. They no longer had to remain immersed in water to maintain healthy body temperatures. Water heats up more slowly than land surfaces. Furthermore, water conducts heat away from animals better than air does. At the same time declining amounts of atmospheric carbon dioxide enlarged the ozone layer above the earth. Such protection shields land animals from lethal doses of ultraviolet radiation. Previously, creatures of any significant size had to remain underwater for protection from the sun's harmful rays. Of equal importance, the injection of more oxygen into the air by Archaeopteris and smaller plants provided enough of the life-giving gas to make it possible for animals to breathe. Scientists find charcoal for the first time during the reign of Archaeopteris, suggesting that with the trees' appearance came sufficient amounts of oxygen to support combustion.

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As logs and large branches started to clutter the bottom of shallow waterways, fish-like creatures with limbs could better propel themselves through the plant debris than those with fins. The increasing organic debris finding its way into waterways would rob them of their oxygen. Creatures that could breathe as well as walk could escape sure death by making their ascent to land where a relatively mild climate, sufficient oxygen, protection from ultraviolet radiation, and plenty of food provided by plants made survival possible. So began the chain of events that has permitted vertebrates to flourish on land so that 400 million years later I can write this proposal and you can read it. Nature wisely kept buried deep in the bowels of the earth the remains of ancient plankton, plants, and trees. Their entombment helped keep the carbon dioxide they captured through photosynthesis out of the atmosphere. But people started to dig up and burn the early trees, better known as coal, when wood fuel became scarce. The seemingly unlimited availability of long buried trees and algae aptly named fossil fuels ushered in a new technological era qualitatively separating those living since the middle of the nineteenth century from the rest of history. This new age of unprecedented growth people call the Industrial Revolution.

The industrial revolution has accelerated the rate of deforestation although this happened much earlier as well. Plato, for example, saw deforestation turn a fertile piece of Attica into rock. He compared this butchered slice of earth to a carcass stripped of all its meat with only the bones remaining. Increased material needs of industry, improvements in transportation, and unparalleled growth in population has made Plato's compelling description of a particular place in Greece universal.

**The growing loss of trees has allowed ever increasing amounts of carbon dioxide to return the atmosphere.** So have the engines of commerce and industry by burning fossil fuels. Scientific investigations have proven that since beginning of the industrial revolution carbon dioxide levels have increased as well as the temperature of the earth. Scientists call the two phenomena global warming.

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## Carbon Cycle

**Carbon is naturally exchanged between the atmosphere, the ocean, and land ecosystems as part of the global carbon cycle.** Hundreds of billions of tons of carbon in the form of $CO_2$ are absorbed by oceans and living biomass (sinks) and are emitted to the atmosphere annually through natural and anthropogenic emissions (sources). When in equilibrium, carbon fluxes among these various reservoirs are roughly balanced. But due to increased fossil fuel combustion since the Industrial Revolution there is a net increase in the rate of GHG into the atmosphere.

### Terrestrial Carbon Sequestration

**As a result of photosynthesis carbon dioxide is removed from the atmosphere and locked into the biosphere.** This is a part of the carbon cycle known as carbon sequestration. Trees and wood are carbon sinks, accumulating carbon as they grow and acting as stable carbon stores upon maturity. This carbon storage applies even when trees are converted to lumber. When trees die or succumb to fire, their stored carbon is released back into the cycle through decay and combustion.

The U.S. government's policy of greenhouse gas reductions recognizes carbon sequestration as a factor in the management of industry emissions. Because forests are sequestering carbon, forest managers would be paid by industry for maintaining carbon sinks, creating a "credit" on emissions by industry towards meeting emission reduction goals. In the U.S., forests (including vegetation, soils, and harvested wood) accounted for approximately 85 percent of the total terrestrial sequestration of $CO_2$. (902.5 Tg $CO_2$ Eq. in 2000)

Rate of Carbon flow (emissions minus sinks)
in billions of metric tons (gigatons) per year (Gt C/yr)

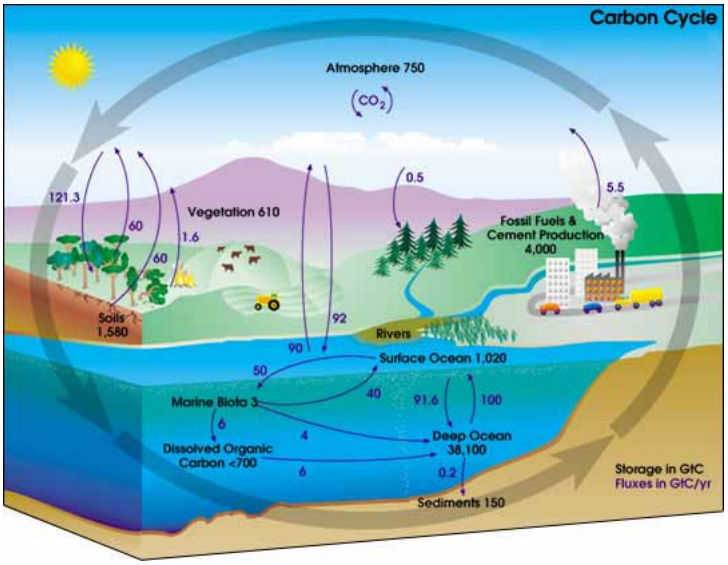
Fossil fuel emissions (into atmosphere)..... 5.5

Oceanic sink (Ocean absorption) ..... 2.0

Net Terrestrial sink (absorption minus release)....0.2

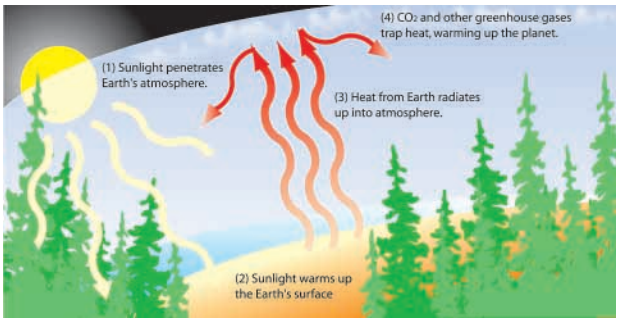
Terrestrial absorption ..... 1.8
Carbon release from deforestation .... 1.6

Total Rate of $CO_2$ increase in atmosphere .....3.3




In any given year, tens of billions of tons of carbon move between the atmosphere, hydrosphere, and geosphere. Human activities add about 5.5 billion tons per year of carbon dioxide to the atmosphere. The illustration to the right shows total amounts of stored carbon in black, and annual carbon fluxes in purple. (Illustration courtesy NASA Earth Science Enterprise)
http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html

## Greenhouse Effect




**The greenhouse effect is a natural process that enables our planet to maintain life.** Certain gases in the atmosphere (water vapor, carbon dioxide, nitrous oxide, and methane) trap energy from the sun. These gases behave much like the glass panes in a greenhouse. Sunlight easily passes through them on the way to the surface. As it reaches the Earth's surface; land, water, and biosphere absorb the sunlight's energy. Once absorbed, this energy is sent back into the atmosphere as heat. Some of the heat passes back into space, but much of it remains trapped in the atmosphere by these gases, causing our world to heat up. Without these gases, heat would escape back into space and Earth's average surface temperature would be about 33ºC (59.4ºF) colder. Because of how they warm our world, these gases are referred to as greenhouse gases (GHGs).

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Unless drastic changes occur socially and technologically, increasing amounts of carbon dioxide will enter the atmosphere as the burning of fossil fuels continues to accelerate along with deforestation. Bad forestry practices help hasten the pace of global warming. Following a clear cut, for example, the formerly forested soil releases tremendous amounts of carbon dioxide into the atmosphere. True, replanting does capture carbon dioxide as new organic matter grows. The losses of carbon dioxide to the atmosphere continue to exceed the removal of carbon in the replanted clear cut for fifteen to twenty five years depending on the type of tree, climate, and soil. Then the trees and the soil underneath start to store more carbon dioxide than released.

Conversely, forests can become a weapon in our arsenal to break global warming if foresters practice enlightened stewardship. Sustainable forestry will need to become the standard on all forest lands globally. Replanting formerly forested land helps if trees are not selectively harvested until the seedlings reach an age where they have taken in more carbon dioxide than has been exhaled. Indeed, trees can play a vital role in reducing atmospheric carbon dioxide. Ultimately, emitters of carbon dioxide will either have to reduce emissions or pay other parties to offset their carbon dioxide emissions. Timberlands verified as carbon-dioxide sinks could qualify as an offset and receive yearly payments. So everyone wins with sustainable forestry—owners of timberlands, the forest products industry, and the general population—as it helps bring the carbon dioxide in the atmosphere back to preindustrial levels.

*This is based on dialogues between John Perlin and Dr. Stephen Sheckler, Professor of Paleobotany, Virginia Tech University.*

### GHGs

**Water Vapor**
The principal greenhouse gas is water vapor (which includes clouds). Water vapor constitutes more than 95 percent of total greenhouse gases.

**Methane ($CH_4$)**
Methane is primarily produced through anaerobic decomposition of organic matter in biological systems; decomposition of wastes in landfills, enteric fermentation associated with domestic livestock, and natural gas systems. Methane is also emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal mining and incomplete fossil fuel combustion.

**Nitrous Oxide ($N_2O$)**
Most of the U.S.'s $N_2O$ emissions come from agricultural soil management, especially the use of synthetic and manure fertilizers. It's also emitted in fossil fuel combustion, adipic (nylon) and nitric acid production; wastewater treatment and waste combustion; and biomass burning.

Trees ARE the Answer

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