Are Forests only temporary Carbon Absorbers in Nature? - The debate has added fuel to the fire on Global Warming.

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Abstract: The world today, in which we are living is full of most serious dangers and threats. These perils and intimidation are not from any alien species, but from the most intelligent animal species of this world. Yes! We the Humans, who have deteriorated the natural ecosystems so much that in near future, we are going to see an end of all civilizations, and the mother planet earth will be *as lifeless as mars*. The most emerging anxiety these days is the *"Global Warming"*. It is so severe that it is precisely called, as "*Global warming is the Global warning*". Due to heavy industrialization and ignoring the scientific parameters of safety, we have transformed our planet in a *fast furnace*, or simply a time bomb! We all know that due to heavy industrializations and burning of fossil fuels etc, the gaseous oxides of Carbon like Carbon-mono-oxide (CO), and Carbon-di-oxide (CO_2) are emitted in the atmosphere. It is a proven study worldwide that green plants, with the help of their *chlorophyll* and accessory photosynthetic pigments take up the (CO_2) and convert it to the glucose, with the help of sun light and water. This whole biochemical process of fixing Atmospheric Carbon-di-oxide by green plants is known as "Photosynthesis". But now a new-fangled trepidation has taken birth within the scientific community. Some scientists believe that the forests, which play a major role in fixing the atmospheric CO_2, are only the temporary source of carbon absorbers in nature. They argue that the current terrestrial carbon sinks (the forests) are themselves a result of change in land-use pattern. It is further argued that the forest will soon be vanished from the different areas of the world, due to the changes in local weather pattern. Then in the future for the full-fledged triumph against the global warming, the scientists should start searching for a more reliable and sustainable carbon sink and the best way to combat global warming is to cut the carbon emissions worldwide. The present paper is an endeavor to comprehend the legitimacy of such claims about the forests. [The Journal of American Science. 2008;4(3):55-61]. (ISSN: 1545-1003).

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Introduction: Carbon sequestration can be defined as the removal of CO_2 from **atmosphere (source)** into **green plants (sink)** where it can be stored indefinitely **(Watson *et al.* 2000)**. These sinks can be above ground biomass (trees) or living biomass below the ground in soil (roots and micro organisms) or in the deeper sub surface environments. Sequestration, which is relatively a new term, can be described as storage of all forms of carbon, including storage in terrestrial, geological and oceanic ecosystem. Through practices and technologies sequestration seeks to quantify and enhance the storage ability of all potential sinks and expand the number and type of sinks in which carbon storage is possible. Enhancing the natural processes that remove CO_2 from the atmosphere is thought to be one of the most useful methods of mitigating the atmospheric levels of CO_2. While the whole world is anxious of the adverse effects of *Global Warming* and taking this as a sign of ***Global Warning***, a team of 30 scientists lead by Professor David Schimel, of the Max Planck Institute for Biogeochemistry in Jena, Germany, has published a paper in the renowned journal ***'Nature',*** arising the question of the sustainability of forests. The researchers have revealed that the world should not expect the terrestrial ecosystems such as forests, grasslands and soils to soak up Carbon di oxide (CO_2) far into the near future. The basis of their predictions is that these terrestrial ***"carbon sinks"* are themselves the product of temporary changes in land use.** They fear that the entire land-based carbon-sink could ultimately disappear. The study is also reviewed by distinguished environmentalist Alex Kirby and is of utmost importance in the present scenario of global warming and climate change. This new revelation has evoked numerous queries in the minds of scientists worldwide. The supporters of the theory argue that forests are going to vanish from different landforms, since they are themselves the product of geological transformations and have become ardent on this issue. Moreover there are instances that certain boreal forest ecosystems in Canada and other northern countries are not sequestering the amount of atmospheric carbon, they were supposed to do. Because of anthropogenic emissions, atmospheric CO_2 has climbed to levels that are presently more than 30% higher than before the industrial revolution, **(Barnolla 1999; Keeling and Whorf, 2000).** Indeed, geochemical measurements made on ancient ocean sediments suggest that atmospheric CO_2 levels over the past 20 million years were never as high as they are today **(J. T. Houghton et al., eds, 2001).**

The terrestrial sink for atmospheric carbon is the theme of substantial disagreement at present, regarding not only its magnitude but also its cause. For many years, researchers have believed that the prevailing sink mechanism is the fertilizing effects of increased CO_2 concentrations in the atmosphere and the addition to soils of fixed nitrogen from fossil fuel burning and agricultural fertilizers. This fertilization mechanism has been incorporated into most existing models of the terrestrial biosphere that are used to predict future concentrations of atmospheric CO_2. **(Sarmiento and Gruber, 2002).** However, a recent analysis of long-term observations of the change in biomass and growth rates, made by the **US Forest Service**, suggests that such fertilization effects are much too small to explain more than a small fraction of the observed sink in the United States of America **(Caspersen et al., 2000).** In addition, long-term experiments in which small forest patches and other land ecosystems have been exposed to elevated CO_2 levels for extended periods show a rapid decrease of the fertilization effect after an initial enhancement **(Schlesinger and Lichter 2001).**

The Present Carbon sink: When we talk about the biogeochemical cycles in nature, there are two important parts – one is the source and the other is the sink. The Source is the pool of that inorganic species, where it is found in free state. Whereas the sink is the region which absorbs that inorganic species. For example, if we talk about the biogeochemical cycle of Carbon di oxide (CO_2) gas, then the source is the atmosphere and the sink is the forest and oceanic ecosystems, with the abundance of **green plants** or **algae (*"Phykos"* or sea weeds).** These **photosynthetic green plants**, with the help of ***chlorophyll*** and accessory photosynthetic pigments, **absorb the CO_2** emitted into the atmosphere by human activities and **fix them in the form of carbohydrates**. This whole process of changing the atmospheric CO_2 into the solid glucose form is a very complex one and is known as ***"photosynthesis".*** Earlier some scientists believed that about 90% of the world's total photosynthesis is carried out by marine algae, but studies conducted later confirmed that only one-third of the total global photosynthesis could be attributed to oceanic algae. Almost all the climatologists believe that **CO_2** and other **Green House Gases (GHGs)** are intensifying the climate's natural changeability. But precisely how much carbon they absorb is unknown. Scientists believe the land and the oceans together absorb about half the CO_2 given off by the burning of fossil fuels.

Forests are carbon stores, and they are carbon dioxide sinks when they are increasing in density or area. In Canada's boreal forests as much as 80% of the total carbon is stored in the soils as dead organic matter **(CFS Science Policy Note, 2007)**.

Because CO_2 is noncreative in the atmosphere, it has a relatively long residence time there. However, its growth rate is presently less than half of what would be expected if all the CO_2 released by fossil fuel burning and land-use change remained in the atmosphere.

The growth rate is lower because the **terrestrial biosphere (plants and soils)** and the **ocean** are taking up a significant amount of anthropogenic CO_2, that is, acting as **"sinks."** The scientific community has made much progress in establishing the relative role of these two major natural sinks on a global scale, and it appears that the missing carbon is about equally divided between them. However, scientists continue to debate aspects of the spatial distribution and mechanisms of these sinks. The future behavior of the sinks turns out to be highly sensitive to whatever mechanisms we assume. Thus, better understanding of their behaviors is key to predicting, and hopefully mitigating, the future impact of anthropogenic CO_2. An important starting point for forecasting the future behavior is to understand its past.

The carbon balance is not fixed in time. As seen in, the atmospheric growth rate varies by a large amount from year to year. Most of the inter annual variability is correlated with the **El Niño southern oscillation** climate mode, with higher growth rates generally being related with **El Niño (warm climate)** episodes. The climate cooling caused by the **Mt. Pinatubo** eruption in the early 1990s appears to have contributed to reduce atmospheric growth rates. The primary cause of the variability remains controversial, but is probably due mostly to the response of terrestrial vegetation to climate variability, with a smaller contribution due to the oceanic response **(Quéré, et al., 2000)**.

As CO_2 concentrations in the atmosphere continue to rise, increases in plant productivity and litter fall are likely. Results suggest that the balance of carbon stored in the soils (thought to be a long-term sink for carbon) can be changed with the addition of fresh leaf litter. The capacity of soils to store carbon might then reduce if global environmental changes such as CO_2 increases and nitrogen deposition boost plant productivity. The study has implications for policy makers considering new approaches to capping carbon emissions such as carbon sequestration. The results suggest unanticipated feedbacks to the carbon cycle that must be taken into account when estimating the potential for carbon sequestration in the soil **(Sayer EJ, Powers JS,** The 30 authors of the report in "Nature" found that the atmospheric CO_2 and oxygen data confirm, that the terrestrial biosphere was mainly neutral with respect to net carbon exchange during the 1980s, but became a net carbon sink in the 1990s. This recent sink can be largely credited to northern extra-tropical areas, and is roughly split between America and Eurasia. Tropical land areas, however, were approximately in equilibrium with respect to carbon exchange, implying a carbon sink that counterbalance emissions due to tropical deforestation. In North America, China and Europe, the authors say that the key reasons were most likely the regrowth of forests, often after farmland was abandoned in the 1980s and 1990s. **(Fig.1)**. A decrease in the frequency of fires also contributed in this.

Fig. 1. Abandoning Farming will help in increasing Carbon Sink.

Provincial differences: Other aspects probably include changes in foliage, plant litter and soil microbes. These in turn are affected by changes in photosynthesis, respiration, fire and insect outbreaks, influenced by huge climate fluctuations such as **El Nino** and its **reverse La Nina effect** or more commonly **ENSO (El Nino Southern Oscillation)** in **the pacific ocean**. Growing trees soak up net quantities of CO_2, and the higher levels of CO_2 and nitrogen in the atmosphere are themselves stimulating tree and plant growth.

But the scientists anticipate that ***"these effects will reach up to a saturation point one day and cease to have an effect thereafter".***

They found big regional variations in the effectiveness of sinks. **Much of Siberia, for example, has warmed by about 0.5 degrees Celsius a decade since the 1960s**.

An increase in wildfires and insect damage appears to have changed it from a sink into a temporary source of CO_2.

In a possible pointer to future changes, Professor David Schimel articulated that, ***"Globally, there appears to be a net release of carbon to the atmosphere during warm and dry years, and a net uptake during cooler years."***

The most astonishing revelation of Professor David Schimel, is that, ***"although carbon sinks have a role to play in absorbing excess CO_2, it is possible that the net global terrestrial carbon sink may disappear altogether in the future."*(Fig. 2).**

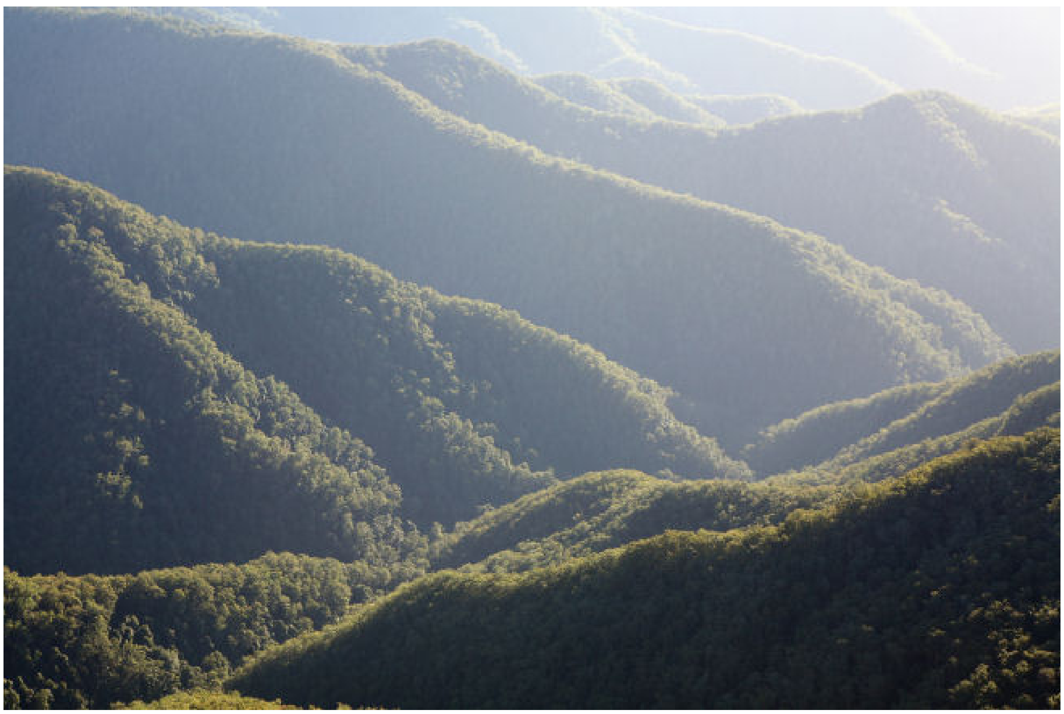

Fig. 2. Forests will not remain forever.

Actual Role of Forests as Carbon Sink: There is certainly no doubt that forests do play a significant role in carbon fixation and are the sink for atmospheric carbon. But different studies worldwide also confirm the uneven effectiveness of the forests as atmospheric carbon sink. Japan appears most likely to rely most heavily on forest and biological sinks to meet its Kyoto targets. For Canada, sinks are likely to play a rather modest role. For the European Union (EU), the role of sinks is likely to be even smaller, with sinks playing no role for some EU countries (including Sweden)**(Masahiro and Sedjo, 2003).**

Carbon uptake via forest activities varies significantly depending on location (tropical, Great Plains, etc.), activity (forest conservation, tree planting, management, etc.), and the assumptions and methods upon which the cost estimates are based. **(G Van Cornelis Kooten and Alison, J. Eagle, 2005).** The new findings pointing towards the uncertainty of the sustainability of Forests also give an idea that the best way to fight against the global warming is to cut carbon emissions worldwide. Some scientists also feel that in the future carbon sinks could become a source of CO2 and other greenhouse gases, such as methane.

There are numerous examples of severe **forest fires** due to **EL NINO** and the reverse **LA-NINA** effect, which occur in a periodic cycle of about 5-7 years in the pacific countries like Australia, Costa-Rica etc. ***Due to these horrible large-scale forest fires, the forest themselves become the sources of high CO2 emissions in the atmosphere, thus adding to the problem of global warming.*** So it is certainly not very much exciting to rely upon the terrestrial ecosystems for a future reliable source of Carbon Sink. Similar examples can also be taken from the northern boreal Canadian forests, which first of all do not sequester the atmospheric carbon in the desired amount and sometimes due to huge forest fires are transformed into big sources of atmospheric carbon **(Fig. 3).**

Fig. 3. Crown Fire in Canadian Boreal Forest.

The **world's forests** contain about **830 Pg C (10^{15} g) Carbon** in their vegetation and soil, with about 1.5 times as much in soil as in vegetation. During the 1980s, analysis of Carbon budgets show that forest of the temperate and boreal countries were a net sink of atmospheric C of about 0.7 Pg yr^{-1}, but the tropics were a net source of about 1.6 Pg yr^{-1}. However, accounting for the imbalance in the global C cycle suggests that forest are not significantly contributing to the net increase in atmospheric CO_2 and thus not contributing to global climate change. However, this may not continue into the future as temperate and boreal forests reach maturity and become a smaller C sink, and if rates of tropical deforestation and degradation continue to accelerate **(Sandra Brown, 1997).**

The green house effect raising the global temperature may trigger a series of changes within the overall global climate system. For instance, **global sea levels have risen by 10-25 cm over the past 100 years**, and are expected to continue to rise due to increases in temperature. We are also seeing increases in severe weather events. Such impacts of climate change could have far-reaching and/or unpredictable environmental, social, and economic consequences. Indeed, the climate change problem and the related changes are among the most serious of the environmental issues that we face today **(Seth, 2005).**

In the U.S., trees and other growth expanded on abandoned agricultural land and a reduction in fires allowed forests to spread. Increased plant growth spurred by the increasing carbon dioxide and nitrogen deposits - a process more noticeable in Europe and Asia - also helped remove carbon dioxide.

But there is a limit to how much forests can fill in and spread. Eventually new trees and grasses reach maturity and soak up less carbon dioxide. In addition, global climate change may have impacts upon the well-being of ecosystems and cause them to decline in extent and vigor. Warm and dry weather was found to reduce the ability of terrestrial ecosystems to act as global sinks.

Under some conditions, forests and peat bogs may become sources of CO_2, such as when a forest is flooded by the construction of a hydroelectric dam. Unless the forests and peat are harvested before flooding, the rotting vegetation is a source of CO_2 and methane comparable in magnitude to the amount of carbon released by a fossil-fuel powered plant of equivalent power. **Duncan Graham-Rowe (2005).**

Life expectancy of forests varies throughout the world, influenced by tree species, site conditions and natural disturbance patterns. In some forests carbon may be stored for centuries, while in other forests carbon is released with frequent stand replacing fires. Forests that are harvested prior to stand replacing events allow for the retention of carbon in manufactured forest products such as lumber. Only a portion of the carbon removed from logged forests ends up as durable goods and buildings - the remainder ends up as sawmill by-products such as pulp, paper and pallets. For instance, of the 1,692 teragrams of carbon harvested from forests in Oregon and Washington (U.S) from 1900 to 1992, only 23% is in long-term storage in forest products. **Harmon, Harmon, Ferrell and Brooks(1996).**

Conclusion: So, in the conclusion we can say that no doubt the forests are working as the terrestrial carbon sinks in nature presently, yet it appears that these carbon sinks are only temporary environmental entities being influenced by natural and anthropogenic activities. We have seen a lot of examples explaining about the temporary survivalship of forests in nature. The ever changing local weather and global wind patterns are also playing key roles in deciding the life expectancy of the forest lands. One thing is for sure that - the best way to fight against global warming is to cut the carbon emission and stop the use of fossil-fuels worldwide. To ensure this all the governments of world must work hand-in-hand and that is the only solution to stop the increasing concentration of the atmospheric carbon. New declarations and policies must be made considiring the important revelation about the sustainability of the terrestrial carbon sinks in nature. Simultaneously the scientists should also seek for some new sources of carbon sink as well, which are not influenced by local weather pattern and might not become a source of carbon themselves in near future. We must start acting today to make a safe and better world for tomorrow.

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