# Your Role in the “Greenhouse Effect”

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It is time to place one aspect of the global warming problem (often interpreted as the Greenhouse Effect) into understandable terms. Occasionally mention is made of the millions of tons of carbon dioxide that are released into the air each year but the numbers are incomprehensible. More relevant would be a consideration of the contribution each of us makes to the carbon dioxide content of the air.

Fresh air contains less than 0.04% carbon dioxide. A human's breath contains almost 5% carbon dioxide. Therefore, we are contributing to the problem with each breath we take. Every person's output varies according to the amount of exercise taken, the food consumed, etc., but for the purpose at hand a reasonable figure is that each person exhales 445 liters of carbon dioxide per day (the average of 1000 samples measured by the USDA). In the course of a year this production by one average person represents 704 pounds of carbon dioxide.

Suppose you drive a car. Let us assume that the American Petroleum Institute is correct with its calculation (for 1995) that the average car in the U.S. uses 551 gallons of gasoline per year. Gasoline is a mixture of many hydrocarbons but, as a reasonable estimate, let us consider it to be octane. Let us also assume that, upon burning, it produces only carbon dioxide and water. With these assumptions we arrive at a figure of 19 pounds of carbon dioxide produced from each gallon of gasoline. If we burn 551 gallons per year, we are producing more than 10,000 pounds of carbon dioxide (> 5 tons). Adding our own metabolic production to that brings the production to roughly 5.5 tons of carbon dioxide per year, for one person driving a car and using the average amount of gasoline.

A Consideration of the Balance in Nature

Take this one step further. Carbon dioxide is absorbed by grasses, plants, shrubs, trees and phytoplankton by the process of photosynthesis. If we assume that the average person has a lawn which serves as an absorber for the carbon dioxide that he and his car produce (certainly an unwarranted assumption), how large must that lawn be? Again, we must rely on an estimate. By using productivity data for "temperate grasses," and assuming that each CO2 produces CH2O (the shorthand notation for cellulose), the area of lawn required to absorb the CO2 by one person and one car is more than 70,000 square feet, approximately 1.5 acres. Obviously most urban residents have considerably less lawn than would be required to absorb the carbon dioxide they produce. This is an interesting figure but perhaps irrelevant. I called a laboratory of the USDA in Beltsville, MD, which is involved with matters of this type and spoke with Jim Bunce who pointed out that I was asking the wrong question. Grass absorbs CO2 but only on a short term basis. Grass clippings decompose or are eaten, but in a relatively short time much of the carbon is released back into the atmosphere as CO2. A more pertinent question would be to ask about the CO2 absorption rate of trees because they are the more permanent absorbers. Trees that have been converted into furniture provide a very long term storage of carbon.

For an estimate of the number of trees required to absorb the one person/one car CO2 production I contacted Gregg Marland, Senior Staff Scientist of the Environmental Sciences Division at Oak Ridge, Tennessee. Before making a judgment on this problem he provided a different statistic: in burning every form of fossil fuel in this country, the carbon produced on a per capita basis is 5.1 tons per year. Expressed as carbon dioxide, this is 18.7 tons per person per year.

Therefore, we have two measures for consideration: 1) A car and driver produce about 5.5 tons of CO2 per year and, 2) When all fossil fuel is considered, every man, woman, and child can be said to be responsible for 18.7 tons of CO2 per year.

An Estimate of the Forest Size Required for Sequestering the CO2 Released by Man and Fossil Fuels in the U.S.

Marland's estimate of the average absorption of a U.S. commercial forest is 0.8 tons of carbon/hectare/year. By converting this number into the units mentioned above, this equals 2.93 tons of CO2 /hectare/year, or 1.19 tons of CO2/acre/year. With this figure as a starting point we have two numbers to ponder:

_. To absorb the CO2 produced by a car and driver, a forest of 4.6 acres is required,

_. To absorb the nation's CO2 production (just from fossil fuel), a forest of 15.7 acres per person is required.

If we were to substitute a fast-growing forest of pine trees for the commercial forest cited above, these areas would be reduced by a factor of about six, which would still be a huge number (i.e. even if we were to have nothing but fast-growing pine trees, there would be a need for 2.6 acres of these trees to absorb the $CO_2$ produced by every person in the U.S). Remember that this calculation regarding the nation's output of $CO_2$ concerns only fossil fuel. Add to that the $CO_2$ exhaled by humans, cattle, pets, horses, birds and soil fungi and the number of acres of forest required becomes much higher.

We must be mindful in making such estimates that there are many unknowns. Forests are not the only absorbers of $CO_2$. Lakes, ponds, rivers, and oceans contain phytoplankton which photosynthesize and produce oxygen which can be shared with our air. Re- member, however, that the fish, insects, mussels, and other components of these aqueous habitats require oxygen which then limits the amount available for equilibration with the atmosphere. I asked Marland if he might comment on the accuracy of the figures con- cerning $CO_2$ production by fossil fuels and the $CO_2$ uptake by forests. He felt that the data on fossil fuel consumption were probably accurate within several percent because there have been reasons to track some of those figures. I was less certain of the calculated rates of $CO_2$ uptake by forests and asked whether they might be off by a factor of two or so. Marland felt strongly that the data (based largely on work done at Harvard) were better than that although not so accurate as those concerning fossil fuels.

## A Need for Humility

Undoubtedly there are yearly changes in any of these large numbers, therefore the caution flag must go up lest they be interpreted too strictly. The recent crisis in the Biosphere 2 project attests to the difficulty of attempting to make one's own little world. Undoubtedly much thought went into that project but the oxygen content of the habitat dropped to less than 14% after about 1 1/2 years. A supposed factor was that the oxygen consumption of the soil microorganisms was greater than anticipated. On the other hand the $CO_2$ concentration did not rise as much as expected because much of it was absorbed by the concrete in the habitat. Another surprise was that the $N_2O$ content of the air went up to 79 parts per million. Also the ant population exploded in a manner that had not been predicted. I mention these items, not as criticisms of the planners, but merely as examples of factors whose importance could not have been predicted.

## How About Our Oxygen Supply?

If oxygen is required to burn all of the fossil fuel, why don't we run out of oxygen? The reason is that for every volume of $CO_2$ absorbed in the photosynthesis process, there is slightly more than one volume of oxygen produced.

With algae, for example, the ratio of $O_2$ produced/$CO_2$ absorbed can range from about 1.06 to 1.18 depending on the nitrogen source being used by the algae (the lower figure is with urea, and the higher with nitrate as the nitrogen source). Furthermore, a slight increase in $CO_2$ concentration in the air can result in a faster rate of photosynthesis although there are limits to this phenomenon.

## Summary

Based on the facts available it appears that the $CO_2$ produced in the continental United States, by human respiration and the burning of fossil fuels, is greater than the $CO_2$ absorption capacity of our forests. These estimates do not include the substantial $CO_2$ produc- tion by animals or by microorganisms in the soil. Despite the tremendous burning rate of fossil fuel, the oxygen content of the atmosphere has remained stable, probably because of the slightly better than 1:1 ratio of $O_2$ production to $CO_2$ absorption.