The Planet's Lungs: Planting Giant Sequoias to Combat Carbon Dioxide

By Matthew Auman

Carbon dioxide concentration in the atmosphere is increasing. This is not controversial. Global warming has been cited as the direst problem from this increasing concentration of atmospheric carbon dioxide, but other more definite problems, like ocean acidification, exist. Almost all of the proposed solutions to prevent or counteract this carbon dioxide increase have been foolish and harmful to human prosperity and happiness- limiting driving, flying, air conditioning, home sizes, etc. Few are discussing a much better solution that improves rather than worsens our living standards - planting very long lived and massive trees to absorb and store carbon dioxide.

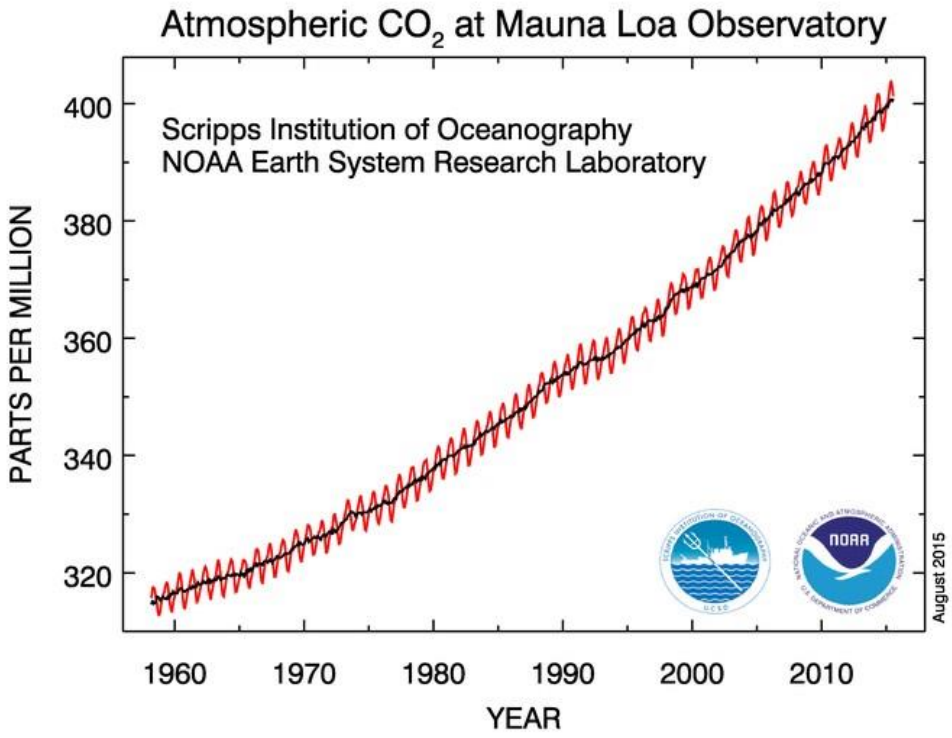

Figure 1: Carbon dioxide concentration in the atmosphere as measured by the Mauna Loa Observatory on Hawaii:.From NOAA, available at http://www.esrl.noaa.gov/gmd/ccgg/trends/, public domain.

The largest tree (and living thing, for that matter) on Earth is the giant sequoia tree (*Sequoiadendron giganteum*), specifically a single tree called "General

Sherman". We wished to calculate how much carbon dioxide a sequoia tree could conceivably sequester or "lock up" in a best case scenario. Sequoias are ideal for sequestering carbon dioxide because of their great volume, extremely long lifespan (several thousand years), and the wide range in which they can be grown. We are currently growing two giant sequoias in Indiana, which is hardly native habitat for the sequoia (native habitat is a small portion of California's Sierra Nevada mountain range).

We went through a fair amount of effort to determine how much carbon dioxide a giant sequoia can sequester. We will spare you the details of this calculation here, but please see our footnote below for our sources and calculations.

The General Sherman sequoia tree in California is the largest living thing on Earth by volume. Its volume of 52,500 cubic feet, or about 1486 cubic meters, contains over one million kilograms (or over 2.2 million pounds) of stored carbon. This volume of stored carbon pulled over 1400 metric tons of carbon dioxide out of the atmosphere.

Americans, on average, produce 16.6 metric tons of carbon dioxide emissions per year (although this number has been decreasing recently due to efficiency gains). The General Sherman sequoia is so large that as a single tree it has stored about 86 years' worth of a person's carbon emissions. The current American lifespan is less than 80 years. In other words, one very large tree has been able to counteract over a lifetime of carbon emissions for the average American. We must note that this is carbon stored in the above ground, easily measurable portion of the General Sherman Tree. This does not include the carbon stored in roots, which are not currently measurable in living trees, or the humus (decaying organic matter) from the tree that had been deposited in the soil over time.

Image 1: The General Sherman Giant Sequoia Tree, from National Park Service, found at http://www.nps.gov/seki/learn/nature/sherman.htm, public domain

These facts about the largest giant sequoia would be interesting but not particularly actionable if not for one simple fact. Giant sequoia trees can be grown in most of the United States - not just California. We are growing two giant sequoias in Indiana, both started with the Waterboxx PlantCocoon®. The sequoia's main requirement is sufficient water, and its water needs can be significant. However, the need for consistent water is most critical during the first few years of a sequoia's life outdoors. We have found that due to soil evaporation, we could not manually water sequoias enough for them to stay alive. Some other system was needed to prevent evaporation and ensure sufficient water available to the roots. It was our interest in planting sequoias in a better way that got us interested in the Groasis Waterboxx PlantCocoon®. One of our sequoias has now graduated from the Waterboxx PlantCocoon® - meaning the Waterboxx PlantCocoon® has been removed and used for other plants. The tree is doing well even though we haven't manually watered it, even once. It takes about 18-24 months to establish a small (6 inch height) sequoia with the Waterboxx PlantCocoon® in our state. You can see our two sequoias in the pictures below. Neither of these trees has had any water from us or any sort of irrigation after initial planting and set up with the Waterboxx PlantCocoon®.

Image 2: Our first successful giant sequoia was planted just outside Indianapolis, with these pictures above showing two years' worth of growth. This tree is now over a meter tall, with no watering at all after planting with the Waterboxx PlantCocoon®. Even after the Waterboxx PlantCocoon® was removed, no watering was needed due to the deeper roots established by the Waterboxx PlantCocoon.

Image 3: This giant sequoia seen above, planted in Southern Indiana, was smaller when transplanted outdoors with the Waterboxx PlantCocoon®. In the 25 month time span seen in the photographs, the tree has dramatically increased in size, and will soon be able to survive without help.

Regardless of your stance on global warming, increasing carbon dioxide in the atmosphere poses other risks (like ocean acidification mentioned above, see the

excellent PBS documentary *Lethal Seas* at http://www.pbs.org/wgbh/nova/earth/lethal-seas.html) as well as some benefits (like faster plant growth). We can take advantage of both of these by planting giant sequoias. If every set of grandparents came together to plant one sequoia each for every new grandchild in their family (for a total of two sequoias per child), that child's carbon dioxide emissions would likely be eventually offset by the sequoias, and the carbon would be stored for thousands of years. Also, we would find our neighborhoods statelier and more shaded from these monumental trees.

If you are interested in planting a giant sequoia, our preferred source is Giant-Sequoia.com. To buy the Waterboxx PlantCocoon®, visit us at DewHarvest.com.

Footnote: Our Calculations and Sources

Note: we use American mathematical nomenclature here (commas to separate 1000s, periods to indicate decimals) with metric units

When calculating carbon dioxide sequestered by a sequoia, it is first necessary to have the density of sequoia wood. We were only able to find this information with great difficulty and after much searching. We did also receive a generous sample of sequoia wood from our friend Joe Welker at giant-sequoia.com (where we bought our sequoia trees). The measured density for a small piece of sequoia wood containing bark was approximately 0.48 g/mL. We obtained this by measuring a small piece of sequoia wood (36 grams) on a very accurate postal scale. We then submerged this same piece in a graduated cylinder, which displaced 75 mL. 36/75 = .0.48g/mL which equals 0.48 g/cc as one milliliter is equal to one cubic centimeter, by convention.

This density of 0.48 g/cc is within the range of densities reported by Wolfgang Knigge in his scientific paper *Giant Sequoia in Europe*, http://www.fs.fed.us/psw/publications/documents/psw_gtr151/psw_gtr151_06_knigge.pdf. His reported densities found average values of 0.345 g/cc in European giant sequoias and 0.369 g/cc in California giant sequoias. Our density of 0.48 g/cc converts to 480 kg/m^3 . The math for this conversion is 0.48g/cc x 1,000,000 cc/m^3. This result is then multiplied by 1 kg/1000 g, equaling 480 kg/m^3.

Next we need to calculate how much mass the largest living sequoia tree, General Sherman, contains. According to the National Park Service, the General Sherman sequoia has a volume of 1,486.6 cubic meters (http://www.nps.gov/seki/learn/nature/sherman.htm). To get total mass of this tree, we multiply 1486.6 m^3 by 480kg/m^3. This gives us a total mass of 713,568 kg for General Sherman.

This mass is of course not all carbon - much being oxygen, nitrogen, and other elements. Most trees are about 50% carbon by mass. However, as giant sequoias have more heartwood (more durable wood in the center of the trunk) than sapwood, and heartwood has a slightly higher carbon content, this 50% value may be too low for sequoias. According to Sean Thomas in his Paper *Carbon Content of Tree Tissues: A Synthesis* (See section 4.1, available here: http://www.mdpi.com/1999-4907/3/2/332/htm), giant sequoias are approximately 55% carbon by mass. When we multiple our calculated mass for General Sherman of 713,568 kg x .55, we get a carbon mass of 392,462 kg.

We next need to convert the mass of carbon into metric tons, so we divide 392,462 kg by 1000 to get a value of 392.4 metric tons or carbon stored in General Sherman.

However, carbon is not the same as carbon dioxide. Carbon dioxide has one carbon atom and two oxygen atoms per molecule. Trees absorb the carbon when growing while (mostly) emitting the oxygen. The atomic weight of carbon is 12.001115, while the atomic weight of oxygen is 15.9994. So the total atomic weight of CO_2 is 43.999915. With a little algebra, we see that since the ratio of carbon dioxide to carbon is 43.999915/12.001115 or 3.6663 units of

carbon in the tree for every unit of carbon dioxide removed from the atmosphere. We obtained this information from the Broward County Florida Climate Change website (https://www.broward.org/NaturalResources/ClimateChange/Documents/Calculating%20CO2%20Sequestration%20by%20Trees.pdf) as well as contact with Richard Campbell from Save The Redwoods).

We can thus multiply our total mass of carbon, 392.462 tons by our conversion factor 3.6663 from above to get 1438.892 total tons of CO_2 removed by the General Sherman giant sequoia.

Americans, on average, produced 16.6 metric tons (or tonnes) of carbon dioxide per year in 2013 (the most recent year available) according to the Netherlands Environmental Assessment Agency (Table A1.2, page 49 found at http://edgar.jrc.ec.europa.eu/news_docs/jrc-2014-trends-in-global-co2-emissions-2014-report-93171.pdf).

When we divide 1438.892 metric tons of carbon dioxide removed by General Sherman by 16.6 metric tons, we get 86.7 years of CO_2. That is 86.7 years of carbon emissions sequestered in a single tree! We find this number so impressive that we checked our math several times.

Life expectancy for Americans, according to the Centers for Disease Control, is 78.8 years as of 2013 (http://www.cdc.gov/nchs/fastats/life-expectancy.htm).

Caveats: General Sherman is the largest sequoia now living, and any trees planted would be unlikely to get quite this large. We chose this tree as good data was available on its volume. Also, it likely took several hundred years to reach this size, with more carbon absorbed at larger sizes. So any sequoias planted are unlikely to absorb a whole person's carbon dioxide output for several decades. However, adults emit considerably more carbon dioxide than young children, so the growth and sequestration of a sequoia may roughly mirror a human's emissions. Also, as mentioned above, above ground volume of a tree does not take into account volume of roots still living below a tree, carbon based fungus (mycorrhizae) living off those roots in a symbiotic relationship, or humus previously produced by that tree, all of which store carbon.

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