Celebrating the Uniqueness & Utilization of California Urban Woods

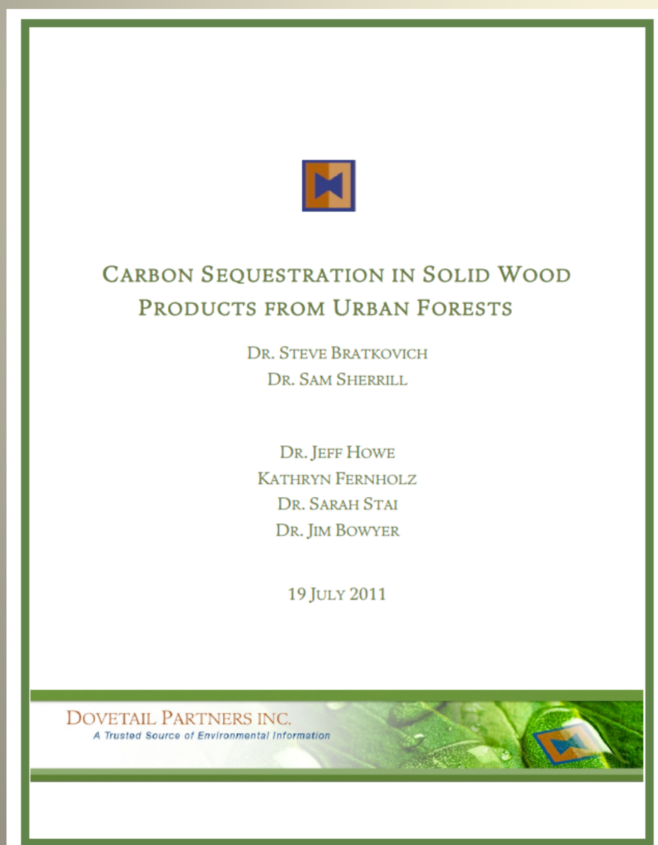
"From Urban Forest to Final Form"

Carbon and Carbon Dioxide Equivalent Sequestration in Urban Forest Products

Friday, April 3, 2015
Palomar College
San Marcos, CA

Presentation based on research conducted by Steve Bratkovich, Ph.D., and Sam Sherrill, Ph.D., in 2011.

Two reports are available at Dovetail Partners website (www.dovetailinc.org). Under Search, enter "carbon sequestration". First entry is public report and the fifth is the technical report submitted to the Forest Service. Can download as PDF's.


CARBON SEQUESTRATION IN SOLID WOOD PRODUCTS FROM URBAN FORESTS

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19 JULY 2011

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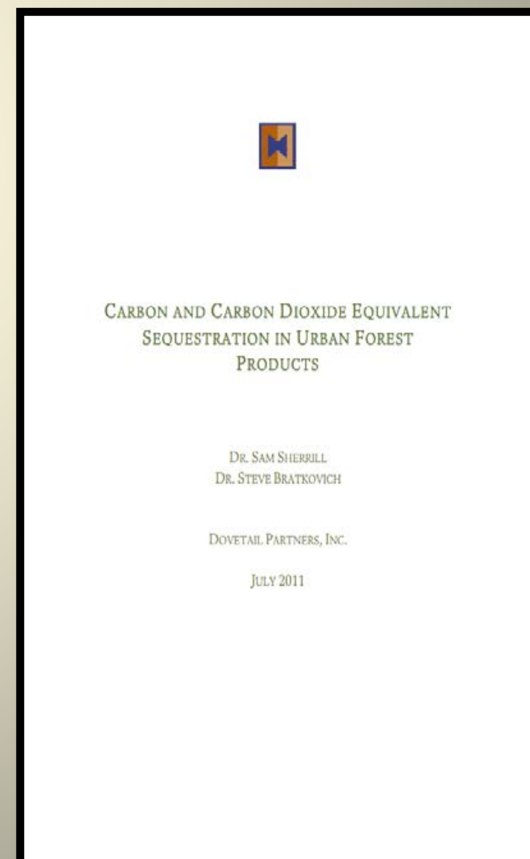
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JULY 2011

SIX BASIC FACTS

Trees both in and out of urban areas sequester carbon.

Urban trees in the U.S. hold about 774 million tons of carbon (Nowak and Crane, 2002).

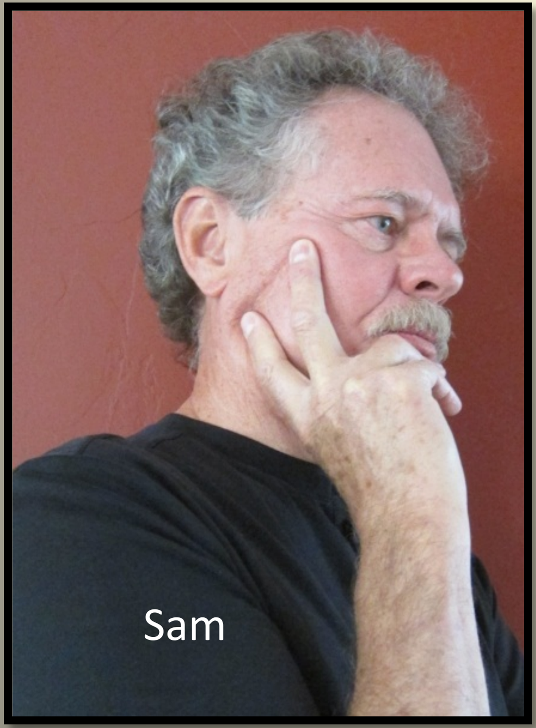
Approximately 2.84 billion tons of CO^2e (equivalent).

Forest product research reveals wood products store carbon.

Research focused only on products made from rural woodlots and non-urban trees.

No comparable research on the sequestration potential of urban wood products.

IDEA!!



Proposed project to estimate net cumulative total amounts of CO^2e that could be sequestered in urban hardwood products.

Three products are:

landscape mulch (Steve),

chips for fuel (Steve), and

solid wood products (Sam).

Plus:

argue for an <u>urban</u> forest products industry <u>separate</u> from the forest products industry.

Obligatory credits ($$):

The work upon which this publication is based was funded in whole or in part through a grant awarded by the Wood Education and Resource Center, Northeastern Area State and Private Forestry, U.S. Forest Service.

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On mulch, Steve concluded:

landscape chips should be classified as a short-term product with zero long-term CO^2e sequestration.

On hardwood chips, Steve:

analyzed as a fossil fuel substitute used to generate electricity.

He concluded:

As fuel, no sequestration.

2000 lbs. of urban wood @50% moisture content displaces about 820 lbs. of coal.

and

also displaces about 1,800 lbs. of CO^2e

Furthermore, for the nation, burning 10 percent of the annual urban tree removals as chips in place of coal would eliminate CO^2e emissions of about <u>2.1 million (short) tons each year</u>.

<u>2.1 million tons</u> is about 0.1% of annual energy-related CO^2 emissions attributable to coal (2,300 million short tons in 2013).

But,

annual removal of <u>2.1 million tons</u> = removal of CO^2 emissions of about 367,000 automobiles from U.S. highways. Not bad!

Nice work, Steve.

So, what did Sam do?

Quantitative Excel Model to Calculate the Total Net CO^2e Sequestration by Region in Urban Hardwood Products for a Thirty Year Period

$$TNS_R = ((((((\sum_{t=0}^{t=29} (Q_{t-1} \times p_{t+1})) + (Q_t \times p_{t=0})) \times .74) \times .50) \times 3.67) - E_t$$

Where TNSR = Total Net CO^2e Sequestration by Region in urban hardwood products for year t

t=0	year 0
t=29	the 30th or last year;
t	current year;
t-1	year before current year t;
t+1	year after year 0;
Qt	quantity C sequestered in current year t (total regional amount sequestered times the proportion, 0.1% , 0.2%, or 0.3% yields what is potentially available);
p	proportion of hardwood products in use and sequestering C;
Et	emissions generated by kiln drying urban wood using fossil fuel grid electricity in year t;
.74	above ground level biomass available for use (i.e., exclusion of roots)
.50	amount of above ground biomass usable for the production of urban hardwood products including but not limited to saw logs; and,
3.67	units of CO^2e (equivalent) for every unit of C.

Oh, no! Please tell us you are not going to explain this in detail.

No. I will quickly list the factors that comprise the model and show a few examples.

Eleven Variable and Fixed Factors in Excel model:

1. growth in sequestration capacity of urban forest (variable from outside model),

2. proportion sequestered in urban hardwood products (variable from outside model),

3. CO^2 emissions attributable to kiln drying (varies within model),

4. carbon currently sequestered in urban forests by region (fixed),

5. proportion of above ground mass of urban trees – exclusion of roots (fixed at 74%),

6. above ground mass usable for urban hardwood products (fixed at 50%),

7. pounds of C/ft.^{3} based on average hardwood density (fixed at 18.7 lbs.),

8. C removal rate from urban forests (fixed at 1% but could vary)

9. proportion of hardwood products in use and sequestering C (fixed but varies year to year over 30 years),

10. CO^2 equivalent (e) for every unit of C (fixed at 3.67 lbs. CO^2e/1 lb. C),

11. Percent hardwood lumber kiln dried (fixed at 80%, an overestimate in my view).

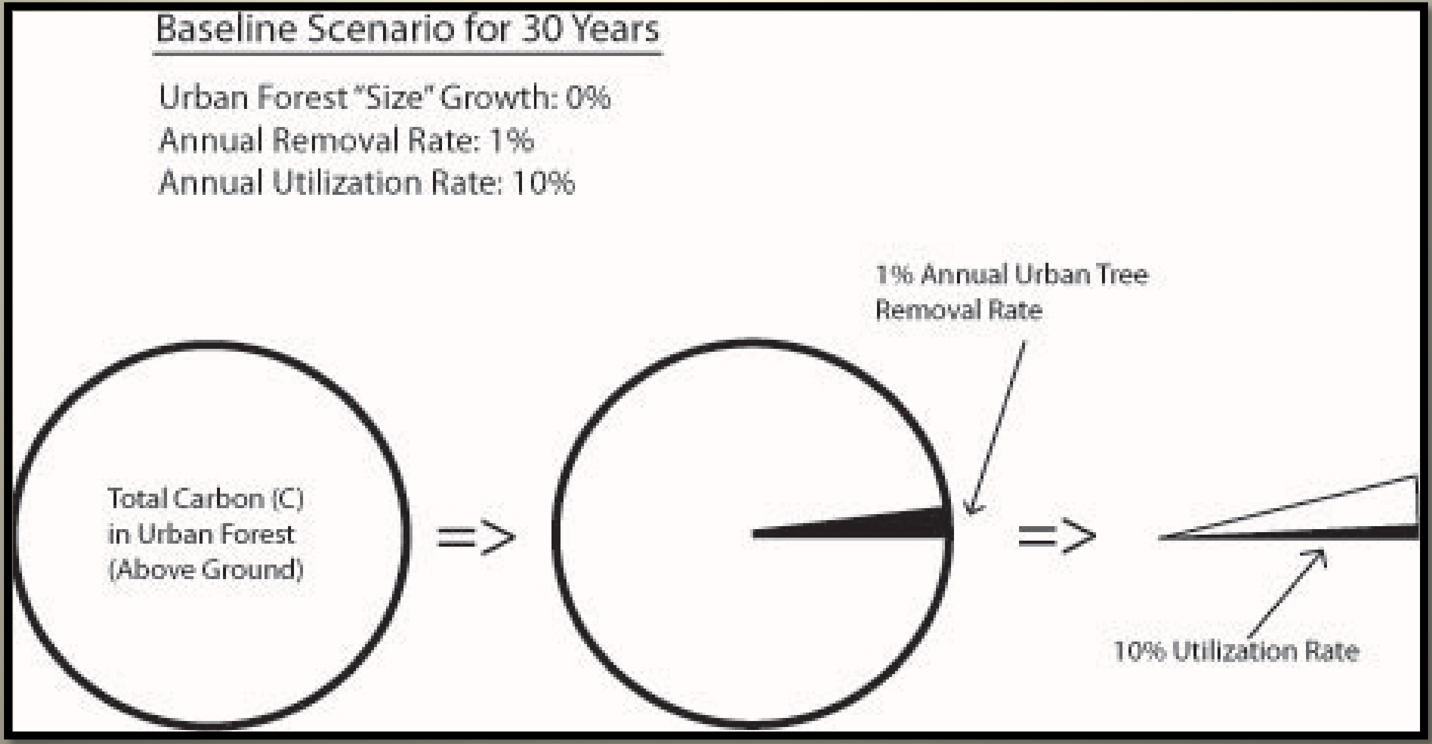
Sequestration estimates vary as a function of changes in one or the other or both of the following two variables:

1. capacity of the nation's urban forests to sequester carbon (this is more than just urban forest size by acres or hectares); and/or

2. potential proportion of CO^2e in urban forests that could be captured in hardwood products.

Steve and I wanted our baseline estimate to be very conservative.

Assumed 0% annual growth in urban forest sequestration capacity, 1% removal rate, and 10% utilization of urban trees to make urban forest products;



This gave us a baseline for comparisons of

124.1 million tons of CO^2e over a thirty year period.

Net Cumulative CO2e Sequestration in Urban Hardwood Products for 30 Years with Fixed Potential Sequestration Rate

Change in C Sequestration Capacity of Urban Forest	Potential Annual Product Sequestration Rate (10% use of 1% annual removal)	Net Cumulative CO^2e Sequestration in Urban Hardwood Products
0.0%	**0.1% (.001)**	**124.1 million tons**
1.0%	0.1% (.001)	139.3 million tons
2.0%	0.1% (.001)	157.2 million tons

Net Cumulative CO2e Sequestration in Urban Hardwood Products for 30 Years with Sequestration Capacity Fixed at 0% Annual Growth Rate

Change in C Sequestration Capacity of Urban Forest	Potential Annual Product Sequestration Rates (10, 20, 30% use of 1% annual removal)	Net Cumulative CO^2e Sequestration in Urban Hardwood Products
0.0%	**0.1% (.001)**	**124.1 million tons**
0.0%	0.2% (.002)	248.1 million tons
0.0%	0.3% (.003)	372.2 million tons

Bear with me, just one more table.

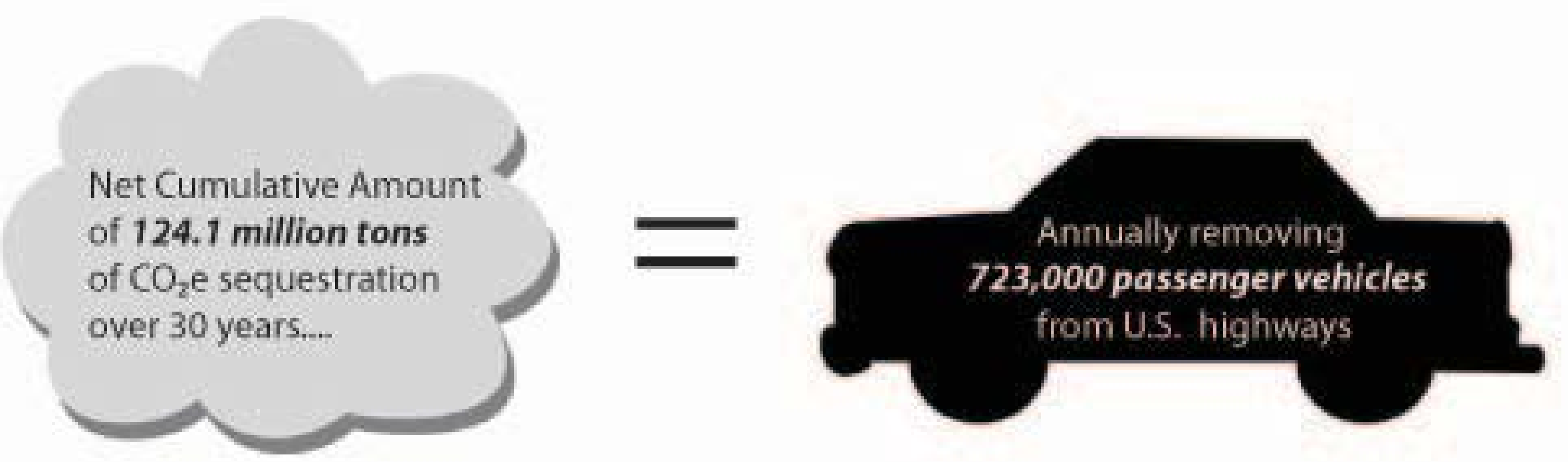
Net Cumulative CO2e Sequestration in Urban Hardwood Products for 30 Years with Sequestration Capacity Fixed at 0%, a 10% removal rate (versus 1%), and Potential Sequestration Rates of 3%

Change in C Sequestration Capacity of Urban Forest	Potential Annual Product Sequestration Rate (Utilization rate over 30 years)	Net Cumulative CO^2e Sequestration in Urban Hardwood Products
0.0%	**0.1% (.001)**	**124.1 million tons**
0.0%	3.0% (.030 @ 10% removal rate, not 1%)	**3,721.7 million tons**

Microsoft Excel
97-2003 Workshee

By the way,

Figure 4.
Urban Forest Products CO_2e Sequestration and Comparison to U.S. Automobiles



substituting chips for coal <u>plus</u> minimum sequestration in urban hardwood products would

eliminate annual CO^2 emissions of about <u>1 million American vehicles/year</u>.

Need Separate Urban Forest Products Industry

National Hardwood Lumber Association standards for grading lumber would eliminate much of the lumber from urban trees.

Thus limiting its product sequestration potential.

Purpose of NHLA standards is to create fungible product that can be sold sight unseen in large quantities.

NHLA standards do not work for urban forest products industry because the standards fail to recognize uniqueness of urban wood.

What makes urban wood unique is:

1. <u>Provenance</u>: where trees/lumber came from.

Biltmore Estate, Asheville, NC. Cucumber magnolia planted in 1901 by G. W. Vanderbilt

2. History: trees with historical significance.

Wood from the last standing Liberty Tree on the grounds of St. John's College in Annapolis, MD was rescued from the landfill and eventually used to make a limited series of acoustic guitars honoring the historical importance of the tree.

3. Figure, Color, Dimensions

Nakashima walnut slab

Late John Metzler

Biltmore cucumber magnolia slabs

Viable Lumber, run by Pete Richardson in St. Petersburg, FL area. Go to Viablelumber.com

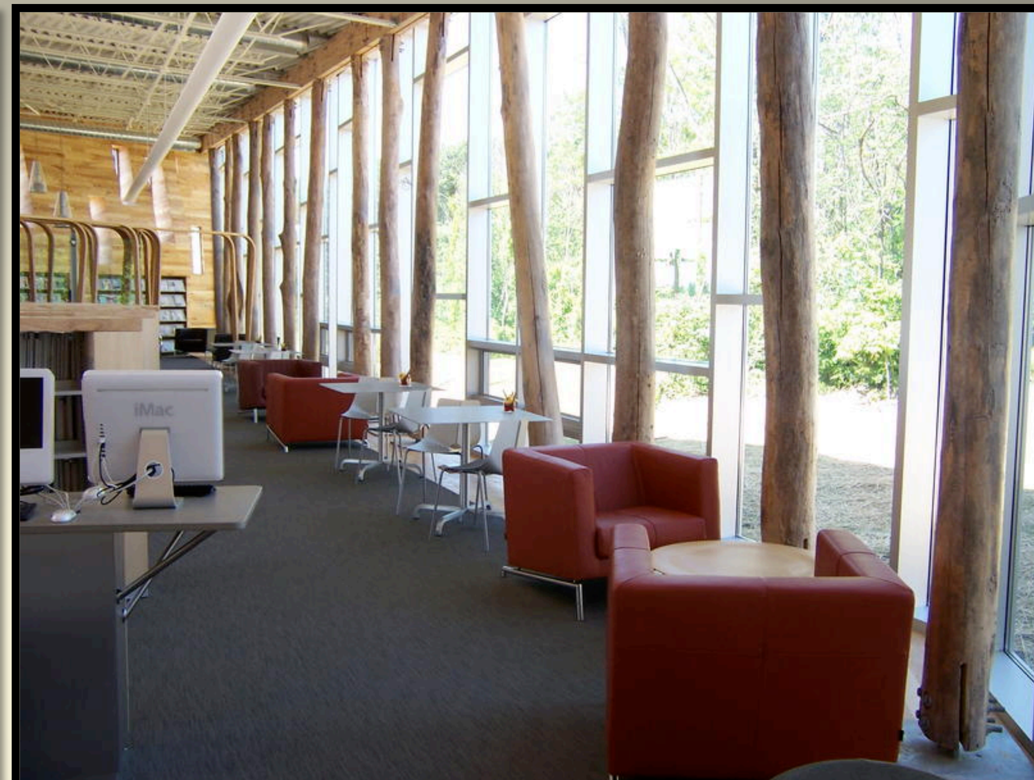
Walnut shelf, live edge, heartwood and sapwood, emerging "organically" from entrance hall wall.

Walnut stained bur oak day bed.

Spaulted maple sofa table.

4. Community Meaning

These benches were made from oak (left) and Osage orange (right) trees removed from a Cincinnati, OH park. Design students at the University of Cincinnati designed and built both benches that were then placed back in city parks.



Traverwood Branch of the Ann Arbor, MI library. Ash trees removed from the new branch library site were incorporated into the building's construction as support beams, flooring, and shelving.

5. Personal Meaning

500 year old bur oak owned by Gatch family

150 year old walnut tree owned by Busken family.


LOG SPLITTING

Urban Wood Utilization Resources

http://www.urbanforestproducts.org/

http://www.semircd.org/ash/education/resources.php

Recycling Municipal Trees: A Guide for Marketing Sawlogs from Street Tree Removals in Municipalities *(Cesa, Lempicki, & Knotts; USDA Forest Service; 2003)*

Urban Wood Utilization and Why It Matters *(Steve Bratkovich, Dovetail Partners)*

Utilizing Municipal Trees: Ideas from Across the Country *(Bratkovich, USDA Forest Service, 2001)Bratkovich, Dovetail Partners)*

http://www.palomar.edu/UrbanWood/

Measures of Wood Resources in Lower Michigan: Wood Residues and the Saw Timber Content of Urban Forests *(Sherrill & MacFarlane, 2007)*

http://www.dovetailinc.org/

Questions?

Been rowing hard … still not there

Amazon Forest Becoming Less of a Climate Change Safety Net
By JUSTIN GILLISMARCH 23, 2015
Photo
A section of the Amazon forest that was illegally slashed and burned next to a section of virgin forest in Brazil. Credit Lalo de Almeida for The New York Times
The ability of the Amazon forest to soak up excess carbon dioxide is weakening over time, researchers reported last week. That finding suggests that limiting climate change could be more difficult than expected.
For decades, Earth's forests and seas have been soaking up roughly half of the carbon pollution that people are pumping into the atmosphere. That has limited the planetary warming that would otherwise result from those emissions.
The forests and oceans have largely kept up even as emissions have skyrocketed. That surprised many scientists, but also prompted warnings that such a robust "carbon sink" could not be counted on to last forever.
In a vast study spanning 30 years and covering 189,000 trees distributed across 321 plots in the Amazon basin, researchers led by a group at the University of Leeds, in Britain, reported that the uptake of carbon dioxide in the Amazon peaked in the 1990s, at about 2 billion tons a year, and has since fallen by half.
Initially, the researchers postulated, the Amazon may have responded well to rising carbon dioxide levels, which are known to increase plant growth, but that response appears to be tapering off. Drought and other stresses could be playing a role, but the main factor seems to be that the initial acceleration of growth sped up the metabolism of the trees.
"With time, the growth stimulation feeds through the system, causing trees to live faster, and so die younger," Oliver L. Phillips, a tropical ecologist at the University of Leeds and one of the leaders of the research, said in a statement.
Further research is needed, but the scientists say that climate forecasting models that assume a continuing, robust carbon sink in the Amazon could be overly optimistic.
At a global scale, studies suggest that forests are still absorbing far more carbon than they release into the atmosphere, even as stresses like fires and beetle attacks increase because of climate change. In essence, rising forces of growth have been outracing rising forces of death in the world's forests.
Perhaps the big question now is whether that will flip. Will forests beyond the Amazon, such as the boreal forest that encircles the Northern Hemisphere, eventually follow the Amazon and weaken as carbon sinks?
That would mean, in effect, that human civilization would have less help from trees, and cuts in carbon emissions would need to be sharper than previously thought to limit global warming to tolerable levels.
"Forests are doing us a huge favor, but we can't rely on them to solve the carbon problem," Dr. Phillips said. "Instead, deeper cuts in emissions will be required to stabilize our climate."
A version of this article appears in print on March 24, 2015, on page D3 of the New York edition with the headline: A Climate Change Safety Net Frays.

The **Keeling Curve** is a graph which plots the ongoing change in concentration of carbon dioxide in Earth's atmosphere since 1958. It is based on continuous measurements taken at the Mauna Loa Observatory in Hawaii that began under the supervision of Charles David Keeling. Keeling's measurements showed the first significant evidence of rapidly increasing carbon dioxide levels in the atmosphere. Many scientists credit Keeling's graph with first bringing the world's attention to the current increase of carbon dioxide in the atmosphere.[1]

Charles David Keeling, of Scripps Institution of Oceanography at UC San Diego, was the first person to make frequent regular measurements of the atmospheric carbon dioxide (CO_2) concentration, taking readings at the South Pole and in Hawaii from 1958 onwards.[2]

Prior to Keeling, the concentration of carbon dioxide in the atmosphere was thought to be affected by constant variability. Keeling had perfected the measurement techniques and observed "strong diurnal behavior with steady values of about 310 ppm in the afternoon" at three locations: Big Sur near Monterey, the rain forests of Olympic Peninsula, and high mountain forests in Arizona.[3] By measuring the ratio of two isotopes of carbon, Keeling attributed the diurnal change to respiration from local plants and soils, with afternoon values representative of the "free atmosphere". By 1960, Keeling and his group had determined that the measurement records from California, Antarctica, and Hawaii were long enough to see not just the diurnal and seasonal variations, but also a year-on-year increase that roughly matched the amount of fossil fuels burned per year. In the article that made him famous, Keeling observed, "at the South Pole the observed rate of increase is nearly that to be expected from the combustion of fossil fuel".[4]

Mauna Loa measurements

The Mauna Loa Observatory

Due to funding cuts in the mid-1960s, Keeling was forced to abandon continuous monitoring efforts at the South Pole, but he scraped together enough money to maintain operations at Mauna Loa, which have continued to the present day [5] alongside the monitoring program by NOAA.[6]

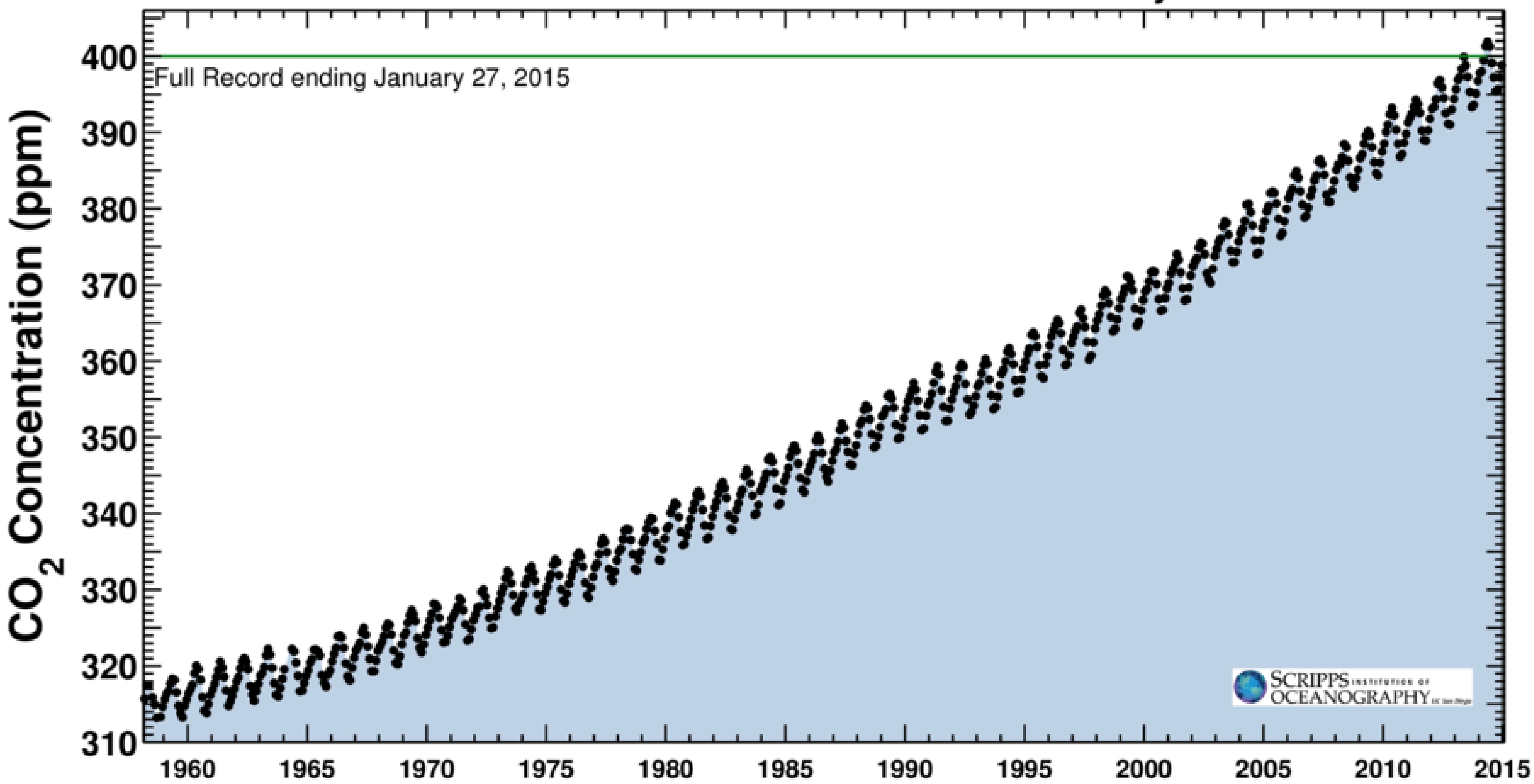
The measurements collected at Mauna Loa show a steady increase in mean atmospheric CO_2 concentration from about 315 parts per million by volume (ppmv) in 1958 to 401 ppmv as of April 2014.[7][8] This increase in atmospheric CO_2 is considered to be largely due to the combustion of fossil fuels, and has been accelerating in recent years. Since carbon dioxide is a greenhouse gas, this has significant implications for global warming. Measurements of carbon dioxide concentration in ancient air bubbles trapped in polar ice cores show that mean atmospheric CO_2 concentration has historically been between 275 and 285 ppmv during the Holocene epoch (9,000 BCE onwards), but started rising sharply at the beginning of the nineteenth century.[9]

Keeling and collaborators made measurements on the incoming ocean breeze and above the thermal inversion layer to minimize local contamination from volcanic vents. In addition, the data are normalized to negate any influence from local contamination.[10]
Measurements at many other isolated sites have confirmed the long-term trend shown by the Keeling Curve,[11] though no sites have a record as long as Mauna Loa.[12]
The Keeling Curve also shows a cyclic variation of about 5 ppmv in each year corresponding to the seasonal change in uptake of CO_2 by the world's land vegetation. Most of this vegetation is in the Northern hemisphere, since this is where most of the land is located. From a maximum in May, the level decreases during the northern spring and summer as new plant growth takes carbon dioxide out of the atmosphere through photosynthesis. After reaching a minimum in October, the level rises again in the northern fall and winter as plants and leaves die off and decay, releasing the gas back into the atmosphere.[13]
Due in part to the significance of Keeling's findings,[5] the NOAA began monitoring CO_2 levels worldwide in the 1970s.[6] Today, CO_2 levels are monitored at about 100 sites around the globe.[1]
Carbon dioxide measurements at the Mauna Loa observatory in Hawaii are made with a type of infrared spectrophotometer first called a capnograph by its inventor, John Tyndall, in 1864 but now known as a nondispersive infrared sensor.[14] Currently (May, 2013) several laser-based sensors are being added to run concurrently with the IR spectrophotometer at Scripps, while NOAA measurements at Mauna Loa use nondispersive infrared sensor tightly calibrated using WMO standards as the main reference for the curve.[15] Multiple other sensors and technologies are also used at Mauna Loa to augment these measurements.
Keeling died in 2005. Supervision of the measuring project was taken over by his son, Ralph Keeling, a professor of geochemistry at Scripps Oceanography.[16]
When C.D. Keeling published his 1960 paper, there did not appear to be any evidence of oceanic absorption. Keeling conjectured that this might be attributable to fluctuations in the causation of the seasonal variation, within the small number of years since his measurements had begun. However it is now understood that allowance should be made for about 50% absorption by the oceanic sinks.[17] Keeling father and son have contributed to the work which has since yielded a much fuller understanding of the relation between atmospheric CO_2 and the entirety of the carbon cycle, including the effects of land and ocean sinks.[18]
On May 9, 2013, the daily mean concentration of carbon dioxide in the atmosphere measured at Mauna Loa surpassed 400 parts per million (ppm) for the first time since measurements began in 1958.[19]

Latest CO_2 reading
January 27, 2015

399.92 ppm

Carbon dioxide concentration at Mauna Loa Observatory



Terrestrial biological carbon cycle (From Wikipedia, the free encyclopedia)

A schematic diagram of the terrestrial biospheric carbon cycle. CO_2 is removed from the atmosphere through gross primary production (GPP) and converted to organic carbon. About half of GPP is respired back into the atmosphere directly. The rest, the net primary production (NPP), stays in the ecosystem and is released into the atmosphere on different time scales through heterotrophic respiration or exported in water in the form of dissolved organic carbon (DOC). Units are gigatons.[1]

Carbon is an essential part of life on Earth. About half the dry weight of most living organisms is carbon. It plays an important role in the structure, biochemistry, and nutrition of all living cells. Living biomass holds between 600 and 1,000 gigatons of carbon, most of which is wood, while some 1,200 gigatons of carbon are stored in the terrestrial biosphere as dead biomass.[2]

Carbon is cycled through the terrestrial biosphere with varying speeds, depending on what form it is stored in and under which circumstances.[1] It is exchanged most quickly with the atmosphere, although small amounts of carbon leave the terrestrial biosphere and enter the oceans as dissolved organic carbon (DOC).

Movement of carbon in the terrestrial biosphere

Most carbon in the terrestrial biosphere is stored in forests: they hold 86% of the planet's terrestrial above-ground carbon and forest soils also hold 73% of the planet's soil carbon.[3] Carbon stored inside plants can be transferred into other organisms during plant consumption. When animals eat plants, for example, the organic carbon stored in the plants is converted into other forms and utilized inside the animals. The same is true for bacteria and other heterotrophs. Dead plant material in or above soils remains there for some time before being respired by heterotrophs. Thus carbon is transferred in every step of the food chain from one organism to another.

Carbon exchange between the terrestrial biosphere and other systems

Atmosphere

Main article: Atmospheric carbon cycle

Autotrophs, such as trees and other green plants, use photosynthesis to convert carbon dioxide during primary production, releasing oxygen in the process. This process occurs most quickly in ecosystems with high amounts of growth, such as in young forests. Because carbon is consumed in the process of autotrophic growth, more carbon is consumed in spring and summer during daytime than in winter and at night, when photosynthesis no longer takes place in most plants. Carbon storage in the biosphere is influenced by a number of processes on different time-scales: while carbon uptake through autotrophic respiration follows a diurnal and seasonal cycle, carbon can be stored in the terrestrial biosphere for up to several centuries, e.g. in wood or soil.

Most carbon leaves the terrestrial biosphere through respiration. When oxygen is present, aerobic respiration occurs, producing carbon dioxide. If oxygen is not present, e.g. as is the case in marshes or in animals' digestive tracts, anaerobic respiration can occur, which produces methane. About half of the gross primary production is respired by plants directly back into the atmosphere. Part the net primary production, or the remaining carbon absorbed by the biosphere, is emitted back into the atmosphere through fires and heterotrophic respiration. The rest is converted into soil organic carbon, which is released more slowly, or "inert" dissolved carbon, which can remain in the biosphere for an unknown period of time.[1]

Geosphere

Main article: Fossil fuel § Origin

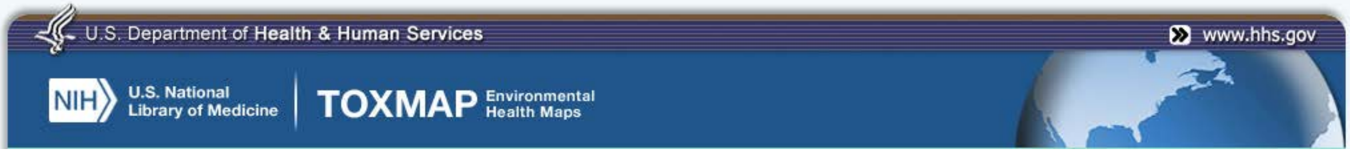
Carbon in the terrestrial biosphere enters the geosphere only through highly specialized processes. When anaerobic decomposition converts organic material into hydrocarbon rich materials and is then deposited as sediment, the carbon can enter the geosphere through tectonic processes and remain there for several million years. This process can lead to the creation of fossil fuels.

Anthropogenic influences

Human activity has large effects on the terrestrial biosphere, changing the way that it acts as a carbon reservoir. Anthropogenically caused fires release large amounts of carbon as CO_2 directly into the atmosphere. More significantly, however, humans modify land cover. Land cover change greatly decreases the amount of carbon uptake in the terrestrial biosphere. It modifies the local ecosystem, often replacing carbon-rich forest with agricultural or urban land use. This releases the carbon stored in the former land cover type and simultaneously decreases the biosphere's ability to absorb carbon from the atmosphere.

Indirectly, human-induced changes in the global climate cause widespread modifications to the terrestrial ecosystem's function in the carbon cycle. As local climates transition, locations that have long been conducive to one type of ecosystem can become more favorable for other ecosystem types. For example, warming in the Arctic has caused stress in North American boreal forests,[4] thus decreasing primary production and carbon uptake, while the same warmer temperatures have led to increased shrub growth in the same areas,[5] producing an opposite effect. Changes in weather patterns can also affect animals. For example, changed weather patterns may create favorable conditions for pine beetles, leading to large beetle outbreaks and forest destruction.[6] Modified precipitation patterns can also lead to droughts or extreme precipitation events, causing additional stress for ecosystems and more erosion. Not only do such influences on the terrestrial ecosystem modify its carbon exchange with the atmosphere - they also can lead to increased outwashing of carbon into the oceans through the transport of organic material in rivers. These widespread changes in land cover also causes changes to the planetary albedo, inducing complex feedbacks in the Earth's planetary radiation budget.

Higher CO_2 levels in the atmosphere can cause photosynthesis to take place more efficiently, thus increasing plant growth and primary production. This could lead to the biosphere extracting more carbon dioxide from the atmosphere. How long this carbon would remain sequestered in the terrestrial biosphere before being rereleased into the atmosphere is unclear, however, and it is likely that other limiting factors (e.g. nitrogen availability, moisture, etc.) would prevent CO_2 fertilization from significantly increasing primary production.



How much of US carbon dioxide emissions are from coal-fired power plants?

The total US energy-related emissions of carbon dioxide (CO_2) by the electric power sector in 2013 were 5,396 million metric tons, or about 41.5 % of total US energy-related CO2 emissions.

About 2,100 million metric tons of carbon dioxide emissions were attributable to electricity generated from coal.
For more information, see the latest analysis from the US EIA.

http://toxmap.nlm.nih.gov/toxmap/faq/2009/08/how-much-of-us-carbon-dioxide-emissions-are-from-coal-fired-power-plants.html