

## **Background for marketing carbon from forest growth in the US.**

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### **Global Warming**

The global climate is believed to be changing in response to the release of large amounts of heat-trapping gases, called greenhouse gases (GHG), into the atmosphere. Greenhouse gases play an important role in protecting the Earth from rapid loss of heat during the night, but abnormally high concentrations are thought to contribute to global climate change. A recent study by the Intergovernmental Panel on Climate Change (IPCC) found that eleven years, out of a recent 12 year period (from 1995 to 2006), were globally ranked among the warmest since 1850.

The predicted effects of the global climate change include increased of the frequency of severe weather events such as hurricanes, and other serious variations in climate that could affect growing seasons and precipitation amount and timing. The changes have significant impact on both human well being and natural environments. According to the IPCC even if the global carbon emissions are controlled and reversed by 2050, it may take centuries for atmospheric carbon levels and temperatures to stabilize.

### *Carbon Cycle*

Carbon is considered the basis of life, providing food, fiber, and energy.. Carbon is exchanged between the atmosphere, the ocean, and terrestrial systems (land). Annually, billions of tons of carbon in the form of CO<sub>2</sub> are emitted by the atmosphere through natural processes and human activity. Ocean phytoplankton and terrestrial green plants absorb carbon dioxide during photosynthesis. Some of that carbon dioxide is released again and some is stored in

biomass and perhaps other form of carbon created by organisms or a product of decay. Figure 1 represents the carbon cycle on Earth. In a given year, billions of tons of carbon move between the atmosphere, hydrosphere (water surfaces), and geosphere (the solid Earth). The numbers in black in Figure 1 indicate how much carbon is stored (in billions of tons) and the purple numbers indicate how much carbon moves between carbon pools each year. On a yearly basis, human activities add about 5.5 billion of CO<sub>2</sub> to the atmosphere.

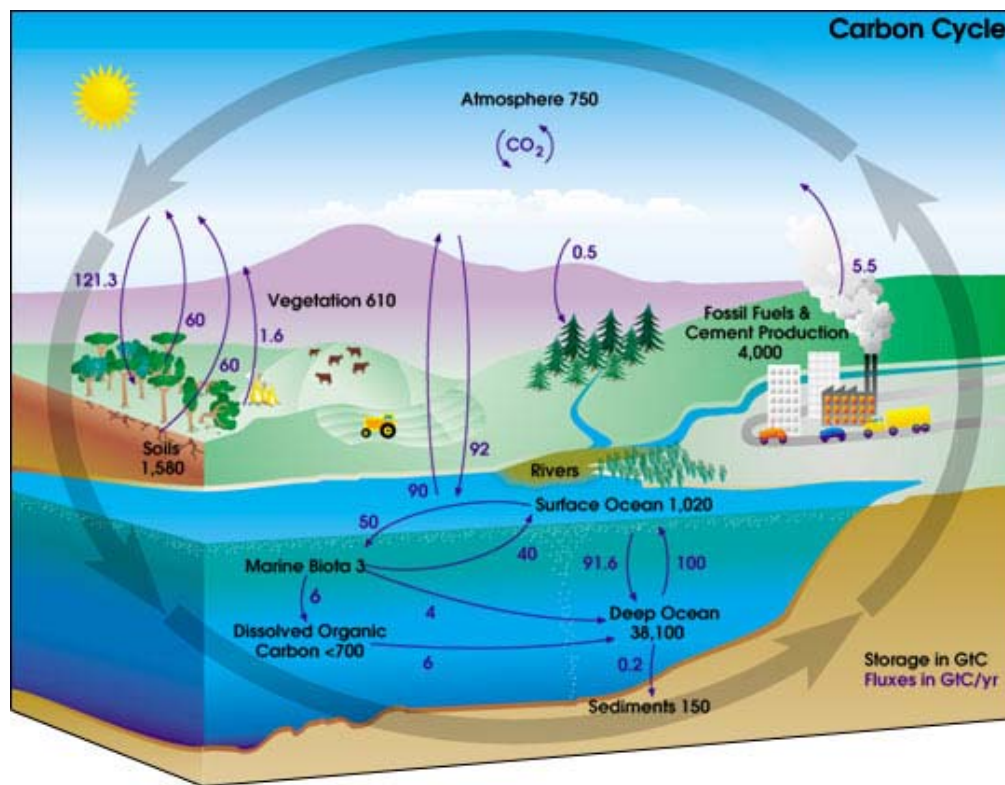


Figure 1. Carbon Cycle (source: [http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon\\_cycle4.html](http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html)).

Forests are the most efficient natural land-based carbon sink. Carbon sink is a carbon dioxide reservoir that is increasing in size. The world's forests cover over 4 billion hectares, containing about 80% of all above ground carbon and approximately 40% of all below ground

terrestrial carbon. In the US, forests are acting as carbon sinks and about 90% of the US terrestrial carbon is stored in forests.

The potential of a forest to act as carbon sinks depends on its age and species composition. Young fast-growing forests absorb CO<sub>2</sub> more rapidly than older forests. The later may not capture any new carbon, but acts as a carbon sink by holding large volumes of carbon as biomass over long periods of time. Carbon is also stored in the forest soils. Typically, forest soils have a high concentration of organic carbon and are able to store twice as much carbon as the atmosphere and three times as much as the plants. On average, over two-thirds of the carbon stored in a forest is contained in the soil and associated peat deposits. This proportion varies among the forest types

**Carbon Sequestration.** Carbon sequestration can be defined as “the process by which CO<sub>2</sub> sinks (removed from the atmosphere) is known as carbon sequestration”, or as “the process where CO<sub>2</sub> is pulled from the atmosphere and stored for a long period of time, or simply as “the action of removing carbon from the atmosphere”.

Forests sequester carbon by conducting photosynthesis, which is the process of converting light energy to chemical energy and storing it in the bonds of sugar. As a tree grows, it absorbs CO<sub>2</sub> through photosynthesis, using solar energy to store carbon in its roots, stems, limbs, and leaves (see Figure 2). Some carbon is released back to the atmosphere through respiration as CO<sub>2</sub>, but a growing tree acts as a carbon sink because it stores more carbon than it releases (higher carbon net uptake). Forest soils also sequester carbon, from dead vegetation accumulated on the surface or as roots inject it into the soil. Carbon is slowly released back to the atmosphere as vegetation decomposes.

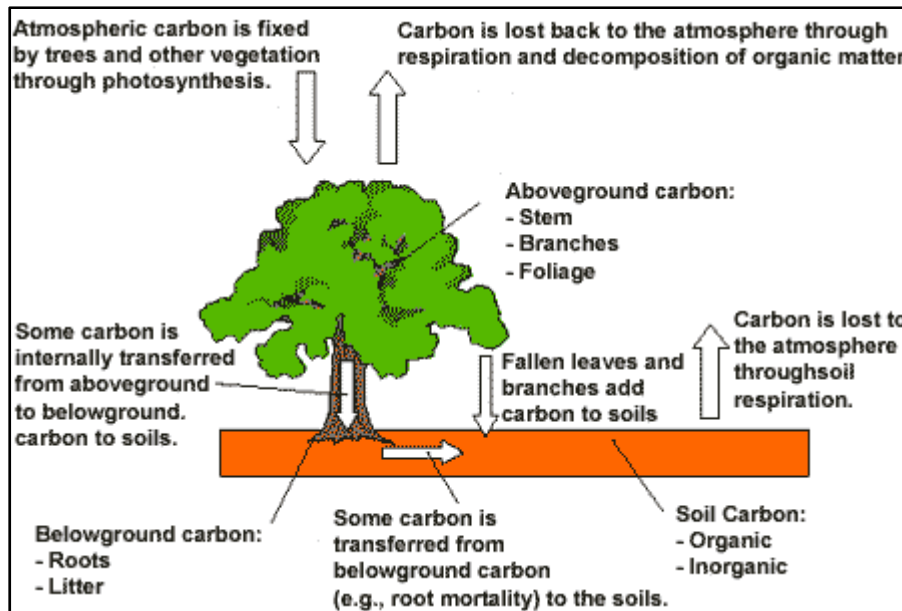


Figure 2. Carbon sequestration from trees – forests acting as a carbon sink, absorbing CO<sub>2</sub> from the atmosphere and storing in tree biomass and forest soils (source: [http://www.epa.gov/sequestration/local\\_scale.html](http://www.epa.gov/sequestration/local_scale.html) ).

Carbon absorption by trees is expected to decline over time because mature forests grow more slowly. Mature trees take up less CO<sub>2</sub> from the atmosphere (lower carbon net uptake) and over time might become carbon neutral. Just less than 50% of a mature tree dry weight is carbon. Even when the tree is not absorbing more carbon than it releases, it still acts as a sink because of the carbon already stored. When a tree dies, it becomes a carbon source releasing more carbon than it absorbs. Stored carbon, however, can be transferred after harvest as wood products (e.g. lumber), which can hold carbon for decades or even longer instead of releasing it right back to the atmosphere.

The rate of CO<sub>2</sub> uptake by trees is a function of tree species, site quality, temperature, and water and nutrients availability. Net rate of carbon uptake is normally greater for hardwoods than of conifers, but because hardwoods are generally deciduous (leaves fall during winter) and conifers are commonly evergreen, the overall capacity of carbon sequestration can be similar. For most forests, total carbon stored increases with time since the last disturbance.

**Management Activities to Increase Carbon Sequestration.** Managed forests have been shown by previous studies to sequester more carbon and have less carbon emission than

unmanaged forests. That is true in part because managed forests are generally younger than unmanaged forests. Managed forests are also less susceptible to insects' depredations and wildfires, resulting in lower GHG emissions.

Forest management practices that have the potential to increase net carbon uptake include: regeneration of forests; thinning and selective harvesting; longer rotations; reducing wildfire; fertilization; site preparation that incorporates wood residues to the soil; and altering species composition. For continuous and overall maximum carbon uptake, a mix of shade-tolerant and shade-intolerant species would provide the best results..

### **Carbon Market/Carbon Trading**

Carbon sequestration by forests is a recognized way to mitigate the effects of industrial CO<sub>2</sub> emissions. Carbon markets arise when these corporations purchase carbon credits from landowners or other entities with the intent of offsetting their carbon emissions.

Carbon credits are a measurable uniform unit of carbon that can be sold as a commodity. Another definition for carbon credits is "formally accredited offsets that can be traded in regulatory or voluntary climate change program". Carbon credits are measured in metric tons of carbon (or CO<sub>2</sub>).

**Carbon Measurement.** In order to enter in the carbon markets, landowners should be able to quantify and verify their carbon stocks. But the verification and quantification of carbon credits can be complicated and expensive. Basically, there are two ways to measure forest carbon: direct and indirect. Direct measurements samples the forested area, while indirect measurements relies on models or carbon look up tables that estimate the amount of carbon in a

certain forest type at a certain age. Direct measurements are often more accurate but also more expensive and time consuming. Indirect measurements using models depend on inventory data, using factors such as timber volume and forest type. Look up tables are standard estimates of forest carbon based on forest type, age, etc.

**Clean Development Mechanism.** The Clean Development Mechanisms (CDM) allows industrialized countries with mandated Kyoto Protocol GHG reduction targets to invest in carbon offset activities implemented in developing countries. The activities can range from reforestation to renewable energy projects, but the only forestry projects recognized by the CDM are afforestation and reforestation. In theory these projects reduce global GHGs concentration at a lower cost than it would in the industrialized country.

### *Registries*

A registry is a legal way for entities to list sequestered carbon and GHG emissions. Carbon registries are established to record and track carbon emission levels over time. Registries can work with carbon markets, helping to quantify and verify tradable carbon credits, but it does not substitute for a carbon market. A registry can benefit landowners by providing ways for documenting carbon sequestration on their land.

A registry can also be used to establish carbon credits ownership. For example, if landowners conduct a reforestation project in their land with seedlings donated by an outside organization, the registry will need to decide who will hold the carbon credits that will be generated.

Some examples of Carbon Registries in the United States include:

- California Climate Action Registry (<http://www.climateregistry.org>) – a private non-profit organization, established in 2001, that serves as a voluntary GHG registry to protect and promote actions to reduce GHG emissions by organizations;
- Regional Greenhouse Gas Initiative (<http://www.rggi.org/home>) – an initiative of ten northeastern states trying to limit CO2 emissions by power plants;
- The Climate Registry (<http://www.theclimateregistry.org/>) – a voluntary collaboration throughout North America, with the ultimate goal of managing a common and transparent GHG emissions reporting system.

## Markets

**Carbon Markets.** Carbon markets have the intent of facilitating the trading of carbon credits . The available carbon markets and a comparison of their importance in terms of volume of carbon traded and US\$ amounts are listed in Table 1.

Table 1. Traded volumes and values of carbon credits

Year	EU Emissions Trading Scheme		Chicago Climate Exchange		OTC Markets	
	Volume (MtCO2 eq.)	Value (US\$ millions)	Volume (MtCO2 eq.)	Value (US\$ millions)	Volume (MtCO2 eq.)	Value (US\$ millions)
2004	-	-	2.25	2.6	-	-
2005	322	8,220	1.47	2.8	-	-
2006	1,101	24,353	10.34	38.2	14.3	58.5
2007	1,600	43,879	22.9	68.7	42.1	258.4

MtCO2 eq. = million metric tons of carbon dioxide equivalent  
Source: Malmshheimer et al. 2008, 4

**Chicago Carbon Exchange.** The Chicago Carbon Exchange (CCX) started in 2003 and it is the world’s first voluntary greenhouse gas reduction and trading system. The CCX was the first open carbon market available in the United States. At the CCX participants make voluntary and legally binding agreements to reduce GHG emissions. The trading program of CCX

essentially works as a registry with the additional of carbon credit trading. CCX permits forest carbon sequestration projects to become carbon credits to be traded among CCX.

**European Union Emission Trading Scheme.** As shown in Table 1 the European Union Emission Trading Scheme is the largest multinational, multisector GHG trading scheme in the world. It was created in 2005 to assist the 25 European countries that committed to the Kyoto Protocol in meeting their emission reduction targets. Forestry activities are not eligible for carbon emission reduction credits through the CDM mechanism. That eliminated investment in forest carbon offset projects with the purpose of meeting the Kyoto's targets.

**Over-the-counter markets (OTC).** Organizations and individuals seeking to mitigate their personal contributions to GHG emissions can participate in the above registries or markets, but also through other voluntary direct sales, referred as over-the-counter transactions. Organizations and individuals can invest directly in specific projects that meet their objectives and their financial limitations. OTC carbon suppliers include well known organizations such as the Climate Fund, the Conservation Fund, and the Pacific Forest Trust. The credits emitted by OTC are referred as voluntary emission reduction (VER) credits.

## **FINAL CONSIDERATIONS**

Forests are recognized to be an effective way to sequester carbon and generate tradable carbon credits. Forest management practices can be applied in order to increase forests' potential to sequester carbon. However, managing forests have its associated costs that must be balanced with the possibility of the extra income than can be generated by trading carbon credits.

The benefits of managing forests specifically for the carbon market have not yet been proven to generate an overall positive financial gain. Worldwide, carbon markets still in their early stages of development, but many experts believe that they will grow strongly and may stay out there for some time. The potential for gains with carbon trading do exist, but are unlikely to become the primary goal of most forest landowner.

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