



## Forest Garden Carbon Brief

### How much CO<sub>2</sub> does a Forest Garden Offset?

On average, a Forest Garden offsets 144.64 metric tons of carbon dioxide (CO<sub>2</sub>) per acre over 20 years.

### Understanding the Process

Trees and plants take in carbon dioxide (CO<sub>2</sub>) and use it during photosynthesis to store carbon (C) and release oxygen (O<sub>2</sub>). In this way, trees are able to store carbon (C) over a long period of time while producing oxygen (O<sub>2</sub>) for us to breathe. The scientific community talks about this process in terms of carbon stored in the tree or ecosystem. But when people talk about *offsetting* it is expressed as the CO<sub>2</sub> equivalent (how much CO<sub>2</sub> is taken in by trees to offset emissions). This document uses two independent studies that measure the carbon storage potential of Forest Gardens to calculate the CO<sub>2</sub> equivalent for offsetting.

### The Calculation

Remember, CO<sub>2</sub> is a molecule made up of two different atoms (Carbon and Oxygen). The atomic weight of carbon is 12. The atomic weight of oxygen is 16. Therefore the atomic weight of Carbon Dioxide (CO<sub>2</sub>) is added up as:  $12+16+16 = 44$ .

So, to convert a carbon storage value to the CO<sub>2</sub> equivalent you must multiply carbon stored times the ratio of CO<sub>2</sub> to Carbon, which equals  $44/12 = 3.67$  (This ratio is used to convert carbon to CO<sub>2</sub>).

A preliminary study on Trees for the Future's Forest Gardens was developed by [Michigan State University Department of Forestry](#). In this study, all trees in Forest Gardens use an estimated carbon storage calculation or CO<sub>2</sub> sequestered per hectare of Forest Garden.

In addition, we now account for the average carbon storage estimate of soil provided by the Intergovernmental Panel on Climate Change (IPCC).

We have added these adjustments to our calculation:

- Forest Gardens sequester 62.8 metric tonnes (t) of carbon/ha over a 20 year lifetime.
- Convert this to acres:  $62.8/2.4 \text{ acre/ha} = 26.17 \text{ metric tons of carbon/acre}$
- Convert this from carbon to CO<sub>2</sub>:  $26.17 * 3.67 = 96.04 \text{ metric tons of CO}_2/\text{acre over 20 years}$
- Add in soil carbon dioxide storage estimates:  $2.43 \text{ metric tons of CO}_2/\text{acre/year}^{*1}$
- If we use a 20 year calculation we would have:  $96.04 \text{ metric tons of carbon} + (2.43 \text{ metric tons of CO}_2/\text{acre/year} * 20 \text{ years}) = 144.64 \text{ metric tons of CO}_2/\text{acre over 20 years}$
- **Therefore, on average, a Forest Garden offsets 144.64 metric tons of carbon dioxide (CO<sub>2</sub>) per acre over 20 years.**

### How to calculate the cost and number of trees needed for a given CO<sub>2</sub> offset:

Cost to Offset = Tonnes to offset divided by 144.64 tonnes of CO<sub>2</sub>/acre \* \$800/acre of FG

Trees required to offset = Tonnes to offset divided by 144.64 tonnes of CO<sub>2</sub>/acre \* 2500 trees/acre of FG

### How to calculate CO<sub>2</sub> offset for a given donation or number of trees:

CO<sub>2</sub> offset over 20 Years = Donation amount divided by \$800/acre of FG \* 144.64 tonnes of CO<sub>2</sub>/acre

CO<sub>2</sub> offset by number of trees planted = # of trees planted divided by 2500 \* 144.64 tonnes of CO<sub>2</sub>/acre

## More on Forest Garden CO<sub>2</sub> Rates

### Size of a Forest Garden

The average Forest Garden is 1 acre in size. One farmer, or one farming family, cares for each Forest Garden on their own land. The [Michigan State Report](#) is based on a hectare because, at the time, that was the average size of a Forest Garden. As we have been able to serve more communities across various landscapes, the average size of a Forest Garden is now an acre. We have factored this into the calculation above.

### **Trees in a Forest Garden**

The average Forest Garden has 2,500 trees. Most of these trees are planted in the first and second year in the parameter of the Forest Garden (we call this the “living fence”). In the third and fourth years, the rest of the trees are strategically planned and placed where it will be most beneficial to the farmer’s Forest Garden.

### **Cost of a Forest Garden**

It costs \$800 to grow a Forest Garden on average. This accounts seeds, biodegradable nursery bags for seedlings, basic tree planting tools (wheelbarrow, shovel, hoe, watering can and pruning shears), and training from field staff.

### **Carbon per Forest Garden**

Trees for the Future estimates our offsets based on the CO<sub>2</sub> equivalent that can be sequestered in a 1 acre Forest Garden ecosystem. This includes carbon stored in above and below ground biomass (trees, plants, shrubs, vines and roots) and soil organic carbon (soc). Combined, the Forest Garden ecosystem collectively stores carbon and provides a multitude of ecosystem benefits. Therefore we prefer to provide a per 1 acre Forest Garden offset, rather than a per tree offset.

### **Time and Care Mean More Carbon Captured**

The growth rate of trees and their carbon storage is not linear. The growth follows an “S” curve<sup>2</sup> (see graph below). This means that trees sequester CO<sub>2</sub> slowly in the initial years of planting and later the carbon storage expands as they grow. The majority of Forest Garden trees have a 20-30 year lifespan. This is because many Forest Garden trees are fruit trees which naturally vary in lifespan. Many of the fruit trees will be replanted from their seeds. Other Forest Garden trees have a lifespan of hundreds of years.

In a Forest Garden, a majority of the trees grown are planted side by side around the parameter of the land. We call this a “living fence.” Trees planted closely together capture less carbon than those planted in the open where they can grow larger. However, trees in the Forest Garden have a far greater chance of 20+ year survival than those planted in the open. This is because trees in the Forest Garden are cared for and protected by farmers. They become a valuable part of a farmer’s livelihood and symbol in the community.

## Certifications on the Horizon

By 2021, Trees for the Future will have the Verified Carbon Standard (VCS) and Community Climate Benefits (CCB) certifications. These will more accurately account for CO<sub>2</sub> sequestration in our projects based on tree species and climate conditions. There is a rigorous process for obtaining these certifications and they are climate and species-specific. To start, we will be conducting the verifications in Senegal and Kenya.

## Additional Forest Garden Climate Benefits

Although we do not yet have a certification for CCB, trees grown in a Forest Garden provide many Community Climate Benefits (CCBs). These benefits prevent future carbon emissions including:

- Local food security that eliminates the need for high CO<sub>2</sub> emissions associated with imports
- Watershed management that prevents flooding
- No chemical fertilizer use, preventing high CO<sub>2</sub> emissions associated with the production of chemical fertilizer and eliminating runoff that causes algae blooms in water and releases methane.
- Prevents further deforestation and biodiversity loss by allowing farmers to grow what they need instead of mining it from the forest
- Planting trees in a Forest Garden with compost and integrated pest management eliminates the use of fertilizers and pesticides thus building up soil carbon

\*<sup>1</sup>The IPCC estimates that converting monocropped land to multi-strata agroforestry system can sequester an additional 1.59 ton carbon/ha/year or  $1.59 \times 3.67 = 5.8353$  metric tons of CO<sub>2</sub>/ha/year through soil organic carbon. Carbon or CO<sub>2</sub> absorption also depends on multiple factors: species, climate, rainfall, elevation, etc. So, keep in mind that these metrics are all averages.

\*<sup>2</sup> Union of Concerned Scientist Graph

Natural Growth Curve of a Tree

