How does Treeapp calculate its statistics?

Providing users with statistics regarding the impact of their contribution to reforestation projects is a crucial part of any reforestation program. Although seeming fairly straightforward, in reality providing this data is quite challenging for several reasons:

① The impact of a single tree is not static but increases over the tree's lifetime into adulthood. Because the impact of the tree is generally quite low at the time of planting, the total impact of the tree is calculated over the course of its life. This calculation is complicated by the uncertainty in the lifetime of the tree.

② Treeapp partners with organizations which use a wide variety of tree species across continents with vastly different climates and soil types. Each tree species has its own qualities, and even within tree species these qualities can vary widely between individuals, different soil types and climate conditions.

③ Numerous websites provide non-scientifically-backed data around reforestation. Treeapp avoids as much as possible using these numbers, who can greatly vary depending on each site.The difficulty in providing average per-tree impact statistics is also reflected in the wide range of figures provided by existing reforestation programs. A thorough internet search revealed the methods used to come up with these statistics are largely shrouded in ambiguity or not provided at all, making it hard to assess their accuracy.

At Treeapp, we believe in transparency, which is why we outline how we calculated the statistics provided on our website and mobile application below. Information was provided by; statistics from peer-reviewed scientific literature and supplemented with data given from our NGO' partners organizations – always making sure to stay on the conservative side of estimates to avoid over-selling the benefits of reforestation. Treeapp recognises that numerous carbon sequestration methods exist (such as Peatland restoration), but will fully focus on tree carbon sequestration. The first major distinction to make is tropical VS non-tropical forest.

Background

Tropical forests are defined by a lack of annual frost events and having marine areas over 18°C (Food and Agriculture Organization [FAO], 2012) having a Koppen-Geiger climate classification of Af (Kottek et al., 2006) (however they can sometimes fall into Am categories described as equatorial monsoon).

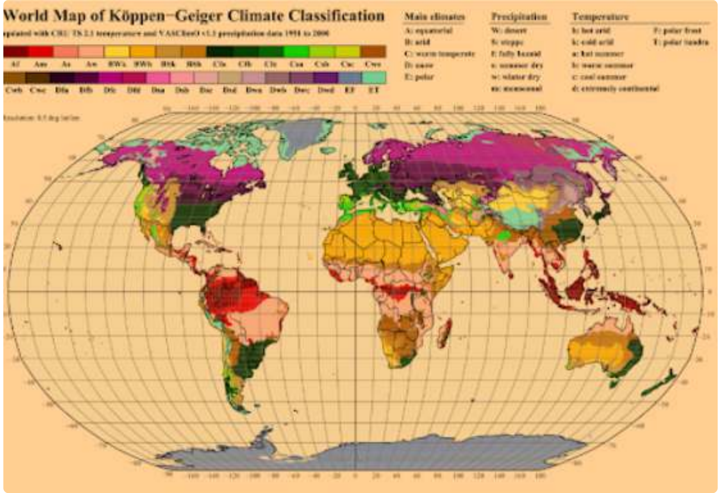

Figure 1: World map of Koppen-Geiger Classifications (Kottek et al., 2006)

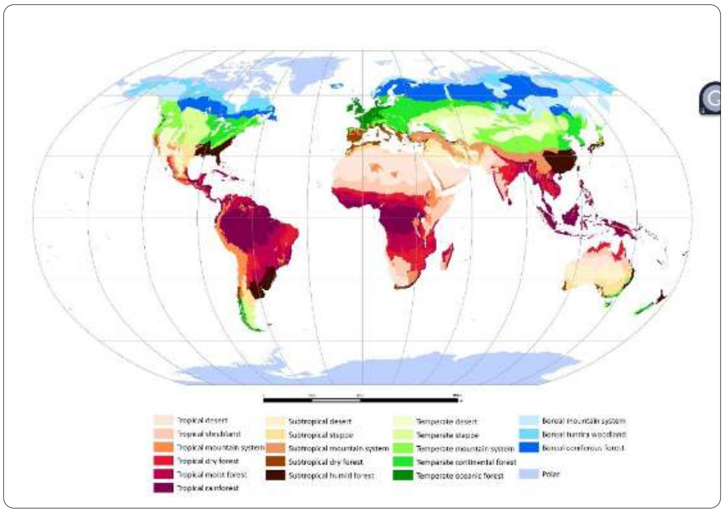

Figure 2: The 2010 Global Ecological Zones Map (Food and Agriculture Organization [FAO], 2012)

Koppen-Geiger classifications are a good start for defining biomes based on climate alone. In 2010, the FAO developed a more detailed map (fig. 2) which Treeapp bases its first assumptions on. Tropical areas in Treeapp projects will mostly be tropical moist and rainforest with rainforest sequestering the most carbon per tree.

On Earth, carbon is stored in six main forms: rocks (as carbonates), sediments, ocean and freshwaters, soils and terrestrial biomass, and the atmosphere in varying amounts (Table 1; Figure 1) (Bruhwiler et al., 2018). Over time, carbon builds up in reservoirs (otherwise known as "pools" or "stocks") which can either act as sinks or sources which respectively increase or decrease in size over time. Transfer between carbon reservoirs are known as "fluxes". Due to the finite size of global carbon stocks and the second law of thermodynamics, carbon never leaves the system, only transfers from pool to pool in a cyclic form. The carbon cycle can be split into two parts: slow and fast cycling. The slow carbon cycle is the exchange of carbon between the atmosphere, land and ocean. The slow cycle takes place on a geological timescale and is not relevant when discussing carbon capture capability. The fast carbon cycle is mainly the transfer of carbon through living organisms, comprising seven main carbon reservoirs: terrestrial and oceanic vegetation and soils, freshwater and shallow oceanic sediment, and the atmosphere (Bruhwiler et al., 2018).

Projects associated with TreeApp focus on carbon sequestration in vegetation, terrestrial soils and shallow oceanic sediment (with mangroves). Carbon sequestration can be defined as “The process of storing carbon that has been removed and collected as CO2 from the atmosphere” (Körner, 2017). Calculating the amount of carbon sequestered per tree is complicated due to its multifaceted nature. Carbon enters trees via photosynthesis which converts carbon dioxide and water into glucose, oxygen and water (below equation).

$$6\ CO_2 + 12\ H_2O + \text{photons} \quad C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$

By this mechanism, plant life assimilates atmospheric carbon into its structures, storing it in wood and passing it to the soil via litter and wood decomposition. To calculate carbon sequestration rates, you need to subtract the net carbon output from the net carbon input and multiply the remainder by the carbon residence time (Körner, 2017). Generalising carbon sequestration calculations is difficult due to the immense interspecies variation of wood characteristics. One of the main reasons that carbon sequestration rates vary so vastly between species is because the density of wood varies greatly across species. This is further confounded by the limited information provided by NGOs about exact species inventories but even with this, great amounts of time and effort would e needed to accurately calculate carbon sequestration rates. Another important factor is belowground carbon stocks. It is generally stated that 20% of the above ground biomass (AGB) is stored belowground but this, again, varies greatly between species and biome with tropical forests holding the highest belowground carbon stocks.

Carbon sequestered by trees also depends on the longevity of individual trees; if trees are not protected and are chopped down for wood burning power stations they effectively lose their carbon sequestration value and will not aid in combating the climate crisis. Treeapp focuses on NGO projects that have a long-term land protection vision. When examining published literature, most studies do not cite carbon sequestered per tree, only per hectare. Bastin et al., (2019) is a great case study to demonstrate how difficult carbon calculations are, the authors grossly overestimate the amount of carbon sequestered by trees. This is mainly due to having to generalise calculations to produce a global dataset, the calculations used, for this reason, are over-simplified. Amongst other elements, they do not take into account soil carbon stocks based upon factors such as canopy cover (a comprehensive description of the flaws in assumptions are provided in (Taylor and Marconi, 2019). For the purposes of Treeapp, we use correction factors provided in the “without soil organic carbon” column in table 1, it describes the carbon stored if canopy cover was increased by 1 Ha, it is the most accurate calculation to date (2020), being published in August 2019 and accounts for the multifaceted nature of carbon dynamics.

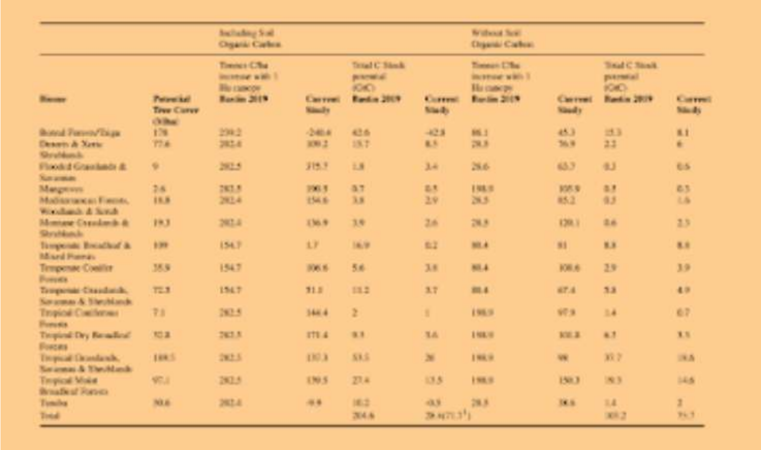

Figure 1: World map of Koppen-Geiger Classifications
(Kottek et al., 2006)

Carbon Calculations

$$\text{Total Carbon} = \frac{(\text{Above Ground Biomass} * \text{Dry Mass Percentage})}{\text{Percent of Carbon in a tree}}$$

$$\text{Total C} = \frac{(\text{AGB} * 0.725)}{0.5}$$

Based on *Shimamoto et al.,* (2014) for tropical forests (which have the highest rate of C sequestration) for a 20 year growing cycle of fast growing trees:

AGB @ 20yrs ≈ 400 Mg/ Ha or 400,000kg Ha-1

Total C = 145,000 Kg / Ha

Total Carbon Per tree (TCPT) = 145,000/ 3,900 (average stocking density per hectare) = 37.17948 kg/ tree/ 20yr

Looking at all Treeapp NGO partners, an average 80% of the trees that are planted will survive in the long term. This means that we estimate each tree to provide:

Carbon Absorbed per Tree: TCPT * Survival rate = 37.17948 * 0.8 = **29.743kg of Carbon**

For Y= Carbon Dioxide Absorbed per Tree: Xkg Carbon * 3.6663 = Y **or** Y = 29.743 * 3.6663 **or** Y= **109kg of CO2**

According to the above calculations, every tree that Treeapp will be planting, will capture the equivalent of 109kg of CO2. These calculations have been conducted by Treeapp's experts in Ecology and Tropical Forestry - they are subject to change: we are working on a more elaborate model to account for the carbon capture of each tree species and will soon be releasing more information about it.

References

Breithaupt, J. L., Smoak, J. M., Iii, T. J. S., Sanders, C. J., & Hoare, A. (2012). Organic carbon burial rates in mangrove sediments : Strengthening the global Organic carbon burial rates in mangrove sediments : Strengthening the global budget. GLOBAL BIOGEOCHEMICAL CYCLES, 26(May 2014). https://doi.org/10.1029/2012GB004375

Food and Agriculture Organization [FAO]. 2012. Global ecological zones for FAO forest reporting: 2010 Update. Forest resources Assessment Working Paper 179: 42.

Körner C. 2017. A matter of tree longevity. Science 355: 130–131.

Kottek M, Grieser J, Beck C, Rudolf B, Rubel F. 2006. World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift 15: 259–263.

Shimamoto CY, Botosso PC, Marques MCM. 2014. How much carbon is sequestered during the restoration of tropical forests? Estimates from tree species in the Brazilian Atlantic forest. Forest Ecology and Management 329: 1–9.

Taylor SD, Marconi S. 2019. Rethinking global carbon storage potential of trees . A comment on Bastin et. al 2019. bioRxiv 1: 1–7.

Nowak, David J., Robert Hoehn, and Daniel E. Crane. 2007 "Oxygen production by urban trees in the United States." Arboriculture & Urban Forestry. 33 (3): 220-226. 33.3.

Webb, P. (1973). Work, heat, and oxygen cost. (report for NASA)