How much will planting a trillion trees slow global warming?

What The Science Says:
Research has shown that maximum afforestation and reforestation (close to a trillion new trees) would sequester around 75 billion tons of carbon, which is 7–8 years of annual human emissions at current rates and enough to slow global warming by less than a quarter degree Celsius.

Climate Myth: Planting a trillion trees will solve global warming
"There is no limit to how much carbon we can store in wood" [Rep. Bruce Westerman (R-AR)]

During his 2019 State of the Union address, Donald Trump announced that the United States will join the Trillion Trees Initiative. House Republicans plan to introduce legislation to plant 3.3 billion trees per year domestically over the next 30 years (an 800 million increase over the 2.5 billion per year that are already planted in the U.S.) as the lynchpin of their party's climate plan. This poses the question – how much impact would the tree planting initiative have on atmospheric carbon dioxide (CO_2) levels and global warming?

Bastin et al. (2019) sought to quantify the potential global tree restoration potential and the carbon sequestration associated with that reforestation and afforestation. The study concluded, "there is room for an extra 0.9 billion hectares of canopy cover, which could store 205 gigatonnes of carbon [GtC] in areas that would naturally support woodlands and forests." For comparison, humans have emitted approximately 640 GtC, so this would represent a significant chunk of human emissions to date. 900 million hectares of land is approximately the size of the United States.

However, several comments identified flaws in the Bastin et al. estimate. Friedlingstein et al. (2019) noted that their estimate of the potential carbon storage of trees in each biome did not account for the carbon already stored in those regions, and thus concluded:

> *the potential carbon storage would be substantially lower than reported … Moreover, forests affect climate through biophysical feedbacks, such as changes in albedo or evapotranspiration, which can counteract the cooling effect from CO_2 uptake … These biophysical feedbacks were not discussed in the article and could substantially reduce the potential of forest reforestation in some of the considered regions.*

Veldman et al. (2019) in concluding that the true maximum tree carbon sequestration potential is closer to 42 GtC, noted:

> *Their analysis inflated soil organic carbon gains, failed to safeguard against warming from trees at high latitudes and elevations, and considered afforestation of savannas, grasslands, and shrublands to be restoration.*

Lewis et al. (2019) noted that the carbon sequestration rate used by Bastin et al. (0.22 GtC per million hectares) was twice that in previously published estimates. Using a variety of methods to roughly approximate the global tree carbon sequestration potential, Lewis et al. estimated the value between 89 and 108 GtC. Moreover, Lewis et al. note:

25% of the new tree cover [would be] in tundra and boreal regions, where warming from forests' lower surface albedo can offset the cooling from new carbon uptake.

Let's examine the carbon sequestration and global warming mitigation potential of planting trees in all available areas outside of tundra and boreal regions, where as Lewis et al. note, replacing relatively reflective land surface with dark tree canopy would offset the cooling from carbon uptake. Using the above referenced studies, as an approximation, let's estimate that doing so could sequester 75 GtC, once the nearly trillion trees have reached maturity.

Humans currently release 10 GtC annually from fossil fuel combustion and other activities; therefore, continuing at current emissions rates would offset the carbon sequestration potential of this maximal tree restoration effort within 7 to 8 years. Thus it's important to note that planting trees cannot replace the phasing out of fossil fuels, but it can complement it.

Under policies and commitments currently in place, global average surface temperatures are on a path for approximately 3°C in 2100 (though headed north of 4.5°C by the time a new equilibrium is reached, unless future policies bring emissions down to zero). This translates into approximately 1,650 GtC of human emissions between 2020 and 2100, or an atmospheric carbon dioxide concentration around 620ppm in 2100. Removing 75 GtC through tree planting would lower that CO_2 concentration to around 585 ppm (see this post for useful conversions). To translate these numbers into global surface temperature changes, we can use the following formula related to the radiative forcing of CO_2:

$$\Delta T_{eq} = \lambda * RF = \lambda * 5.35 * ln(C/C_o)$$

Where the left side of the formula represents the global surface temperature change once a new equilibrium is reached, RF is the radiative forcing (in this case, from increased CO_2), lambda is the climate sensitivity parameter (approximately 0.8), C is the atmospheric CO_2 concentration, and Co is the initial CO_2 concentration (280 ppm pre-industrial).

At equilibrium, the temperature change associated with 620 ppm CO_2 is 3.4°C, and for 585 ppm is 3.15°C (this doesn't account for non-CO_2 greenhouse gases or other forcings). By 2100 when the climate system will not yet be in equilibrium, the CO_2-caused temperature changes would be closer to 2°C and 1.85°C, respectively. In short, maximal tree planting would offset around 0.15°C warming by 2100 and a quarter degree Celsius at equilibrum.

Domestically, the US emits about 5.3 Gt CO_2 per year. Planting another 800 million new trees per year at about 6 kg CO_2 per young tree per year and 22 kgCO_2 per mature tree per year corresponds to about 500 Mt CO_2 sequestered over 10 years and 6 Gt CO_2 sequestered if the planting continues over 30 years. This proposal would offset about 1% of US carbon emissions at current rates over the next 10 years, or potentially 4% over 30 years. However, if the US reduces its emissions to zero by 2050, the tree carbon sequestration could amount to 8% of total US emissions over 30 years.

It's worth noting that reforestation and afforestation occupy a number of high slots on the Project Drawdown list of top climate solutions, including #5 and #12. However, adding them all up accounts for just around 40 GtC. This is probably a more realistic number than our 75 GtC, since we can't plant trees on every available hectare of land. Doing so would decrease agricultural production and thus increase food prices, for example. This highlights why Project Drawdown lists 100 different individual solutions.

Planting trees won't be enough to solve climate change unless they're Ents and do to our fossil fuel infrastructure what they did to Isengard in *Lord of the Rings*.

[*see video at **this link**.*]

There is no climate change silver bullet; planting trees helps, but it's just one piece of silver buckshot among the many solutions needed to avert a climate crisis.

Skeptical Science explains the science of global warming and examines climate misinformation through the lens of peer-reviewed research. The website won the Australian Museum 2011 Eureka Prize for the Advancement of Climate Change Knowledge. Members of the Skeptical Science team have authored peer-reviewed papers, a college textbook on climate change and the book Climate Change Denial: Heads in the Sand. Skeptical Science content has been used in university courses, textbooks, government reports on climate change, television documentaries and numerous books.