Are young trees or old forests more important for slowing climate change?

July 30 2020, by Tom Pugh

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Forests are thought to be crucial in the fight against climate change—and with good reason. We've known for a long time that the extra CO_2 humans are putting in the atmosphere makes trees grow faster, taking a large portion of that CO_2 back out of the atmosphere and storing it in wood and soils.

But a recent finding that the world's forests are on average getting "shorter and younger" could imply that the opposite is happening. Adding further confusion, another study recently found that young forests take up more CO_2 globally than older forests, perhaps suggesting that new trees planted today could offset our carbon sins more effectively than ancient woodland.

How does a world in which forests are getting younger and shorter fit with one where they are also growing faster and taking up more CO_2? Are old or young forests more important for slowing climate change? We can answer these questions by thinking about the lifecycle of forest patches, the proportion of them of different ages and how they all respond to a changing environment.

The forest carbon budget

Let's start by imagining the world before humans began clearing forests and burning fossil fuels.

In this world, trees that begin growing on open patches of ground grow relatively rapidly for their first several decades. The less successful trees are crowded out and die, but there's much more growth than death overall, so there is a net removal of CO_2 from the atmosphere, locked away in new wood.

As trees get large two things generally happen. One, they become more vulnerable to other causes of death, such as storms, drought or lightning. Two, they may start to run out of nutrients or get too tall to transport water efficiently. As a result, their net uptake of CO_2 slows down and can approach zero.

Eventually, our patch of trees is disturbed by some big event, like a landslide or fire, killing the trees and opening space for the whole process to start again. The carbon in the dead trees is gradually returned to the atmosphere as they decompose.

New trees absorb lots of carbon, old trees store more overall and dead trees shed their carbon to the atmosphere. Credit: Greg Rosenke/Unsplash,

The vast majority of the carbon is held in the patches of big, old trees. But in this pre-industrial world, the ability of these patches to continue taking up more carbon is weak. Most of the ongoing uptake is concentrated in the younger patches and is balanced by CO_2 losses from disturbed patches. The forest is carbon neutral.

Now enter humans. The world today has a greater area of young patches of forest than we would naturally expect because historically, we have harvested forests for wood, or converted them to farmland, before allowing them to revert back to forest. Those clearances and harvests of old forests released a lot of CO_2, but when they are allowed to regrow, the resulting young and relatively short forest will continue to remove CO_2 from the atmosphere until it regains its neutral state. In effect, we forced the forest to lend some CO_2 to the atmosphere and the atmosphere will eventually repay that debt, but not a molecule more.

But adding extra CO_2 into the atmosphere, as humans have done so recklessly since the dawn of the industrial revolution, changes the total amount of capital in the system.

And the forest has been taking its share of that capital. We know from controlled experiments that higher atmospheric CO_2 levels enable trees to grow faster. The extent to which the full effect is realised in real forests varies. But computer models and observations agree that faster tree growth due to elevated CO_2 in the atmosphere is currently causing a large carbon uptake. So, more CO_2 in the atmosphere is causing both young and old patches of forest to take up CO_2, and this uptake is larger than that caused by previously felled forests regrowing.

The effect of climate change

But the implications of climate change are quite different. All else being equal, warming tends to increase the likelihood of death among trees, from drought, wildfire or insect outbreaks. This will lower the average age of trees as we move into the future. But, in this case, that younger age does not have a loan-like effect on CO_2. Those young patches of trees may take up CO_2 more strongly than the older patches they replace, but this is more than countered by the increased rate of death. The capacity of the forest to store carbon has been reduced. Rather than the forest loaning CO_2 to the atmosphere, it's been forced to make a donation.

So increased tree growth from CO_2 and increased death from warming are in competition. In the tropics at least, increased growth is still outstripping increased mortality, meaning that these forests continue to take up huge amounts of carbon. But the gap is narrowing. If that uptake continues to slow, it would mean more of our CO_2 emissions stay in the atmosphere, accelerating climate change.

Overall, both young and old forests play important roles in slowing climate change. Both are taking up CO_2, primarily because there is more CO_2 about. Young forests take up a bit more, but this is largely an accident of history. The extra carbon uptake we get from having a relatively youthful forest will diminish as that forest ages. We can plant new forests to try to generate further uptake, but space is limited.

But it's important to separate the question of uptake from that of storage. The world's big, old forests store an enormous amount of carbon, keeping it out of the atmosphere, and will continue to do so, even if their net CO_2 uptake decreases. So long as they are not cut down or burned to ashes, that is.

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