BIOENERGY

Hold on – is burning biomass bad for the climate?

Is replacing coal burning with biomass good for climate change or, as some have suggested, does it actually create more emissions? *John D Sterman* argues the latter, based on a recently published lifecycle analysis of US forests.

An example of clearcutting in North Carolina in 2017
Photo: Dogwood Alliance

Wood bioenergy is booming as governments around the world struggle to cut their greenhouse gas emissions.

The European Union declared all biofuels to be carbon neutral to help meet its goal of 20% renewable energy by 2020, triggering a surge in wood use. The UK subsidises wood pellets for electric power generation and is now the world's largest pellet importer. The US has just declared forest bioenergy to be carbon neutral, while at the 2017 UN climate summit 19 nations including Brazil, Canada, China, India and Indonesia joined the Biofuture Platform initiative to increase use of 'sustainable bioenergy'.

But are biofuels really carbon neutral? Is wood really good?

The appeal is intuitive: burning fossil fuels injects carbon sequestered in geological reservoirs for millions of years into the atmosphere, causing global warming. In contrast, biofuels recycle carbon from the atmosphere, so, people argue, there are no net emissions.

Unfortunately, science shows otherwise. Burning wood to produce energy can actually worsen climate change, at least through the year 2100 – even if wood displaces coal, the most carbon-intensive fuel.

Why, and how do we know?

Supply and regrowth

First, some basic physics:

- Carbon dioxide is the principal greenhouse gas causing global warming.
- Burning wood adds carbon dioxide to the atmosphere.
- Carbon dioxide is only removed from the atmosphere if the forests harvested to supply wood bioenergy grow back and keep that carbon sequestered in biomass and soils.
- Regrowth takes time.
- Regrowth is not certain. Fire, insect damage, re-harvest, or conversion to other uses (eg agriculture, development) can limit or prevent forest recovery.

The climate impact of wood and other biofuels therefore depends on some critical questions.

First, at the point of combustion, do biofuels generate more or less carbon dioxide per unit of end-use energy than the fuel they displace? Emissions accounting must consider emissions both from combustion and from the fuel supply chain.

Second, how much carbon can the harvested land remove from the atmosphere as it grows back, how long does regrowth take, and how do the answers to these questions depend on the fate of the harvested land?

To answer these questions my colleagues and I extended the widely-used C-ROADS climate policy model to explore the dynamic impact of biofuels on carbon emissions and climate. The model is fully documented and freely available. Our research is independent, funded neither by bioenergy producers, who support wood use, nor by environmental groups, some of which oppose it. Indeed, given the urgency and magnitude of emissions reductions needed to limit global warming to no more than 2°C, my sincere hope was that wood would prove to be part of the climate solution.

Unfortunately, our results indicate that wood worsens climate change through the rest of this century at least – even when wood displaces coal, the most carbon-intensive fuel.

Repaying carbon debts

Although wood has approximately the same carbon intensity as coal per kwh, the combustion and processing efficiencies of wood pellets, the dominant wood bioenergy in the EU and the UK, are lower. Consequently, pellet-fired power plants generate more carbon dioxide per kWh than coal. Burning wood instead of coal therefore creates a carbon debt – an immediate increase in atmospheric carbon dioxide compared to fossil energy.

That carbon debt can be repaid over time – if the forest regrows. To illustrate, **Figure 1** depicts a simulation showing what happens to the carbon stored in a hardwood forest in the southern US after clear-cut (where all trees are cut down).

Clearcutting removes nearly all the biomass, burning it for bioenergy adds carbon dioxide to the atmosphere, accelerating climate change. Lacking sufficient biomass to move carbon from leaves to roots, the stock of carbon stored in the soil falls for several decades even as trees start to grow back. Biomass and soil carbon gradually recover, yet after 100 years the total carbon stored in the forest will still remain below the initial level.

This example is typical. We examined a wide range of forests in the US, the largest supplier of pellets to the UK. Carbon debt payback times averaged 87 years after clear-cut, and 63 years when forests are thinned.

These payback times are optimistic: we assume all land harvested for bioenergy recovers without re-harvest, unplanned logging or conversion to other uses, and without damage from fire, insects, severe weather or other ecological disturbances that would harm carbon uptake or inject greenhouse gases into the

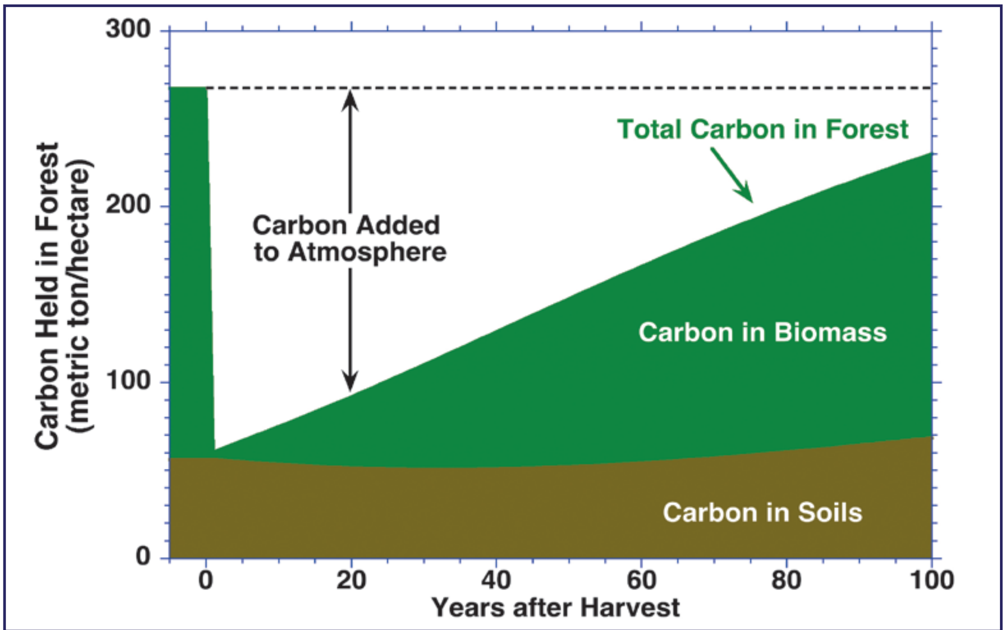

Figure 1. Simulation showing the recovery of an oak-hickory forest in the southern US after clear-cut – assuming the land is not converted to pasture, agriculture, or other uses, not re-harvested, and suffers no fire, insect damage or other events that could harm regrowth

Source: John Sterman, Lori Siegel, Juliette Rooney Varga, ***bit.ly/forestbioenergy***

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atmosphere. It is worth noting that climate change worsens fire, insect, and severe weather risks.

Taking out more credit

The International Energy Agency and the bioenergy industry project substantial growth in wood use for decades to come. Such expansion would steadily add to atmospheric carbon dioxide, even if the harvested lands fully recover.

To see why, consider the national debt of the United States. The US repays the bonds it issues in full at maturity. However, because the government runs a deficit, new borrowing exceeds repayment of maturing debt, increasing the national debt. Similarly, every year wood biofuel use grows, the carbon dioxide added to the atmosphere when that wood is burned exceeds the carbon removed by regrowth, increasing atmospheric carbon dioxide even if all carbon debt is eventually repaid in full.

Critically, during the decades before the carbon debt is repaid, the additional carbon dioxide in the atmosphere from wood bioenergy worsens climate change. Higher carbon dioxide concentrations resulting from wood use then accelerates global warming, raising sea level faster and intensifying other damages including ocean acidification, the incidence of extreme weather, water stress and crop yield decline.

These impacts persist for centuries or more. They are not reversed even if the forests harvested for bioenergy eventually take up all the carbon dioxide released when they are burned.

Could this be mitigated if forests are managed sustainably, by thinning instead of clear-cut? Large pellet users and suppliers claim that they never cause deforestation and source low-grade wood including tree tops, branches, and thinnings (small trees). These claims are disputed.

But analysis indicates that wood bioenergy worsens climate change even if never sourced by clearcutting. We examined scenarios in which all wood bioenergy is harvested by thinning. Although less damaging than clear-cut, the average carbon debt payback time for the US forests we examined was still 63 years, and the resulting climate damage persists for centuries even if the carbon debt from thinning is fully repaid.

What if wood pellets are sourced from fast-growing managed tree farms instead of slow-growing natural forests? Counter to intuition, harvesting existing forests and replanting with fast-growing species in managed plantations worsens the climate impact of wood biofuel. The carbon density of managed plantations is lower than unmanaged forests, so the carbon sequestered in plantations never offsets the carbon taken from the original forest. Converting forests to plantations permanently worsens climate change.

Accounting fiction

The assumptions of our study favour bioenergy. Specifically, we assume wood is used to offset coal, the most carbon-intensive fossil fuel. Carbon dioxide emissions per unit of primary energy from wood are about the same as coal, but 30% higher than fuel oil and 80% higher than natural gas.

We assume that the decline in coal use resulting from wood does not lower coal prices, and increases coal demand elsewhere. Such rebound coal demand would mean the carbon debt from burning wood would never be repaid, permanently worsening global warming. Finally, we don't consider ecological damage from harvesting wood, including erosion and soil loss, habitat fragmentation and resulting wildlife loss, or declines in hunting, recreation and tourism.

Of course, these results do not support continued coal use. To have any decent chance of limiting global warming to no more than 2°C, global greenhouse gas emissions must start to decline in the next few years. Solar and wind with storage, and especially energy efficiency, are the cheapest, safest, and quickest ways to cut emissions while providing the goods and services people need. These technologies have a far smaller footprint than forest bioenergy and immediately lower emissions, without the need to wait for uncertain regrowth of forest lands.

Government policies should not violate basic laws of physics. Declaring that wood biofuels are carbon neutral, as the EU, UK and others have done, assumes regrowth is rapid and certain. Neither is true. This accounting fiction promotes costly policies that accelerate climate change. Through renewable energy subsidies, the UK and Europe are paying power plants to make climate change worse.

Proper accounting would tally the emissions from all sources of energy, whether coal, gas, solar or wood. For wood and other biofuels, offsetting reductions in atmospheric carbon dioxide should be credited only when and if there is net new growth on the lands harvested to supply the biomass.

Instead of subsidies that harm the climate, a market-based approach combining accurate accounting with a meaningful price on carbon and other greenhouse gas emissions – no matter where and how they arise – would lead to far larger emissions cuts at far lower cost. ●

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