**Hello and welcome to Just Have Another Think, our twice monthly look at the environmental, ecological and social impacts of our twenty first century climate emergency.**

**Back in March of this year, a research paper was published in a journal called Frontiers in Forests and Global Change.**

**The paper’s objective was to accurately assess the extent to which the Amazon basin is now acting either as a carbon sink or a carbon source, as a result of sustained human activities in the region over recent decades. It referenced well over a hundred previous research papers, each focussed on a specific aspect of the intricate interconnections and dynamics of the Amazon ecosystem and it’s interaction with the local and global atmosphere.**

**Until recently, climate research in the Amazon has been overwhelmingly focused only on the cycling of carbon dioxide and its implications for the global climate. What hasn’t been so well considered are the climate impacts of other, non CO2 variables including methane, nitrous oxide, black carbon particles, evapotranspiration, and albedo. All these things respond dynamically to local events like fire, land-use change, infrastructure development, and storms, and to global events like warming, drying, and even to some extent to El Niños, which from time to time warm the tropical Atlantic.**

**So that’s our checklist.**

**Net Carbon Dioxide exchange between the Amazon and the atmosphere is a balance of CO2 intake by weathering and primary production, which is basically photosynthesis as plants and trees grow, and CO2 output as a result of respiration, decomposition of plant residues in soil and water and the burning of biomass. A 2012 study estimated that the Amazon at that time held between a hundred and fifty and two hundred billion tonnes of carbon. Between nineteen ninety and two thousand and seven, the best research suggests that the Amazon was sequestering about half a billion tonnes of carbon from atmospheric CO2 every year. Since then, land conversion, drought and sustained forest degradation have reduced the amount of above ground biomass by a third. The consequence of that is that between twenty ten and twenty seventeen the soils of the Amazon basin have been transformed from a net carbon store to a net emitter of at least two hundred million tonnes of carbon per year. The complex river systems of the Amazon are the lifeblood of the regions ecosystem and biodiversity. They transport essential nutrients and drain carbon and sediment out to the Atlantic Ocean, which acts as a massive carbon sink. The sediment settles onto the ocean floor and the carbon gets used in the process of photosynthesis in aquatic life like phytoplankton that eventually dies and also settles on the bottom. It used to be assumed that the vast majority of organic matter from trees and vegetation got swept out of the Amazon and permanently stored in the oceans via this system, but more recent studies have shown that the increase in the levels of this waste material could be fuelling as much as fifty percent of the CO2 out gassing from the rivers before they reach the coast.**

**There are now more than a hundred and ninety dams on the river network, with another two hundred and forty-six hydroelectric reservoirs planned or currently under construction. The dams wreck migration routes for many species, change the temperature of rivers, reduce water quality, and alter the frequency and timing of essential flooding across wetlands and freshwater ecosystems. As the sediment moves downstream, some of the carbon content is deposited in floodplain lakes. Dams are disrupting that movement as well, decreasing river productivity and harming fisheries. Hydroelectric plants are touted as a low carbon alternative to fossil fuels, but in fact, research suggest that their net climate impact may be greater than the power plants they replace.**

**Older studies of Amazonian rivers and wetlands suggested they were a source of about four hundred and seventy million tonnes of carbon released into the atmosphere every year. Those studies have now been expanded to include streams, small rivers, lakes, floodplains in different tributaries and the lower section of the Amazon River. That expanded assessment has increased estimates of Carbon Dioxide emissions from the Amazon water system four-fold to one point eight billion tonnes of CO2 per year.**

**Tropical forests are a globally important source of Nitrous Oxide. Although it’s not a carbon-based molecule, it is nevertheless an impactful greenhouse gas that’s two hundred and sixty-five times more potent than CO2. Climate studies from all of the tropical regions suggest that there are ebbs and flows of nitrous oxide depending on what’s happening in a local area. For example, drying soil reduces N2O emissions in upland forests, but conversely that drying and warming also influences the frequency and severity of forest fires, which has the effect of increasing emissions. And the warming atmosphere increases soil enzyme activity in humid tropical forests, which again causes an uptick in the amount of nitrous oxide released. As we humans have burned more and more forest land to clear space for agriculture and mining, that burning biomass has released very large quantities of nitrous oxide. Reservoir construction in the Amazon may also be increasing nitrous oxide emissions by as much as eighty percent according to one research paper. The limited research that’s been carried so far indicates that the Amazon basin now emits about one point nine million tonnes of this greenhouse gas each year. And because of its potency, that’s equivalent to nearly half a billion tonnes of carbon dioxide.**

**Methane doesn’t last as long in the atmosphere as carbon dioxide. It’s relatively quickly broken down by what are known as hydroxyl radicals. But while its up there, it’s a far more potent greenhouse gas. More than eighty times more impactful over a twenty-year period and about twenty-eight times more over the course of a century. Soils and sediments can both produce AND consume methane. Well drained upland soils in the Amazon currently take in between one and three million tonnes each year. But waterlogged soils, sediments and vegetation release significant amounts of methane. It’s also a product of activity by indigenous plants called tank bromeliads and by native animals and insects. The rapidly increasing quantity of livestock now being reared on vast tracts of deforested Amazon land is massively adding to that methane output.**

**Even more land is being cleared for agriculture like soybean production for animal feed and of course for the logging industry. Both those activities tend to compact the soil, which decreases its ability to store methane. Cattle ranching and soybean planting are especially interconnected, self-reinforcing industries. Once the ranchers have secured and exploited a frontier of newly cleared pastureland, they sell that land to the soy producers for a nice tidy profit and then move on to slash and burn another zone and establish a new frontier deeper into the basin, and so the demise of forestry land is continued on and on through these commercial arrangements.**

**And as a macabre additional kicker, the smouldering fires from all that deforestation produce large quantities of carbon monoxide. And Carbon monoxide is very good at removing those hydroxyl radicals that break down methane in the atmosphere. The result of that is that the average lifetime of atmospheric methane is extended.**

**Then there’s the flooding that happens as a direct result of all the dam construction we just talked about. That flooding decreases oxygen levels in the local aquatic ecosystem, which means more organic matter decomposes without oxygen. The product of that anoxic process is yet more methane. Studies show that the effect is ten times stronger in tropical regions than it is in dams built in temperate parts of the world.**

**Once the papers researchers had extrapolated all the available field study results, they found that the Amazon now emits about forty-three million tonnes of methane every year, which is about eight percent of the global total and the equivalent of between one and four billion tonnes of CO2, depending on what timescale you measure it’s atmospheric presence over.**

**Black carbon is mainly produced by the incomplete combustion of fossil fuels, biofuels, and biomass. There’s no fixed global warming potential number relative to carbon dioxide, so it’s difficult to be precise about it’s atmospheric influence, but research does show that forty percent of global open fire emissions come from forest burning in the tropics, and carbon emissions of about a third of a million tonnes come from black carbon in Latin America. About a hundred and forty thousand tonnes of that is due to forest degradation and deforestation across South America. Despite the fact that the Amazon is undoubtedly a large contributor to this figure, management and minimisation of Black Carbon is not included in Brazil’s Nationally Determined Contributions toward the Paris agreement, nor does that look likely to change at the COP 26 conference in November this year. The indirect impacts of black carbon particulates on things like cloud formation, which in turn affects atmospheric warming, get worse as more biomass is burnt down. At low rates of burning, black carbon in the atmosphere actually have a modest dimming and cooling effect, but that switches to a strong warming influence as the atmospheric concentrations increase. And as a little extra gut punch, Black Carbon emissions have also been found to be speeding up the melting of glaciers in the Andes by an estimated three percent. That number will certainly increase as widespread drought-intensified burning increases black carbon emissions in the future.**

**Evapotranspiration is a critical driver of local and regional climate in the Amazon. It provides surface cooling and water recycling, and it controls vegetation patterns throughout the Basin. Regional changes in rainfall patterns closely mirror changes in local hydrological cycles that have happened as a result of land use change. Generally speaking, the more we humans remove vegetation from the area, the more we reduce evapotranspiration. That intensifies surface water runoff, which dries the soils, and alters moisture transport dynamics in way that increases local temperatures. That effect is particularly pronounced during the dry season. Transpiration is thought to be an important factor in triggering and sustaining the onset of the wet season, so a reduction means longer dry seasons which leads to reduced growth in secondary forests, which are in turn more vulnerable to drought stress and at greater risk from fire. Research has shown that even modest deforestation-driven reductions in rainfall can dry the atmosphere enough to put a region into decline. That results in even more reduction in rainfall, which combines with intense warming to accelerate forest dieback still further. Analysis of atmospheric water fluxes in the Amazon suggests this self-amplification effect might reduce forest cover by somewhere between ten and thirteen percent. More than enough to offset the cooling effect of increased albedo that land clearance might bring about.**

**Historically, the Brazilian “arc of deforestation” along the southern and southeastern edges of the forest, which was largely a product of soybean cropping and meat production, was the epicentre of deforestation in the Amazon Basin, but in recent years, other countries like Peru and Bolivia have also experienced large-scale deforestation. In Peru, its driven by the palm oil industry and artisanal gold mining. In Bolivia, its mainly a result of soybean planting. Since 2017, political decisions of regional governments have been accelerating deforestation. Ironically, the signing of a peace agreement in Colombia meant that forestry areas previously occupied by revolutionary FARC guerrillas are now being cleared for cattle ranching. In the Brazilian Amazon, deforestation rates have increased by more than sixty percent since 2013. In the first year of the Bolsonaro administration, nearly ten thousand square kilometres of the Amazon was deforested. That was a thirty percent increase over the previous year. Indigenous land rights are being compromised and monitoring and enforcement agencies are being scaled back or wound down completely, giving more or less free rein to the land grabbers.**

**Between 2005 and 2015, legal and illegal mining resulted in about twelve thousand square kilometres of unauthorised deforestation beyond mining operation lease boundaries. That’s almost ten percent of the total Amazonian forest losses during that period. Registered mining interests now account for more than a million square kilometres of Amazonia, including indigenous land and some strictly protected areas. There are plans to open at least two more large areas north of the Amazon River to mining and road building. Oil and gas drilling projects are also widespread, leading to even more deforestation in addition to the well documented impacts on human health through water and food contamination.**

**2019 saw the highest rates of forest fires since 2008, with exceptionally high levels of fire in protected areas. Climate change is highly likely to amplify fire risk, especially in drought hit regions. Model projections suggests that intensification of fires in the southern Amazon could double the area burnt to sixteen percent of the total rainforest by 2050, accelerating biodiversity and biomass loss.**

**The paper concludes that despite uncertainty in their responses to change, current warming from non-CO2 variables, especially methane and nitrous oxide, largely offsets, and most likely exceeds, the carbon sink provided by atmospheric CO2 drawdown. The research also finds that most human impacts are increasing the surface temperature in the rainforest. The authors argue that simply focussing just on carbon uptake and storage is way too simplistic and misses a wide range of crucial biogeochemistry of the climate in a rapidly changing Amazon Basin.**

**I must admit this was quite a difficult video to compile and produce, not just difficult from a technical editorial point of view, but also on a more visceral level, in discovering yet more evidence of the profligate and wreckless violence that human beings are capable of inflicting upon our own, and only, life support system.**

**I hope it’s given you some food for thought. And I hope it’s provided you with some impetus to do whatever you can, wherever you are, either by looking at your own lifestyle and purchasing choices, or through collective action to put pressure on elected representatives to influence the direction and urgency of climate mitigation.**

**Thanks for watching, and I’ll see you soon.**