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Negative Emission Technologies and Land Use

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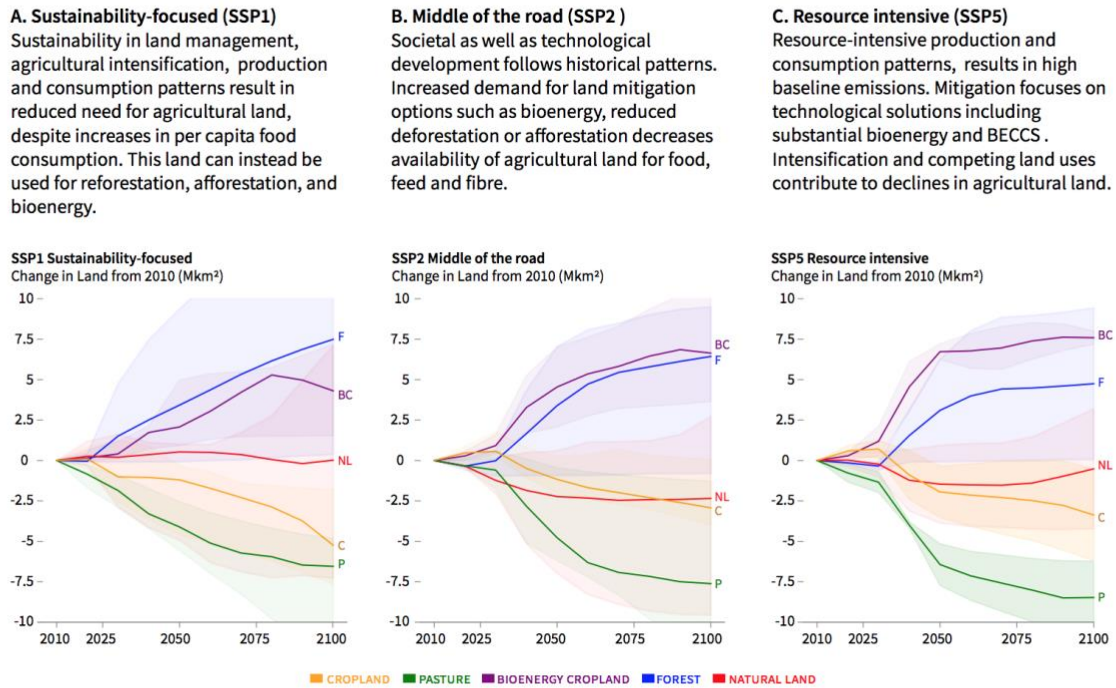
Given the aspirations of the Paris Accord, the challenge facing humanity can be expressed in simple terms: halve annual CO_2 emissions by 2030, halve them again by 2040, and again by 2050. The difficulty of the task goes up the longer peak emissions are delayed, as does the ultimate amount of negative emissions needed by 2100. Negative Emissions Technologies (NET) are a suite of technologies that can draw down CO_2 from the atmosphere and by use or storage keep it from reentering the air. This simplistic prescription of halving annual emissions pencils out to reducing the 40 billion tons of CO_2 ($GtCO_2$) emitted today in each decade: first to 20, then to 10, and finally to 5 $GtCO_2$. The final 5 $GtCO_2$ offset by reducing land use emissions to zero and ramping up CO_2 removal to 5 $GtCO_2$ – all happening in about 30 years (Rockstrom et al. 2017, Faulk, 2019).

If massive negative emissions are required this century to stay below 2°C of warming, what are the likely approaches and their characteristics at the scale of $GtCO_2$ removed per year? To meet Paris Accord targets, many of the models used by the Intergovernmental Panel on Climate Change (IPCC) rely heavily on Bioenergy with Carbon Capture and Storage (BECCS) – a process of growing biomass and then burning it to produce energy while capturing the produced CO_2.from the combustion process and ultimately storing it. The models consider other CO_2 removal methods including afforestation, reforestation, enhanced weathering, biochar, and direct air capture of CO_2. None of these approaches has been tested at the scale needed to achieve the Paris Accord goals. Here we focus on some aspects of land-use and negative emission technologies (NET) dependent on the land. Ultimately the scale of NET deployment needed is reduced to near zero if policies are adopted that aggressively drive the reduction of fossil fuel emissions while simultaneously ramping up efficiency and clean energy technologies such as wind and solar.

The following figure from the IPCC Special Report on Land (2019) shows three of the Shared Socioeconomic Pathways (SSPs) used by integrated assessment models to explore possible futures, with a notable decrease in pasture and increase in land for bioenergy and forest.



In the SSP scenarios, change in cropland area varies depending on assumptions about intensive agriculture, human population, diet, and other factors. Each scenario above is accompanied by a brief description of the pathway and how it alters land use for cropland, pasture, land dedicated to bioenergy, forest, and natural land. All these scenarios significantly increase land set aside for bioenergy compared to present day, ranging from about 3 to 7 million km^2. But how do these land use changes impact agriculture, biodiversity, and other considerations?

Ice-free land, perhaps once imagined as nearly infinite centuries ago is 130 million km^2 or about 25% of the total area of the Earth. Of this, 1% is dedicated to infrastructure, with the rest consisting of cropland at 12%, 37% pasture, 22% plantation forests, and 28% unforested ecosystems which include intact forests with minimum human use, and barren land. The concern about counting heavily on BECCS as a future component of achieving the Paris Accord is the significant impacts it would create in water use and land appropriation from other valuable uses such as habitat for biodiversity and agricultural land providing food security for our growing human population.

How much more land-based carbon uptake can be expected during this century if BECCS is pursued? Estimates of the amount of land required for BECCS biomass production depend on land availability and productivity assumptions and characterizations of what is considered sustainable. The medium confidence estimate of potential for BECCS is 0.4 to 11.3 $GtCO_2$ removed per year – up to about a quarter of present day annual emissions. However, when further sustainability constraints are in place, the estimates are reduced significantly (IPCC 2019). For example Fuss and colleagues estimate a negative emissions yield of 0.5–2 $GtCO_2$ per year for

BECCS by 2050. They estimate that with similar sustainability constraints, other NET approaches could yield equal or greater negative emissions by also by 2050 of 0.5–3.6 $GtCO_2$ for afforestation and reforestation, 0.5–2 $GtCO_2$ for biochar, 2–4 $GtCO_2$ for enhanced weathering, 0.5–5 $GtCO_2$ for direct air capture, and a maximum of about 5 $GtCO_2$ for soil carbon sequestration. All of these NET approaches have their own set of impacts, costs and limitations such as the permanence of the carbon stored (Fuss 2018).

Cost estimates vary and are uncertain for all NETs primarily due to the lack of operations at scale, unproven technologies, and particularly for BECCS, unknown land productivity at higher temperatures due to climate change, land degradation, and other land use priorities. Fuss and colleagues estimate the cost of BECCS at 100-200 US$ per tCO_2. The full range of BECCS costs in the literature is 15-400 US$ per tCO_2. Beyond 2050, the IPCC expects the need for negative emissions to continue increasing for scenarios consistent with or more ambitious than a 2°C future. The Fuss study states in its conclusion:

"This review shares the wide-spread concern that reaching annual deployment scales of 10–20 $GtCO_2$ [per year] via BECCS at the end of the 21st century, as is the case in many scenarios, is not possible without severe adverse side effects" (Fuss 2018).

Analyses to date by the IPCC, the National Academies of Sciences, and many articles in the scientific literature stress the importance of peaking global emissions as soon as possible, followed by rapid deployment of zero emission technologies to displace fossil fuels. The extent to which carbon emissions remain determines the need for increased NET approaches. BECCS may be a useful technology, but it and other forms of NET are secondary to the present need for rapid CO_2 emissions reductions as the preferred path.

References

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