New study shows how conversion of forests to cropland affected climate

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The conversion of forests into cropland worldwide has triggered an atmospheric change that, while seldom considered in climate models, has had a net cooling effect on global temperatures, according to a new Yale study.

Writing in the journal *Nature Climate Change*, Professor Nadine Unger of the Yale School of Forestry & Environmental Studies (F&ES) reports that large-scale forest losses during the last 150 years have reduced global emissions of biogenic volatile organic compounds (BVOCs), which control the atmospheric distribution of many short-lived climate

pollutants, such as tropospheric ozone, methane, and aerosol particles.

Using sophisticated climate modeling, Unger calculated that a 30-percent decline in BVOC emissions between 1850 and 2000, largely through the conversion of forests to cropland, produced a net global cooling of about 0.1 degrees Celsius. During the same period, the global climate warmed by about 0.6 degrees Celsius, mostly due to increases in fossil fuel carbon dioxide emissions.

According to her findings, the climate impact of declining BVOC emissions is on the same magnitude as two other consequences of deforestation long known to affect global temperatures, although in opposing ways: carbon storage and the albedo effect. The lost carbon storage capacity caused by forest conversion has exacerbated global warming. Meanwhile, the disappearance of dark-colored forests has also helped offset temperature increases through the so-called albedo effect. (The albedo effect refers to the amount of radiation reflected by the surface of the planet. Light-colored fields, for instance, reflect more light and heat back into space than darker forests.)

Unger says the combined effects of reduced BVOC emissions and increased albedo may have entirely offset the warming caused by the loss of forest-based carbon storage capacity.

"Land cover changes caused by humans since the industrial and agricultural revolutions have removed natural forests and grasslands and replaced them with croplands," said Unger, an assistant professor of atmospheric chemistry at F&ES. "And croplands are not strong emitters of these BVOCs—often they don't emit any BVOCs."

"Without doing an earth-system model simulation that includes these factors, we can't really know the net effect on the global climate. Because changes in these emissions affect both warming and cooling

pollutants," she noted.

Unger said the findings do not suggest that increased forest loss provides climate change benefits, but rather underscore the complexity of climate change and the importance of better assessing which parts of the world would benefit from greater forest conservation.

Since the mid-19th century, the percentage of the planet covered by cropland has more than doubled, from 14 percent to 37 percent. Since forests are far greater contributors of BVOC emissions than crops and grasslands, this shift in land use has removed about 30 percent of Earth's BVOC sources, Unger said.

Not all of these compounds affect atmospheric chemistry in the same way. Aerosols, for instance, contribute to global "cooling" since they generally reflect solar radiation back into space. Therefore, a 50 percent reduction in forest aerosols has actually spurred greater warming since the pre-industrial era.

However, reductions in the potent greenhouse gases methane and ozone—which contribute to global warming—have helped deliver a net cooling effect.

These emissions are often ignored in climate modeling because they are perceived as a "natural" part of the earth system, explained Unger. "So they don't get as much attention as human-generated emissions, such as fossil fuel VOCs," she said. "But if we change how much forest cover exists, then there is a human influence on these emissions."

These impacts have also been ignored in previous climate modeling, she said, because scientists believed that BVOC emissions had barely changed between the pre-industrial era and today. But a study published last year by Unger showed that emissions of these volatile compounds

have indeed decreased. Studies by European scientists have produced similar results.

The impact of changes to ozone and organic aerosols are particularly strong in temperate zones, she said, while methane impacts are more globally distributed.

The sensitivity of the global climate system to BVOC emissions suggests the importance of establishing a global-scale long-term monitoring program for BVOC emissions, Unger noted.

More information: www.nature.com/nclimate/journa … ll/nclimate2347.html

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