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The importance of land use change as a driver of anthropogenic mercury pollution

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Terrestrial ecosystems, especially forests, take up approximately one third of all mercury (Hg) emissions to the atmosphere, thereby reducing the burden of Hg entering the ocean and eventually the marine food chain. Similar to carbon dioxide (CO_2), foliage absorbs gaseous elemental mercury (Hg^0) from the atmosphere, later transferring the Hg to soils where it can be stored for long timescales. Many scientific assessments have investigated the role of land use change (such as deforestation) in perturbing the carbon cycle. For Hg, on the other hand, there is little quantitative information available about the impacts of land use change on historical and future Hg cycling, and land use change is not currently addressed by Hg policy efforts like the Minamata Convention on Mercury. Therefore, we apply global mechanistic models for the atmosphere (GEOS-Chem) and soil erosion (GloSEM) to investigate land use change impacts on Hg cycling, focusing specifically on Amazon deforestation and global-scale reforestation. If deforestation in the Amazon continues at business-as-usual rates, by 2050 the Amazon Hg sink will be weakened by 65% compared to 2003 forest conditions. The removal of forests leads to decreased Hg^0 deposition to the Amazon (–105 Mg yr^{-1}), enhanced Hg^0 volatilization from deforested soils (+35 Mg yr^{-1}), and biomass burning emissions (+15 Mg yr^{-1}). Deforestation in the business-as-usual case also increases erosion of Hg by 33%, enhancing the transfer of Hg from soils to aquatic systems. Stricter conservation policies would prevent 92 Mg yr^{-1} of Hg from being emitted compared to the business-as-usual case, a flux greater than Brazil's current primary anthropogenic Hg emissions. In a potential global reforestation scenario, the inputs of Hg to the ocean are reduced by 98 Mg yr^{-1}, equivalent to nearly 5% of global anthropogenic emissions. The benefits of reforestation are mostly from tropical forests, illustrating that reforestation efforts in Northern extratropical areas alone would not compensate for deforestation Hg emissions from the Amazon. Our study demonstrates that land use change is a substantial anthropogenic source of Hg pollution, which should be accounted for in anthropogenic Hg emission inventories and global Hg policy.