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Tropical Deforestation and Greenhouse Gas Emissions

Abstract
Achard et al. (2002) estimated tropical deforestation and atmospheric carbon emissions from 1990-1997 and concluded that both were substantially lower than found in previous studies. However, we assert that they markedly underestimated carbon emissions, by omitting key factors and making some invalid assumptions. The net effect is a potentially large underestimate of the impact of tropical deforestation on global warming.

Achard et al. (*1*) estimated tropical deforestation and atmospheric carbon (C) emissions from 1990-1997 and concluded that both were substantially lower than found in previous studies. However, we believe that the evidence favors higher estimates, particularly for C emissions.

First, they confined their study to "humid tropical forests," excluding extensive drier forest types that were incorporated in earlier studies of tropical forests worldwide (*2*) and Brazilian Amazonia (*3*). As a result, deforestation estimates were reduced by 16.6% in Brazilian Amazonia (*3*) and by even greater amounts in tropical regions that include large expanses of seasonal forest.

Second, their estimates of forest biomass are clearly too low. These were derived by averaging two sets of published numbers. The first dataset (*4*) was not intended as an estimate of forest biomass for each country, but rather as a methodological primer for assessing biomass from forestry surveys. Indeed, for the vast Brazilian Amazon—which contains nearly half of the world's tropical forest—biomass was extrapolated from a preliminary survey of a single site (*5*). Far more representative studies of biomass are available for Brazilian Amazonia, based on nearly 3000 1-ha plots that were weighted both by individual vegetation types and deforestation activity (*6,7*), and that yield considerably higher estimates of C emissions.

The second set of published numbers is actually a mean of three estimates (*8*). The "low" case (*9,10*) substantially underestimates biomass due to omissions of palms, vines, stranglers, and other understory vegetation, and because an overly low form factor was used to calculate wood volume from tree diameter and height measurements (*11,12*). The "medium" case (*8*) is extrapolated from just 56 plots, some as small as 0.2 ha; this is obviously very crude when compared to studies of nearly 3000 1-ha plots (*6,7*). The "high" case (*8*) is most realistic because it was based on a detailed allometric study of Amazonian trees (*13*) and includes adjustments for biomass components (*6*) omitted from other estimates. Thus, the second set of values was generated by averaging a realistic value with two others that underestimate biomass, and is biased downward.

Third, the principal forest-biomass estimates used by Achard et al. for Brazilian Amazonia (*4,9,10*) fail to include dead material (necromass), which increases forest C stocks by 8-10% (*8,14,15*). Their method of calculation should produce an underestimate of 5.3-6.7% in C emissions (because two-thirds of their dataset [*4,8*] lacked necromass data, and multiplying this fraction by 8-10% yields 5.3-6.7%). Reductions in soil C (including fine roots <2 mm in diameter) following deforestation are also not included; for Brazilian Amazonia, including C loss from the top meter of soil (*7,16*) would add 9.6% to the emissions estimate by Achard et al.

Fourth, the authors assumed that secondary forests would regenerate rapidly on abandoned lands, recovering about 70% of their biomass in just 25 years. Such rapid recovery may occur during shifting cultivation but is far less likely on degraded pastures (*17*), which predominate in Amazonia. Moreover, they implicitly assume that regenerating forests will remain undisturbed over the next 75 years, whereas in reality such forests are often re-cleared (*17,18*).

Fifth, they assumed that only 72% of C stocks in cleared primary forests will be released to the atmosphere. This estimate is for committed flux during the first decade after forest clearing but does not include the remaining C stock (28%), which will also eventually be emitted (*6,7,19*). (The impact of deforestation is underestimated because the time-line for C emissions is truncated at year 10, while the area is simultaneously restricted to a single year's clearing. If the full landscape were considered—including areas cleared in prior years—then decay of previously felled biomass in those areas would contribute the missing 28% of C emissions, if deforestation rates are assumed to be constant. Hence, important fluxes are omitted when the time horizon for emissions and the area of cleared land under consideration are both truncated. To provide a valid index of the impact of deforestation on global warming, either an estimate of net committed emissions for each year's clearing [*6*] or the annual balance of emissions from the full landscape [*7*] is needed.)

Sixth, they did not consider effects of trace gases, such as methane and nitrous oxide, that add 6-25% to the impact of deforestation emissions as compared to counting only changes in C stocks (based on published emission factors and land clearing and burning practices in Brazilian Amazonia [*19*]). For example, methane is produced by burning and by termites on recently deforested lands, and each Mg of C released as methane has 7.6 times more impact on global warming than does the same amount of C released as CO_2 (*19*). By restricting their analysis to simple C emissions, they understate the contribution of tropical deforestation to global warming, especially when policy-makers use their results for comparisons with fossil-fuel emissions.

Finally, Achard et al. do not include emissions from selective logging (*19*), forest fragmentation (*20*), and other forms of degradation that reduce forest C stocks but do not cause deforestation per se. Tropical logging and other thinning caused annual emissions of over 400 Tg C during the 1980s (*19*).

The cumulative effect of these omissions and other choices is a large underestimate of greenhouse gas emissions. By excluding various components of land-use change and C stocks in affected landscapes, one is not "reducing the amount of uncertainty," as the authors claim, but is merely producing a less-complete estimate.

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