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Debating the future of the Brazilian Amazon

We are pleased to respond to Schwartzman and Bonnie, who assert that the study by the Instituto de Pesquisas Ambientais na Amazônia (IPAM) (*1, 2*) is more conservative than ours (*3*) and provides a better basis for policy conclusions. While we were careful to give due credit to the pioneering work of IPAM, we believe that we have built a better mousetrap and dispute both of Schwartzman and Bonnie's assertions. The IPAM estimates are not "more conservative" but only less complete.

Like us, the IPAM group evaluated historical deforestation along Amazonian highways and then extrapolated these results into the future. However, the IPAM effort was based on a subset of only four highways that had caused especially heavy deforestation. We used a more reliable method, which involved assessing deforestation along *all* Amazonian highways, including several that had caused only limited deforestation. Our calculations were therefore more conservative and robust than those of IPAM. Because of this important bias, the IPAM study actually projects a greater increase in future deforestation rates (400,000-900,000 ha yr^{-1}) than does our study (269,000-506,000 ha yr^{-1}).

In addition, the IPAM study is far from comprehensive, because it fails to account for the effects of infrastructure projects and unpaved roads on Amazonian forests. Some roads, such as the Northern Perimeter Road, will carve large swaths across the Amazon, strongly influencing deforestation, logging, mining, and other activities. Infrastructure projects such as powerlines, gaslines, and hydroelectric reservoirs also contribute directly to forest-degrading activities because they require road networks for construction and maintenance. Examples of this can be seen in the Ecuadorian and Brazilian Amazon, where roads associated with gas- and powerlines and reservoirs have led to dramatic rises in slash-and-burn farming, logging, market hunting, and land speculation (*4, 5*). Our assumption that major infrastructure projects will behave like unpaved roads—because they cannot be constructed without first making roads—therefore is logical and defensible.

The IPAM study has other key limitations. It does not consider vast forested lands that would be inundated by planned hydroelectric reservoirs in the Amazon. It also fails to consider the influence of protected and semi-protected areas (such as national parks, national forests, and indigenous reserves) on spatial patterns of forest loss and degradation. Finally, it distinguishes only between forested vs. deforested lands. Many activities, such as selective logging, forest fragmentation, surface fires, wildcat mining, and overhunting, can degrade forest ecosystems without causing deforestation *per se*. Thus, the failure of the IPAM study to predict the extent of forest degradation significantly reduces its utility.

While most of Schwartzman and Bonnie's assertions can be easily rebutted, they do raise a valid point. A debatable aspect of our models is the assumption that river-channelization projects would likely lead to increased logging, deforestation, and other degrading activities along rivers, comparable to those caused by unpaved roads. No such

projects exist in the Amazon on which to base projections. While our remote-sensing analyses suggest that forests near rivers with heavy boat traffic are especially prone to deforestation (*5*), further studies are needed to predict the impacts of river-channelization on Amazonian forests. Contrary to Schwartzman and Bonnie's suggestion, however, our analysis does not exaggerate impacts by double-counting deforestation from river channeling (or other) projects in already deforested areas because our geographic information system automatically tracks the status of each point in the landscape, preventing any one from being deforested twice.

In summary, many of the large infrastructure projects included in our study—such as the Porto Velho-Urucu gasline, which will penetrate into the "pristine" heart of the Amazon—are likely to have dramatic impacts on the pattern and pace of forest conversion. While predictive models such as ours can always be improved, ignoring such projects in the name of waiting for better data would be to neglect one of the most important features of Avança Brasil. Our Policy Forum article helped to initiate a vigorous debate about the Avança Brasil program, and we regard this as a very healthy and timely development.

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