IIC Brazil Summer Policy Lab

Hydropower Construction and Deforestation: Linking Forest Cover to Changes in Water Balance

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Hydropower construction represents the largest potential driver of deforestation in the Amazon as a result of: (1) Road construction creating access to remote areas; (2) Migrant workers leading to rapid increases in population density; and (3) Infrastructure construction necessary to support this population growth. As of November 2015, 237 dams were planned or under construction in the Brazilian Amazon [1]. Hydropower construction in the Tapajós River Basin represented one third of this total. The amount of deforested area in the Tapajós River Basin was estimated to be between 42% and 105% greater than background rates of deforestation by 2030 (Fig. 1). In early August 2016 the environmental license to build the largest of these dams, the São Luiz do Tapajós, was denied. In addition to future expansion of hydropower throughout the Amazon, 43 dams are still planned for the Tapajós River Basin.

The Effect of Deforestation on Local and Regional Water Balance

Rainfall is dependent on both the water vapor being transported from upwind and the local water vapor input via evapo-transpiration (ET). Deforestation is known to have several important negative effects on the cycling of water and the energy in tropical ecosystems. First, pastures and crops absorb less energy from the sun and evaporate less water than forests, dramatically reducing the amount of energy and water returned to the atmosphere. By starving the atmosphere of energy and water local and regional rainfall is decreased [3]. As a result of removing water from the atmosphere and changing the energy balance, rainfall is expected to decrease at local and regional scales, with potentially negative consequences for crop production [4]. Next, by changing evaporation and rainfall, river discharge is

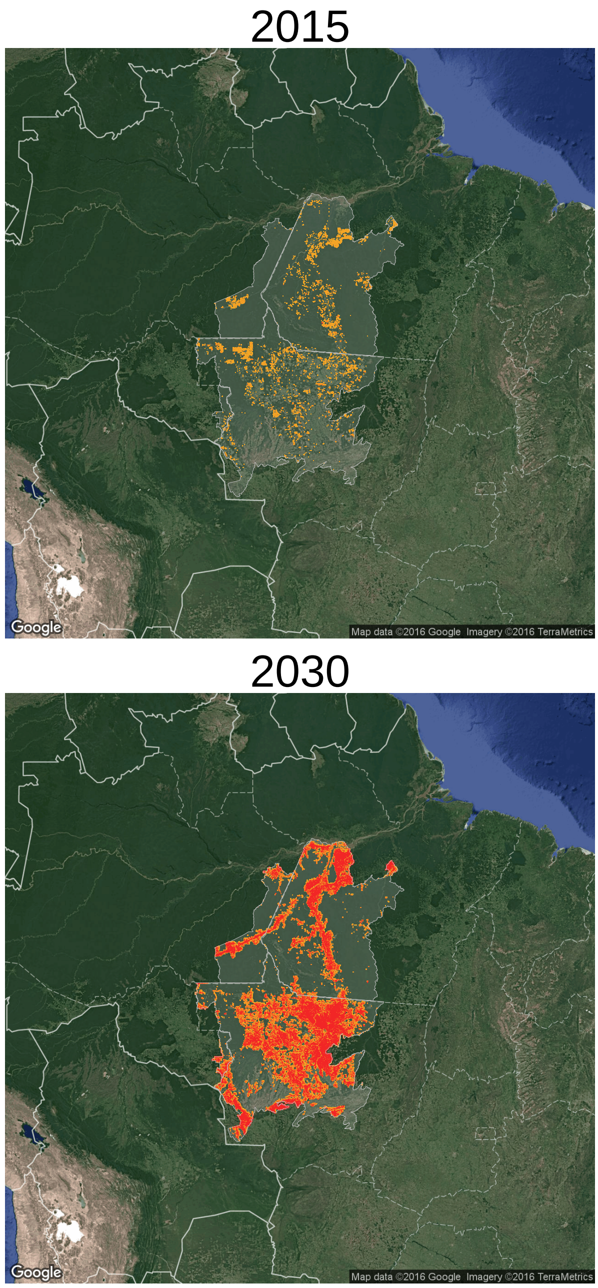

Figure 1: Observed deforestation in 2015 and projected deforestation in 2030 among municipalities in the Tapajós river basin.

affected. A forested landscape provides a slow release of water into streams during the dry season. A deforested landscape can result in big changes in the seasonal flow of river water, often with much more in the wet season and much less in the dry season. These types of changes can be especially difficult for consistent hydroelectric power generation and change the ecological function of rivers and streams[2].

Our Question

How will deforestation in the Tapajós River Basin affect seasonal variability in river discharge, ET and net energy (rainfall potential)? Below we use results from land-surface modeling (IBIS) to quantify the effect of deforestation on the magnitude of change in several water and energy balance characteristics in the Tapajós River Basin [3].

Results and Recommendations

We find that with the current level of deforested area in the Tapajós River Basin (34%), the discharge of the Tapajós River is much lower in the dry season, while ET is lower during the rainy season. Similarly, we find that total net energy returned to the atmosphere, which is a driver of rainfall, is strongly decreased by deforestation. We recommend the following policy strategies to avoid or offset these effects:

- Hydropower construction undermines its own potential for energy production through the associated deforestation, by creating more seasonally variable source of water. We suggest the use of alternative energy strategies, such as solar and wind energy as much as possible, to maintain the proper functioning of the water cycle.
- Deforestation in one place can affect rainfall hundreds of miles away potentially affecting crop production and natural ecosystems. Policies to reduce the amount of deforestation that are directly and indirectly associated with dam construction, reduce the costs of forest restoration, and incentivize the maintenance of forested areas should be made a priority.
- Some of the costs of enforcement, restoration, and protection should be built into the costs of government funded construction projects.

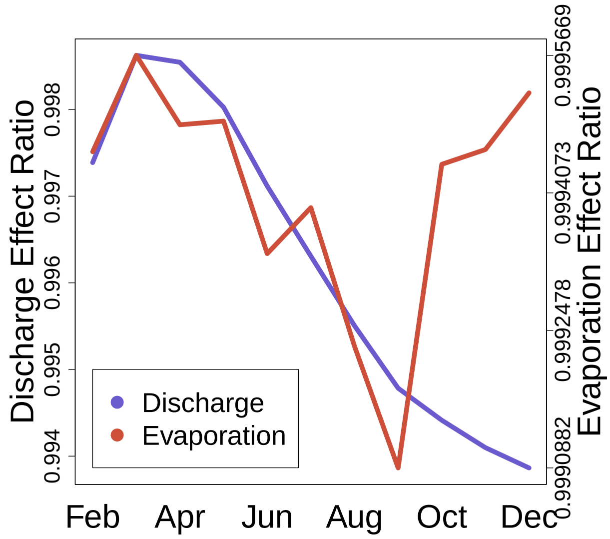

Figure 2: The effect of deforestation on discharge and ET for each month from year 2000 to 2014. If there were no effect of deforestation we would expect both lines to be flat at a ratio of 1 across all months.

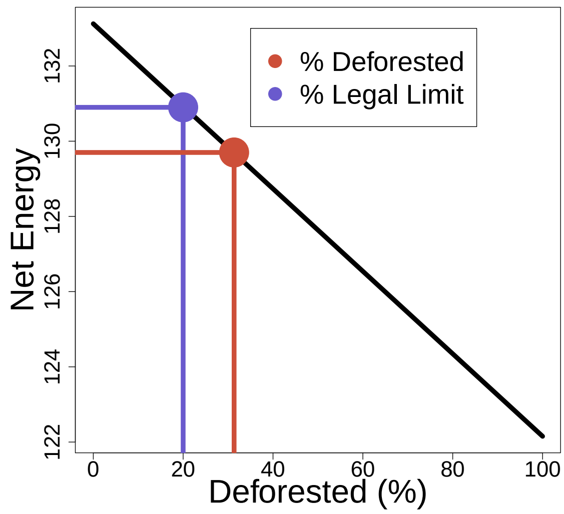

Figure 3: Difference in net energy (rainfall potential) under the legal limit of deforested area (blue) and observed level of deforestation (red).

References

[1] L. Castello and M. N. Macedo. Large-scale degradation of Amazonian freshwater ecosystems. *Global change biology*, 2015.

[2] M. Coe, E. Latrubesse, M. Ferreira, and M. Amsler. The effects of deforestation and climate variability on the streamflow of the Araguaia River, Brazil. *Biogeochemistry*, 105(1-3):119–131, 2011.

[3] M. T. Coe, M. H. Costa, and B. S. Soares-Filho. The influence of historical and potential future deforestation on the stream flow of the Amazon river–land surface processes and atmospheric feedbacks. *Journal of Hydrology*, 369(1):165–174, 2009.

[4] L. J. Oliveira, M. H. Costa, B. S. Soares-Filho, and M. T. Coe. Large-scale expansion of agriculture in Amazonia may be a no-win scenario. *Environmental Research Letters*, 8(2):024021, 2013.

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