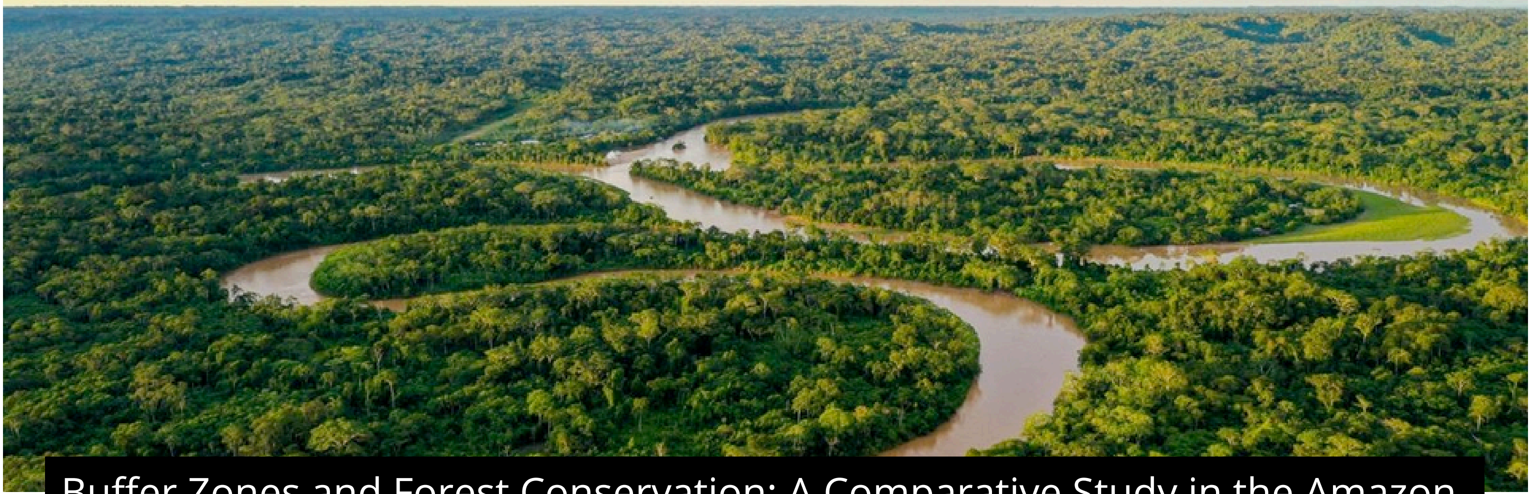
Policy Brief



Buffer Zones and Forest Conservation: A Comparative Study in the Amazon

Context and relevance

The amazonian region holds some of the most active agricultural and livestock areas of expansion worldwide, where forest conversion for different land-use purposes continues to be one of the main causes of forest cover loss and environmental degradation (Giudice and Guariguata, 2023). This expansive dynamic, which has been powered by the opening of new roads, gold mining, and the growing demand for productive lands, compromises biodiversity, ecosystem services, as well as rural livelihoods (Giudice and Guariguata, 2023). In this context, several conservation initiatives have been implemented by governments as well as environmental bodies, such as the creation of national parks, to initiatives that are based on economic incentives such as REDD+ and payment for ecosystem services (PES). Protected areas (PAs) and buffer zones (BZs) have also consolidated as key environmental conservation instruments in the region (Giudice and Guariguata, 2023).

In the MAP (Madre de Dios-Acre-Pando) frontier, the tensions between conservation and development are aggravated by overlapping titles and land-use changes, road expansion (such as the Interoceanic Highway), and informal gold mining (Scullion et al., 2014; Weisse and Naughton-Treves, 2016; Schilling et al., 2024; Perz et al., 2013). Land-use assignment decisions, particularly the coexistence of mining and agricultural titles in or adjacent to conserved areas, can weaken the effectiveness of protection instruments, and proximity to roads and settlements increases the risk of forest conversion (Weisse and Naughton-Treves, 2016).

Furthermore, the effectiveness of conservation initiatives in the MAP region has been in many cases moderate, it is likely to decrease in areas where many land-uses overlap, and compliance and adequate governance mechanisms are critical conditions for achieving long-term sustained impacts (Weisse and Naughton-Treves, 2016; Scullion et al., 2014).

The MAP region constitutes a particularly relevant setting for the analysis because the construction and paving of the Interoceanic Highway produced a shared transboundary shock that simultaneously increased accessibility, land-use pressures and incentives for resource extraction across Peru, Bolivia and Brazil (Perz et al., 2013; Baraloto et al., 2015). As a result, deforestation dynamics throughout the tri-national frontier were altered, while institutional responses, governance, capacities and land-use change differed substantially between the three countries (Weisse and Naughton-Treves, 2016; Schilling et al., 2024; Wallace et al., 2018; Vadjunec et al., 2009). This combination of a common external shock makes the MAP region an ideal natural setting to compare the effectiveness of a BZ and two PAs under distinct institutional contexts (Perz et al., 2013).

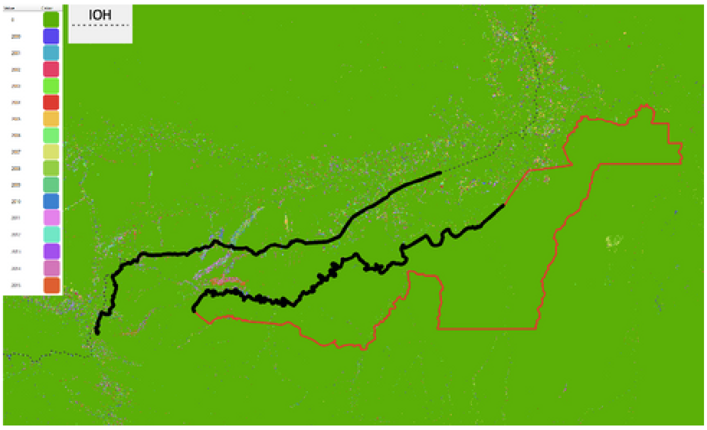


Figure 1. Polygon of the Tambopata National Reserve (in red) and its BZ's northern and southern limits. The dashed line represents the Inter Oceanic Highway. The legend represents the color codes for forest cover loss each year, with 0 meaning that there was no loss. Source: QGIS layers

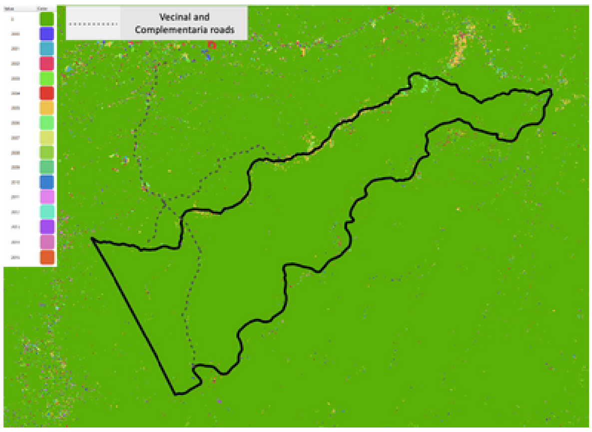


Figure 2. Polygon of the Manuripi National Reserve (MNR). The dashed lines represent two complementary roads. The legend represents the color codes for forest cover loss each year, with 0 meaning that there was no loss. Source: QGIS layers

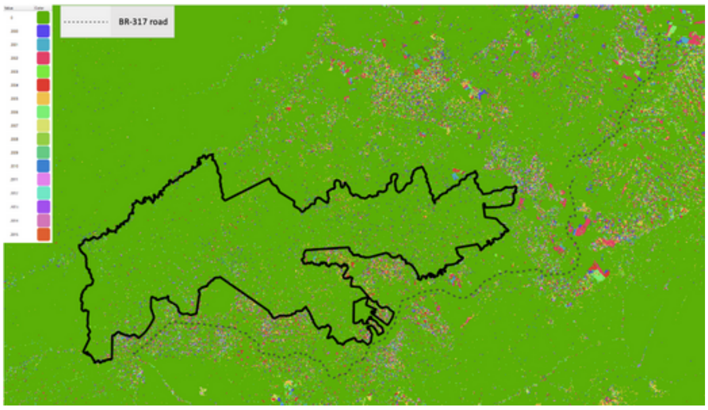


Figure 3. Polygon of the CMER. The dashed line represents the BR-317 road. The legend represents the color codes for forest cover loss each year, with 0 meaning that there was no loss. Source: QGIS layers

Approach

- The effectiveness of the Tambopata National Reserve's BZ, the Manuripi National Reserve, and the CMER (see figures 1, 2, 3) in containing deforestation was assessed by performing a spatial Regression Discontinuity Design (RDD).

- The effects were estimated by controlling for relevant biophysical covariates such as the distance to the Interoceanic Highway, soil properties, annual forest cover, elevation, and slope.

- The analysis was performed by adopting a spatiotemporal approach inspired in Liu et al. (2024), in which the effects were estimated separately for each year of the study period (2000 - 2015). This strategy allowed to capture how deforestation dynamics varied over time across the three study sites.

Key findings

- The northern limit of the Tambopata National Reserve's BZ is mostly effective in containing deforestation at the beginning of the period of analysis (early to mid 2000s). However, after the paving of the Interoceanic Highway was completed (~ 2011), the effect is reverted: the BZ is no longer showing protection against high external pressures (see figure 4).

- The southern limit of the Tambopata National Reserve's BZ maintains a protective effect that is consistent over time. Deforestation remains mostly inside the BZ without directly invading the core nucleus of the national reserve. This finding reflects that the BZ is effective when exposed to low external pressures (see figure 5).

- In the Manuripi National Reserve, the road shock does not generate a clear and persistent protective effect over time. The estimated effects remain positive for most of the period of analysis, yet very close to zero. The effects revert slightly only after 2010 (see figure 6).

- In the CMER, no persistent or systematic differences in deforestation rates are observed. The estimated effects fluctuate throughout the period of analysis, thus reflecting an unclear and non-persistent protective effect over time. This is a similar behavior to that observed in the Manuripi National Reserve (see figure 7).

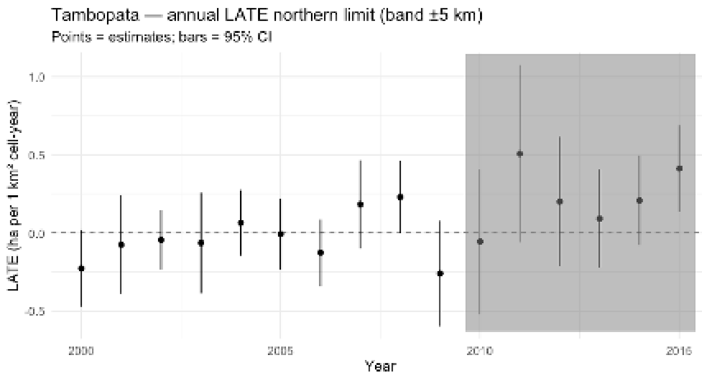


Figure 4. Plot showing a visual representation of the estimated effect on deforestation (LATE) for the Tambopata National Reserve's buffer zone over time in its northern limit, ±5km bandwidth. The shaded area represents the effect in years following the paving of the Interoceanic.

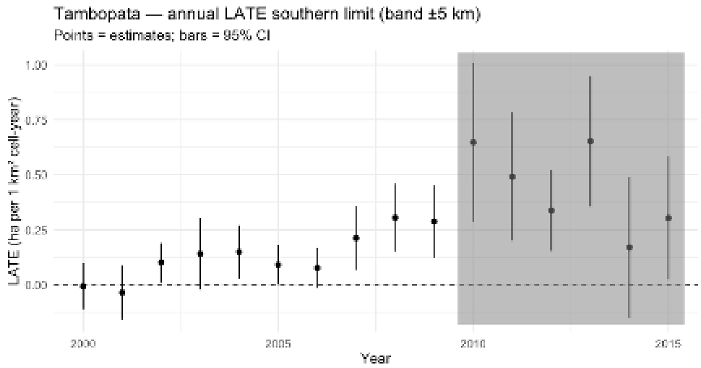


Figure 5. Plot showing a visual representation of the estimated effect on deforestation (LATE) for the Tambopata National Reserve's buffer zone over time in its southern limit, ±5km bandwidth. The shaded area represents the effect in years following the paving of the Interoceanic.

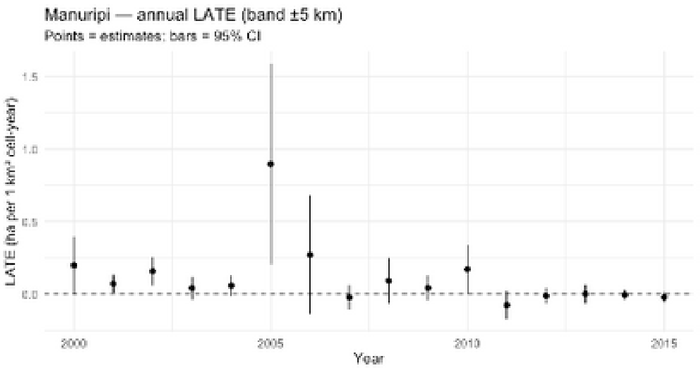


Figure 6. Plot showing a visual representation of the estimated effect on deforestation (LATE) for the Manuripi National Reserve over time, at a ±5km bandwidth.

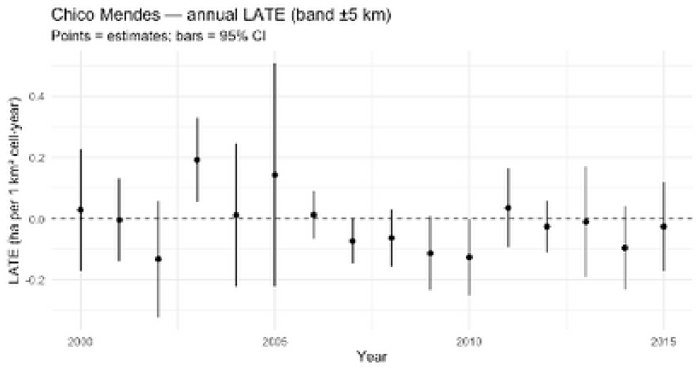


Figure 7. Plot showing a visual representation of the estimated effect on deforestation (LATE) for Chico Mendes Extractive Reserve over time, at a ±5km bandwidth.

Explanatory mechanisms & causal linkages

- The behavior observed in the northern segment of the BZ is explained by the high amount of pressures this segment is subject to. In the north, the BZ is expected to function as a filter that slows down deforestation advancing from the non-protected frontier; however, after the paving of the Interoceanic Highway, accessibility improves and the BZ becomes increasingly attractive for agricultural expansion and illegal mining, eroding its protective effect.

- In contrast, at the southern limit, where the BZ directly borders the interior of the national reserve, the BZ operates along an internal gradient between the PA and its buffer, where the main function is to accommodate compatible uses while keeping the core of the reserve intact. In this segment, deforestation tends to remain within the BZ, and the interior of the Tambopata National Reserve is relatively less affected.

- The behavior observed in the Manuripi National Reserve could be explained due to the fact that the Interoceanic Highway is geographically more distant and less directly connected to the reserve (Perz et al., 2013). The interpretation of results should also be made in light of the reserve's social and institutional context: an inhabited reserve with significant degrees of permitted land uses and increasing exposure to external pressures such as artisanal and large-scale mining (Schilling et al., 2024).

- The behavior observed in the CMER is consistent with the institutional nature of extractive reserves: the CMER allows resident communities to conduct regulated productive activities (such as rubber tapping, small-scale agriculture, and Brazil-nut harvesting), reducing the contrast between the land-use regimes inside and outside the reserve (Wallace et al., 2018).

Policy implications

1 Strengthening control and monitoring at the northern limit of the BZ

- Preventive zoning that identifies high-risk corridors prior to major road investments, defining permissible and non-permissible land uses before construction begins.
- Ecological control corridors and permanent monitoring points co-managed by environmental authorities, regional governments and local communities, specifically in segments exposed to accessibility shocks.
- Early warning systems to detect new settlement fronts, informal mining camps or agricultural clearings in the immediate surroundings of the BZ northern limit.

2 Making multilevel governance an operative mechanism rather than a formal principle

- Formalize co-management agreements that define concrete roles and responsibilities for community organizations, PA authorities and municipal/regional governments.
- Create permanent inter-agency management bodies with operating budgets and decision-making authority over surveillance and sanctioning.
- Integrate spatial, land and concession information into a unified cadaster to reduce overlaps between forest, mining and agricultural uses: an issue that particularly affects the Manuripi National Reserve.

3 Designing productive policies linked to verifiable conservation outcomes

- Link agroforestry and certification programs to verifiable reductions in deforestation using satellite monitoring.
- Channel payments for ecosystem services (PES) to households and communities that maintain forest cover inside the BZ or PA.
- Implement digital traceability systems proportionate to local capacities, to verify the sustainable origin of forest-compatible products and prevent disguised agricultural expansion

4 Incorporating ex-ante assessments into infrastructure planning

- Implement deforestation-risk models tied to accessibility scenarios and potential leakage effects along future road segments.
- Mandatory mitigation and compensation frameworks as conditions for project approval.
- Adaptive governance clauses requiring enhanced monitoring and enforcement if deforestation increases beyond expected thresholds.

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Author: Ricardo J. Herrera Agudelo, M.Sc. candidate, The University of Bonn.