An Analysis of the Conservation Importance of Amazon Borderlands Using Geographic Information Systems

Ben Weinstein, Dr. David Salisbury, Kim Klinker and the University of Richmond Spatial Analysis Lab

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Introduction

At 6,000,000 km^2, the Amazon basin is a critical hotspot of global biodiversity. The Amazon lowland is often incorrectly portrayed as a single homogenous unit, a vast and unpopulated region (Eva & Huber 2005). In actuality, nine countries comprise the Amazon, creating a mosaic of ecological, cultural and political boundaries (Manne 2003, Maffi 2005). Our aim is to test whether these Amazonian borderlands have greater conservation significance than the Amazonian interior. The political geography has profound effects on conservation as each country designates and maintains area differently (Eva & Huber 2005). Depending on management type, protected areas shelter ecosystems from an array of environmental disruption including: resource extraction, hunting, large-scale agriculture and urban encroachment (Rodrigues et al. 2004). Due to these protections, we assume that regions with higher percent of protected area are more biodiverse than similar unprotected areas (Bruner et al. 2001). Therefore, we use national protected areas as a proxy for biological diversity.

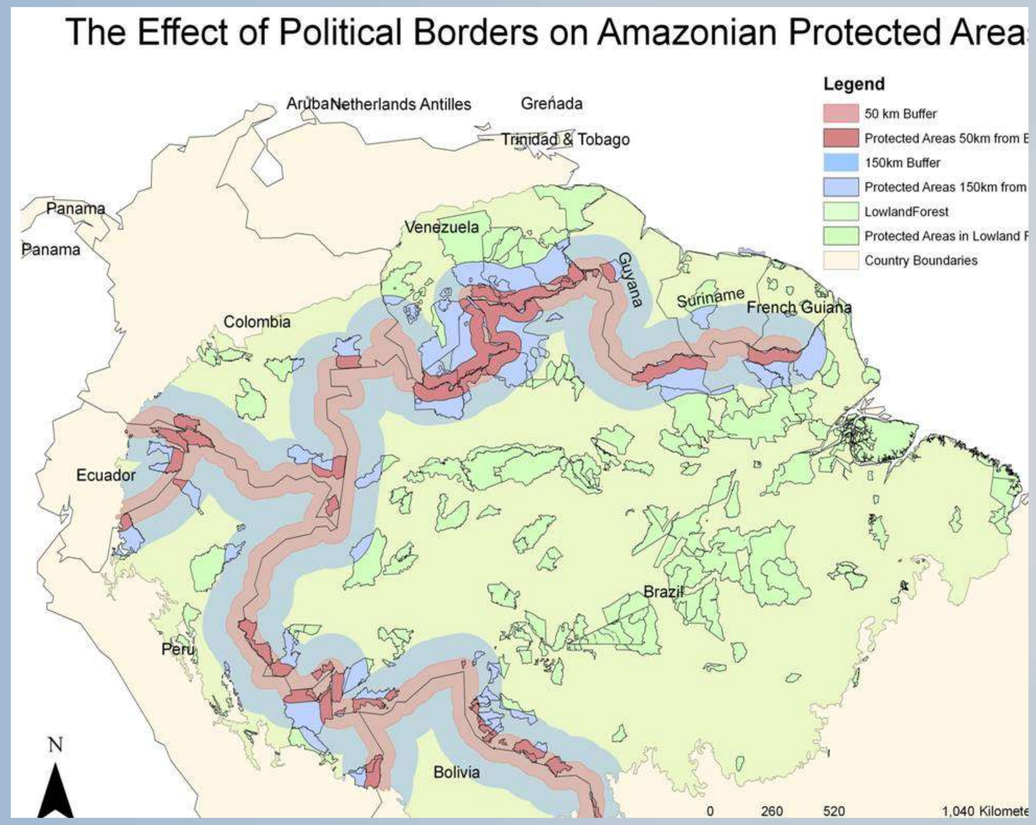


Figure 1. A map created in ARCGIS displaying the change in protected units relative to distance to a political border. Protected units within the Amazon were given three designations: 50km from a border, 150km from a border, and within Lowland forest. The three zones are also shown, with colors corresponding the color of the protected unit designation. For example, all protected units within 50km are red, and fall within the 50km buffer from a political boundary, which is also shown in red.

Methods

The protected areas for the nine Amazonian countries: Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname, and Venezuela were downloaded from the World Database on Protected Areas (WDPA). The data was inspected for overlapping polygons, slivers and other topology errors (Figure 2). Buffer regions were created at 50km, 150km from political borders, and within the Amazon lowland. These buffer regions were created following policy definitions articulated in the two largest Amazonian countries, Peru and Brazil (Salisbury et al. in press). Following Jenkins (2009) protected area data was cleaned to eliminate conservation units that were hypothetical, indigenous territories or international. These features were disregarded to allow comparison between countries. In particular, the indigenous territories were removed because many units were represented solely as a point, making geometry and area difficult to calculate. The country protected areas were merged together to show all conservation units within the Amazonian Lowland Forest as defined by Eva & Huber (2008).

Each of buffers (50km, 150km, Lowland Forest) were clipped by the country boundaries, which allowed calculation of the total area of the country within each buffer. To determine the amount of protected area (50km, 150km, Lowland Forest), the conservation units were clipped by the corresponding buffer. To calculate the percentage of protected area, the protected area within the buffer is divided by the country area within the buffer.

Results

Using GIS we found area conserved at four spatial scales: 50km, and 150km from a political border, as well as within the entire lowland Amazon forest and the country. In addition to area, we calculated the relative percentage protected within each spatial scale (Table 1). Results from the analysis showed more protected area closer to the border. In the aggregated data (Figure 4), which represents all Amazon Countries, the protected area within 50km of the border (27.33%), exceeded all other spatial scales. The total extent of protected area varied between countries. In the 50km buffer, the % protected ranged between 0% (Suriname) and 73.69%(Venezuela) (Table 1). An ANOVA, with Suriname removed as an outlier, showed significant variance between 50km and Entire Amazon (P = .054). A tukey test showed significance only between 50km and the Lowland Amazon, and not between any other designations. The resulting map, projected in South American Albers Equal Area Conic , is shown (Figure 1).

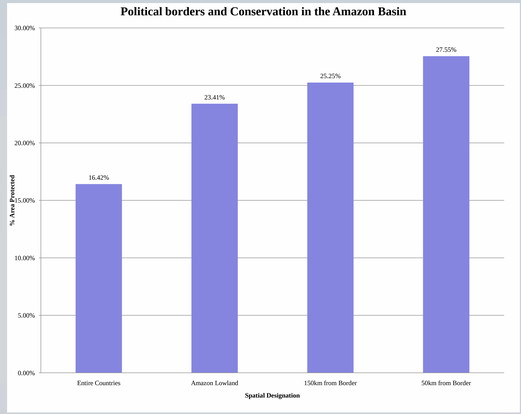


Figure 3. The total protected area, grouped by buffer type. For each designation, area was aggregated for every country, and divided by the area of protected units falling within that designation.

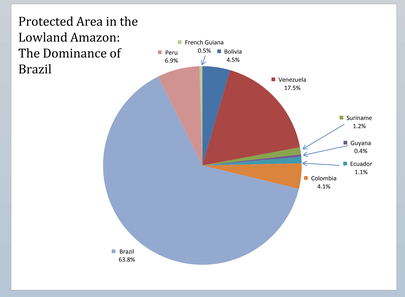


Figure 4. The sum of the protected area in the Lowland forest was divided into composite countries. Percentages are found by dividing the area of the country within the lowland definition, by the entire lowland area.

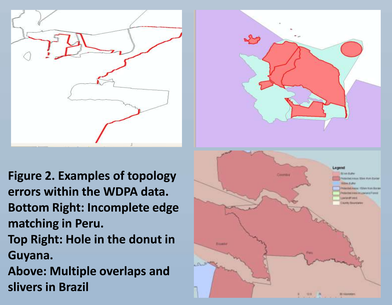
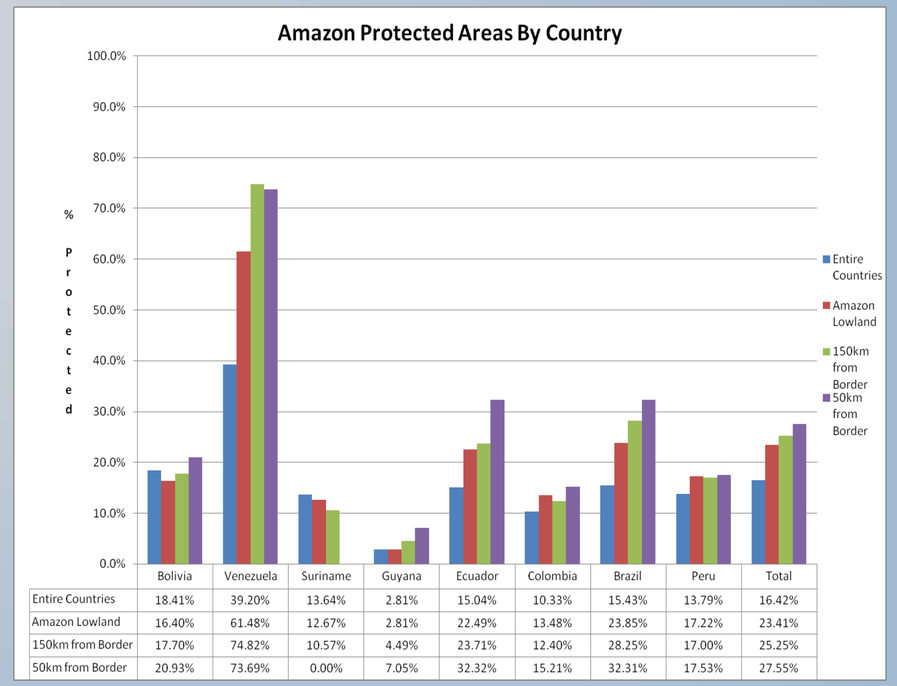


Figure 2. Examples of topology errors within the WDPA data.
Bottom Right: Incomplete edge matching in Peru.
Top Right: Hole in the donut in Guyana.
Above: Multiple overlaps and slivers in Brazil

Discussion

Our results explore the relationship between political borders and conservation through an analysis of the Amazon borderlands. The significance of the 50km buffer compared to the lowland forest (p=.054) suggests that proximity to the political border may have a positive correlation with increased protected area, and therefore biodiversity. The insignificance of the 50km versus 150km implies there may be no arbitrary line delineating a 'border effect'. The borderlands-protection relationship may be continuous, and is unlikely to follow discrete designations. The increase in protection in the borderlands may be a result of known high levels of biodiversity in these boundary zones. Alternatively, these areas may be created due to the political expediency of designating protected areas in distant border zones superficially deemed uninhabited. The concept of creating protected areas to assert sovereignty over borderland territory or to create transboundary peace parks deserves more study.

The individual country data (Figure 5) showed similar trends to the aggregate data (Figure 3), with the exception of Suriname. We attribute this outlier to the small area of Suriname, and overall small number of Suriname protected areas (N=9). The role of Brazil in protecting Amazonia is paramount, since 63.8% of the total lowland forest lies within the country (Figure 4). In addition to raw area, the percentage of area protected highlights the different management strategies of the Amazonian countries. Venezuela designates over 73% of their 50km borderlands as protected area, however it is unclear whether increased area designated unilaterally implies effective protection. The relative value of protected areas, in terms of preserving biodiversity remains unclear (Bruner et al. 2001). Current data resolution and lax enforcement preclude a more precise analysis of effective biodiversity protection (Manne 2003, Pomara 2009). While there is a concern that the majority of Amazonia protected areas are "paper parks", protected areas in name only (Terborgh 2001), research also finds protected areas inhibiting fire and slowing land clearing (Nepstad et al. 2005; Bruner et al. 2001). The remote nature of Amazon borderland protected areas may lead to less effective enforcement, particularly if the protected area abuts the political boundary line with no adjacent protected area in the neighboring country. Trans-boundary impacts of road building (IIRSA 2010; Hazera and Salisbury 2008), logging, military projects (Salisbury et al. in press), drug trafficking (Salisbury et al. 2010) are a few factors threatening these borderland protected areas. This project emphasizes the ecological diversity present in the borderlands, the complexities of using international data sets, and the need for increased intergovernmental cooperation to address trans-boundary conservation challenges.



	Bolivia	Venezuela	Suriname	Guyana	Ecuador	Colombia	Brazil	Peru	Total
Entire Countries	18.41%	39.20%	13.64%	2.81%	15.04%	10.33%	15.43%	13.79%	16.42%
Amazon Lowland	16.40%	61.48%	12.67%	2.81%	22.49%	13.48%	23.85%	17.22%	23.41%
150km from Border	17.70%	74.82%	10.57%	4.49%	23.71%	12.40%	28.25%	17.00%	25.25%
50km from Border	20.93%	73.69%	0.00%	7.05%	32.32%	15.21%	32.31%	17.53%	27.55%

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