

# Conservation value and biodiversity indicators for properties and supply chains in Colombia

## Introduction

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### 1. Forest and biodiversity policy in Colombia

Colombia is among the world's most biodiverse countries; to protect this biodiversity and its remaining 59 million hectares (Mha) of tropical forest, the Colombian government has made increasingly ambitious national and international environmental commitments over time. The country is a signatory to the Convention on Biological Diversity (CBD), the 2019 Leticia Pact and the 2014 New York Declaration on Forests (NYDF). More recently, Colombia was among the 141 nations that signed the Glasgow Declaration on Forests and Land Use in November 2021 (Butler 2021). As part of its commitment under this declaration, the nation increased the ambition of its Nationally Determined Contribution (NDC) for the Paris Agreement from a relatively typical pledge to reduce greenhouse gas emissions (GHG) by 20% (30% if international support was provided) from business-as-usual scenarios to a more ambitious 51% reduction (*Gobierno de Colombia* 2021). Soon after his term began, current President Gustavo Petro's administration announced a Deforestation Containment Plan, in September 2022 (Tarazona 2022; MADS 2022).

The Strategy Against Deforestation, with its community-based focus, is a marked departure from the prior administration's approach, which relied heavily on the military to accomplish its environmental goals. The Petro administration's plan has five core components: 1) sociocultural forest management and raising of public awareness, 2) creation of forest development nuclei and closure of the agricultural frontier, 3) cross-sectoral management of territorial planning, 4) permanent and integrated monitoring and enforcement, and 5) generation and strengthening of legal, institutional and financial systems (*Gobierno de Colombia* 2021; Zuluaga et al. 2022). In addition, the administration announced revised deforestation goals that call to limit annual deforestation to less than 140,000 ha, as well as large-scale plans for reforest of 1.8 Mha by 2026, through a combination of restoration and tree planting (Alexander 2023).

Colombia has a rich biodiversity policy mix combining over 180 public and private initiatives to ensure the conservation and sustainable management of the country's biodiversity and ecosystem services (Etcheverri et al., 2023). Command and control policies have historically dominated the environmental policy landscape, resulting for example, in 769 protected areas that encompass nearly 24 Mha (BAP 2017). More recently, standards, commitments and pledges as well as information and network instruments have become more frequent, and numerous biodiversity policies that intersect with goals for climate change, pollution and agriculture have appeared (Etcheverri et al., 2023). *Herencia Colombia* or "Heritage Colombia", supported by a combination of private and public funds, is a good example of such policies. Aimed at increasing Colombia's protected areas to a total of 32 Mha, *Herencia Colombia* would help the country meet its 30x30 commitment along with other international climate, sustainable development and biodiversity targets while working with local communities to ensure their livelihoods (WWF 2022, Mongabay 2022).

Within the framework of the CBD, Colombia's Ministry of Environment and Sustainable Development created the Biodiversity Action Plan (BAP) as a tool to implement a national management plan shifting from a purely conservation view of biodiversity to a sustainable use perspective. The BAP intends to manage Colombia's increasing productivity taking into account biodiversity and ecosystem services and acknowledging their public value. This will be particularly important when allocating and administering regained territories that had not been accessible until recently due to the armed conflict, to avoid increased deforestation and biodiversity decline, which is expected to be anywhere between 38-52% higher than before the peace agreement (Salazar et al., 2018; Guerrero-Pineda et al., 2022). The BAP recognizes Colombia's biodiversity wealth, and consists of a series of policies with 5 main purposes: 1) strengthening environmental institutions, 2) promoting sustainable development and green growth, 3) developing incentives to promote the conservation and restoration of ecosystems, 4) strengthening environmental information systems, and 5) fostering intersectorial agreements and programs at local and regional scales (BAP 2017). While an ambitious and all encompassing set of actions, the BAP-similar to most biodiversity policies in Colombia- does not specifically target any particular ecosystem or environmental scale. Indeed, despite having ~ 59,000 species, 3,600 of which are endemic, and 1,200 of which are threatened, Colombia continues to lack strong, species-specific policies (Etcheverri et al., 2023). Creating more targeted policies could help prioritize vulnerable areas, maximizing impact and ensuring conservation of highly endemic and biodiverse hot spots while guiding the creation of newly protected areas to maintain ecosystem connectivity.

## 2. Recent Deforestation Trends

In 2016, after 4 years of negotiation, the government of Colombia and the largest rebel group – the Revolutionary Armed Forces of Colombia (FARC by its Spanish acronym) – signed a peace accord ending over 5 decades of armed conflict (Salazar et al., 2018). Although the deforestation trends in the aftermath of the peace accord have been worrying, Colombia's most recent national deforestation data report was positive (Figure 1). It showed 123,517 ha of forest loss in 2022, a 29% decline from the previous year (IDEAM 2023). The large decline was a departure from the elevated deforestation trends seen since 2016. Indeed, an outcome of the peace accord was the emergence of new pressures on landscapes that had previously been conserved as a side effect of the displacement, high levels of insecurity and forest codes enforced by dissident and paramilitary groups (Sabater et al. 2017; Clerici et al. 2019; Murillo-Sandoval et al. 2020).

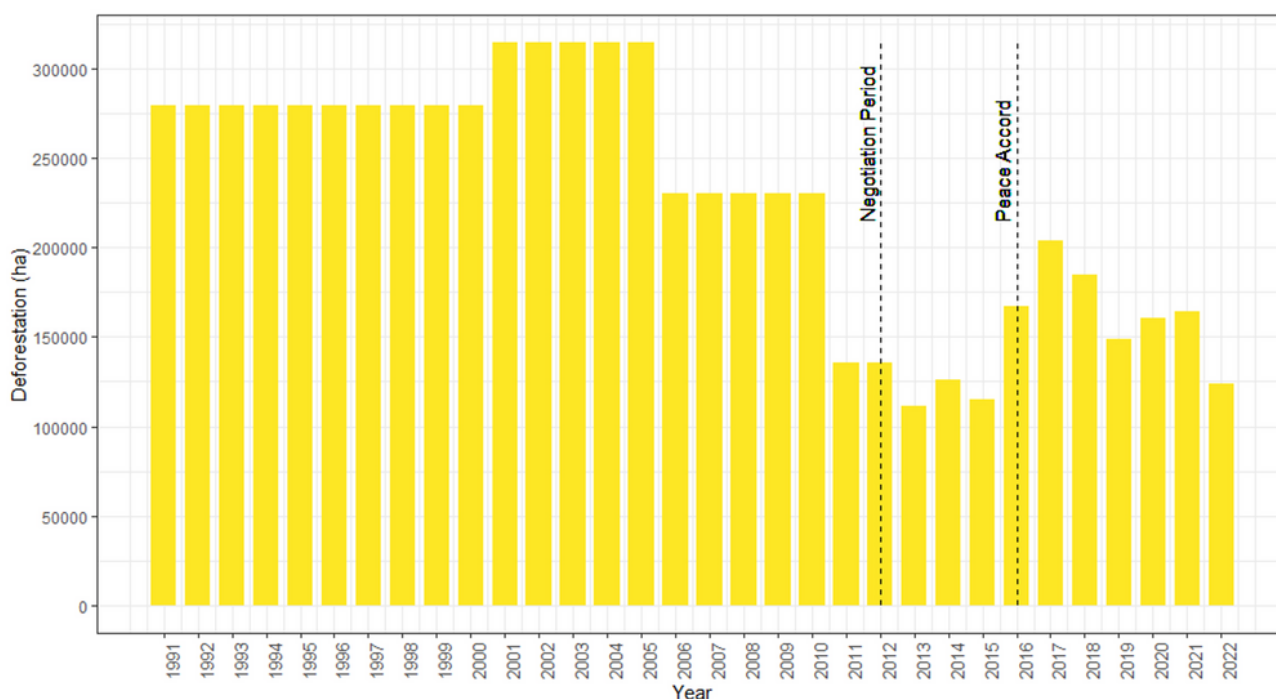


Figure 1. Annual national deforestation (hectares) from 1991-2022. Data from 1990-2012 is based on land cover classifications that span multiple years (1991-2000, 2001-2005, 2006-2010, 2011-2012) and has been annualized. Source: IDEAM 2023

Nearly 370,000 ha, or 42% percent of deforestation that occurred following the peace accord (2017-2021), took place in Caquetá and southern Meta (IDEAM 2020). These departments make up an ecologically important region, the Andean-Amazon Transition (AAT) zone, which is at the intersection of the Andes, Amazon and Orinoco, and is both high in forest carbon and is a biodiversity hotspot (Armenteras et al. 2014).

The shift in the trajectory of deforestation seen in 2022 will need to be sustained in order for Colombia to achieve the targets for its various environmental commitments. Reaching these targets will require balancing conservation and sustainable use and utilizing a diverse set of strategies. Proposed strategies include tree planting, land restoration, carbon taxes, REDD+, supply chain governance through zero deforestation agreements, strengthening institutions, empowering communities, enforcement of environmental regulations, restriction of land conversion outside of an agricultural frontier, and conservation within protected areas and Indigenous Reserves. These strategies involve an array of different actors, from individual farms to large companies to public agencies, and span landscapes with a variety of governance types, from private to public to communally held.

Nowhere is the challenge of balancing sustainable use and conservation more apparent than in Colombia's cattle sector. Commodity-driven deforestation linked to the cattle sector is responsible for a significant portion of land use and land cover change in Colombia (Armenteras et al. 2006; Armenteras 2014, Dávalos et al. 2014; Castro-Nunez et al. 2017), and the sector is therefore critically important to the country's climate, forest, and development goals. Typical cattle management in Colombia is extensive, and cattle pastures occupy 36 Mha or 32% of Colombia's land area, and 90% of its agricultural land (IGAC 2012). The country has Latin America's fourth largest cattle herd, with a population of 29.6 million animals as of 2022, managed in beef-focused, dairy-focused and dual purpose systems (ICA 2023). Over 620,000 farming households depend on cattle for their livelihoods and 81% percent of these households are smallholders with less than 50 heads of cattle, while half have less than 10 animals (DANE 2014; ICA 2023). In Caquetá and southern Meta alone, there are 3.4 million cattle and 32,157 registered ranches (ICA 2023). Cattle inventories have expanded rapidly in this area in recent years (Vianchá et al. 2020).

Current low productivity systems have high emissions per unit output in both the dairy and beef sectors (Durango et al. 2017). Thus, changes to livestock management and reductions in pasture expansion are two pathways identified to achieve forest conservation goals and national climate commitments (Arango et al. 2020; Serna et al. 2017). For instance, the Nationally Appropriate Mitigation Actions (NAMAs) for the cattle sector call for significant reconfiguration of landscapes including avoiding 2.5 Mha of deforestation, expanding agrosilvopastoral systems to cover 1.25 Mha, transitioning 4 Mha from pasture to different sustainable uses, and increasing uptake of improved pastures and pasture rotation to provide additional carbon sequestration benefits (Durango et al. 2017). Strategies proposed to achieve these changes include sustainable intensification, avoided deforestation, and improved tree cover and carbon storage within pastures (Tapasco et al. 2019). Sustainable intensification policies like those focused on increasing adoption of silvopastoral systems, low carbon agriculture or pasture management improvements operate mainly at the property scale, while zero deforestation agreements (ZDAs) operate at both the supply chain and the property scale. ZDAs may be signed by different actors in the supply chain, including beef or dairy companies and farmers associations, which means that these conservation goals are promoted at various scales and to various degrees across the production landscape, but they may not target the critical areas where deforestation is most rampant if the actors in such regions are not inclined to make these commitments.

For our analysis, we focus on the cattle sector and evaluate the contributions of different actors to deforestation in order to inform current policy efforts like the ZDAs that target the sector, companies in it, and ranchers. At the national scale, we characterize forest cover and forest change in the beef and dairy sectors. We use maps of beef and dairy sector infrastructure to map supplysheds, or the possible catchment area around key supply chain infrastructure to help identify which parts of the sector and which types of companies are critical to include in supply chain led policies like zero

deforestation agreements. We evaluate the distribution of recent deforestation, current forest cover, and biodiversity across properties in the departments of Caquetá and southern Meta, excluding northern Meta given its large extent and the overall lack of cattle-related activities and deforestation in this region. We rely on official deforestation data from IDEAM for our analyses, and have annualized the deforestation maps from 1991-2012, which IDEAM released only sporadically and therefore cover multiple years (1991-2000, 2001-2005, 2006-2010, 2011-2012). Property boundary data is from the public digital cadaster data from the Instituto Geográfico Agustín Codazzi (IGAC)[1] (IGAC 2022). We overlay these with deforestation and biodiversity data to better understand the area and location of forest in beef and dairy company supplysheds by company type and the area of forest and deforestation on properties with and without pasture (by size) in the deforestation hotspots of Caquetá and southern Meta. To assess biodiversity, we use the Biodiversity Intactness Index (BII) (Newbold et al., 2016), distribution of ranges of endemic and threatened species across several taxa from IUCN (IUCN, 2022), and boundaries of Key Biodiversity Areas (KBAs) (BirdLife International, 2021).

## Results

### 1. What is the area and location of forest in supplysheds in the beef and dairy sector?

We mapped beef and dairy sector infrastructure nationally and classified supply chains by types (Figure 2) in order to define supplysheds, or the possible catchment area around key supply chain infrastructure. For the beef sector, these types are: export-certified slaughterhouses, which export beef products and meet the highest sanitation standards, such as those

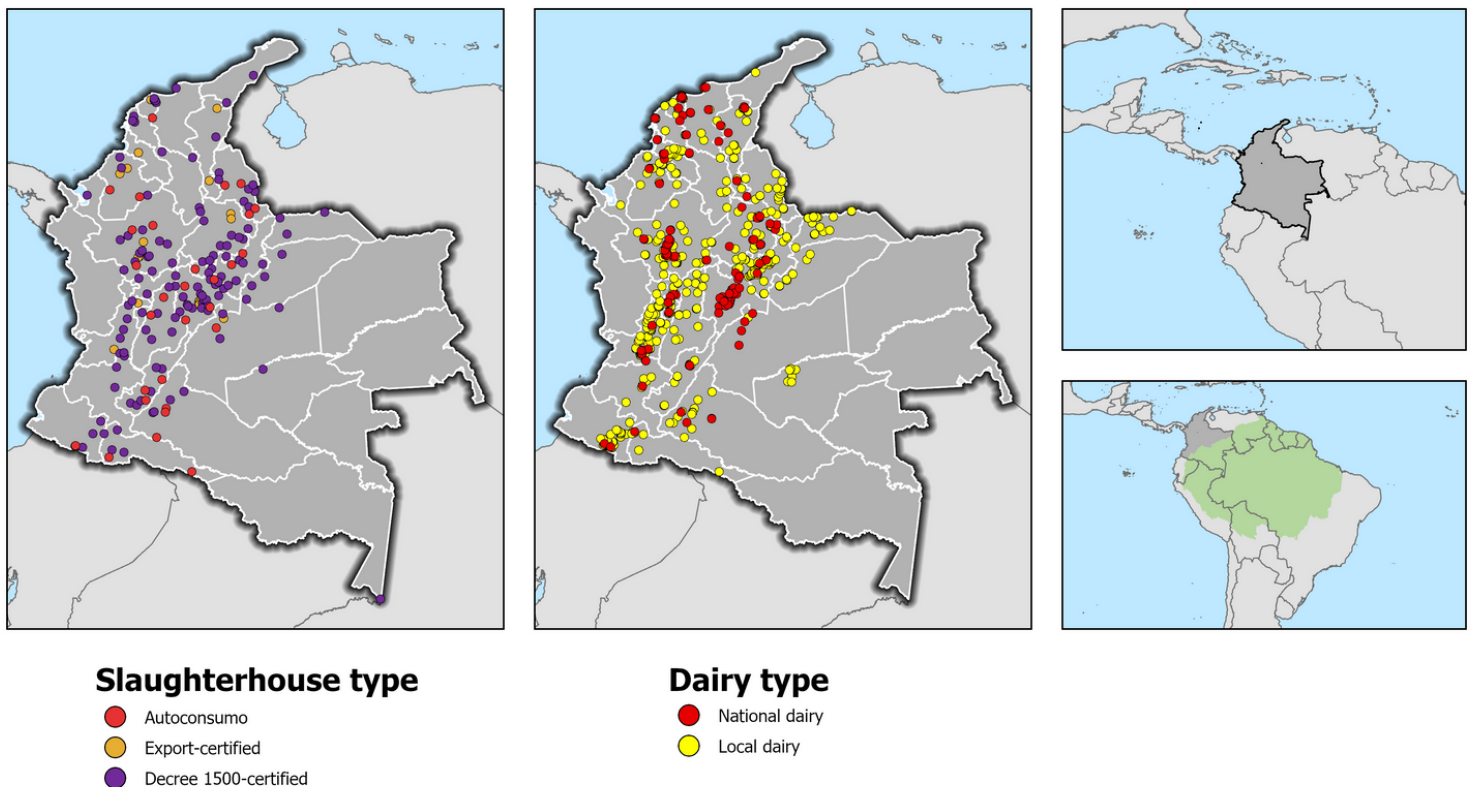


Figure 2. Beef and dairy sector infrastructure classed by type. Map of Colombia and the Amazon.

[1]Updating and modernizing a multipurpose cadaster is part of Point 1. Comprehensive Rural Reform specified in Colombia’s peace accord. This aims to correct complex data issues and strengthen the capacity of the multiple institutions involved in formal property rights (IGAC, Agencia Nacional de Tierra (ANT), Superintendencia de Notarías y Registros) while addressing the complex social dimensions of high levels of informality in the land sector, dispossession and land grabbing, and isolation from national institutions as a result of conflict. Funding of projects like USAID’s Tierra Prospera along with loans from institutions like the World Bank and International Development Bank have supported these efforts. The current dataset has gaps in coverage, and contains both updated and non-updated boundary data. This is the best available datasource on property boundaries.

required by the international markets, Decree 1500-certified slaughterhouses, which meet a 2013 national sanitation standard and can distribute their products nation-wide, and Autoconsumo (“own-consumption” in Spanish), which are limited to processing cattle from the municipality where they are located and whose products can only be sold in the same municipality. For the dairy sector, we class dairies into regionally or locally oriented depending on whether they are in the top 83 dairy companies by market share (La Nota 2018).

Spatially referencing the supplysheds helps to identify the parts of the sector and the types of companies that are critical to include in supply chain led policies like the ZDAs (Table 1 & 2). We find that 12.3Mha of Colombia's forests are within dairy sector supplysheds, this is 21% of Colombia's forests that are outside of PAs. Fifty-one percent of recent deforestation overlaps with the dairy sector. An important part of the supply chain are local dairies and it will be critical to include these smaller companies in deforestation free sourcing and forest conservation policies. The dairy ZDAs currently have good market coverage and include both important regional and local companies; however, they currently cover 2.5Mha or 5% of forests outside of PAs. In the beef sector, the ZDAs have higher coverage, with 27% of Colombia's forests outside of PAs within the supplysheds of current signatories including 65% of recent deforestation. They also have potential to reach a larger area of forests. Full adoption of the ZDAs could cover 48% of Colombia's forests outside of PAs and 90% of recent deforestation. Implementation of the ZDAs with the most able companies, such as Export-certified slaughterhouses would include a large percentage of forests (38%) within their supplysheds as well as most of the recent deforestation (77%).

Table 1. Area of forest (2021) and recent deforestation (2011-2021) within different types of dairy sector supplysheds (supplysheds of different categories can have overlapping areas).

| Type of supplyshed           | Infrastructure points | Forest     |     | Forest outside of PAs |     | Deforestation (2011-2021) |     | Deforestation in forests outside of PAs (2011-2021) |     |
|------------------------------|-----------------------|------------|-----|-----------------------|-----|---------------------------|-----|-----------------------------------------------------|-----|
|                              |                       | ha         | %   | ha                    | %   | ha                        | %   | ha                                                  | %   |
| <i>Dairy Sector</i>          | 541                   | 12,362,595 | 21% | 10,296,568            | 21% | 844,972                   | 51% | 785,720                                             | 51% |
| <i>Regional dairies</i>      | 124                   | 5,453,560  | 9%  | 3,387,533             | 7%  | 251,600                   | 15% | 246,401                                             | 16% |
| <i>Local dairies</i>         | 417                   | 11,851,957 | 20% | 9,785,030             | 20% | 837,349                   | 51% | 778,097                                             | 50% |
| <i>Dairy ZDA signatories</i> | 34                    | 2,870,425  | 5%  | 2,462,157             | 5%  | 61,512                    | 4%  | 59,618                                              | 4%  |

## 2. Forests, Deforestation and Biodiversity in Caquetá and southern Meta

Deforestation hotspots in Caquetá and southern Meta have been a focus for forest governance since the signing of the peace accord in 2016. This area has over 8 Mha of tropical forest and was heavily impacted by Colombia's conflict, which resulted in de facto protection for many of these forested areas; it is also an important region for dairy and beef production

Table 2. Area of forest (2021) and recent deforestation (2011-2021) within different types of cattle sector supplysheds (supply sheds of different categories can have overlapping areas).

| Type of supplyshed | Count | Forest     |     | Forest outside of PAs |     | Deforestation (2011-2021) |     | Deforestation in forests outside of PAs (2011-2021) |     |
|--------------------|-------|------------|-----|-----------------------|-----|---------------------------|-----|-----------------------------------------------------|-----|
|                    |       | ha         | %   | ha                    | %   | ha                        | %   | ha                                                  | %   |
| <i>Signatories</i> | 5     | 17,584,473 | 30% | 1,017,974             | 27% | 1,090,345                 | 66% | 1,011,251                                           | 65% |
| <i>Export</i>      | 18    | 24,408,781 | 42% | 18,836,520            | 38% | 1,285,459                 | 78% | 1,195,687                                           | 77% |
| <i>Decree 1500</i> | 130   | 30,402,572 | 52% | 23,508,006            | 48% | 1,501,784                 | 91% | 1,397,600                                           | 90% |
| <i>Autoconsumo</i> | 27    | 1,523,165  | 3%  | 13,198,817            | 2%  | 66,123                    | 4%  | 56,433                                              | 4%  |
| <i>Beef sector</i> | 175   | 30,700,798 | 53% | 23,793,733            | 48% | 1,400,809                 | 91% | 1,400,809                                           | 90% |

(Figure 3), which has only expanded in the wake of the peace accord. There are many Indigenous Territories (ITs) and several large Protected Areas (PAs) including Nukak, La Macarena, Tinigua, and Chiribiquete as well as a network of on-farm protected patches designated as part of the reservas naturales de la sociedad civil (RNSC) program, but large extents of forest fall outside of these reserves on private properties or on land with no or unclear classification.

In total, 66% (5.3Mha) of the remaining forest in both departments is within either PAs or Indigenous Territories (ITs) (Figure 4A). About half of the forests in the region (4.1 Mha) are within PAs. While PA status is the strictest form of protection, forests within these PAs are still at risk and 74,023 ha were deforested between 2011-2021 (Figure 4B). This alarming rate raises concerns about connectivity loss and the biological integrity of the region (Murillo-Sandoval et al. 2022).

ITs and Afro-Colombian Territories cover 3.1 Mha in Caquetá and southern Meta and hold 1.1 Mha of forests. These lands are collectively held and their populations have some independence and sovereignty apart from the Colombian state. The collective titles restrict commodity agriculture production. The importance of restoring land rights for Indigenous communities is increasingly recognized as vital for biodiversity and forest conservation (Fa et al. 2020). While ITs in the region lost 19,000 ha of forest between 2011-2021 (Figure 4B), nationally, studies have found that this type of governance has a small but significant effect in terms of reducing deforestation (Bonilla-Mejía and Higuera-Mendieta 2019).

Large expanses of forest, or more than 34% (2.8 Mha) of the forest area, fall outside of these two classes that grant conservation status. Indeed, there are 1.6 Mha of forest within private properties and 1.2 Mha in undesignated areas (Figure 4A). These forests are under the greatest pressure. Over 500,000 ha or 84% of recent deforestation since 2011 has occurred within these properties and undesignated areas (Figure 4B). Forests on private land have historically been a lower priority for conservation efforts in Colombia. However, the conservation value of forest fragments within a landscape can

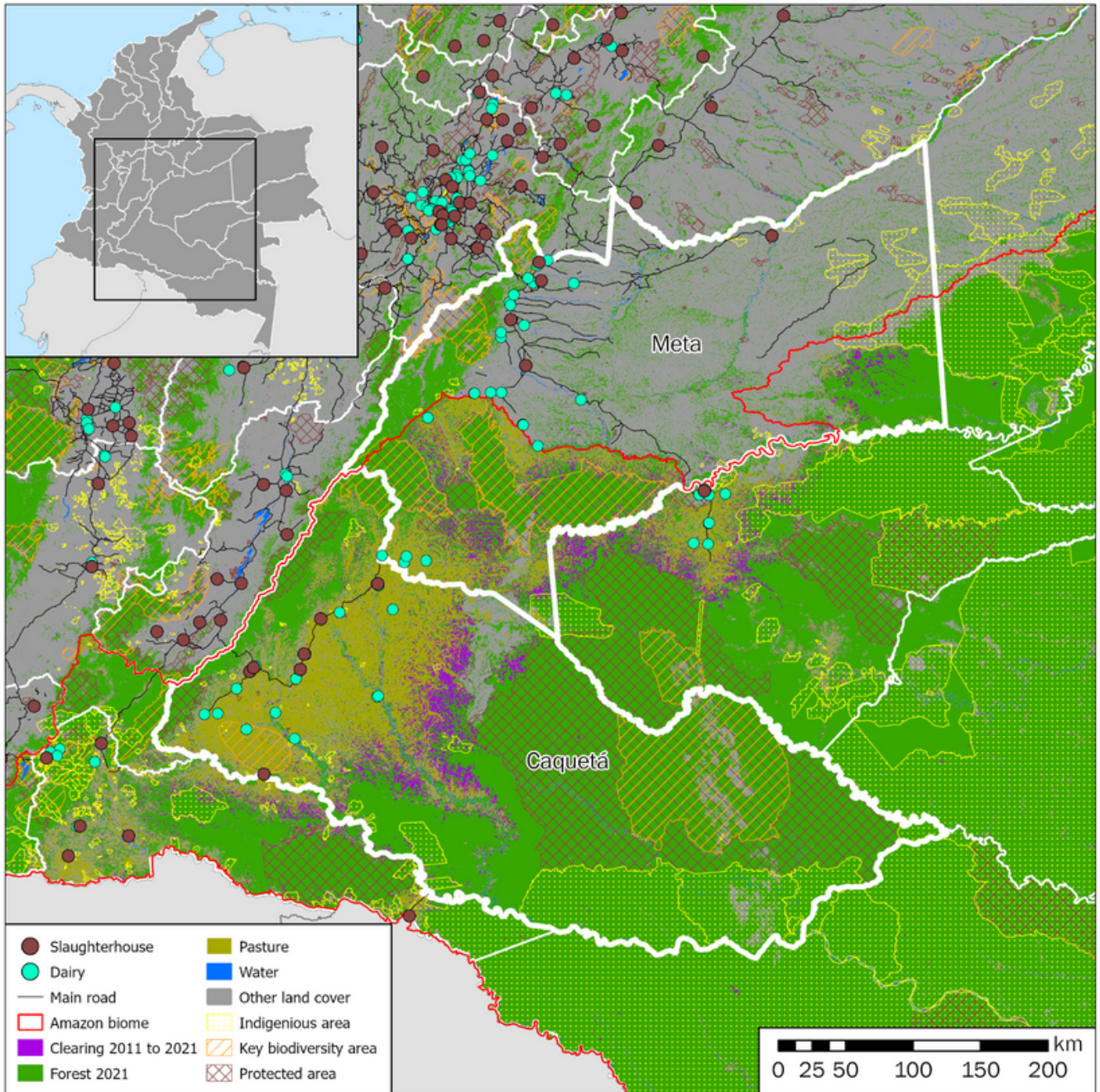


Figure 3. Caquetá and southern Meta with dairy and beef infrastructure, forest, forest clearing, pasture, Key Biodiversity Areas, Protected Areas and Indigenous Territories

be significant, though this depends on many factors, including the needs and characteristics of the species present (Sykes et al. 2020), the number and size of neighboring patches and the type of surrounding land covers (Riva and Fahrig 2022), along with their distance to larger patches of protected forest (Gilroy et al. 2014).

Over 32,000 of these mapped properties, covering 6.2 Mha, have pasture, and we consider them to be part of the cattle sector for this analysis. Conservation of forests on farms will require working with a large number of farmers and finding solutions that support both conservation and production. Insecure land tenure and informality with regard to land holdings –where land titling documentation is lacking– is estimated to be as high as 45% in Meta and 58% in Caquetá (Neva and Diaz 2020). Informal land tenure can hinder these conservation initiatives, since farmers without legal claim to their properties might be less inclined to participate in government programs and might not have access to credits and other government assistance tools (Thomson et al., 2022). Strategies for targeting deforestation in undesignated land may present a different challenge. Additionally, land grabbing and deforestation have increased in areas previously held by guerilla groups and outside of the agricultural frontier, beyond which farming and ranching are not supposed to occur (Murillo-Sandoval et al. 2020; Murillo-Sandoval et al. 2023).

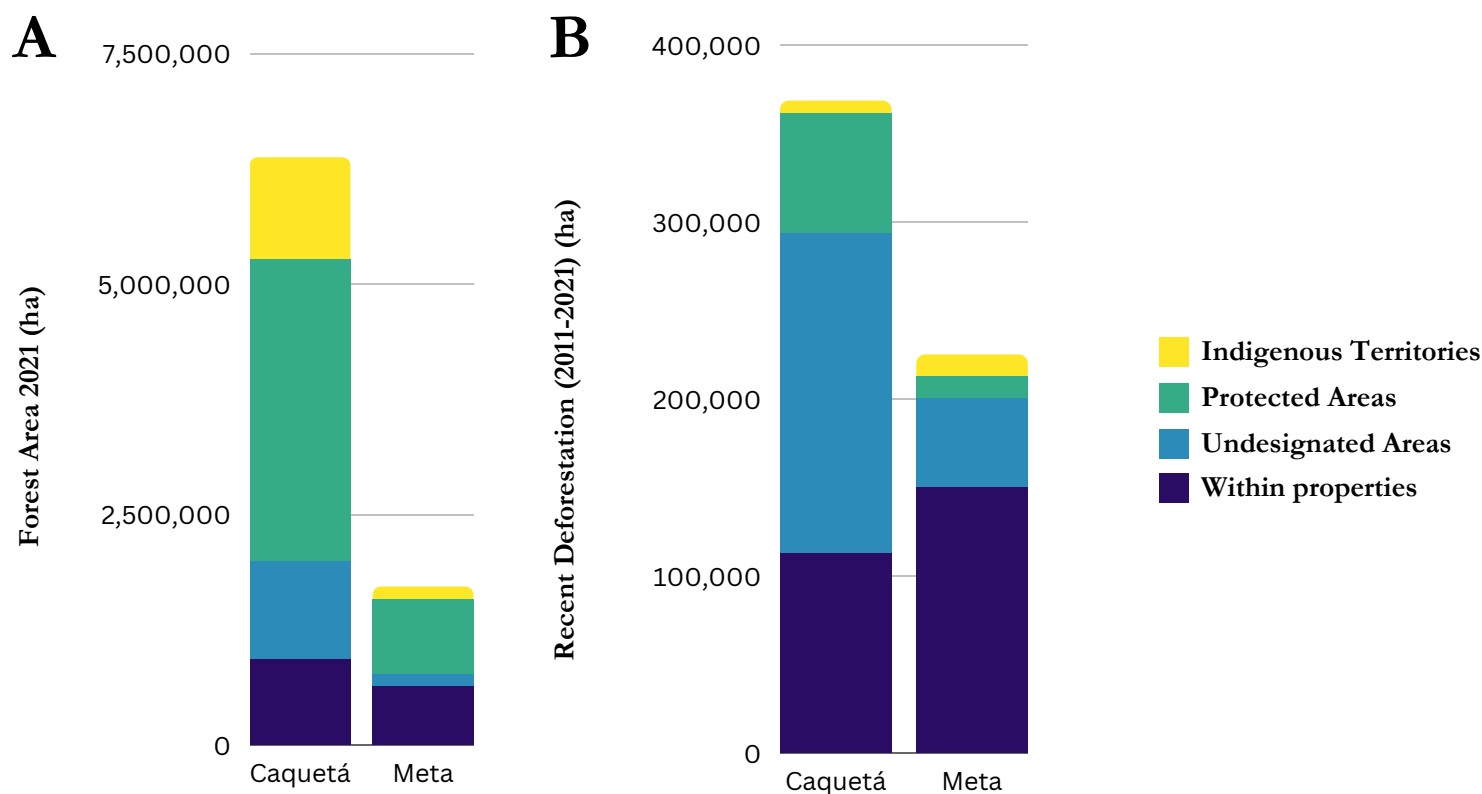


Figure 4. A) Forest area (2021) and B) recent deforestation (2011-2021) in land with different governance types in Caquetá, and southern Meta

### 3. What are the contributions of properties of different sizes to forest conservation and recent deforestation in Caquetá and southern Meta?

We characterized property boundaries in the region by five size classes ( $>10$  &  $<100$ ,  $\geq 100$  &  $<500$ ,  $\geq 500$  &  $<1000$ ,  $\geq 1000$  &  $<5000$ ,  $>5000$  ha) to evaluate what types of landholdings are driving deforestation. Landholding in Colombia is highly unequal, with an estimated 81% of land held by just 1% of the population (ECLAC 2022; Oxfam 2017). This unequal land access was in fact a driver of the country's decades long conflict, which was itself associated with massive displacement and land grabbing (Castro-Nunes et al. 2017; Murillo-Sandoval et al. 2023). Rural land reform is a central, though complex and slow moving, tenet of the peace process that is being implemented through programs that restore, regularize, and redistribute land. Understanding the potential of these programs, should they be effective at reducing inequality in this region, to shift the distribution of forests among landholders should be of interest to environment and conservation policymakers as well.

As is the case with the overall distribution of landholdings, we find that large-holder properties currently contain the majority of both the forest and the deforestation in this region. In Caquetá, 86% of the 2.2 Mha of forest on private properties was encompassed on just 14 properties that were larger than 5,000 ha (Table 3). Properties under 500 ha made up the majority of the total properties in the region (26,813), but held only 10% of the forest (227,851 ha). Similarly, in Meta, 85% of the 1,180,551 ha of forests was on just 33 properties larger than 5,000 ha. Just 8% of the forest (94,853 ha) was located on the 97% (5,658) of properties that were under 500 ha.

Deforestation was also concentrated on the largest properties in 2021, in both departments, but this has only been true since around the time the Peace Accords was signed in 2016 (Figure 5 & 6). In 2021, properties  $>10$  &  $<100$  ha held only about 10% of the deforestation that occurred in private properties in Caquetá, and properties  $\geq 100$  &  $<500$  ha held an additional 21%. In contrast, very large properties ( $\geq 5000$  ha) now hold 60% of the deforestation. In southern Meta, very large properties ( $\geq 5000$  ha) had the largest share of deforestation over the whole time series (1991-2021), starting at 37%



of deforestation. In Caquetá, the share of deforestation in large properties ( $\geq 5000$  ha) has surged since the peace accord, reaching 73% of deforestation in 2021. The share of deforestation on smaller properties (10 &  $< 100$  ha) is also declining in Meta, from 25% in 1991 to 6% in 2021.

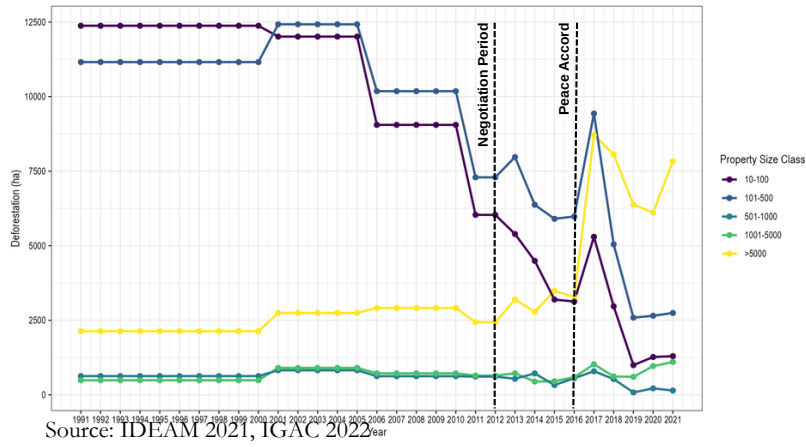
This trend of increasing large-scale conversion of forest to pasture, potentially for land speculation, has been found in other studies (Murillo-Sandoval et al. 2023). These large properties in both Caquetá and southern Meta may represent large-scale individual landholdings, or may have overlapping claims, as in the case of “baldios” or public land classes such as vacant land, targeting them for distribution to farmers or additional undesignated land (Faguet et al. 2020; Murillo-Sandoval et al. 2023).

Table 3. Characterization of area of forest (2021), recent deforestation (2011-2021) and biodiversity within cattle properties by size classes

| Department    | Size class     | Count of Properties | Total Area (ha) | Forest (2021) (ha) | Recent Deforestation (2011-2021) (ha) | Pasture (2020/2021) (ha) | Avg. Count of Overlapping Ranges of Species | Avg. Count of Overlapping Ranges of Threatened Species |
|---------------|----------------|---------------------|-----------------|--------------------|---------------------------------------|--------------------------|---------------------------------------------|--------------------------------------------------------|
| Caquetá       | >10 & <100     | 21,479              | 984,280         | 89,461             | 28,037                                | 815,609                  | 328.4                                       | 13.5                                                   |
|               | >101 & <=500   | 5,334               | 821,662         | 138,390            | 48,690                                | 609,370                  | 360.2                                       | 13.5                                                   |
|               | >501 & >1000   | 113                 | 74,778          | 17,379             | 3,904                                 | 48,325                   | 380.9                                       | 13.7                                                   |
|               | >1000 & <5000  | 88                  | 175,216         | 65,693             | 6,526                                 | 41,552                   | 422.7                                       | 13.6                                                   |
|               | >5000          | 14                  | 2,132,271       | 1,895,668          | 49,838                                | 110,256                  | 461.9                                       | 15.8                                                   |
|               | Total          | 27,028              | 4,188,206       | 2,206,591          | 136,995                               | 1,625,112                | -                                           | -                                                      |
| Southern Meta | >10 & <100     | 4,237               | 198,160         | 32,916             | 11,055                                | 151,162                  | 340.4                                       | 15.1                                                   |
|               | >101 & <=500   | 1,421               | 231,790         | 61,937             | 15,427                                | 145,933                  | 375.4                                       | 14.6                                                   |
|               | >501 & >1000   | 55                  | 37,659          | 15,701             | 2,057                                 | 10,439                   | 407.6                                       | 13.7                                                   |
|               | >1001 & <=5000 | 77                  | 166,112         | 62,589             | 7,916                                 | 29,197                   | 399.1                                       | 13.4                                                   |
|               | >5000          | 33                  | 1,408,987       | 1,007,409          | 69,368                                | 191,636                  | 488.1                                       | 14.4                                                   |
|               | Total          | 5,823               | 2,042,708       | 1,180,551          | 105,823                               | 528,367                  | -                                           | -                                                      |

Source: IDEAM 2021, IGAC 2022, SINCHI 2022, and IUCN 2022

**A**



**B**

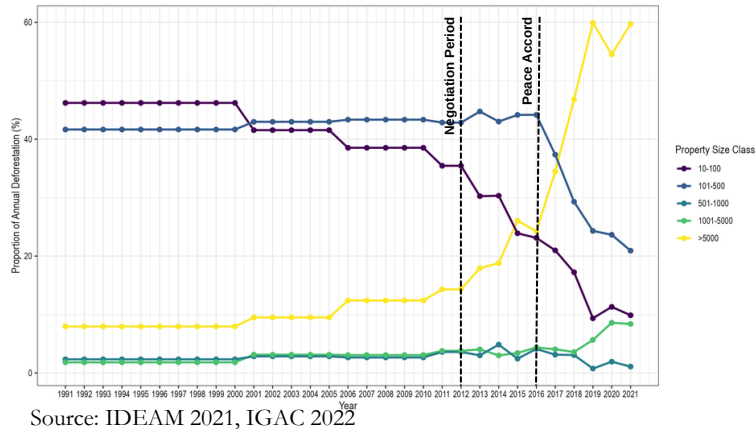
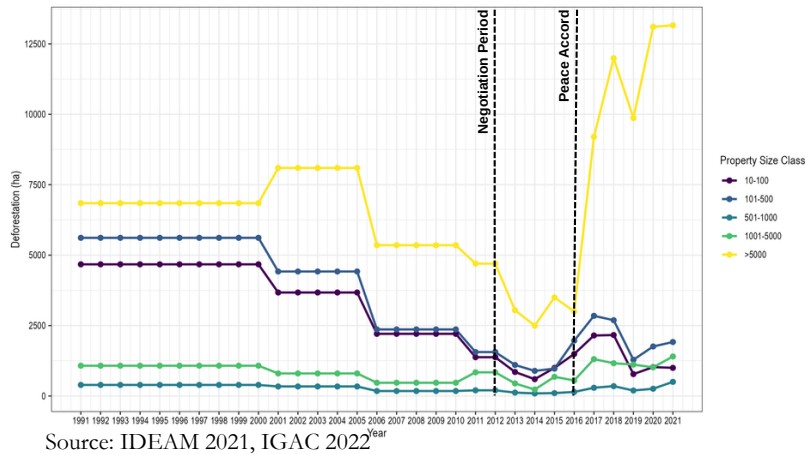


Figure 5. A) Area of annual deforestation (ha) (1991-2021) and B) proportion of annual deforestation (1991-2021) in property boundaries with pasture by size class in Caquetá

**A**



**B**

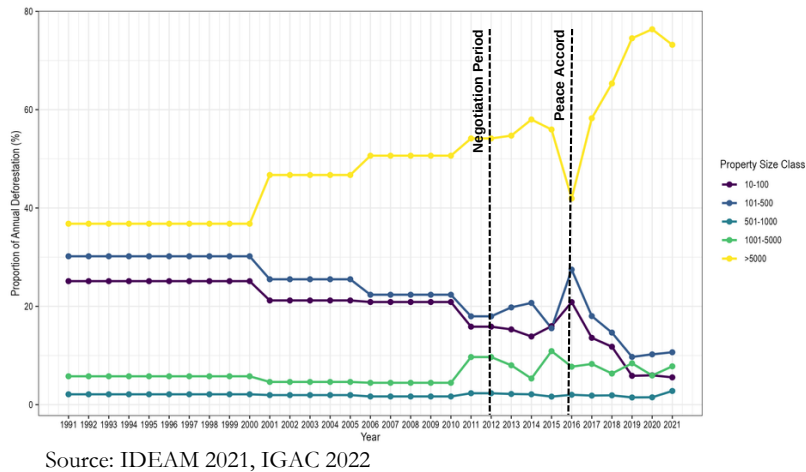


Figure 6. A) Area of annual deforestation (ha) (1991-2021) and B) proportion of annual deforestation (1991-2021) in property boundaries with pasture by size class in southern Meta.

#### 4. Biodiversity: Overlapping ranges of all species and endemic and threatened species

To assess biodiversity status in this hotspot, we delimited the ranges of the region's species of mammals, birds, amphibians, and reptiles with species range maps produced by the International Union for Conservation of Nature (IUCN) and also of the subset that is on the Red List of Threatened Species with the class of Endangered (EN), Vulnerable (VU) or Near Threatened (NT). Species on the Red List face the highest threat due to deforestation. We combined this IUCN data with other high resolution spatial datasets and species-specific data about habitat suitability, such as elevation ranges and land cover preferences, in order to identify the ecologically suitable habitat within the coarser range estimates. We call this refined area, the Area of Habitat (AOH). This method has been found to improve the accuracy of the IUCN data (Brooks et al. 2019; Ocampo-Peñuela et al. 2016). We overlaid these AOHs to count the overlapping ranges of all species and at-risk species classes. Figure 7 shows the spatial patterns of overlapped AOHs across Caqueta and southern Meta with species counts ranging from 187 to 736. In Caqueta, the average number of species is 316, while in southern Meta, the average number of species is 283. The highest counts are in the region's remaining forested landscapes and PAs; these lowland tropical forests of western Amazonia are some of the most diverse in the Amazon (Hoorn et al. 2010). Overall counts are lowest in cleared regions and lower on the eastern slopes of the Andes than in the lowland forest. However, endemism in Andean transition zone is high. Figure 8 shows the spatial patterns of overlapped AOHs of at-risk species with species counts ranging from 8 to 34. The average number of at-risk species in Caqueta is 13, and in southern Meta, it is 14. Here, the spatial pattern is reversed, with the highest counts of at-risk species on the eastern slopes of the Andes and lower counts in the lowland forests.

For bird species, we focus on forest dependent species, and define that as any bird species that requires forest for nesting (Hilty and Brown 1986), resulting in the identification of 1,000 forest dependent bird species for the country. We refined the ranges by integrating new e-bird observations of occurrence and then refined them with suitability data as previously described (Ocampo-Peñuela et al. 2022). We assumed that any land classed as "forest" in 2021 and within a species' range,

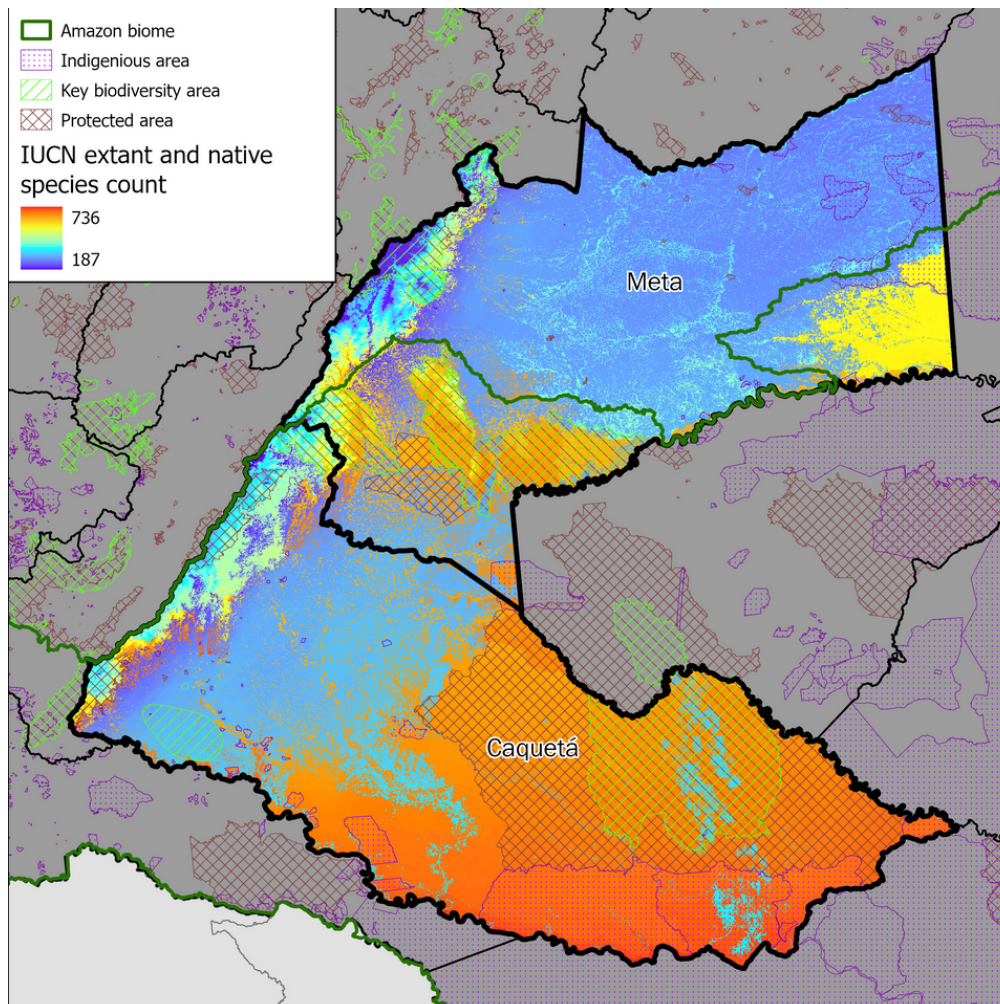


Figure 7. Overlapping ranges of extant and native species (mammals, birds, amphibians, and reptiles)

regardless of that forest's location in relation to other land uses or features, type or composition could be considered potential habitat. To assess the importance of forest conservation on cattle properties for these species, we evaluate the species' AOH within cattle properties and also create a metric called "Conservation Responsibility", or the percent of each species' area of suitable habitat within cattle properties (Burivalova et al 2022).

We identify 132 forest dependent birds in Colombia that are classed as endemic or in the three most at-risk classes (EN, VU, and NT) on the IUCN Red List. Twenty-seven of these bird species are found on cattle properties in Caqueta and southern Meta. Figure 9 shows the spatial patterns of their overlapped AOHs, again with the highest counts of at-risk species on the eastern slopes of the Andes. See Appendix 1 for a full list of these bird species, along with their common names, their AOH in Colombia, and the proportion of that AOH in cattle properties in Caqueta and southern Meta. Of the bird species within this at-risk subgroup in Caqueta and southern Meta, 2 are EN, 14 are Near NT and 11 are VU. Eight of these species have over 10% of the AOH within cattle properties (Figure 10). One of these species is the Spot-winged Parrotlet (*Touit stictopterus*). The bird's population is declining largely due to habitat loss; its habitat is tropical moist montane forests in southwestern Colombia, and its current range is 2,979,133ha. There is 621,881ha within the region, or 21% of this AOH is within cattle properties (Figure 11, Appendix 1). Looking at the total AOH versus the conservation responsibility highlights some distinctions between these at-risk species (Figure 12). Some like the Harpy eagle (*Harpia harpyja*) and Black and Chestnut eagle (*Spizaetus isidori*), have large extents within cattle properties though they represent relatively small portions of their ranges. These species require large territories but are rare within their ranges.

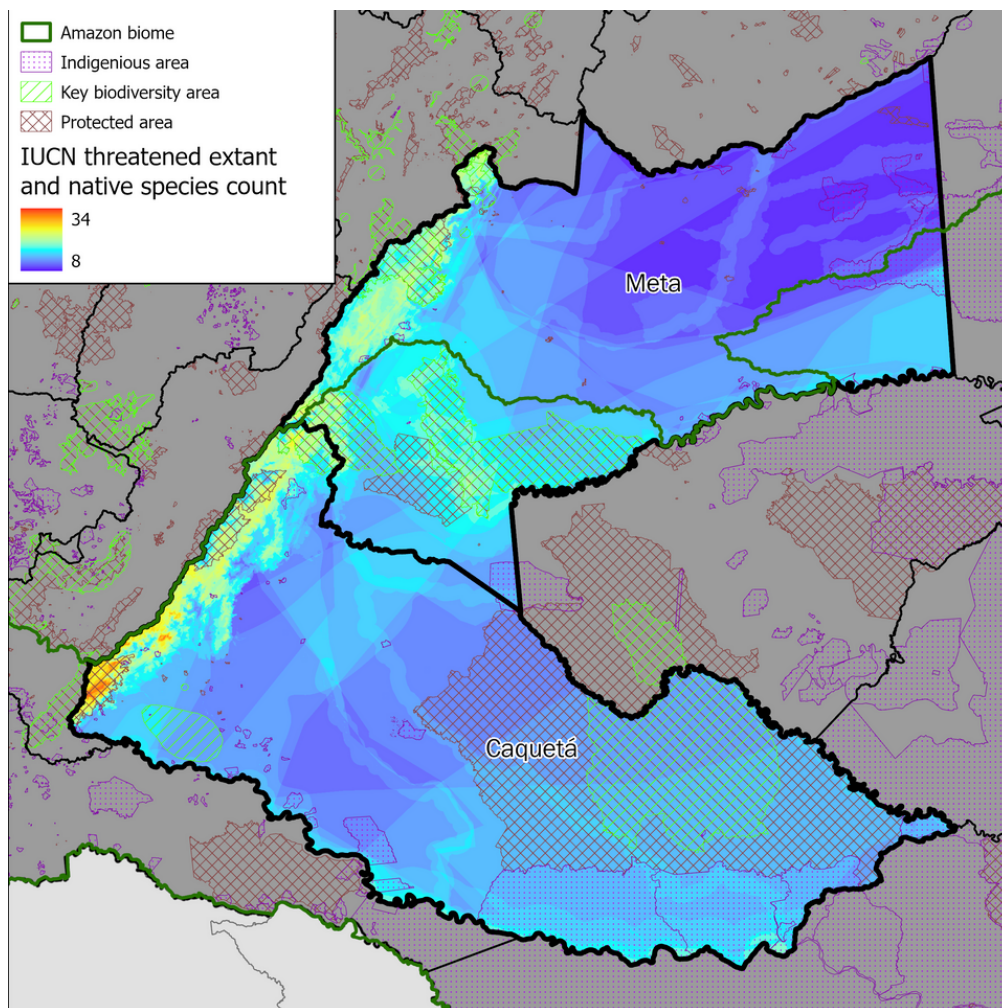


Figure 8. Overlapping ranges of extant and native threatened species (mammals, birds, amphibians, and reptiles)

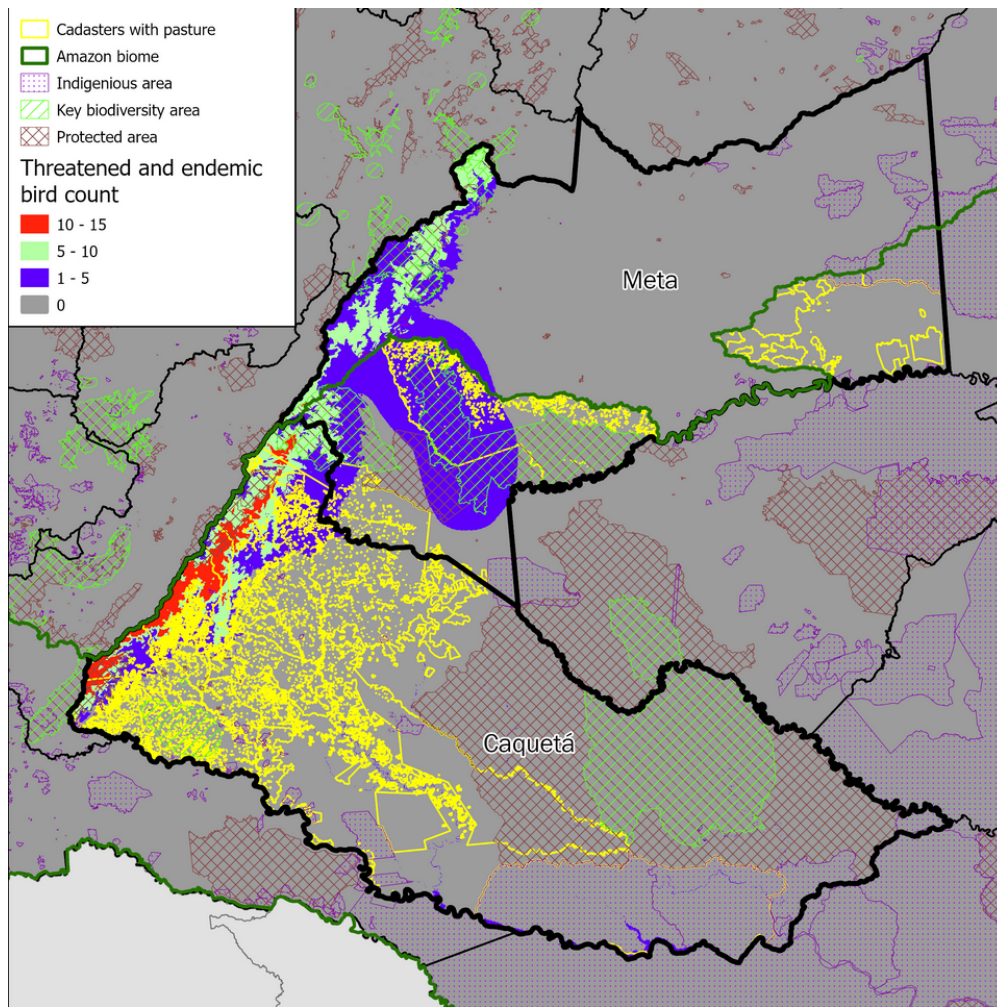


Figure 9. Overlapping ranges of extant and native threatened forest dependent bird species

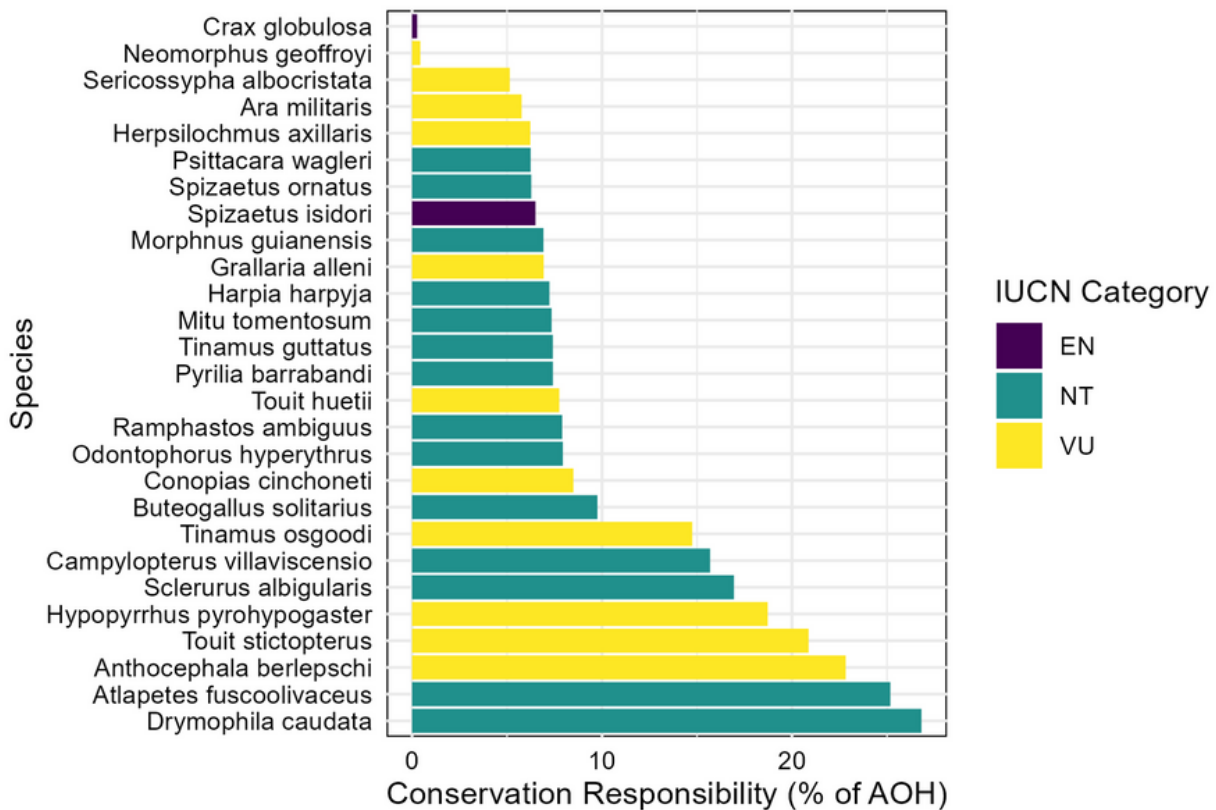


Figure 10. Conservation responsibility metric (Percent of area of suitable habitat within the region) for all forest dependent bird species classed as Endangered (EN), Vulnerable (VU) or Near Threatened (NT) by the IUCN, bars are colored by IUCN class.

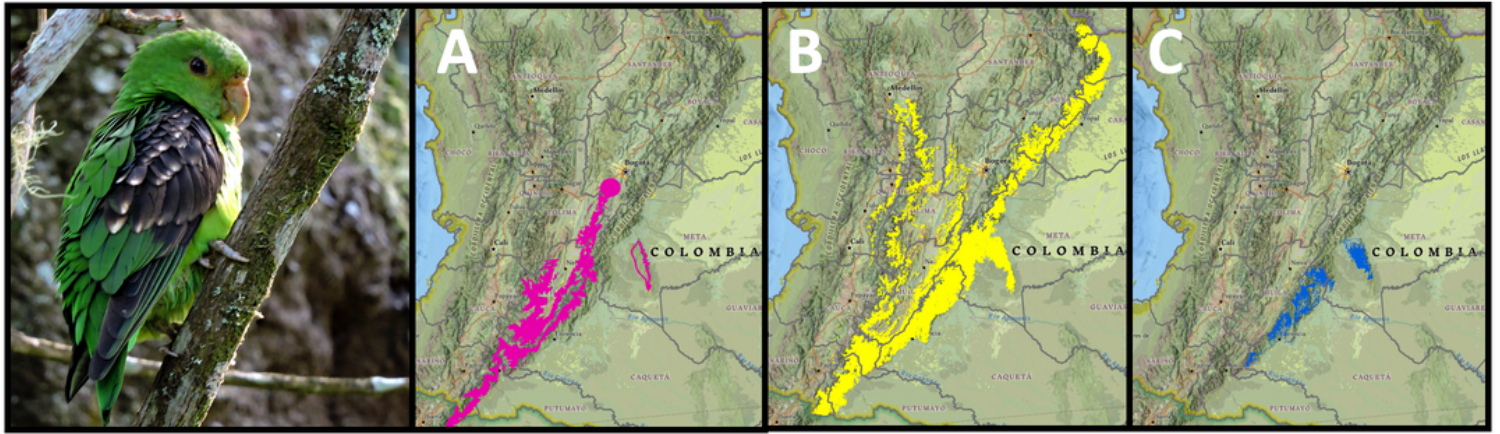


Figure 11. A. Example of IUCN range, B. Area of Habitat (AOH) and C. Area of Conservation Responsibility (percent of area of suitable habitat within the region) for the Spot-winged parrotlet (*Touit Stictopterus*).

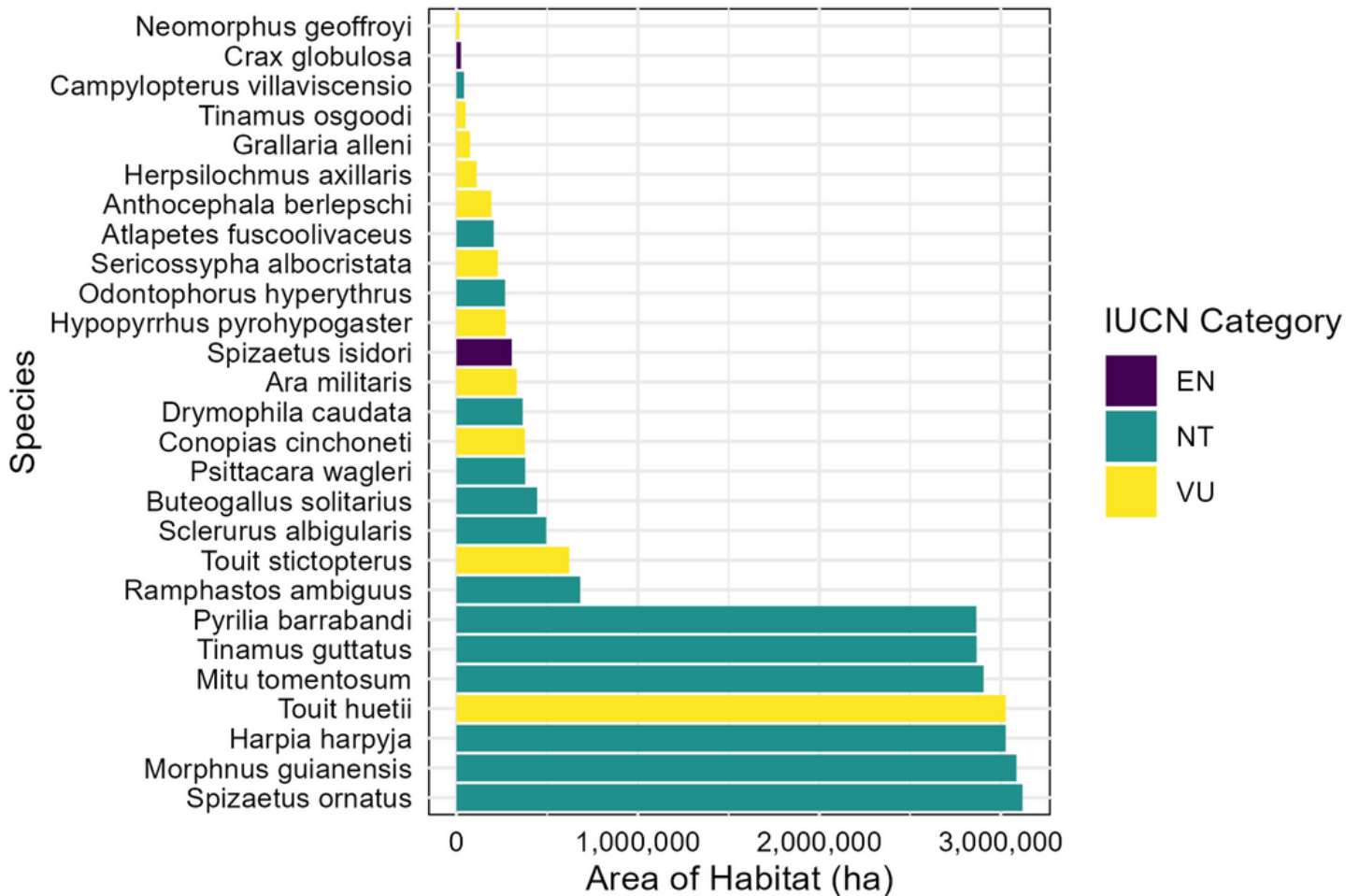


Figure 12. Area of Habitat (AOH) for all forest dependent bird species classed as Endangered (EN), Vulnerable (VU) or Near Threatened (NT) by the IUCN, bars are colored by IUCN class.

## 4. Key Biodiversity Areas

We assessed recent deforestation in KBAs and the overlap between these areas and private properties. KBAs are biologically important areas identified due to their significance for threatened biomes, for threatened species, or for either range, or biome-restricted species (Eken et al., 2004). Sites can also be identified as Alliance for Zero Extinction (AZEs) sites or Important Bird and Biodiversity Areas (IBAs). There are 152 KBAs in Colombia, covering 15% of the country's territory. Of those, 10 KBAs covering 2.7 Mha that are partly within Caquetá and southern Meta, (Table 4). Many of these areas are legally protected as part of Colombia's protected area system, but two are not. These KBAs were designated due to the presence of range restricted species like the Niceforo's poison frog (*Ameerega ingeri*) (Figure 13) and critically endangered species and range restricted species like the Caquetá titi monkey (*Plecturocebus caquetensis*) (Figure 13) (IUCN 2022). Cattle ranchers will be critical actors in conserving these areas and the patches of forests that remain within them, as they are entirely made up of private properties and predominantly pastures (Table 5).

Table 4. Key Biodiversity Areas (KBAs) in Caquetá and southern Meta

| Name                                               | Location              | Description                                                                                                                                                           | Area (ha) | Within PA |
|----------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----------|
| Asarrio                                            | Caquetá               | AZE, habitat of Niceforo's poison frog                                                                                                                                | 1,587     | No        |
| Parque Nacional Natural Cueva de los Guácharos     | Caquetá, Huila        | IBA<br>It was the first PA in the country. It is home to numerous endemic species, such as the Guácharo bird, which is of cultural importance for native communities. | 7,133     | Yes       |
| Riberas del Río Duda                               | Meta                  | IBA<br>Highly biodiverse due to the fact that it is located at the confluence of the Amazon, Orinoco and Andean biomes                                                | 12,793    | Yes       |
| Orteguaza - Caquetá                                | Caquetá               | Habitat of Caquetá titi monkey                                                                                                                                        | 136,119   | No        |
| Serranía de los Churumbelos                        | Caquetá, Cauca, Huila | IBA, CEPF hotspot<br>The park is rich in endemic species, hosting a large number of butterflies and insects, and 25% of the bird species in Colombia                  | 97,223    | Yes       |
| Parque Nacional Natural Cordillera de los Picachos | Caquetá, Meta         | Habitat of Painted stubfoot toad, endemic and critically endangered.<br>There are almost 30 threatened/endangered species in the park                                 | 287,911   | Yes       |
| Parque Nacional Natural Chiribiquete               | Caquetá               | IBA<br>It has been extended twice due to its natural and cultural importance, making it the largest terrestrial PA in Colombia                                        | 1,303,086 | Yes       |
| Parque Nacional Natural Sumapaz                    | Meta                  | IBA, AZE, CEPF hotspot,<br>Multiple community-conservation strategies are being developed in this park to protect its unique vegetation                               | 221,748   | Yes       |
| Parque Nacional Natural Sierra de la Macarena      | Meta                  | IBA, CEPF hotspot<br>It is home to 27% of all bird species in Colombia.                                                                                               | 620,517   | Yes       |

Table 5. Forest area (2021), pasture (2020-2021), recent deforestation (2011-2021) in Key Biodiversity Areas (KBAs)

|                   | No. of properties >5ha | Total Area (ha) | Forest (2021) (ha) | Pasture (2020/2021) (ha) |
|-------------------|------------------------|-----------------|--------------------|--------------------------|
| Ortegaaza-Caquetá | 2,911                  | 149,028         | 9,210              | 127,129                  |
| Asarrio           | 37                     | 2535            | 89                 | 2,182                    |

Source: Birdlife 2021, IDEAM 2022, IGAC 2022, and SINCHI 2021

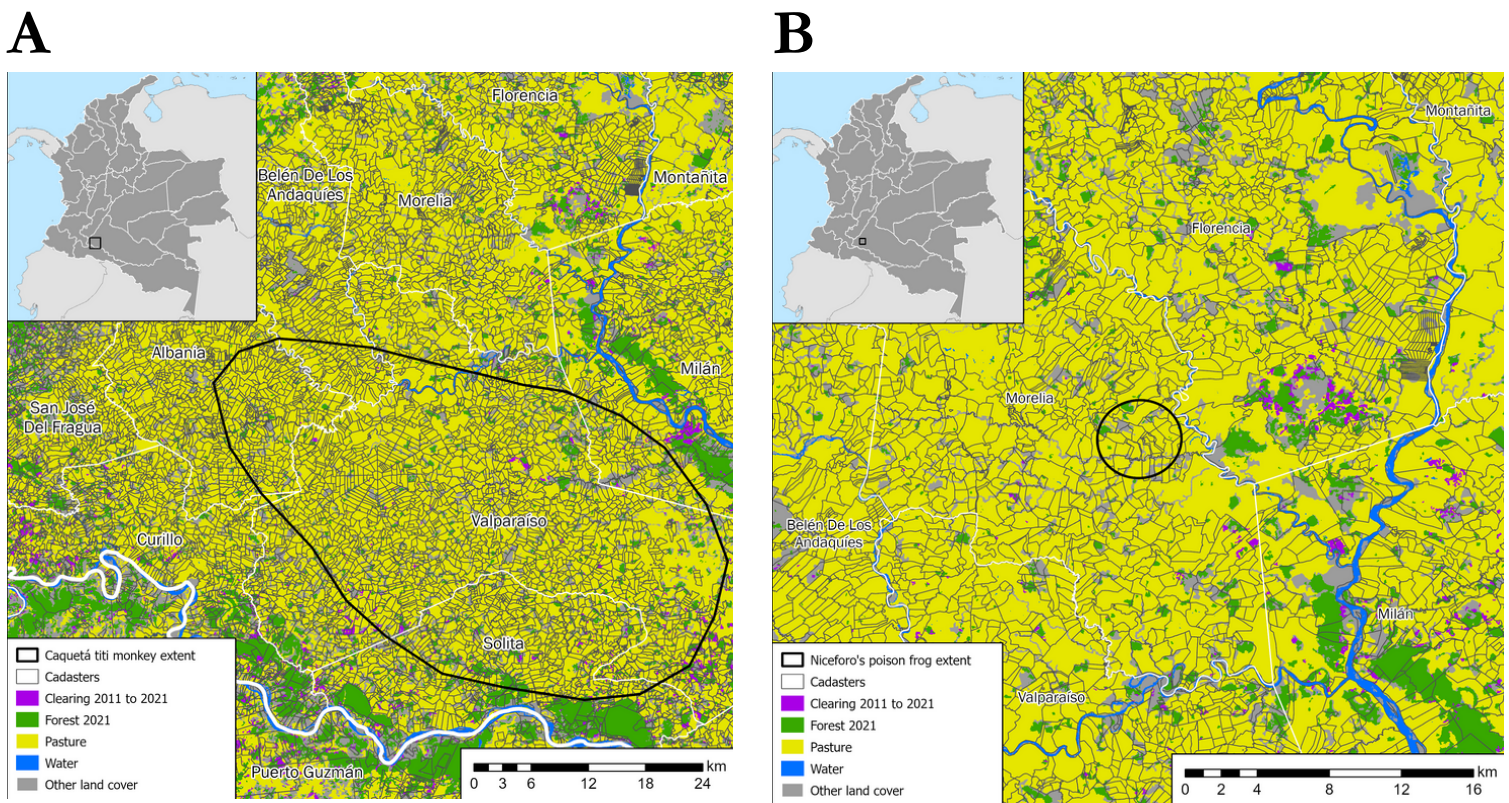


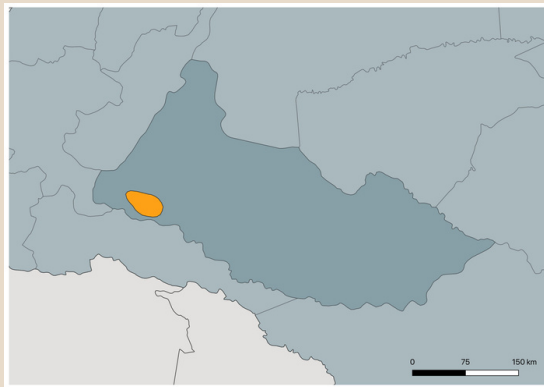
Figure 13. (A) Caquetá titi monkey (*Plecturocebus caquetensis*) and (B) Niceforo's poison frog (*Ameerega ingeri*) range

While deforestation and land cover change from agriculture are considered some of the main threats to biodiversity and are therefore amply covered by Colombia's biodiversity policy mix (Echeverry et al., 2023) more targeted initiatives are needed to ensure biodiversity conservation outside of protected areas and specifically within private properties and undesignated lands. As of now, there are over 316 native species in Caquetá, with over 13 listed as threatened, and over 283 native species in Meta, with over 14 threatened. While over a third of the area in these states is encompassed in PAs, a combination of species-specific or even ecosystem-specific policies along with community conservation initiatives directed towards farmers holding most of the remaining forest could benefit these species and help minimize the post-peace accord expected biodiversity decline. Additionally, considering KBAs that do not currently overlap with protected areas in the context of Herencia Colombia could raise the conservation status of the vulnerable species within them and ensure their protection, such is the case of the Niceforo poison frog and the Caquetá titi monkey.



## Caquetá Titi Monkey

The Caquetá titi monkey is a recently identified primate species found in the piedmont of the Cordillera Oriental along the Río Caquetá and Río Orteguaza between 190-500m above sea level (Defler et al. 2010; IUCN 2023). Study of this primate has been limited, but soon after its discovery it was declared critically endangered due to habitat loss caused by deforestation, and it is now considered Colombia's most at risk primate species. The Caquetá titi monkey is endemic to a small area of around 4,000 km<sup>2</sup> that has lost over 200,000 ha of

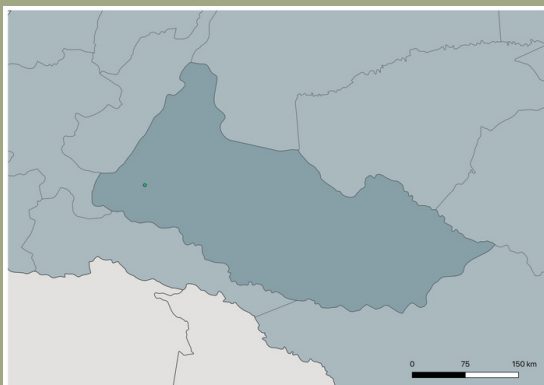


forest in the last decade (IDEAM) mainly due to the cattle industry (Mongabay 2018), leaving only 20% of its range covered by remaining forest. Its population may be less than 250 individuals, with a present extent of occurrence estimated to be under 100 km<sup>2</sup>, and an area of occupancy of less than 10 km<sup>2</sup> within forest fragments in an agriculture dominated landscape (ibid. 2010).

Critical patch sizes needed by the Caquetá titi monkey are not well known but similar species show a preference for gallery forests, where patches as small as 3 ha can sustain populations or 14 ha in closed canopy forests (Garcia et al. 2010). 100% percent of its range is within cattle sector supplysheds, and no formally protected areas have been declared.

## Niceforo's poison frog

The Niceforo's poison frog or Inger's poison frog is endemic to the Colombian Amazon, specifically to Asarrio in the Caquetá department. It is thought to have a very small range in the Río Pescado at 200 m above sea level, in an area that has been under constant deforestation due to the cattle industry since the 1980s (Núñez Román, 2013). Only 89 ha of forest remain within this area, which is dominated by pasture. Currently, there are no protected areas overlapping the frog's range



The population is thought to be decreasing in number, but information about this species is very limited and it is classed as "Data Deficient" by the IUCN and vulnerable by Colombia's Ministry of the Environment and Sustainable Development (MADS). It's possible that the species is extinct or nearly extinct as no new specimens have been found since the 1970s in Asarrio. A recent survey in a nearby but higher elevation part of Caquetá provides some hope for the species as several possible specimens were found, but the specimens are still being evaluated to confirm whether they are actually Niceforo's poison frog (Gutierrez Lamus).

## Summary of Findings/Conclusions

- 12.3Mha of Colombia's forests and 845,000 ha of recent deforestation are within dairy sector supplysheds, this is 21% of Colombia's forests that are outside of PAs and 51% of recent deforestation. 23.8 Mha of Colombia's forests and 1.4 Mha of recent deforestation are within beef sector supplysheds, this is 48% of Colombia's forests that are outside of PAs and 90% of recent deforestation. Therefore, the ZDAs have potential to reach a significant percentage of Colombia's forests and include deforestation hotspots but require increased participation and implementation in both sectors.
- Large expanses of forest, or more than 1.6 Mha of the forest area, fall within private properties in Caquetá and southern Meta. This is 19% of the remaining forest area, and 39% of the forest area outside of PAs. Over 350,000 ha or 61% of recent deforestation has occurred within private properties. Policies like ZDAs that aim to reduce deforestation on farms or sustainable intensification strategies like low carbon agriculture that aim to help farmers increase their productivity without expanding the production area can help conserve these forests.
- While there are 1.2 Mha of remaining forests in undesignated areas, 38% of recent deforestation has occurred in these areas, making them a critical focus for deforestation policies. Much of this area is outside of the 2018 legal agricultural frontier, so institutional reach may be weak and claims to land more complex.
- Very few large properties (>5000 ha), namely 14 in Caquetá and 33 in Meta, hold both, the vast majority of the remaining forest –nearly 3 Mha– and most of the deforestation encompassed in private properties in those states.
- Additionally, there is nearly 500,000 ha of forest within properties that are <5000 ha. The share of deforestation on smaller properties (>10 ha & <=100 ha) is declining in both Caquetá and southern Meta, and was 10% and 6% respectively in 2021. Conversely, deforestation is surging within very large properties (>5000 ha) in both departments. Reaching the actors responsible for this deforestation may present similar challenges of unclear or overlapping claims to those in undesignated areas.
- Thirty-two of Colombia's 132 at-risk forest dependent bird species are found in Caquetá and southern Meta, and 10 of these species have over 20% of the AOH within the AC region.
- Two KBAs in the region are outside of PAs and within private properties inside of cattle sector supplysheds. Policies like ZDAs or reservas naturales de la sociedad civil (RNSC) that aim to limit the conversion of forests on farms would also have important benefits for the conservation of biodiversity in this area.

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# Appendix 1.

## Endemic and threatened species in Caqueta and southern Meta

Table S1. Endemic and Threatened Birds Area of Habitat and Conservation Responsibility

| Species                             | Common name                 | IUCN Category | AOH in Colombia | AOH with Caqueta and southern Meta | Conservation Responsibility | Species information                                                                                                                                                                                           |
|-------------------------------------|-----------------------------|---------------|-----------------|------------------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Anthocephala berlepschi</i>      | Tolima Blossomcrown         | VU            | 843,945         | 192,640                            | 23%                         | <a href="http://datazone.birdlife.org/species/factsheet/tolima-blossomcrown-anthrocephala-berlepschi">http://datazone.birdlife.org/species/factsheet/tolima-blossomcrown-anthrocephala-berlepschi</a>         |
| <i>Ara militaris</i>                | Military Macaw              | VU            | 5,766,270       | 332,519                            | 6%                          | <a href="http://datazone.birdlife.org/species/factsheet/military-macaw-ara-militaris">http://datazone.birdlife.org/species/factsheet/military-macaw-ara-militaris</a>                                         |
| <i>Atlapetes fuscolivaceus</i>      | Dusky-headed Brush-finch    | NT            | 814,596         | 205,093                            | 25%                         | <a href="http://datazone.birdlife.org/species/factsheet/dusky-headed-brush-finch-atlapetes-fuscolivaceus">http://datazone.birdlife.org/species/factsheet/dusky-headed-brush-finch-atlapetes-fuscolivaceus</a> |
| <i>Buteogallus solitarius</i>       | Black Solitary Eagle        | NT            | 4,558,033       | 444,735                            | 10%                         | <a href="http://datazone.birdlife.org/species/factsheet/black-solitary-eagle-buteogallus-solitarius">http://datazone.birdlife.org/species/factsheet/black-solitary-eagle-buteogallus-solitarius</a>           |
| <i>Campylopterus villaviscensio</i> | Napo Sabrewing              | NT            | 266,880         | 41,867                             | 16%                         | <a href="http://datazone.birdlife.org/species/factsheet/napo-sabrewing-campylopterus-villaviscensio">http://datazone.birdlife.org/species/factsheet/napo-sabrewing-campylopterus-villaviscensio</a>           |
| <i>Crax globulosa</i>               | Wattled Curassow            | EN            | 9,304,245       | 24,879                             | 0%                          | <a href="http://datazone.birdlife.org/species/factsheet/wattled-curassow-crax-globulosa">http://datazone.birdlife.org/species/factsheet/wattled-curassow-crax-globulosa</a>                                   |
| <i>Drymophila caudata</i>           | East Andean Antbird         | NT            | 1,361,657       | 365,122                            | 27%                         | <a href="http://datazone.birdlife.org/species/factsheet/east-andean-antbird-drymophila-caudata">http://datazone.birdlife.org/species/factsheet/east-andean-antbird-drymophila-caudata</a>                     |
| <i>Grallaria alleni</i>             | Moustached Antpitta         | VU            | 1,079,623       | 74,801                             | 7%                          | <a href="http://datazone.birdlife.org/species/factsheet/moustached-antpitta-grallaria-alleni">http://datazone.birdlife.org/species/factsheet/moustached-antpitta-grallaria-alleni</a>                         |
| <i>Harpia harpyja</i>               | Harpy Eagle                 | NT            | 41,859,465      | 3,027,092                          | 7%                          | <a href="http://datazone.birdlife.org/species/factsheet/harpy-eagle-harpia-harpyja">http://datazone.birdlife.org/species/factsheet/harpy-eagle-harpia-harpyja</a>                                             |
| <i>Herpsilochmus axillaris</i>      | Yellow-breasted Antwren     | VU            | 1,786,722       | 111,248                            | 6%                          | <a href="http://datazone.birdlife.org/species/factsheet/yellow-breasted-antwren-herpsilochmus-axillaris">http://datazone.birdlife.org/species/factsheet/yellow-breasted-antwren-herpsilochmus-axillaris</a>   |
| <i>Hypopyrrhus pyrohypogaster</i>   | Munchique Wood-wren         | VU            | 1,452,313       | 271,876                            | 19%                         | <a href="http://datazone.birdlife.org/species/factsheet/munchique-wood-wren-henicorhina-negreti">http://datazone.birdlife.org/species/factsheet/munchique-wood-wren-henicorhina-negreti</a>                   |
| <i>Mitu tomentosum</i>              | Crestless Curassow          | NT            | 39,545,647      | 2,905,299                          | 7%                          | <a href="http://datazone.birdlife.org/species/factsheet/crestless-curassow-mitu-tomentosum">http://datazone.birdlife.org/species/factsheet/crestless-curassow-mitu-tomentosum</a>                             |
| <i>Morphnus guianensis</i>          | Crested Eagle               | NT            | 44,632,675      | 3,086,491                          | 7%                          | <a href="http://datazone.birdlife.org/species/factsheet/crested-eagle-morphnus-guianensis">http://datazone.birdlife.org/species/factsheet/crested-eagle-morphnus-guianensis</a>                               |
| <i>Neomorphus geoffroyi</i>         | Rufous-vented Ground-cuckoo | VU            | 3,818,958       | 16,619                             | 1%                          | <a href="http://datazone.birdlife.org/species/factsheet/rufous-vented-ground-cuckoo-neomorphus-geoffroyi">http://datazone.birdlife.org/species/factsheet/rufous-vented-ground-cuckoo-neomorphus-geoffroyi</a> |
| <i>Odontophorus hyperythrus</i>     | Chestnut Wood-quail         | NT            | 3,376,895       | 268,095                            | 8%                          | <a href="http://datazone.birdlife.org/species/factsheet/chestnut-wood-quail-odontophorus-hyperythrus">http://datazone.birdlife.org/species/factsheet/chestnut-wood-quail-odontophorus-hyperythrus</a>         |
| <i>Psittacara wagleri</i>           | Scarlet-fronted Parakeet    | NT            | 6,066,546       | 378,857                            | 6%                          | <a href="http://datazone.birdlife.org/species/factsheet/scarlet-fronted-parakeet-psittacara-wagleri">http://datazone.birdlife.org/species/factsheet/scarlet-fronted-parakeet-psittacara-wagleri</a>           |
| <i>Ramphastos ambiguus</i>          | Yellow-throated Toucan      | NT            | 8,631,952       | 682,128                            | 8%                          | <a href="http://datazone.birdlife.org/species/factsheet/yellow-throated-toucan-ramphastos-ambiguus">http://datazone.birdlife.org/species/factsheet/yellow-throated-toucan-ramphastos-ambiguus</a>             |
| <i>Sclerurus albigularis</i>        | Grey-throated Leaf-tosser   | NT            | 2,918,010       | 494,483                            | 17%                         | <a href="http://datazone.birdlife.org/species/factsheet/grey-throated-leaf-tosser-sclerurus-albigularis">http://datazone.birdlife.org/species/factsheet/grey-throated-leaf-tosser-sclerurus-albigularis</a>   |
| <i>Sericossypha albocristata</i>    | White-capped Tanager        | VU            | 4,417,564       | 227,336                            | 5%                          | <a href="http://datazone.birdlife.org/species/factsheet/white-capped-tanager-sericossypha-albocristata">http://datazone.birdlife.org/species/factsheet/white-capped-tanager-sericossypha-albocristata</a>     |
| <i>Spizaetus isidori</i>            | Black-and-chestnut Eagle    | EN            | 4,692,943       | 304,921                            | 7%                          | <a href="http://datazone.birdlife.org/species/factsheet/black-and-chestnut-eagle-spizaetus-isidori">http://datazone.birdlife.org/species/factsheet/black-and-chestnut-eagle-spizaetus-isidori</a>             |
| <i>Spizaetus ornatus</i>            | Ornate Hawk-eagle           | NT            | 49,711,747      | 3,119,813                          | 6%                          | <a href="http://datazone.birdlife.org/species/factsheet/ornate-hawk-eagle-spizaetus-ornatus">http://datazone.birdlife.org/species/factsheet/ornate-hawk-eagle-spizaetus-ornatus</a>                           |
| <i>Tinamus guttatus</i>             | White-throated Tinamou      | NT            | 38,678,160      | 2,866,916                          | 7%                          | <a href="http://datazone.birdlife.org/species/factsheet/white-throated-tinamou-tinamus-guttatus">http://datazone.birdlife.org/species/factsheet/white-throated-tinamou-tinamus-guttatus</a>                   |
| <i>Tinamus osgoodi</i>              | Black Tinamou               | VU            | 342,659         | 50,531                             | 15%                         | <a href="http://datazone.birdlife.org/species/factsheet/black-tinamou-tinamus-osgoodi">http://datazone.birdlife.org/species/factsheet/black-tinamou-tinamus-osgoodi</a>                                       |
| <i>Touit stictopterus</i>           | Spot-winged Parrotlet       | VU            | 2,979,133       | 621,881                            | 21%                         | <a href="http://datazone.birdlife.org/species/factsheet/spot-winged-parrotlet-touit-stictopterus">http://datazone.birdlife.org/species/factsheet/spot-winged-parrotlet-touit-stictopterus</a>                 |

Table S2. Endemic and Threatened Amphibians Area of Habitat and Conservation Responsibility

| Species name                       | Common name                   | Status        | Department Area of Habitat (ha) | National Area of Habitat (ha) | Conservation Responsibility | IUCN Link                                                                                                                                                         |
|------------------------------------|-------------------------------|---------------|---------------------------------|-------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Allobates picachos</i>          |                               | EN            | 14,891                          | 35,890                        | 41.49%                      | <a href="https://www.iucnredlist.org/species/55131/49337104#assessment-information">https://www.iucnredlist.org/species/55131/49337104#assessment-information</a> |
| <i>Callimedusa perinesos</i>       | Orange-spotted Leaf frog      | EN            | 29,325                          | 39,493                        | 74.25%                      | <a href="https://www.iucnredlist.org/species/55860/85905113">https://www.iucnredlist.org/species/55860/85905113</a>                                               |
| <i>Centrolene medemi</i>           | Medem's Glassfrog             | EN            | 98,935                          | 199,563                       | 49.58%                      | <a href="https://www.iucnredlist.org/species/54926/49364088">https://www.iucnredlist.org/species/54926/49364088</a>                                               |
| <i>Centrolene solitaria</i>        | Lonely Cochran Frog           | EN            | 3,271                           | 33,740                        | 9.69%                       | <a href="https://www.iucnredlist.org/species/54993/49367566">https://www.iucnredlist.org/species/54993/49367566</a>                                               |
| <i>Hemiphractus bubalus</i>        | Ecuador Horneds Treefrog      | NT            | 386,323                         | 1,645,334                     | 23.48%                      | <a href="https://www.iucnredlist.org/species/55366/85898639">https://www.iucnredlist.org/species/55366/85898639</a>                                               |
| <i>Hyloscirtus torrenticola</i>    | El Pepino Treefrog            | VU            | 76,158                          | 347,983                       | 21.89%                      | <a href="https://www.iucnredlist.org/species/55678/85903935">https://www.iucnredlist.org/species/55678/85903935</a>                                               |
| <i>Niceforonia dolops</i>          | Rana Gorda del Río Reventador | VU            | 54,155                          | 331,494                       | 16.34%                      | <a href="https://www.iucnredlist.org/species/56568/85865812">https://www.iucnredlist.org/species/56568/85865812</a>                                               |
| <i>Niceforonia elassodiscus</i>    | Cuyuja Robber Frog            | NT            | 44,669                          | 344,751                       | 12.96%                      | <a href="https://www.iucnredlist.org/species/56575/85866073">https://www.iucnredlist.org/species/56575/85866073</a>                                               |
| <i>Pristimantis corniger</i>       |                               | EN            | 86,106                          | 276,222                       | 31.17%                      | <a href="https://www.iucnredlist.org/species/56523/85857874">https://www.iucnredlist.org/species/56523/85857874</a>                                               |
| <i>Pristimantis hernandezi</i>     | Hernandez's Robber Frog       | EN            | 11,819                          | 30,208                        | 39.13%                      | <a href="https://www.iucnredlist.org/species/56652/85862951">https://www.iucnredlist.org/species/56652/85862951</a>                                               |
| <i>Pristimantis limoncochensis</i> |                               | NT            | 71,461                          | 706,447                       | 10.12%                      | <a href="https://www.iucnredlist.org/species/87738555/176968036">https://www.iucnredlist.org/species/87738555/176968036</a>                                       |
| <i>Pristimantis petersi</i>        | Peter's Robber Frog           | NT            | 19,206                          | 99,364                        | 19.33%                      | <a href="https://www.iucnredlist.org/species/56849/85982274">https://www.iucnredlist.org/species/56849/85982274</a>                                               |
| <i>Pristimantis pugnax</i>         | Agua Robber Frog              | Critically EN | 3,175                           | 5,471                         | 58.03%                      | <a href="https://www.iucnredlist.org/species/56886/85872104">https://www.iucnredlist.org/species/56886/85872104</a>                                               |
| <i>Pristimantis tamsitti</i>       | San Adolfo Robber Frog        | VU            | 138,208                         | 551,966                       | 25.04%                      | <a href="https://www.iucnredlist.org/species/56993/151286115">https://www.iucnredlist.org/species/56993/151286115</a>                                             |
| <i>Rhinella cristinae</i>          |                               | EN            | 2,055                           | 4,263                         | 48.20%                      | <a href="https://www.iucnredlist.org/species/54619/85866977">https://www.iucnredlist.org/species/54619/85866977</a>                                               |
| <i>Strabomantis cornutus</i>       | Rio Suno Robber Frog          | VU            | 55,988                          | 373,070                       | 15.01%                      | <a href="https://www.iucnredlist.org/species/56524/11491912">https://www.iucnredlist.org/species/56524/11491912</a>                                               |

Table S3. Endemic and Threatened Aquatic Mammals Area of Habitat and Conservation Responsibility

| Species name                  | Common name          | Status | Department Area of Habitat (ha) | National Area of Habitat (ha) | Conservation Responsibility | IUCN Link                                                                                                             |
|-------------------------------|----------------------|--------|---------------------------------|-------------------------------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------|
| <i>Inia geoffrensis</i>       | Amazon River Dolphin | EN     | 732,696                         | 8,647,238                     | 8.47%                       | <a href="https://www.iucnredlist.org/species/10831/50358152">https://www.iucnredlist.org/species/10831/50358152</a>   |
| <i>Lontra longicaudis</i>     | Neotropical Otter    | NT     | 6,118,088                       | 112,697,777                   | 5.43%                       | <a href="https://www.iucnredlist.org/species/12304/219373698">https://www.iucnredlist.org/species/12304/219373698</a> |
| <i>Pteronura brasiliensis</i> | Giant Otter          | EN     | 4,659,475                       | 46,347,887                    | 10.05%                      | <a href="https://www.iucnredlist.org/species/18711/222719180">https://www.iucnredlist.org/species/18711/222719180</a> |
| <i>Sotalia fluviatilis</i>    | Tucuxi               | EN     | 448,068                         | 7,824,384                     | 5.73%                       | <a href="https://www.iucnredlist.org/species/190871/50386457">https://www.iucnredlist.org/species/190871/50386457</a> |
| <i>Tapirus pinchaque</i>      | Mountain Tapir       | EN     | 119,870                         | 2,825,069                     | 4.24%                       | <a href="https://www.iucnredlist.org/species/21473/45173922">https://www.iucnredlist.org/species/21473/45173922</a>   |
| <i>Tapirus terrestris</i>     | Lowland Tapir        | VU     | 4,297,129                       | 56,371,748                    | 7.62%                       | <a href="https://www.iucnredlist.org/species/21474/45174127">https://www.iucnredlist.org/species/21474/45174127</a>   |

Table S4. Endemic and Threatened Reptiles Area of Habitat and Conservation Responsibility

| Species name                  | Common name       | Status        | Department Area of Habitat (ha) | National Area of Habitat (ha) | Conservation Responsibility | IUCN Link                                                                                                                 |
|-------------------------------|-------------------|---------------|---------------------------------|-------------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------|
| <i>Atractus occipitoalbus</i> | Grey Ground Snake | NT            | 21,253                          | 795,876                       | 2.67%                       | <a href="https://www.iucnredlist.org/species/44581256/44581265">https://www.iucnredlist.org/species/44581256/44581265</a> |
| <i>Crocodylus intermedius</i> | Orinoco Crocodile | Critically EN | 156,182                         | 4,751,159                     | 3.29%                       | <a href="https://www.iucnredlist.org/species/5661/181089024">https://www.iucnredlist.org/species/5661/181089024</a>       |

Table S5. Endemic and Threatened Terrestrial Mammals Area of Habitat and Conservation Responsibility

| Species name                     | Common name                   | Status        | Department Area of Habitat (ha) | National Area of Habitat (ha) | Conservation Responsibility | IUCN Link                                                                                                                     |
|----------------------------------|-------------------------------|---------------|---------------------------------|-------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| <i>Aotus brumbacki</i>           | Brumback's Night Monkey       | VU            | 1,498,103                       | 12,367,865                    | 12.11%                      | <a href="https://www.iucnredlist.org/species/39915/17923405">https://www.iucnredlist.org/species/39915/17923405</a>           |
| <i>Aotus lemurinus</i>           | Colombian Night Monkey        | VU            | 298,519                         | 15,542,140                    | 1.92%                       | <a href="https://www.iucnredlist.org/species/1808/17922601">https://www.iucnredlist.org/species/1808/17922601</a>             |
| <i>Ateles belzebuth</i>          | White-bellied Spider Monkey   | EN            | 4,928,401                       | 18,370,241                    | 26.83%                      | <a href="https://www.iucnredlist.org/species/2276/191684587">https://www.iucnredlist.org/species/2276/191684587</a>           |
| <i>Atelocynus microtis</i>       | Short-eared Dog               | NT            | 1,555,007                       | 19,788,949                    | 7.86%                       | <a href="https://www.iucnredlist.org/species/6924/12814890">https://www.iucnredlist.org/species/6924/12814890</a>             |
| <i>Bassaricyon neblina</i>       | Olinguito                     | NT            | 15,958                          | 9,991,086                     | 0.16%                       | <a href="https://www.iucnredlist.org/species/48637280/166523067">https://www.iucnredlist.org/species/48637280/166523067</a>   |
| <i>Callimico goeldii</i>         | Goeldi's Monkey               | VU            | 21,249                          | 8,413,349                     | 0.25%                       | <a href="https://www.iucnredlist.org/species/3564/191700340">https://www.iucnredlist.org/species/3564/191700340</a>           |
| <i>Cebuella pygmaea</i>          | Wesdtern Pygmy Marmoset       | VU            | 1,748,596                       | 13,423,816                    | 13.03%                      | <a href="https://www.iucnredlist.org/species/136926/200203263">https://www.iucnredlist.org/species/136926/200203263</a>       |
| <i>Cheracebus medemi</i>         | Colombian Black-handed Titi   | VU            | 6,429                           | 1,562,058                     | 0.41%                       | <a href="https://www.iucnredlist.org/species/39944/217755677">https://www.iucnredlist.org/species/39944/217755677</a>         |
| <i>Cuniculus taczanowskii</i>    |                               | NT            | 239,562                         | 14,385,588                    | 1.67%                       | <a href="https://www.iucnredlist.org/species/700/2197554">https://www.iucnredlist.org/species/700/2197554</a>                 |
| <i>Dasypus sabanicola</i>        | Northern Long-nosed Armadillo | NT            | 647,099                         | 18,945,866                    | 3.42%                       | <a href="https://www.iucnredlist.org/species/6292/47441316">https://www.iucnredlist.org/species/6292/47441316</a>             |
| <i>Lagothrix lagothricha</i>     | Common Woolly Monkey          | VU            | 1,735,290                       | 2,554,136                     | 67.94%                      | <a href="https://www.iucnredlist.org/species/160881218/192309103">https://www.iucnredlist.org/species/160881218/192309103</a> |
| <i>Leopardus tigrinus</i>        | Northern Tiger Cat            | VU            | 6,116,062                       | 70,445,605                    | 8.68%                       | <a href="https://www.iucnredlist.org/species/54012637/50653881">https://www.iucnredlist.org/species/54012637/50653881</a>     |
| <i>Leopardus wiedii</i>          | Margay                        | NT            | 4,252,520                       | 79,971,228                    | 5.32%                       | <a href="https://www.iucnredlist.org/species/11511/50654216">https://www.iucnredlist.org/species/11511/50654216</a>           |
| <i>Leptonycteris curasoae</i>    |                               | VU            | 189,011                         | 38,781,646                    | 0.49%                       | <a href="https://www.iucnredlist.org/species/11699/22126917">https://www.iucnredlist.org/species/11699/22126917</a>           |
| <i>Lonchorhina marinkellei</i>   | Marinkelle's Sword-nosed Bat  | VU            | 30                              | 15,890,938                    | 0.00%                       | <a href="https://www.iucnredlist.org/species/12272/22038923">https://www.iucnredlist.org/species/12272/22038923</a>           |
| <i>Lonchorhina orinocensis</i>   | Orinoco Sword-nosed Bat       | VU            | 1,928,488                       | 21,384,114                    | 9.02%                       | <a href="https://www.iucnredlist.org/species/12273/166505026">https://www.iucnredlist.org/species/12273/166505026</a>         |
| <i>Myrmecophaga tridactyla</i>   | Giant Anteater                | VU            | 5,783,595                       | 82,297,751                    | 7.03%                       | <a href="https://www.iucnredlist.org/species/14224/47441961">https://www.iucnredlist.org/species/14224/47441961</a>           |
| <i>Nasuella olivacea</i>         | Western Mountain Coati        | NT            | 350,333                         | 16,207,258                    | 2.16%                       | <a href="https://www.iucnredlist.org/species/72261737/45201571">https://www.iucnredlist.org/species/72261737/45201571</a>     |
| <i>Panthera onca</i>             | Jaguar                        | NT            | 5,976,294                       | 86,982,495                    | 6.87%                       | <a href="https://www.iucnredlist.org/species/15953/123791436">https://www.iucnredlist.org/species/15953/123791436</a>         |
| <i>Pithecia milleri</i>          | Miller's Saki                 | VU            | 1,523,062                       | 4,114,672                     | 37.02%                      | <a href="https://www.iucnredlist.org/species/17407/192446875">https://www.iucnredlist.org/species/17407/192446875</a>         |
| <i>Platyrrhinus ismaeli</i>      |                               | NT            | 440,696                         | 2,177,053                     | 20.24%                      | <a href="https://www.iucnredlist.org/species/136232/22002129">https://www.iucnredlist.org/species/136232/22002129</a>         |
| <i>Plecturocebus caquetensis</i> | Caquetá Titi Monkey           | Critically EN | 130,117                         | 136,120                       | 95.59%                      | <a href="https://www.iucnredlist.org/species/14699281/192453101">https://www.iucnredlist.org/species/14699281/192453101</a>   |
| <i>Plecturocebus ornatus</i>     | Ornate Titi Monkey            | VU            | 753,266                         | 2,383,556                     | 31.60%                      | <a href="https://www.iucnredlist.org/species/39928/17974735">https://www.iucnredlist.org/species/39928/17974735</a>           |
| <i>Priodontes maximus</i>        | Giant Armadillo               | VU            | 5,644,573                       | 63,527,653                    | 8.89%                       | <a href="https://www.iucnredlist.org/species/18144/47442343">https://www.iucnredlist.org/species/18144/47442343</a>           |
| <i>Rhogeessa minutilla</i>       | Tiny Yellow Bat               | VU            | 31,588                          | 15,756,150                    | 0.20%                       | <a href="https://www.iucnredlist.org/species/19682/22007845">https://www.iucnredlist.org/species/19682/22007845</a>           |
| <i>Speothos venaticus</i>        | Bush Dog                      | NT            | 6,055,509                       | 100,231,664                   | 6.04%                       | <a href="https://www.iucnredlist.org/species/20468/9203243">https://www.iucnredlist.org/species/20468/9203243</a>             |
| <i>Tayassu pecari</i>            | White-lipped Peccary          | VU            | 4,224,025                       | 59,057,404                    | 7.15%                       | <a href="https://www.iucnredlist.org/species/41778/44051115">https://www.iucnredlist.org/species/41778/44051115</a>           |
| <i>Tremarctos ornatus</i>        | Andean Bear                   | VU            | 510,527                         | 5,957,275                     | 8.57%                       | <a href="https://www.iucnredlist.org/species/22066/123792952">https://www.iucnredlist.org/species/22066/123792952</a>         |
| <i>Vampyressa melissa</i>        |                               | VU            | 2,904,996                       | 14,549,670                    | 19.97%                      | <a href="https://www.iucnredlist.org/species/22839/22058315">https://www.iucnredlist.org/species/22839/22058315</a>           |
| <i>Vampyrum spectrum</i>         | Spectral Bat                  | NT            | 6,118,088                       | 103,804,020                   | 5.89%                       | <a href="https://www.iucnredlist.org/species/22843/22059426">https://www.iucnredlist.org/species/22843/22059426</a>           |