Conservation planning for non-human primates in Colombia (South America)

by

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Abstract

Primates play an important role in the maintenance and functioning of tropical ecosystems. However, habitat loss due to land use conversion threatens the persistence of primates worldwide. Colombia has a diverse fauna of primates with 12% of its terrestrial territory protected under the country's national natural park system. However, threats remain, even within protected areas, with important habitats for threatened species remaining underrepresented or unprotected. Indeed, ~53% of species and subspecies of primates are imperiled in Colombia. Here I examined conservation planning for primates in Colombia to identify conservation gaps in and prioritize new sites for protection. First, I developed environmental niche models for 39 primate taxa predicting suitable habitat for each species in Colombia. Second, I used the Zonation conservation planning software to rank conservation priorities within primary and secondary forest across Colombia. I identified thirty-seven potential conservation sites using targets of 17, 22 and 27% terrestrial protection. Irreplaceability and vulnerability ranking of these conservation sites facilitated assessments of socio-economic threats from mining and illicit crops. Conservation gaps and areas of high vulnerability were most common to the Andes region.

“Conservation is a state of harmony between men and land”.

Yet,

“We shall never achieve harmony with the land, anymore than we shall achieve absolute justice or liberty for people. In these higher aspirations the important thing is not to achieve but to strive.”

— Aldo Leopold —

Dedicated to my beloved parents, to my amazing husband and to my lovely son, who are indeed a treasure from life.

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1. Primates in Colombia: conservation needs and approaches

Primate research in Colombia has increased considerably over the last decade. However, the state of knowledge about primates remains insufficient to guide conservation actions with most research limited to only a few localities and species (Defler & Bueno 2010 and Stevenson et al. 2010). Likewise, there is still much uncertainty regarding the distribution of many primates in Colombia (Rodríguez-Mahecha et al. 2006). These data and knowledge gaps result in uninformed decision making with respect to protected area planning and more specifically conservation of primates. To address this shortfall, clarification of the geographic distribution of its primates in Colombia is required, followed by a rigorous evaluation of threats to habitats and species to target protection of particular forests and more specifically specific habitats to conserve imperilled species (Defler & Bueno 2010 and Stevenson et al. 2010). My study focuses on the conservation of primates in Colombia by addressing the following two questions: (1) where are new protected areas most needed for improving the representation of key habitats in Colombia's national park system? and (2) if conservation gaps are identified, which areas face higher levels of vulnerability/threat?

To further contextualize these objectives, this introductory chapter offers background information about the current state of protection for primates in Colombia, along with information on the national system of protected areas and the basic physical features of the country that make it environmentally and biologically diverse.

1.1 Colombia's natural regions and the protected areas system

Colombia is located at the northwestern part of South America between the latitudes 12°26'46" N and 4°13'30" S, and longitudes 66°50'54" E and 79°02'33" W (Armenteras et al. 2003) and organized into 32 administrative divisions or Departments. Colombia borders Panama and the Caribbean Sea to the north, Ecuador, Peru, and Brazil to the south, Venezuela to the east, and the Pacific Ocean to the west. Colombia together with these four South American countries share the Amazon rainforest region. Considered as one of the 17-megadiverse countries in the world (Mittermeier et al. 1998), Colombia is also one of the world's richest country in aquatic resources, containing large watersheds represented mainly by four large sub-continental basins comprising the Amazon, the Cauca, the Magdalena and the Orinoco rivers.

Total area of Colombia is 114,174,800 hectares with 30% of the continental mass comprising the Andean mountains that range between 500 and 5400 m of altitude with three main branches (west, central and east mountain range or “cordilleras”) that run across most of the country from south to north. The remaining parts of Colombia include plains of lowland savannah east of the Andes, lowland rainforests to the south and to the east (with the Baudó and Serranía del Darien mountains ranges in this area), and plains in the Caribbean coast to the north with the Sierra Nevada de Santa Marta mountain range. This mountain range in the north includes the Cristobal Colón peak at 5780 m, the highest elevation of the country. Additional highlands within Colombia include the Serranía de la Macarena along the east flank of the Andes, and plateaus and hills associated with the Guiana shield in the south and eastern parts of the country.

Given the complexity of Colombia’s geography, more than 311 types of ecosystems have been described (Hernández et al. 1992) with six natural regions recognized based on climatic, vegetation, soil, and physical features. These regions consist of one maritime area or the Insular region (Pacific and Caribbean islands), and five mainland regions that include the Amazon, Andean, Caribbean, Orinoco, and Pacific regions (Figure 1.1). The Amazon and Pacific (Choco Biogeographic) regions, comprise the largest portion of tropical rainforest and include the majority of indigenous and African descent communities. Because of its high biological diversity, vulnerability to human activities, and high rates of endemism, the Andean region represents one of the world’s top conservation priorities (Mittermeier et al. 1999). This region includes the Cauca and Magdalena river valleys, which are important regional water resources. The Cauca and Magdalena river valleys within the Caribbean region have dry forests, savannah, desert, and alluvial deposits. The Orinoco region includes vast areas of savannahs and gallery forests, and contains catchment areas of the Meta, Guaviare and Vichada rivers. Geographic sub-areas within each natural region have particular topographic, vegetational and hydrographic features. These sub-areas are used as place names to categorize the general locations of new conservation sites proposed in this thesis. Appendix A provides a map illustrating these sub-areas.

Different climates are also associated with the diverse geography of Colombia. Temperature (annual isotherms) and precipitation patterns associated with changes in elevation define different altitudinal thermic levels or “thermal floors”. These include: (1) hot lands (>24°C) between sea level and 1,000 meters; (2) temperate lands (18–24°C) between 1,000 and 2,000 meters; (3) cold lands (12–18°C) and sub-paramo (6–12°C) between 2,000 and 3,000 meters; (4) paramo (1.5–6°C) between 3,000 and 4,000 meters; and (5) perpetual snow (< 1.5°C) located above 4,000 meters (Hernández-Camacho & Defler 1988). Hot lands are associated with heavy annual rainfall, while temperate lands have moderate rainfall and temperatures. The term 'paramo' refers to treeless regions adjacent to the cold zone. The Köppen-Geiger climate classification provides a more detailed classification of climate zones for Colombia (Pell et al. 2007; Figure 1.2).

The National System of Protected Areas (SINAP for its acronym in Spanish) incorporates seven management categories with six categories of public nature and one private category known as natural reserves of civil society. The protected area categories for public nature include: (1) natural national park system; (2) protective forest reserves; (3) natural regional parks; (4) integrated management districts; (5) soil conservation districts; and (6) recreational areas (MAVDT 2010). The Natural National Parks System (SPNN for its acronym in Spanish) consists of 59 reserves composed of six different types including Natural Park, Natural Unique Area, National Natural Reserve, Fauna and Flora Sanctuary, and "Vía Parque" or on the way to become National Natural Park (MAVDT 2010). The SPNN protects ~13% of the country's terrestrial (12%) and maritime (1%) habitats of high conservation and cultural value. People of indigenous and African descent are present in 'cultural sites', in which alterations to ecosystems by human influences is considerably low (PNN-C 2015).

1.2 An overview of primate conservation in Colombia

Primates play a vital role in the maintenance and functioning of tropical ecosystems. For example, primates are seed dispersers and pollinators, as well as prey for large carnivores (Chapman & Chapman 1995, Wright & Jernnvall 1999 and Lovett & Marshall 2006). Primates are also important as seed dispersers in mitigating effects of climate change by maintaining forest cover that is critical for carbon sequestration (Bello et al. 2015). Nevertheless, habitat loss due to conversion of forests to agriculture and other activities threaten many species of primates (Chapman & Peres 2001). Indeed, at least 259 (60%) of the 530 known primate species in the world are listed as "Critically endangered (CR)", "Endangered (EN)" or "Vulnerable (VU)" primarily due to habitat loss (IUCN 2016). Given the current annual rate of loss of tropical forests at 13 million hectares (Laurence 2010), there is a strong global need for additional conservation policies.

Within Colombia, the state of primate conservation is worrisome. The International Union for the Conservation of Nature (IUCN, 2016) places 57% of species of primates in Colombia (17 species out of 30) at high levels of risk, and furthermore, Defler (2013) emphasizes extinction risk for over 53% of the 40 taxa of primates recognized by Defler (2010). However, the number of species and subspecies of primates included in the Colombian primate fauna varies depending on taxonomic classification, and so the percent of endangered species in the country varies depending on its source. For instance, the APC (2016) recognizes 35 species and 16 subspecies (45 taxa) of primates in Colombia. Two previously recognized subspecies of spider monkeys have been recently integrated into a monospecific taxon, *Ateles hybridus* (CR), while at the same time, the subspecies within *Callicebus torquatus* are now recognized as individual species, but under two new genera (*Cheracebus* and *Plecturocebus*) proposed by Byrne (2016). Lastly, the APC (2016) recognized *Aotus trivirgatus* (LC) as native to Colombia, although there is no confirmed report of its occurrence in the country. Thus, as long as taxonomic conflicts and uncertainties about the occurrence of species persist, the exact number of primate taxa within Colombia will be subject to debate.

Nonetheless, the fact remains that primates in Colombia are in jeopardy. Table 1.1 provides a complete description of the global and national status of threatened primates in Colombia as well as conservation needs for these species. About 80% of the Inter-Andean lowland rainforest, a vital habitat for the critically endangered brown spider monkey (*Ateles hybridus*), has disappeared in the last decade (Morales-Jimenez 2004). Under the current rate of land use conversion in Colombia, a significant number primates are at risk of extinction. This includes the endemic white-footed tamarin (*Saguinus leucopus*) and the varied white-fronted capuchin (*Cebus albifrons versicolor*), which are both categorized as endangered species (de la Torre et al. 2015c). In fact, 60% of the range of the white-footed tamarin has disappeared, and the species has been extirpated from some localities of its historical range (Roncancio et al. 2013).

Likewise, the newly described and critically endangered *Plecturocebus caquetensis* (Caqueta titi monkey) of the Amazon piedmont faces high levels of forest fragmentation. The piedmont area has the highest annual rate of primary forest loss (Armenteras et al. 2006) with only 28% of natural vegetation remaining as remnants. The Serranía La Macarena mountain range is among the most diverse ecosystems in Colombia. It is the confluence of Amazon, Andean, and Orinoco regions and has numerous endemic species, but the area also has high levels of land use transformation with only 68% of the original vegetation cover remaining (Armenteras et al. 2006). Primate species here include the critically endangered Colombian woolly monkey (*Lagothrix lagotricha lugens*), the endangered long-haired spider monkey (*Ateles belzebuth belzebuth*), the varied white-fronted capuchin (*Cebus albifrons versicolor*), and other vulnerable primates.

Another important biodiverse area is the Chocó Biogeographic rainforest in the Pacific region, it contains many endemic species, but retains only about 24% of its native vegetation. It is thus identified as one of the 25 global biodiversity hotspots for conservation (Myers et al. 2000). The area contains vulnerable populations of the south Pacific blackish howler monkey (*Alouatta palliata aequatorialis*) and the critically endangered Colombian black spider monkey (*Ateles fusciceps rufiventris*).

The main drivers of deforestation in Colombia are socio-economic with native habitats converted to agriculture, cattle ranching, mining, and colonization. The Andean, Inter-Andean, Pacific and Amazon regions are the most affected by lowland tropical forest clearing (Armenteras et al. 2003, Armenteras et al. 2006 and Etter et al. 2006), with some of these are regions having among the highest diversity of primates. Deforestation patterns vary from region to region due to dissimilarities on biophysical traits and accessibility that include differences in soil fertility, population density, rain frequency, distance to towns or to roads or even to rivers, which in the Amazon, for example, are the main modes of transportation (Etter et al. 2006). Etter et al. (2006) suggests that the Andean region is by far the most affected by forest clear-cutting (agricultural conversion mostly) with current hotspots of deforestation occurring in biodiverse enclaves of flora and fauna primarily in both the Pacific and Amazon piedmont regions. Rodríguez-Eraso et al. (2013) suggest that by 2050 up to 30% of the remaining natural areas in the Colombian Andes will be lost due primarily to land use conversion to pastures and agricultural use. This does not bode well for Colombian biodiversity and, in particular, for primates.

Illicit crops and decades of civil conflict have also affected land use dynamics in Colombia. Although cultivation of coca leaf has been an ancient custom for native groups, that consider it sacred, the flourishing traffic of cocaine in the 1980's, along with associated armed conflicts caused by the intensification of illicit crops by drug cartels, local guerillas, and paramilitary groups, had a catastrophic effect on rural/native people and the associated ecosystems. Indeed, Colombia has the highest rate of internally forced displacement of people in the world (UNHCR 2016), with numbers displaced estimated at 6.9 million people (Human Rights Watch 2015 and UNHCR 2016). The displacement of people is primarily due to illicit coca crops that have replaced rural and indigenous small-scale agricultural farming. This has led to the loss of adjacent natural forested areas with high rates of forest fragmentation (Alvarez 2003).

By the beginning of the 1990's coca crops covered 40,000 hectares (60% of these were intended for subsistence crops of less than two ha). Over the following decade there was an increase of 146,000 hectares of coca, spreading along isolated areas of peasant colonization, indigenous reserves, forest reserves, and buffer zones of national parks. The highest incidence of new coca crops was in the Orinoco and Amazon regions, areas of high biological and cultural value with coca leaf production accounting for 78.6% of the countries' total production (Diaz & Sanchez 2004). Despite a decrease in number of cultivated hectares of coca in Colombia by 2013 (89,215 ha in total) due to manual and aerial eradication, 16,334 hectares of forest were still clear-cut in that same year with 58% being primary forest (UNODC 2014). Illicit crops are therefore a major threat to natural ecosystems in Colombia and habitats for primates.

Similarly, mining activities, which are one of the pillars of Colombia's economy, have been recognized as one the main drivers of deforestation and water contamination (Nepstad et al. 2013). Although the total extent of forest loss due to mining is unknown, oil exploration/exploitation licenses account more than 19 million hectares (ANH 2016) of Colombia with mining titles totaling more than five million hectares (MME 2013) or 20% of the country. Low governance capacity in remote regions, which also contain areas of high biodiversity like the Amazon, Orinoco and Pacific regions, increases the chance of both legal and illegal mining operations even in areas where economic development is prohibited – e.g., Forest reserves (Nepstad et al. 2013). The situation has recently worsened with declaration by the national government of strategic areas for mining in the Amazon and the Choco Biogeographic regions. Indeed, illegal mining now accounts for ~80% of gold production in Colombia (MADS 2014).

Mountain and dry forests in the Andean and Caribbean region have been the most affected by mineral exploitation (Davalos 2001 and Saenz et al. 2013). This has negatively affected the endemic and critically endangered cotton-top tamarin (*Saguinus oedipus*) with a 30% decrease in suitable habitat (Miller et al. 2004), as well as threatening other vulnerable populations of primates such the grey-handed night monkey (*Aotus griseimembra*).

Other threats to primates in Colombia include subsistence hunting and illegal traffic of primates, especially for larger primates including the howler and spider monkeys (Hernández-Camacho & Defler 1985, Palacios & Peres 2005 and Defler 2013,). Bush meat from primates is common in the Amazon and Pacific regions where it is an important part of the culture of indigenous and communities of African descent. Indeed, densities of large primates have decreased considerably within some national parks and indigenous reserves due to hunting (Ulloa et al. 1996, Palacios & Peres 2005, Castillo-Ayala & Palacios 2007 and Defler 2013). In some cases, this has led to local extirpation of species, including the endangered longhaired spider monkey (*A.s b. belzebuth*) in the Amazon region (Boubli et al. 2008). Although larger primates are most often hunted, smaller primates are sometimes also hunted, as is the case of the endangered varied white-fronted capuchin (de la Torre et al. 2015c), but usually these smaller species are poached for the pet trade (Defler 2013) or biomedical investigation (Maldonado et al. 2009, Defler & Bueno 2010 and Maldonado & Peck 2014). In some cases, other primates are killed because they are considered as crop pests (de la Torre et al. 2015c and Castillo-Ayala C. pers. obs).

1.3 State of knowledge of primates in Colombia

Despite recent research, there are significant gaps in knowledge about the distribution and the status of primate populations in Colombia. In particular, there is scarcity of basic biological and natural history information for endemic taxa (Stevenson et al. 2010), as well as a general deficiency in peer-reviewed publications. In addition, field research on primates in Colombia presently comprises only few localities due to lack of access or security (threats) from civil conflict.

Red howler monkeys (*Alouatta seniculus seniculus*), brown spider monkeys, tufted capuchin (*Cebus apella fatuellus*) and woolly monkeys are among the species for which research has been most active. However, basic biological data is especially scarce for the critically endangered

Colombian black spider monkey (*Ateles fusciceps rufiventris*) and the white-footed tamarin (Defler 2010 and Defler 2013). The status of species within highly threatened areas is also quite vague, such as for the Río Cesar white-fronted capuchin (*Cebus albifrons cesarae*) and the endemic Brumback's night monkey (*Aotus brumbacki*) (Defler 2013). Nevertheless, establishment of conservation programs for the endemic cotton-top tamarin (*Saguinus oedipus*) and the brown spider monkey (*A. hybridus hybridus*) (Link et al. 2013 and Savage& Causado 2014) have improved our knowledge of the biology and habitat requirements for these critically endangered species.

Although the distribution of primates has recently been reviewed at regional and national scales (Rodríguez-M et al. 2006 and IUCN 2016), species distribution maps are generally quite coarse in scale (resolution/grain size), especially given the level of analysis (i.e., range maps instead of occurrences). Assessment of the effectiveness of currently protected areas requires consistent information about the distribution of species. Species (environmental) niche models provide an alternative approach to identifying environments, habitats, and sites where suitable primate habitat occurs. Thus far, however, Colombian primate species for which there are niche models include spider monkeys (Morales-Jimenez 2004, Burbano-Giron 2013, Link et al. 2013 and Rodríguez-Bolaños et al. 2013), woolly monkeys (Burbano-Giron 2013 and Rodríguez-Bolaños et al. 2013) and the white-footed tamarin (Roncancio et al. 2013). The present study therefore represents a valuable contribution to clarifying the distributional range, via niche analyses, for most primate taxa in Colombia and an analysis of conservation gaps related to the existing reserve network.

1.4 Global/National status and conservation needs for species of primates in Colombia

There are discrepancies about the conservation status for 35% of the 45 taxa listed for Colombia. Three taxa (i.e., *Cebus capucinus curtus*, *Pithecia hirsuta*, and *A. s. seniculus*), for example, are not listed by the IUCN (2016), while a national conservation status is still needed for three other taxa (i.e., *Cebus capucinus curtus*, *Aotus jorgehernandezi*, and *Aotus nancymae*). The Hernández-Camacho night monkey (*A. jorgehernandezi*) and the Rio Caqueta white-fronted capuchin are considered data deficient at the global level. However, in the national conservation status, assessment of the latter has changed from Near Threatened (NT) to Endangered (EN) (Defler 2013).

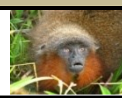
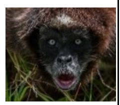
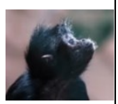
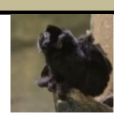
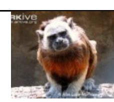
At least five primate species are considered endemic to Colombia: *Aotus brumbacki*, *Saguinus leucopus*, *Saguinus oedipus*, *Plecturocebus ornatus* and *Plecturocebus caquetensis*. Six additional taxa have their distributions restricted to Colombia (see Table 1.1). The Colombian black spider monkey (*Ateles f. rufiventris*) is the only taxon recognized as endangered in Colombia, three more species (the two subspecies of *Ateles hybridus* and the Caqueta titi monkey) are critically endangered, and 14 taxa considered vulnerable. In addition, at least two taxa are not protected under any category of the National Park System (*Leontocebus nigricolis graellsi* (NT) and the Red titi monkey *Plectorucebus discolor* (VU)).

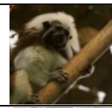
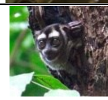
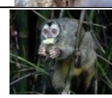
1.5 Thesis scope and goals

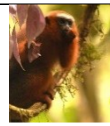
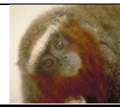
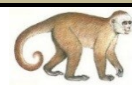
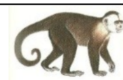
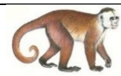
As a result of my review and experience in Colombia, the objectives of this thesis are threefold as follows: 1) model relative probability of occurrence for each species / subspecies to address uncertainties in species distributions of primates in Colombia, 2) prioritize new conservation sites of high irreplaceability to achieve the Aichi Biodiversity Target 11 of 17% terrestrial protection, and 3) assess vulnerability of areas of high irreplaceability as they relate to relevant socio-economic pressures (current and future threats). The information derived from this study is relevant to addressing basic biogeographic information about primates of Colombia and requirements for their conservation. The thesis comprises a single analytical chapter that includes both the niche/distribution models of Primates in Colombia and a prioritization analysis that ranks value of sites for future protection based on existing conservation gaps for these same primates. A final section of the thesis summarizes the implications of my findings, discusses its limitations, and offers some recommendations to improve conservation decision making in Colombia.

1.6 Tables

Table 1.1 National conservation status of primates in Colombia that are at risk as listed by Rodríguez-M et al. (2006) with annotations on conservation needs. Each group (a) correspond to **National** conservation status based on the IUCN Red List Categories: CR= Critically Endangered; EN= Endangered; VU= Vulnerable; NT= Near Threatened; LC= Least Concern; DD= Data Deficient. Information on each species includes (b) **Global** status by IUCN 2015, and suggested conservation needs (Rodríguez-M et al. 2006 and IUCN 2015). Protection requirements for the species *Callicebus caquetensis* and *Callicebus torquatus medemi* (c) were adapted from Defler et al. (2010) and García et al. (2010).

Critically Endangered (CR)[a]		
Plectorucebus caquetensis (Caquetá Tití Monkey) CR[b]		Remarks: severe habitat fragmentation, small area of occurrence and population in high risk of decline. Conservation needs: clarify distribution (range) and design protected areas.[c] **Photo credit:** ©Thomas Defler (Arkive.org)
Ateles hybridus bruneus (Brown spider monkey CR[b]		Remarks: population trend decreasing. Habitat greatly fragmented. Land conversion for agriculture, hunting, and colonization recognized as main threats Conservation needs: identify and evaluate local populations, even within protected areas. **Photo credit:** ©Wilfredorrh2012 (flickr.com)
Ateles hybridus (Variegated spider monkey) CR[b]		Remarks: due to habitat loss and hunting, population has decreased by 80% over the past 45 years (three generations) and acuteness of threats in its distribution is the norm. Conservation needs: studies on the ecology and population dynamics are still required. **Photo credit:** ©Diana Liz Duque Sandoval (Arkive.org)
Endangered (EN)[a]		
Ateles fusciceps rufiventris (Colombian black spider monkey) CR[b]		Remarks: hunting and exploitation of forest for timber are its main threat. Large portions of suitable habitat have disappeared. Restricted access to areas of occurrence due to the presence of illegal army forces. Conservation needs: evaluate the status of the population, and establish conservation programs. **Photo credit:** ©Steve Wilson (flickr.com)
Vulnerable (VU)[a]		
Callimico goeldii (Goeldi's Monkey) VU[b] / Appendix I CITES		Remarks: rare. Conservation needs: generate information on occurrences and assess population status (long-term studies). Design conservation programs in protected areas or in potential new reserve areas. Control trade and hunting. **Photo credit:** ©Jaime Pinzon
Saguinus leucopus (White-footed Tamarin) EN[b] / Appendix I CITES		Remarks: **endemic**. Under-protected habitat highly threatened by human colonization. Conservation needs: establishment new reserves to improve protection. **Photo credit:** ©Alba Lucia Morales Jimenez (Arkve.org)

Saguinus oedipus (Cotton-top Tamarin) CR[b] / Appendix I CITES		Remarks: **endemic.** Part of one of the most solid conservation programs in the country. Conservation needs: deficiencies on protecting key habitats. **Photo credit:** ©Jaime Pinzon
Aotus brumbacki (Brumback's night monkey) VU[b] / Appendix II CITES		Remarks: **endemic**. Current area of occurrence with high amounts of human disturbance (cattle and agriculture). Conservation needs: address major information gaps on its distribution (range). Protect riparian forest. **Photo credit**: ©filin.vn.ua
Aotus griseimembra (Grey-handed night monkey) VU[b] / Appendix II CITES.		Remarks: scarce, status of the population is unknown. Forest loss is a major threat. Conservation needs: censuses and establishment of protected areas. Regulate and control the use of the species in biomedical studies. Monitor population and design appropriate conservation strategies. **Photo credit:** ©Papiliorama Foundation (Arkive.org)
Aotus lemurinus (Colombian night monkey) VU[b] / Appendix II CITES		Remarks: status of population is unknown. Habitat highly threatened by human colonization. Conservation needs: assess population status and establish protected areas. **Photo credit:** www.npr.org
Aotus zonalis (Panamanian night monkey) DD[b] / Appendix II CITES		Remarks: less than 10% of suitable habitat. Status of population is unknown. Conservation needs: identify populations and establish protected areas. Monitor populations and design appropriate conservation strategies. **Photo credit:** © Joe McKenna (flickr.com)
Lagothrix lagotricha lugens (Colombian woolly monkey) CR[b] / Appendix II CITES		Remarks: hunting and habitat loss as a major threat. Distribution along the Andes where human disturbance is high. Conservation needs: establish new areas to protect relict populations. Identify more relict populations. Develop and implement monitoring programs and reinforce protection laws. Create education programs. **Photo credit:** ©Sergio Vargas (Arkive.org)
Alouatta palliata aequatorialis (South Pacific blackish howler monkey) VU[b] / Appendix I CITES		Remarks: wide distribution across Central and South America. Considered vulnerable in Colombia due to rapid decline in its populations. Conservation needs: present in National Parks. However, threats need evaluation. **Photo credit:** ©costarica-nature.org
Ateles belzebuth (Long-haired spider monkey) EN[b]		Remarks: habitat loss (deforestation) and hunting (population decreasing) is of primary concern. Distribution (range) in areas of high colonization. Conservation needs: population assessments are needed and a need to resolve doubts on its occurrence in the eastern portion of the Andes mountain range (Amazonia foothills). **Photo credit**: ©Miguel Rangel jr. 2011
Pithecia milleri (Miller's saki) DD[b]		Remarks: distribution (range) occurs in areas of high threats due to human colonization. Habitat loss and rapid population declines. Conservation needs: confirm the presence of the species in legally protected areas. Define the eastern limit of its distribution to determine effectiveness of protection. **Photo credit:** Planetofmonkeys.com
Cheracebus medemi (Colombian Black-handed titi) VU[b] / Appendix II CITES		Remarks: habitat loss due to timber harvesting of uncontrolled slash-and-burn agriculture and ranching. Conservation needs: assess status of population. Occurs in one National Park but there is the need of new protected areas.[c] **Photo credit:** © 2005 Finding Species Inc.

Plectorucebus discolor (Red titi monkey) LC[b]		Remarks: small distribution (range) in the country, detrimental effect on suitable habitat because of fumigation actions to eradicate illicit crops. Conservation needs: population assessments, vulnerability assessments and areas legally protected within its range in Colombia. **Photo credit:** ©Chris Schmitt 2007
Plectorucebus ornatus (Ornate tití monkey) VU[b] / Appendix II CITES		Remarks: **endemic**. Severe habitat fragmentation, small area of occurrence and population in rapid decline. Conservation needs: Clarify distribution (range). **Photo credit:** ©Gustl Anzenberger (Primate Info net)
Near Threatened (NT)[a]		
Cebus albifrons cesarae (Río Cesar White-fronted Capuchin) EN[b]		Remarks: hunting and habitat loss are major threats. Conservation needs: occurs in National Natural Parks. Evaluate conservation status of populations and identify potential threats. **Photo credit:** ©Margarita Nieto (Defler 2010)
Cebus albifrons malitiosus (Santa Marta White-fronted Capuchin) EN[b]		Remarks: hunting and habitat loss are major threats. Conservation needs: occurs in National Natural Parks. Evaluate conservation status of populations and identify potential threats. **Photo credit:** ©Margarita Nieto (Defler 2010)
Cebus albifrons versicolor (Varied White-fronted Capuchin) EN[b]		Remarks: hunting and habitat loss are major threats. Conservation needs: occurs in National Natural Parks. Evaluate conservation status of populations and identify potential threats. **Photo credit:** ©Margarita Nieto (Defler 2010)
Lagothrix lagotricha (Humboldt's Woolly Monkey) VU[b] / Appendix II CITES		Remarks: Hunting is a major threat. Conservation needs: identify potential threats. Design adequate conservation policies. **Photo credit:** ©Lucy Molleson/IPPL (Arkive.org)
Cacajao ouakary (Golden-backed Black Uakari) LC[b] / Appendix I CITES		Remarks: Subsistence hunting and population under rapid decline are major threats. Conservation needs: present in some Natural Parks, but the extension of its occurrence in these areas is undefined. Determine the distribution (range) and apply conservation strategies. **Photo credit:** ©Luis Claudio Marigo (Primate Info Net)

1.7 Figures

Figure 1.1 Natural regions of Colombia.

Adapted from: http://geoportal.igac.gov.co/mapas_de_colombia/IGAC/Tematicos2012/RegionesGeograficas.pdf

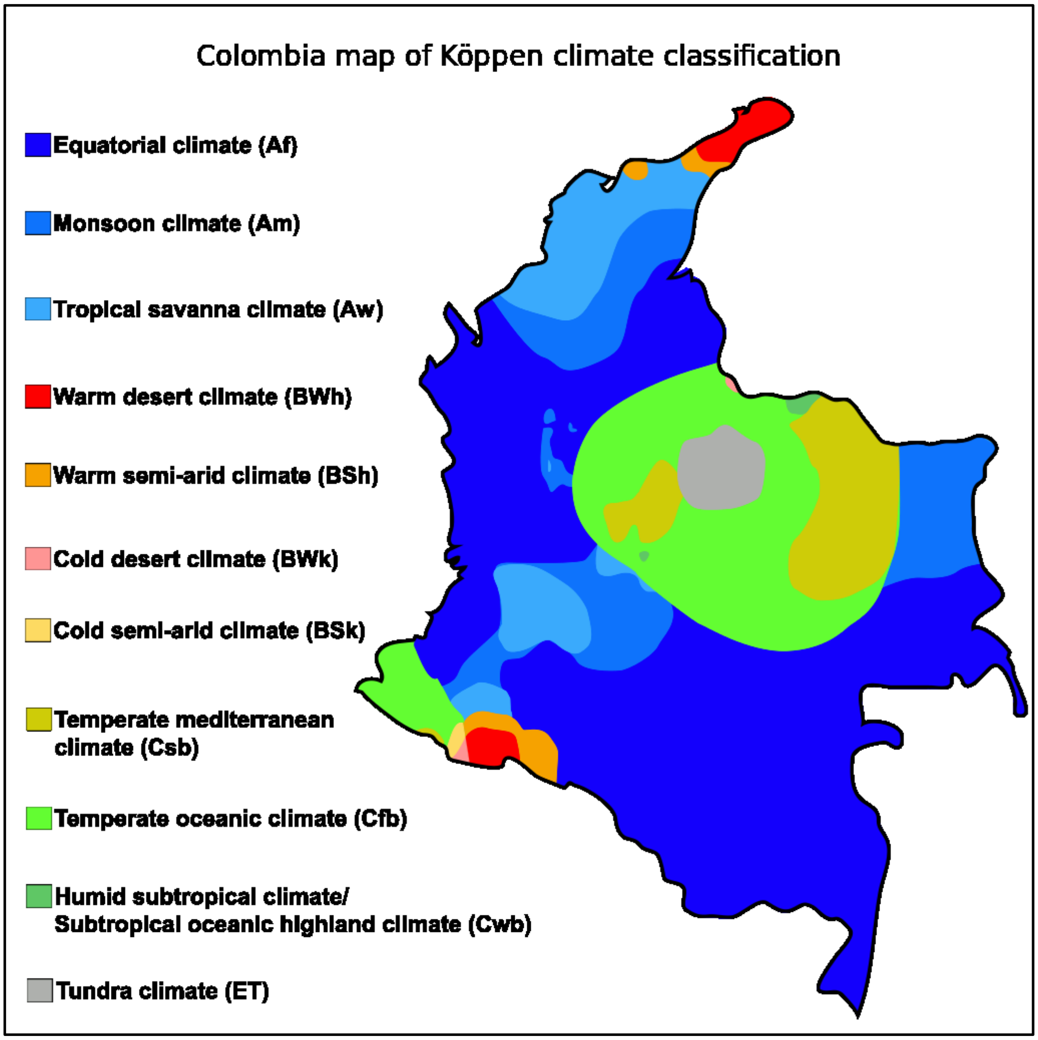


Figure 1.2 Climate zones in Colombia adapted from Pell et al. (2007). https://commons.wikimedia.org/wiki/File:World_Koppen_Classification_(with_authors).svg

2. Prioritizing conservation areas for primates in Colombia

2.1 Introduction

Colombia is a tropical country that contains one of the most diverse assemblages of primates in the world consisting of ~30 species and 25 subspecies (Grooves 2005 and Defler 2010). However, most species (18 or 53% of all recognize species) are considered threatened (Defler 2013) with two species recognized as critically endangered, one species endangered, 14 species vulnerable, and six species near threatened (Rodríguez-Mahecha et al. 2006). Some of these species, however, have different global conservation status using the IUCN categories (IUCN 2016, Table 2.1). The rate of habitat loss and alterations to primate habitats has accelerated in Colombia over the past few decades due to human population growth and land use and land cover conversion (Miller et al. 2004, Etter et al. 2011 and Rodríguez Eraso et al. 2013). In addition, there are substantial knowledge gaps on about the status of subspecies, and uncertainty remains about ranges/distribution for many species (Defler 2010). This limits the identification of effective national conservation priorities for primates in Colombia.

Establishment and management of protected areas has been one of the most valuable strategies to address conservation shortfalls, given its clear potential to safeguard species through assuring the continuity of ecosystems (Cowlishaw & Dunbar 2000). In the case of Colombia, the National System of Protected Areas ("Sistema Nacional de Áreas Protegida", SINAP is its acronym in Spanish) incorporates seven management categories to be administered in alliance with governmental, non-governmental, public and private sectors depending on the nature of the protected area (MAVDT 2010). Across these categories, the Natural National Parks System ("Sistema the Parques Nacionales Naturales de Colombia", SPNN for its acronym in Spanish) consists of 59 parks protecting 13% of the country's terrestrial and maritime habitats (PNN-C 2015) within areas of high conservation and cultural value that have been little altered by human activities.

Nonetheless, there are significant conservation gaps that include some ecosystems of high biodiversity value (Conpes 2010, Forero-Medina & Joppa 2010). In fact, under the Natural National Parks System, terrestrial protected areas in Colombia represent only 11.27% (12,877,086 ha) of the country's territory (PNN-C 2015), which is a 5.73% (6,532,629 ha) shortfall relative to the Aichi Biodiversity Target 11 on safeguarding 17% of terrestrial habitats by 2020 (Convention on Biological Diversity, 2010). Moreover, Corzo (2008) identified protection shortfalls for important biomes, including those with high restoration potential. Thus, key habitats remain underrepresented or even unprotected within the protected area system thereby increasing the level of vulnerability for threatened primate species (Rodríguez-Mahecha et al. 2006 and Stevenson et al. 2010). In particular, existing analyses of conservation gaps for primates in Colombia suggest a shortfall in protection for woolly monkeys (Rodríguez-Bolaños et al. 2013), spider monkeys (Morales-Jimenez 2004, Link et al. 2013 and Rodríguez-Bolaños et al. 2013), and the White-footed tamarin (*Saguinus leucopus*) (Roncancio et al. 2013). However, there is little information available to identify suitable habitats for these and other primates, as is required to prioritize areas for further protection.

The main goal of this study was to identify conservation gaps for primates in Colombia and prioritize new protected areas to improve representativeness of key habitats in the country's national park system. Specifically, I had three objectives: 1) develop environmental niche models for species and subspecies of primates in Colombia in order to address uncertainties in the distribution of many species, 2) prioritize new conservation sites based on primate distributions in a way that achieves the Aichi Biodiversity Target 11 of 17% protection, and 3) identify areas of high vulnerability (current and future threats) relative to high primate biodiversity value. To do this, I first used a combination of environmental niche (species distribution) modeling for primates of Colombia to map suitable primate habitat using the MaxEnt software (Phillips et al. 2011), and then ranked irreplaceability of sites for future protected areas using Zonation software (Moilanen et al. 2014). Finally, I prioritized the irreplaceability values from Zonation by relating them to a vulnerability ranking of human threats based on the occurrence of major socio-economic threats in Colombia. This identified where conservation actions should be focused first.

2.2 Methods

2.2.1 *Study Area*

Colombia is situated at the northwestern part of South America between the latitudes 12°26'46" N and 4°13'30" S, and longitudes 66°50'54" E and 79°02'33" W (Armenteras et al. 2003; Figure 2.1). Total area of Colombia is 114,174,800 hectares containing five major ecosystems known as "natural regions". This includes the Andes Mountains with the diverging by the valleys of the Magdalena and Cauca rivers cutting the three main mountain ranges of western, central and eastern cordilleras, the Pacific Ocean coastal, the Atlantic coastal, the Orinoco (plains) and the Amazon regions. These natural regions vary widely in climate, habitats, and species, leading to the Colombia flora and fauna being among the richest and most diverse in the Neotropic region (Hernández-Camacho & Cooper, 1976), and indeed, the world (http://rainforests.mongabay.com/03highest_biodiversity.htm).

2.2.2 *Primate species occurrences*

I considered 39 primate taxa (19 species and 20 subspecies) with occurrence records in Colombia (Table 2.1). This taxonomy follows the arrangement used by Defler (2010), as well as the new categorization for genera in the subfamilies Callicebinae and Callitrichinae by Byrne (2016) and Buckner et al. (2015), respectively, and the new classification by Marsh (2014) for the genus *Pithecia*. My analysis was restricted to species with five locality records in Colombia so as to facilitate environmental niche modeling (Table 2.1). Although it is preferable to have a larger number of occurrence records (e.g., 10 to 50) to obtain more accurate distribution patterns (Peterson 2001, Stockell & Peterson 2002 and Pearson et al. 2007), Environmental Niche Models (ENM) using MaxEnt have demonstrated that 5 is a minimum sample size (Hernández et al. 2006, Pearson et al. 2007 and Hernández et al. 2008).

Occurrence records for each species were collected from the Ara Colombia species database (Rodríguez-Mahecha et al. 2013) from Conservation International Colombia, that included more than 8,000 georeferenced records from species occurrence records across the country, museum specimens and Thomas Defler (personal data base). All duplicate records, records outside of known species ranges, or with partial geographic coordinates, were discarded. Additional sources of primate records included peer reviewed literature, databases with historical occurrences of species from museum records (Appendix B) and my own personal observations made in the Amazon region and gallery forests of the Bita river (Orinoco region). Data were organized into a database that contained information on sources, specimens, and observers/collectors (Appendix C). In total, this included more than 1,800 records with geographic coordinates individually checked to establish reliability. The final list of geographic locations of primates used for environmental niche modeling included 1,476 occurrences from 19 species and 20 subspecies with each species having at least five location records that were considered independent of one another (different sites), based on place names or geomorphological units. For new taxonomic changes within the genus *Pithecia*, older subspecies occurrence records were adjusted to geographic distributions of new species as suggested by Marsh (2014).

2.2.3 *Environmental predictors of primate habitat*

Thirty-one environmental predictors were considered in building Environmental Niche Models (ENMs) for each primate species and subspecies. I grouped environmental predictors into the following four major themes: (1) climate, (2) vegetation indices, (3) soils, and (4) physical features (Appendix D). Climatic factors included 19 potential variables based on 'current' climate conditions of precipitation and temperature using interpolations of observed data from 1950 to 2000 (Hijmans et al. 2005 and WorldClim 2015). Vegetation indices include average available amount of biomass (Net Primary Productivity - NPP) for 2010 (UNEP 2015), forest canopy height mapped from Lidar-derived satellite data for the year 2005 (Simard et al. 2011), and percentage of tree cover (PTC) derived from the MODIS sensor of Terra at 30 arc-seconds resolution (ISCGM 2003). Soil factors were based on 6 different soil quality indicators (Trabucco & Zomer 2010, ISRIC 2013 and Hengl et al. 2014), while physical and terrain factors were based on four different variables representing a digital elevation model (DEM) created using 1 arc-second (30m) ASTER data (LP DAAC 2001) and three categorical variables (land cover, biomes and watersheds) based on data from the geographic viewer SIG-OT (2009). Detailed information about variables, resolution, and acquisition sources are described further in Appendix D. All environmental raster layers were masked to the extent of Colombia and resampled to a common resolution of one-kilometer cell size (ArcGIS 10.2.2, ESRI 2013) using the official reference system of Colombia of a GAUSS_BTA_MAGNA coordinate system with a D-CGS-SIRGAS Datum (IGAC 2004).

I used Pearson's correlation analysis in R software v.3.2.0 (R Core Team 2015) to assess variable and model collinearity, using 100,000 locations (raster cells) randomly selected within Colombia. A correlation coefficient equal or higher to $|0.7|$ was considered indicative of a strong co-linear relationship for any pair of variables, and I subsequently excluded one of the variables (Naoki et al. 2006, Giovanelli et al. 2010, Hegel et al. 2010 and Zhang & Zhang 2012). Elevation, for example, was negatively correlated with annual mean temperature-BIO1 (r = -

0.96), isothermality-BIO3 was correlated with temperature seasonality-BIO4 (r = -0.79), annual precipitation-BIO12 was correlated with soil pH (r = -0.77), and temperature mean diurnal range-BIO2 was correlated to temperature annual range-BIO7 (r = 0.75). Correlation values among all continuous environmental variables are presented in Appendix E.

Considering the variation of thermogradients due to local changes in altitude (Hernández-Camacho & Defler 1988), along with a strong relationship between elevation and habitat heterogeneity and the effect of altitude on the distribution and patterns of adaptability exhibited by species of primates (Hernández-Camacho & Defler 1988 and Shanee et al. 2014), elevation was chosen as a predictor variable over that of annual mean temperature (BIO1). Likewise, pH, temperature seasonality, and temperature annual range were selected over the other strongly correlated variables. To minimize the number of remaining climate variables, all "extreme or limiting environmental factors" (e.g., temperature of the coldest and warmest month), as defined in the WorldClim database (www.worldclim.org/bioclim), were removed (Appendix D). This resulted in three final climatic variables: temperature seasonality (BIO4), temperature annual range (BIO7) and precipitation seasonality (BIO 15). The final number of candidate environmental variables used in ENMs was therefore reduced from 31 to 16 final variables (Table 2.2).

2.2.4 *Environmental Niche Models (ENMs)*

Due to the presence-only nature of the data available for this study, Maximum Entropy software (MaxEnt; Phillips et al. 2011) was used to model relative probability of species occurrence (e.g., habitat suitability). MaxEnt is a statistical algorithm that models probable occurrences of species by estimating the density of environmental variables on which a particular species depends (Franklin 2010). Furthermore, MaxEnt allows interactive associations between continuous and categorical features in the generation of probability distributions, even with a low number of training locations (Phillips et al 2006). To avoid overfitting, only linear and quadratic features were considered when the number of presence records was below 50 (Elith et al. 2011), while the "product" option (interactions) was tested for species with more than 50 localities to allow fitting of simple interactions (Elith et al. 2011). Similarly, the random test percentage for cross-validation was set as zero when the number of locations per species (or subspecies) locations was <30, while set to a 20% test percentage for taxa with ≥30 occurrences. In each MaxEnt run, a backwards model selection was use to reduce model complexity, by identifying and removing variables that contributed <1% to the explained distribution of the species, while the Jackknife method was used to evaluate importance of remaining variables (Phillips 2010).

To assess model fit and predictive performance, environmental variables were combined into 39 different models (Appendix F). Given the number of variables used in the models and the low number of presence records for most taxa, this initial set of 39 models was used in MaxEnt runs for only the most prevalent taxa (nine taxa with >50 locations). Model predictive performance was evaluated first by assessing the modeled distributions against known geographic range maps of each species and secondly by exploring differences in the model AUC (Area Under the Curve from the Receiver Operating Characteristic ROC). AUC values >0.9 indicated strong predictive power (Hanley & McNeil 1982 and Swets 1988), values between 0.7 to and 0.9 moderate performance, and poor model performance for values <0.7 (Willey et al. 2003, Elith et al. 2006 and Fawcett 2006). Out of 39 models assessed, only seven models with the best performance were selected (see Appendix I) and used in MaxEnt runs for all the remaining taxa with <50 total occurrences (geographic locations).

The single best predictive model was then designated for each of the 39 primate taxa (see models highlighted in red in Appendix I.a). In addition to spatial comparisons, model selection and accuracy were assessed by the use of the logistic threshold at "Equal training sensitivity and specificity", with corresponding training omission rates, and the fractional predicted area. More parsimonious models accounted for lower fractional predicted area and reduced omission errors (Franklin 2010). Plots depicting the variation of sensitivity (1 - omission rate) and predicted area (1 - specificity) in relation with the cumulative threshold, and AUC values were also used to assess the predictive power of the models (e.g., Fawcet 2006, Hernández et al. 2006, Lobo et al. 2008 and Zhang & Zhang 2012).

2.2.5 *Conservation Planning*

Two different cell removal rules of Core-Area Zonation (CAZ) and the Additive Benefit Function (ABF) were used to run conservation planning scenarios in the Zonation software (v.4.0, Moilanen et al. 2014). All scenarios considered existing protected areas as "locked in" with hierarchical models ranked in terms of local occurrence of species (Moilanen 2007, Lehtomaki & Moilanen 2013 and Moilanen et al. 2014) and solutions that would most improve the representation of suitable habitats for modelled primates. New conservation sites were therefore ranked based on distribution patterns of species relative to the current protected area network. The Core-Area Zonation (CAZ) cell removal rule emphasized high suitability for a single or rare biodiversity features in terms of high probability of occurrence, while the Additive Benefit Function (ABF) cell removal rule prioritized sites based on species richness, giving more importance to biodiversity rich locations.

Species were weighted in all scenarios in terms of their national conservation status (Rodríguez-Mahecha et al. 2006) with cells having higher weights removed last. Species weights were assigned as follows: five point five (5.5) for endemic species considered Critically Endangered (CR) or Endangered (EN), five (5) for CR and EN species, four point five (4.5) for vulnerable (VU) and endemic, four (4) for VU species, three point five (3.5) for endemic species Near Threatened (NT), three (3) for those considered as NT, two point five (2.5) for the Least Concern (LC) but endemic, two (2) for LC, and finally one (1) for species that were Data Deficient (DD).

Analyses were restricted (masked) to terrestrial (non-aquatic) forested habitats of Colombia by using a binary ASCII derived from 1 km rasters of land cover (IGAC 2007b) and the current National Natural Park System (PNN-C 2014) clipped to the extent of Colombia's mainland. The land cover raster was reclassified as one (1) for natural (primary) and secondary forest and zero (0) for water systems, rocky outcrops, pastures, crops and disturbed areas. This binary mask was used as an "Analysis area mask" in Zonation (Moilanen et al. 2014) to omit areas that were unlikely to contain significant primate habitat. Although pastures can have patches of woodlands and stubble fields that are potentially used by some species, such as tamarin and titi monkeys, this land cover unit was not considered here because the majority of its extent is represented by herbaceous fields intended for livestock (IGAC 2007b).

Similarly, the reclassify tool in ArcGIS was used to create a binary protected areas raster where one (1) related to protected areas (SPNN) and zero (0) unprotected areas. This raster was converted to an ASCII file and used as the "Hierarchical Removal Mask" (Moilanen et al. 2014) to "lock in" the inclusion of existing conservation areas in the analysis (Lehtomäki et al. 2009).

Finally, full Zonation ranks that identified the biologically most valuable and least valuable areas for each of the cell removal rules (Appendix G) were adjusted to identify the most valuable 17, 22 and 27% of landscape to protect. Thus, zonation ranking for each scenario was compared using three different conservation thresholds at 17% (11,789,398 ha), 22% (15,256,868 ha) and 27% (18,724,338 ha) of masked forested areas in Colombia. The logic of having conservation targets greater than the 17% threshold was to allow for subsequent connectivity assessments, as well as providing more options for conservation sites based on different socio-economic threats. For instance, the potential for conservation threats at some sites could require alternative sites. Geographical locations of prioritized conservation sites were identified via the online Geoportal from the Institute Agustin Codazzi (IGAC 2015), Google Earth, and Tremarctos Colombia (Rodríguez-Mahecha 2015).

2.2.6 *Vulnerability Analysis*

A vulnerability analysis was used to identify areas of threat relative to areas of high conservation value (i.e., irreplaceability). More specifically, priority ranks derived from Zonation analyses at different protection targets were overlaid with existing mining rights (INGEOMINAS 2012), oil concessions (ANH 2016), and density of illicit crops (UNODC 2014). Mining rights refers to current mining titles that grant the right to explore, exploit and ultimately extract relevant minerals (MME 2003), while oil concessions related to areas of exploration, production, reserve (in standby due to political, environmental, social or exploratory factors), and technical evaluation (TEA) for assessing potential hydrocarbon development (ANH 2015).

To consider both conservation value and future threats, an irreplaceability-vulnerability ranking was used to identify sites of both high conservation value and high levels of risk given the magnitude of threats (Margules & Pressey 2000 and Lawler et al. 2003). Thus, a two-dimensional vulnerability matrix (Margules & Pressey 2000) was used to pair the Zonation rank (conservation values) with the percent of threats relative to local human influence in order to identify sites of high vulnerability (high threat and high biodiversity value, Priority #1) and high biodiversity (Priority #2) (see Figure 2.2 for a schematic diagram).

Human influence was defined as the Human Footprint Index (HFP) where 1% represented the least influenced (“wildest”). The HFP index was derived from global data from 1995 to 2005 and accounted for population density ("human population pressure"), land cover/use, urban areas and night time lights ("human land use and infrastructure"), and "human access" (shorelines, road and rail network, navigable and waterways) at a 1 km raster scale (WCS & CIESIN 2005).

To derive the two-dimensional vulnerability matrix, zonation prioritization ranks for each of the two removal cell rules and the HFP index were reclassified for each into seven categories based on the percentage of conservation/threat value at a site (Appendix H). For both the Zonation and HFP index a minimum value of zero was given to low ranked values (≤1), below average HFP for 1-25, moderate HFP rank for 26-50, high and very high HFP for 51-75 and 76-99 respectively, and finally the top priority/threat at 100% biological/HFP value.

2.3 Results

2.3.1 *Environmental Niche Models for primates of Colombia*

The total of 1476 occurrences used to model habitat suitability for primates in Colombia gave an average of 37 locations per species (minimum of 7 and maximum of 266). Considering the 39 taxa modeled, four taxa (three species/one subspecies) had less than 10 location records, 19 (9 species/10 subspecies) ranged from 10 to 29 locations, six taxa (one species/five subspecies) between 30 to 50 locations, and ten taxa (five species/5 subspecies) with more than 50 locations (Table 2.1).

Out of the 39 preliminary models, seven models were considered reliable (Table 2.3). In general, all models involving soil variables were rejected since they appeared to over-predict species distributions (modeled probability of occurrence was always much larger than known range maps). With the removal of soil variables, the number of missing/omitted environmental data decreased, while the number of sites for training (data used to fit the model) increased. Similarly, models that included Net Primary Productivity (NPP) also over-predicted species distributions (wider than known range maps) and these were therefore removed. Among the set of selected models (Table 2.3), only two combinations of variables – vegetation and climate – were consistently selected as important. Predictive performance of the models ranged from moderate at an AUC = 0.764 for *Alouatta seniculus seniculus* to high at an AUC = 0.999 for *Leontocebus nigricollis*. Average AUC among species was impressively high at 0.948 (Appendix Ia).

The best-fit models to known range maps for 12 species with <10 locations were based on models that included all climate and physical variables (Model E). The next best fits, respectively, were for eight species using all climate variables, elevation, land cover, and watershed (Model C), seven species using the three physical variables (Model F), and six species using model climate, biomes, elevation, and watershed variables (Model D) (Table 2.3 & 2.4). In contrast, models that include vegetation variables (Models B & G), were the most parsimonious combinations for the Spix's night monkey (*Aotus vociferans*) and the South Pacific blackish howler monkey (*Alouatta palliata aequatorialis*) respectively. Species models had reliable predictive performance with an average AUC value of 0.961 (minimum = 0.804; maximum = 0.998; Table 2.4). However, training omission rates in models for the red howler monkey (*A. s. seniculus*), the collared titi monkey (*Cheracebus lugens*) and the tufted capuchin (*Cebus apella fatuellus*) were not close to the predicted omission line suggesting lower reliability of predictions.

Fractional predicted areas (FPA) ranged from a minimum of 0.004 for *Plectorucebus caquetensis* to a maximum of 0.253 for *A. s. seniculus* with total number of observations not necessarily correlated with FPA values (Table 2.4). Rare species (lower number of observations) that were consistent with the FPA included the Spix's black mantle tamarin (*L. n. nigricollis*) with 12 observations and a FPA of 0.004, and the Brumback's night monkey (*Aotus brumbacki*) obtaining a FPA of 0.010 with 10 observations. By comparison, most "common" species, such as the red howler monkey (266 observations) and the tufted capuchin (102 observations), obtained high values of FPA (0.253 and 0.185 respectively). In general, values of FPA for all the species observed were low (< 0.25), with lower values of FPA associated with lower omission rates (Table 2.4).

The minimum relative probability of occurrence was 0.82 for the Caquetá tití monkey (*P. caquetensis*), and as high as 1.00 for the Cotton-top tamarin (*Saguinus Oedipus*) and the Western pygmy marmoset (*Cebuella pygmaea pygmaea*), with an average value of 0.95 among all species with 10 or more presence records (Table 2.4). Finally, predicted distributions of species were narrower than the known range map of species for 23% of taxa: *A. p. aequatorialis*, *Aotus brumbacki*, *Aotus griseimembra*, *Aotus zonalis*, *Ateles b. belzebuth*, *Ateles fusciceps rufiventris*, *Cebus capuchinus, Saguinus inustus*, and *Saimiri sciureus albigena*. On the other hand, predicted distributions of species were wider than known range maps for 20.5% of species including *Cacajao ouakary*, the collared titi monkey (*Cheracebuss lugens*), *Cebus albifrons*, the two subspecies of woolly monkeys, the Miller's saki monkey (*Pithecia milleri*), the White-footed tamarin (*Saguinus leucopus*), and the Humboldt's squirrel monkey (*Saimiri s. cassiquiarensis*) (Appendix I.a).

Although AUC values indicated strong model performance for four species (*Cheracebus medemi*, *Callimico goeldii*, *Cebus albifrons malitiosus* and *Leontocebus nigricollis hernandezi*) with <10 occurrences (average AUC = 0.974, Appendix I.b), these species were not included in Zonation analysis because their predicted species distributions did not match known range maps. The exception was for the Santa Marta white-fronted capuchin (*C. a. malitiosus*) (Appendix J) that has a restricted distribution (range) with severely fragmented populations as a result of locally high rates of deforestation (de la Torre et al. 2015a). There are, however, uncertainties about the current status of this species with some sub-populations already protected.

2.3.2 *Importance of environmental factors*

Physical variables were by far the most important factors affecting the distribution of primates in Colombia (Table 2.4). In particular, the watershed categorical variable was a key predictor of primates for all the species/subspecies, except the Spix's night monkey. Percent contribution of the watershed variable ranged from 20.7% for the white-fronted capuchin (*Cebus albifrons albifrons*) to 86% for the cotton-top tamarin (*Saguinus oedipus*). The second most important variable was the biome category which was included in 74.3% of species models and the land cover categorical variable which was included in 80% of species models with maximum percent contributions of 51.2% (white-fronted capuchin) and 46.3% (red howler monkey).

In comparison, the effect of climate was marginal with variable contribution ranging from values of less than 1% for ~10 species to a maximum of 36% for the precipitation seasonality variable for the Spix's night monkey. The importance of annual range in temperature ranged up to 16% for the collared titi monkeys, while temperature seasonality contributed up to 12% to the Panamanian night monkey (Table 2.4).

Vegetation variables generally, if surprisingly, made little contribution to explaining the distribution patterns of primates in Colombia. The South Pacific blackish howler monkey and the

Spix's black mantle tamarin were marginally predicted by percent tree cover (4.1% and 2.2% respectively), while forest canopy height marginally influenced (1.1%) distribution of the Spix's black mantle tamarin.

2.3.3 Representativeness of species and prioritized sites for conservation

A total of 37 new prioritized conservation sites was identified in the Zonation analyses under 17% conservation goal (Appendix K), with 14 identified by the Additive Benefit Function (ABF, Figure 2.3), 14 by the Core-Area Zonation (CAZ, Figure 2.4) rule, and nine sites by the two cell removal rules. The overlapping areas identified in the 17% conservation goal represented 98% of the 17% conservation goal total area (11,789,400 ha) (Figure 2.3).

Under a 17% conservation goal (Figure 2.3), areas prioritized by the additive benefit function (ABF) were located mainly in the Amazon and Andean regions, representing 94.5% (~10,928.700 ha) of the ABF total area. Additional ABF areas (5.4%, ~639,900 ha) include new sites located in the Caribbean and the north side of the Pacific region. In comparison to the ABF, areas prioritized by the core area zonation rule (CAZ) were located mostly in the Amazon, Andean and Caribbean regions, representing 95.4% (~11,249,800 ha) of the CAZ total area (Figure 2.3). Additional CAZ areas comprise ~300,600 ha (2.5% of the CAZ total area) in the Orinoco and Pacific regions, with new sites were identify in the north and south side of the Pacific region.

In terms of overlapping priorities identified by the two cell removal scenarios (~11,556,200 ha) (Figure 2.3), two large areas of overlap were identified, one adjacent to the west side of the Central Cordillera (northern side of the Andean region) and other in the southeast foothills of the Amazon region. Some scattered small areas of overlap were located along the coastline in the Caribbean region and the north side of the Pacific region (Figure 2.3).

After expanding conservation targets to 22% and 27% (respectively, Figure 2.4 and 2.5), areas increased in both number and size. For instance, a 22% conservation threshold (Figure 2.4) resulted in a larger patch of Core-Area Zonation (CAZ) areas in the north side of the Caribbean region that represent an increment of ~616,300 ha compared with the initial set of areas in the 17% conservation goal. Additional CAZ areas were located in north, south (creating a belt of areas that connected a present national park with the coast) and central sides of the Pacific region, all together representing 3.9% (~598,700 ha) of the CAZ total area for the 22%

conservation goal. Also 1.4% (~211.100 ha) of the CAZ total area was located in the southeast side of the Orinoco region, but 85.5% (~13,040,200 ha) were located in the Andean (~4,136,000 ha) and Amazon (~8,904,200) regions, some of them associated to increase in size of five national parks (Figure 2.4).

Under the 22% conservation goal, areas prioritized by the Additive Benefit Function (ABF) rule in the Amazon region (60%, ~9,155,500 ha of the CAZ total area) were located along riparian forests and the southeast side of the east cordillera mountain range, and increments in size accounted ~645,300 ha compared with the initial set of areas included in the set identified under the 17% conservation goal. In the Andean region, a combination of larger and new areas represented 26.5% (~4'050,200 ha) of the ABF total area and were located in the north across the north side of the region, some of them easily accommodated by expansion of two national parks (Figure 2.4). Additional ABF areas covered ~305,300 ha (2% of the ABF total area) in the Orinoco region, ~549,300 ha (3.6%) in the Pacific region and ~778,200 (5.1%) in the Caribbean region (Figure 2.4). Overlapping priorities from the two cell removal represented 92.6% (~14,123,500 ha) of the full extent of prioritized areas under the 22% conservation goal, and connectivity areas were identified in the south side of the Amazon region, between the Putumayo and Amazonas river basins.

Under the 27% conservation goal (Figure 2.5) the number and size of overlapping areas in the Andean, Caribbean, and Pacific regions further increased. Overlapping areas connected the Munchique national park with the Pacific coast, as well as the three national parks in the foothills of the east cordillera. Overlapping areas comprised ~16,786,100 ha of forest, representing 89.6% of prioritized areas for the 27% conservation goal scenario. ABF areas expanded within riparian forest in the Orinoco (~295,800 ha more compared with the 22% conservation goal and in the Amazon region (an additional ~458,200 ha), as well as north areas of the Andean region (an additional 1,902,100 ha) (Figure 2.4). The Amazon region comprised the largest amount of the priority Core-Area Zonation total area (50%, ~9,362,400 ha), followed by the Andean region (32.2%, ~6,038,100 ha) and the Orinoco region (2.4%, ~456,900 ha).

2.3.4 Vulnerability for the species of primates in Colombia

Illicit crop areas were mainly distributed in three regions of Colombia: (1) north parts of the Andes, (2) central and southern areas in the Pacific, and (3) north and western areas of the Amazon plains. Additional scattered illicit crops were also located in the Orinoco region (Figure 2.5). Major areas of illicit crops, predominantly of less than 4 ha/km^2 in density, were associated with 18 of 59 (30.5%) current protected areas. When considering zonation priority sites, ABF and CAZ scenarios for the 17% protection target were almost all affected by the presence of illicit crops, with the exception of sites located in western areas in the Caribbean region, and northern side of the Andean region (Figure 2.6).

Zonation priority ranks for 22% and 27% were not closely related to illicit crops in the central and north parts of Colombia. However, areas of coca crops clearly overlapped with CAZ and ABF conservation sites in the Amazon and the Andean regions (Figure 2.6).

When considering the impacts of mining activities on conservation sites identified by Zonation (Figure 2.7), the central and northern areas of the Andes cordilleras and the Caribbean region were the most affected with mining activities overlapping conservation sites. In particular, oil concessions for exploration and production were nearby Core-Area Zonation (CAZ) and Additive Benefit Function (ABF) in areas described as of high importance for primates (i.e., Serranía de San Lucas, Serranía de las Iglesias, and the middle Magdalena region), and a vast extent of the Caribbean region where conservation sites with key habitats for some vulnerable species of primates occur. Likewise, mining rights granted in the western, central, and eastern cordilleras were near prioritized areas, some of which were essential for critically endangered and vulnerable species (e.g., CAZ areas in the north of the Andean region), while the overlap of mining activities with critical conservation areas was minimal for the Pacific region (Figure 2.7).

Habitats for critically endangered species of primates were located near exploited mining activities in the Amazon piedmont (foothills of the Eastern cordillera) and in portions of the southeast side of the Orinoco plains (Figure 2.7). Finally, few mining titles that may sustain mining operations are adjacent to natural national parks in the east side of the Amazon region.

Vulnerability analysis using the human influence index identified ~821,700 ha of prioritized ABF and CAZ areas of high vulnerability (Priority #1), while ~57,418,400 ha of areas selected by the two rules were considered as of high biodiversity value (Priority #2) (Figure 2.8). Vulnerability assessments were similar between cell removal rules, with the exception of an area of high vulnerability between the Pacific and Andean regions identified in the CAZ scenario that was considered at high threat in the Additive Benefit Function zonation rank (Figure 2.8a).

Most areas of high vulnerability were identified in the Andean region (66.5%, ~546,700 ha) concurring with mining operations and enclaves of high biodiversity as the Nechí refuge, while 24.4% (~200,400 ha) were identified in the Caribbean region. Priority #1 areas comprise ~14600 ha (1.77%) in the Pacific region, and ~19,000 ha (2.17%) in the Orinoco region. Lastly, the incidence of areas of high vulnerability in the Amazon region was minimal 0.32 % (~2,700 ha), with areas located in the eastern cordillera with a few scattered sites in the Amazon piedmont that concur with highly fragmented habitats for the critically endangered Caqueta titi monkey. Areas of high biodiversity value were found in the northern parts of the Andean mountains, across Caribbean savannahs, as well as in the Pacific region for more than half of the extent of the Department of Choco and across the extent of the Amazon region (Figure 2.8b).

In relation to national parks, my vulnerability assessments identified areas of high vulnerability adjacent to the northeast side of the Farallones de Cali National Park, and nearby the Tayrona and near the Catatumbo Bari National Parks (Figure 2.8b).

A map of primate richness (Figure 2.9a) derived from the sum of binary species distribution maps (thresholded at values of “Equal training sensitivity and specificity”) identified the Amazon as the most biodiverse area in the country, followed by the Andean region and foothills in the western part of the Orinoco region. These findings agree with the elevational and latitudinal diversity gradient suggested by Hernández-Camacho & Defler (1989). The incidence of species of concern (endemic, rare and/or highly threatened -critically endangered and endangered) were also higher in the Andean region and east foothills of the east cordillera between the Amazon and Orinoco region (figure 2.9b). This overlaps with areas of high vulnerability and prioritized conservation sites selected by the Core Area Zonation cell removal rule (Figure 2.9c, d).

2.4 Discussion

2.4.1 Environmental niche models for primates of Colombia

Predictive accuracy of species distributions model for primates of Colombia were considered to be acceptable, despite many species having few occurrence records. Species distribution models should ideally be based on >100 occurrences (Stockwell & Peterson 2002, Hernández et al. 2006 and Hanberry et al. 2012). These results are consistent with other MaxEnt models that have performed well with smaller data sets (Phillips et al. 2006 and Pearson et al. 2007). Environmental variables that best explained the distribution of primates in Colombia tended to be categorical definitions of watershed, biomes and land cover.

The close relationship between these categorical variables and biogeographical patterns of the taxa helps explain the high percent contribution of these variables. For instance, watershed highlighted the role that river systems play limiting species distributions, especially for species of small body size such as marmosets and tamarins (subfamily Callitrichinae), as well as correlating broadly with soil properties and vegetation type. Likewise, biomes broadly represented differences in habitat heterogeneity that relate to specific ecological requirements of species and their distribution (Cowlishaw & Dunbar 2000 and Defler 2010). Indeed, Pearson & Dawson (2003), suggested land use and elevation are the key factors affecting the distribution of species at regional scales.

Given that species with less than seven occurrence records had low predictive performance, there is a significant need for increased sampling efforts for rare species in Colombia to better evaluate geographic ranges, ecological requirements and conservation status. In particular, data (presence location information) gaps are evident for the Goeldi's marmoset monkey (*Callimico goeldii*), the Colombian black-handed titi monkey (*Cheracebus medemi*) and endemic the Hernández-Camacho's black-mantled tamarin (*Leontocebus nigricollis hernandezi*)

Net primary productivity (NPP) and soil nutrient levels have in general been positively related to density of plant consuming primates (Kay et al. 1997 and Peres 1997), with NPP correlated to nutrients absorption, canopy leaf area, flower and fruit production, and exudate quality (Malhi et al. 2011), which are associated with richness of local primate assemblages (Lehman 2000 and Stevenson 2001). However, in my study NPP and soil variables were not strongly associated with factors affecting primate distribution. When used, these variables often led to over prediction of species geographic distributions. This may be explained by the scarcity of reliable data and the inability to quantify net primary productivity in tropical forest at local scales. This is partially due to sampling bias, lack of continuity, improper measures, and differences in sampling methods (Clark et al. 2001a and Clark et al. 2001b). Similarly, the lack of predictive power for soil variables could be the result of low spatial resolution, and/or a significant variability across the region, despite the indirect effect that soil properties have on species distributions (Franklin 2010).

Environmental niche models presented in this study offer valuable information to clarify uncertainties in the ranges of some taxa, although issues relating to errors in species identification during field surveys and lack of occurrence records for many of the taxa continue to be a challenge. For instance, the broader distribution (range) for the Humboldt's woolly monkey (*Lagothrix l. lagotricha*) in the eastern slopes of the eastern cordillera is due to historical records in areas of occurrence of *Lagothrix l. lugens* (Stevenson & Link 2008, Defler 2010 and Rodríguez-Bolaños et al. 2013), and frequent misidentification of these subspecies based on coat color has been noted (Botero & Stevenson 2014 and Defler 2014). However, ENMs developed here were more consistent with the known range of the species than are those obtained by Rodríguez-Bolaños et al. (2013).

2.4.2 Priority areas for conservation and vulnerability

The use of two different cell removal rules allowed assessment of complementarity for the current reserve system while increasing the representativeness of key habitats for primates. Priority conservation sites proposed here provide a balance between sites that are important refugia for rare species, on the one hand, with the potential to harbor higher species richness, on the other hand (Figure 2.9). Additional evidence of this includes selection of areas across a latitudinal and elevation gradient of primate diversity (Appendix L) and overlapping areas from the two cell removal scenarios.

Considering new conservation areas in the 17% conservation goal, the most notable conservation gap that is filled in terms of habitat representativeness for primates is the incorporation of sites for critically endangered species that are not currently protected (i.e., *Ateles hybridus brunneus* and *Plecturocebus caquetensis*) (Link et al. 2013, Defler 2010, García et al. 2010 and Stevenson et al. 2010). Also, Zonation priority areas identified in this study comprise important sites for species with some level of protection (present in at least one reserved area), but currently or eventually facing significant levels of threats (e.g., hunting, colonization cores and land use/conversion), principally in the Andean and Pacific regions.

Core areas of higher suitable habitat for primates were prioritized for protection within areas of primary and secondary forest in Colombia. These sites presumably also convey biodiversity value (surrogacy and umbrella effects) to other species of flora and fauna in Colombia. By considering vulnerability of these sites to current and future development, these products provide guidance for conservation planning in Colombia. This is especially important in centers of endemism and speciation such as the Nechi and Chocó refugia. For instance, the conservation sites suggested in this study can fill conservation gaps in the current protected area system (Corzo 2008). Corzo (2008) considered over eight million hectares (7% of the total extent of the country) to be of urgent ("urgentes") conservation need, given the high level of potential threat due to future development within these areas. In addition, Corzo (2008) recognized nearly 13 million hectares (11.31% of the country) as protected area omissions ("omisiones") where the representation of critical habitats in protected areas is very low or absent, and over 73 million hectares (64.32% of the country's continental extent) as insufficient ("insuficientes") given existing targets for protection.

Conservation sites proposed in the Nechí Valley and Pacific region by the analyses of this thesis overlap with areas considered insufficient for existing conservation targets, while priority sites identified in the Yariguies mountain range, could be used to fill gaps of sites urgently needed to protect habitats omitted entirely from the reserve system. In addition, conservation sites prioritized in this thesis for the northwest of the Choco Biogeographic region and the mountain ranges of Serranía de San Lucas and Las Iglesias (Andean region) concur with areas classified as appropriate, urgent, and with omissions. This area is also considered to be among the highest conservation priority for Colombia being linked to the largest enclaves of biodiversity in the country (Corzo 2008). These findings, along with the selection of priority sites that pair with two new national parks recently declared by the government (MADS 2015) (Figure 3.1), indicate the agreement between the methods and models produced in this thesis with expert-opinion of recent conservation planning initiatives by the government. Models from this thesis are therefore an important tool for providing even further guidance and decision-making for conservation planning throughout Colombia.

Another important outcome from the conservation portfolio presented here is the prioritization of areas in regions presently undergoing habitat fragmentation. For example, the existence of dry tropical forest has substantially diminished in the Caribbean region (Miller et al. 2004, Savage & and Causado 2014) and remnants of Inter-Andean rainforest represent a mere 20% of its original extension. Likewise, habitat fragmentation has been recorded as a major concern for the viability of populations of critically endangered species (Defler et al 2003 and Defler 2010). Consequently, prioritized conservation areas in central and north sides of the east cordillera could provide viable habitats for these species, especially considering that Protective Forest Reserves already exist within this region, so enlargement of this reserves or reclassification to a higher protective status might be considered as an additional means of enforcing conservation actions.

It is important to clarify that a Protective Forest Reserve allows "sustainable" use of forest resources present inside the area, which may imply easier access to bush meat and pet trade. Thus, management of some animal populations would be improved by enlarging the forest reserves. Such species include the variegated spider monkeys and the Colombian woolly monkey, a preferred sources of animal bush meat by rural and indigenous groups, as well as the varied white-fronted capuchin monkey for which declines in populations are the result of pet trade and excessive hunting (de la Torre et al. 2015c). However, management of animal populations are still a major challenge even within national natural parks (Urbani et al. 2008). Additional stressors in the central and north areas of the Andean region include oil exploration, mining rights, and the general presence of high human influence (Figures 2.6 & 2.7).

New conservation sites prioritized in the southern part of the Amazon region are associated with areas of high biodiversity value, and connectivity areas identified under 22% and 27% conservation goals could represent potential biological corridors. These include areas of primary forest without human influence like the Purite river where the near threatened Humboldt's woolly monkey occurs. This area is also adjacent to the Amacayacu NNP and an enlargement of this protected area towards the Brazilian border has been suggested by Defler (2001) in order to safeguard the most diversity within the Amazon region. Prioritized conservation areas proposed here occurs throughout the Purite river expanding this initiative. In addition, other areas in the Amazon river basin and areas adjacent to the southern side of the Rio Pure national park identified as important in this conservation plan can be part of the expansion plan. However, small communities are present in this area and they are an important factor in the establishment of new conservation sites since use of forest resources, cooperation, control and management plans must be considered in effective conservation planning.

Comparison among conservation targets at 17, 22 and 27% revealed that increases in protection thresholds were mostly associated with expanding current and my initially proposed conservation areas, as well as increases in number of potential conservation sites. This will offer a larger array of areas of high conservation value to select from when determining the best set of new sites for protection, especially in regions with significant incidence of habitat conversion and human influence (i.e., areas of high vulnerability). As an example, the Cienaga de Barbacoas (Andean region) considered under the scenario of 27% of terrestrial protection could be a conservation area for *A. hybridus hybridus* (Urbani et al. 2008). Vulnerability analysis demonstrated high incidence of stressors in natural ecosystems where prioritized sites are more likely to occur under 22% and 27% conservation goal scenarios. This indicates that the selection of new areas to improve representation of habitats for primates should be based in conservation of sites identified under these thresholds. In fact, to be able to achieve the Aichi Biodiversity Target 11 of 17% terrestrial protection (~19,407,716 ha of the total extent of Colombia), selection of conservation areas based on primate habitat requirements (~69,349,400 ha of forested areas) would concur with the extension of prioritized areas under a 27% conservation goal (~18,789,400 ha).

Habitat loss due to land use conversion for illicit crops in current national parks could be alleviated by incorporating neighboring forests that can harbor not only populations of primates but also many other threatened species of fauna and flora. For instance, by 2013 there was a 12% rise in coca cultivation within national natural parks, of which 86% took place in four parks: Nukak, Sierra de la Macarena, Catatumbo-Barí and La Paya (UNODC 2014). In this context, prioritized sites that would enlarge the size of the Catatumbo Barí (north of the Andean region) could be an important input for securing the last remnant of tropical rainforest in this part of the country (Sesana 2006). This region is a home to not only for endangered species of primates but also for vulnerable (VU) species, including the South American Tapir (*Tapirus terrestris*), the spectacled bear (*Tramarctos ornatus*), and the nationally threatened Abarco tree (*Cariniana pyriformis*). Moreover, new Core-Area Zonation sites along the Micay River basin that connect the Pacific coast with the Munchique NNP (Pacific region) would contribute to a major biological corridor, along with facilitating the preservation of adequate habitats for 28.5% of the Colombian avifauna (BirdLife International 2015). Similarly, recommended conservation sites adjacent to the national natural park Sierra La Macarena (Orinoco/Amazon regions) would also benefit endemic and rare birds (BirdLife International 2015). However, the set of priority conservation areas in the northeastern part of the Orinoco region is still under-represented with only two confirmed, wide-ranging and secure species (the white-fronted capuchin and the red howler monkey) in the region.

Finally, other potential gains linked to higher protection targets, include connectivity areas that can represent potential biological corridors, more protection of Andean and Caribbean regions where habitat fragmentation threatens primates, and riparian forests selected along river bodies in the Amazon Department (Amazon region) that can be included in the new conservation initiative of protected rivers. Along with harboring numerous wild species of flora and fauna, including elements of the Napo-Imerí refugia, these riparian forests are of great importance to the subsistence of indigenous groups and settlers. Approximately 29.5% of the total indigenous reservation areas in Colombia are represented in this Department, and the total population, including colonization cores, was about 72,858 inhabitants by 2011 (Rodríguez-Celis 2012).

2.5 Conclusions

I created new environmental niche models for 34 primate taxa. Despite low occurrence records, models demonstrated high predictive accuracy for the majority of the taxa, and physical variables were the most important drivers of primate geographic ranges and suitable areas. This includes watersheds (highest general importance), probably due to its effect as geographic barrier and the influence on different environmental components of the landscape.

In regards to new conservation sites, about ~37 new sites were proposed benefiting the protection of threatened and near threatened species of primates. Zonation models also improved the representation of key habitats for taxa with major deficiencies in protection (species not currently protected in national park system, or already protected but at low levels).

Although the initial top 17% of conservation priorities may offer an adequate set of areas to cover representation for primates, further enlargement of conservation sites modelled in the 22% and 27% conservation scenarios increases the opportunity to select new conservation areas as we learn more. It also allows prioritization and triage of locations based on areas of high vulnerability (i.e., especially in the North portion of the Andean region).

Despite declaration of new conservation-oriented areas (1,660,000 ha in total) by the Colombian government in 2015, there is still a deficit of 6,532.629 ha to reach even the Aichi Biodiversity Target 11 of 17% inland protection in Colombia. Sites for primate conservation suggested in the conservation plan presented here provide important input for selecting additional conservation areas to fulfill that deficit. However, other considerations are important, including species ability to adapt to disturbance, and assessing both impacts of climate change and species vulnerability to climate change. Of course, a primate focus only approximates the priority for other species of animals or plants. Inclusion of other taxa may offer a different array of potentially important sites for consideration. Prioritized conservation areas identified in this study depend on the nature of the environmental niche models, and thus the nature of the occurrence data used to model habitat suitability and the spatial information defining environmental factors.

Finally, conservation areas proposed within indigenous reserves must include local participation in the definition of management plans, together with sustainable economic alternatives and environmental education programs. These are critically important inputs into the conservation of threatened species, while ensuring the permanency of traditional ways of life.

2.6 Tables

Table 2.1 Species of primates present in Colombia, including number of occurrences, global and national conservation status. Taxa with five or less observations (in bold) were ignored in distribution modeling analyses. Nomenclature follows the taxonomic arrangement proposed by Defler (2010). In addition to new considerations by for species of the *Pithecia* genus (Marsh 2014), as new categorization for genera in the subfamilies Callitrichinae (Buckner et al. 2015) and Callicebinae (Byrne et al. 2016).

Family	Subfamily	Genus	Species	Subspecies	Common Name	Global[1]	National[2]	Obs.
Cebidae	Callitrichinae	*Saguinus*	*oedipus* (Linnaeus, 1758) *		Cotton-top tamarin	CR	VU	55
			geoffroyi (Pucheran, 1845)		Geoffroy's tamarin	LC	LC[3]	13
			inustus (Schwartz, 1951)		Mottled-faced tamarin	LC	LC[3]	16
			leucopus (Günter, 1876) *		White-footed tamarin	EN	VU	78
		Leon-tocebus[(a)]	*nigricollis*	***graellsi*** (Jiménez de la Espada, 1870)	**Graell's black-mantled tamarin**	**NT** *Saguinus*	**LC[3]**	**4**
				hernandezi Hershkovitz, 1982**	Hernández-Camacho's black mantle tamarin	LC *Saguinus*	LC[3]	7
				nigricollis (Spix, 1823)	Spix's black mantle tamarin	LC *Saguinus*	LC[3]	12
			fuscus (Lesson, 1840)		Saddle-backed tamarin	LC	LC[3]	33
		Cebuella	*pygmaea*	*pygmaea* (Spix, 1823)	Western pygmy marmoset	LC	LC[3]	12
		Callimico	*goeldii* (Thomas, 1904)		Goeldi's marmoset	VU	VU	7
	Cebinae	*Cebus*	*albifrons*	*albifrons* (Humboldt, 1812)	White-fronted capuchin	LC	LC	37
				cesarae Hershkovitz, 1949**	Río Cesar white-fronted capuchin	DD *Cebus cesarae*	NT	13
				cuscinus Thomas, 1901**[(b, c)]**	**Shock-headed capuchin**	**NT** *Cebus cuscinus*[(b)]	**LC[3]**	**0**
				malitiosus Elliot, 1909**	Santa Marta white-fronted capuchin	EN *Cebus malitiosus*	NT	7
				versicolor Pucheran, 1845**	Varied white-fronted capuchin	EN *Cebus versicolor*	NT	59

			apella	*fatuellus* (Linnaeus, 1766)	Tufted capuchin	LC *Sapajus macrocephalus*	LC[3]	102
Cebidae	Cebinae	*Cebus*	*capucinus*	*capucinus* (Linnaeus, 1758)	Colombian white-throated capuchin	LC	LC[3]	53
				curtus **Bangs, 1905*[d]**	**Gorgona white-faced capucin**	No Listed	No Listed	**?**
	Saimirinae	*Saimiri*	*sciureus*	*albigena* (Von Pusch, 1941) **	Colombian squirrel monkey	NT	LC[3]	35
				cassiquiarensis (Lesson, 1840)	Humboldt's squirrel monkey	LC	LC[3]	21
				macrodon (Elliot, 1907)	Ecuadorian squirrel monkey	LC	LC[3]	29
Aotidae		*Aotus* [e]	*brumbacki* Hershkovitz, 1983*		Brumback's night monkey	VU	VU	10
			griseimembra (Elliot, 1912)		Grey-handed night monkey	VU	VU	70
			jorgehernandezi Defler & Bueno, 2007		**Hernández-camacho's night monkey**	**DD**	**?**	**?**
			lemurinus I. Geoffroy, 1846		Colombian night monkey	VU	VU	68
			nancymaae Hershkovitz, 1983		**Nancy Ma's Night Monkey**	LC	No Listed[4]	**5[f]**
			vociferans (Spix, 1823)		Spix's night monkey	LC	LC[3]	17
			zonalis (Goldman, 1912)		Panamanian night monkey	DD	VU[3]	20
Pitheciidae	Pitheciinae	*Pithecia*	*hirsuta* (Spix, 1823)		Hairy saki	No Listed	LC	12
			milleri J.A. Allen, 1914		Miller's saki	DD	VU	21
		Cacajao	*ouakary* (Hershkovitz, 1987)		Golden-backed Black Uakary monkey	LC *Cacajao melanocephalus*	NT	18
	Callicebinae	*Plecturo-cebus*	*caquetensis* Defler, Bueno & García 2010[p]*		Caquetá tití monkey	CR *Callicebus caquetensis*	CR[1]	18
			discolor (I. Geoffroy & Deville, 1848)		**Red titi monkey**	**LC** *C. discolor*	**VU**	**1**
			ornatus (Gray, 1866)		Ornate tití monkey	VU *C. ornatus*	VU	32
		Cheracebus	*lucifer* Thomas, 1914		Yellow-handed Titi Monkey	LC *Callicebus lucifer*	LC[3]	10
			lugens (Humboldt, 1811)		Collared titi monkey	LC *Callicebus lugens*	LC[3]	23

			Medemi Hershkovitz, 1963**		Colombian Black-handed Titi	VU *C. medemi*	VU[3(g)]	7
Atelidae	Atelinae	*Ateles*	*belzebuth*	*belzebuth* Geoffroy, 1806	Long-haired spider monkey	EN	VU	41
Atelidae	Atelinae	*Ateles*	*fusciceps*	*rufiventris* Scalter, 1872	Colombian black spider monkey	CR	EN	31
			hybridus	*brunneus* Gray, 1870**	Brown spider monkey	CR	CR	24
				hybridus I. Geoffroy, 1829	Variegated spider monkey	CR	CR	25
		Lagothrix	*lagotricha*	*lagotricha* (Humboldt, 1812)	Humboldt's woolly monkey	VU *Lagothrix lagotricha*	NT	64
				lugens Elliot 1907**	Colombian woolly monkey	CR *Lagothrix lugens*	VU	56
	Alouattinae	*Alouatta*	*palliata*	*aequatorialis* Festa, 1903	South Pacific blackish howler monkey	VU	VU	26
			seniculus	*seniculus* (Linnaeus, 1766)	Red howler monkey	No Listed (LC)	LC[3]	266

[1]IUCN 2016 (Assessment on species designated by specialist assessor(s) in 2008); [2] Rodríguez-Mahecha et al. 2006 (National status designated in 2004); [3]Conservation status suggested by Defler 2010; [4] Records confirmed by IGUN (2012). [(a)]Buckner et al. 2015 placed the genus within the family Callitrichidae; [(b)] Not reported in Colombia by the IUCN 2016; [(c)] Not reported in Colombia by APC (2016); [(d)] Restricted to the Gorgona Island NNP; [(e)] One more subspecies, *A. nancymae*, is listed by APC (2016) but major doubts about its occurrence in the country exist; [(f)] None ENM elaborate for this species; [(g)] Not listed in Rodríguez-Mahecha et al. 2006; [*]Endemic; [p*]Probably endemic; [**] Distribution restricted to Colombia.

Table 2.2 List of environmental variables used to generate preliminary and final environmental niche models (ENMs) for the species of primates in Colombia. All variables were masked to the extent of the country at 1-kilometer cell size resolution. Net Primary Productivity and Soil variables were not used in final ENMs due to overestimation of primate habitat based on known geographic ranges of species.

Group	Variable Name	Year	Description
Climate Models[1]	BIO4	2005	T° Seasonality (standard deviation *100)
	BIO7		T° Annual Range (BIO5-BIO6)
	BIO15		Precipitation Seasonality (Coefficient of Variation)
Vegetation Models	Net Primary Productivity[2]	2010	Amount of atmospheric carbon fixed by plants and accumulated as biomass (Multi Year average)
	Forest Canopy Height[3]	2005	Global Forest Canopy Height - forest vertical structure (Simard et al. 2011)
	Tree Cover[4]	2003	Percent tree cover (%) or density of trees on the ground (0 – 100). Ratio of the area covered with branches and leaves of trees (tree canopy) to the ground surface seen from the above (vertical direction).
Soil Models[5]	Actual Evapo - transpiration	1950-2000	Soil water balance (yearly average)
	BulkDensity_0-5mean	2013	Bulk density in kg / cubic-meter (mean estimate) for 2.5 cm depth
	Clay_0-5mean	2013	Soil texture fraction clay in percent (mean estimate) for 2.5 cm depth
	Organic_Carbon_0-5mean	2013	Soil organic carbon content (fine earth fraction) in per Milles (mean estimate) for 2.5 cm depth
	pH_0-5mean	2013	Soil pH x 10 in H2O (mean estimate) for 2.5 cm depth
	Sand_0-5mean	2013	Soil texture fraction sand in percent (mean estimate) for 2.5 cm depth
Physical Models	Elevation[6]	2001	Global Digital Elevation Model (GDEM) _1 arc-second (approximately 30–m at the equator) grid.
	Land Cover[7]	2007	19 classes (Appendix D) relating areas cover by with natural vegetation, transformed lands, cultivated, coastal and inland wet areas and water surfaces. Relevant subclasses were also established.
	Biomes[7]	2007	32 classes (Appendix D) Defined by the relationship among geo-pedology, vegetation and climate features.
	Watershed[7]	2002	43 areas (Appendix D)

[1]WorldClim - Hijmans et al. 2005; [2]UNEP 2015; [3]Simard et al. 2011; [4]ISCGM 2003; [5]ISRIC 2013; [6]LP DAAC 2001; [7]SIG-OT 2009. **BIO5**: Maximum Temperature of Warmest Month; **BIO6**: Minimum Temperature of Coldest Month.

Table 2.3 Selected combinations of variables that best predict the geographic distribution of primates in Colombia. Only the top model was used to generate an ENM for each species.

MODEL	VARIABLES								
	CLIMATE			VEGETATION		PHYSICAL			
A	BIO4	BIO7	BIO15			Bio	Elev	Land	
B	BIO4	BIO7	BIO15	PTC	Canp	Bio		Land	
C	BIO4	BIO7	BIO15				Elev	Land	Wat
D	BIO4	BIO7	BIO15			Bio	Elev		Wat
E	BIO4	BIO7	BIO15			Bio	Elev	Land	Wat
F						Bio		Land	Wat
G	BIO4	BIO7	BIO15	PTC	Canp		Elev		Wat

BIO4: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range (BIO5: Maximum Temperature of Warmest Month - BIO6: Minimum Temperature of Coldest Month); **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height; **Bio**: Biomes; **Elev**: Elevation (DEM); **Land**: Land Cover; **Wat**: Watershed.

Table 2.4 Area Under the receiver operating characteristic curve (AUC) value, importance of environmental variables and other main statistics for a final distribution model for each taxon of primates in Colombia with 10 or more occurrence records. Final environmental niche models are illustrated in Appendix I.

Species / Sub-species	M	Obs	OTr	POc	AUC	LT	FPA	TOR	Percent Contribution								
									PTC	Can	BIO 4	BIO 7	BIO 15	Bio	Elev	Land	Wat
Alouatta p. aequatorialis	H	26	23	0.84	0.991	0.128	0.042	0.048	4.1	<1	4.0	3.1	11.9	-	<1	-	76.8
Alouatta seniculus seniculus	F	266	205	0.99	0.804	0.368	0.253	0.268	-	-	-	-	-	23.0	-	46.3	30.7
*Aotus brumbacki**	E	10	10	0.98	0.995	0.638	0.010	0.000	-	-	2.0	<1	<1	17.1	1.2	18.6	61.2
Aotus griseimembra	F	70	56	0.99	0.958	0.285	0.108	0.107	-	-	-	-	-	31.7	-	31.5	36.8
Aotus lemurinus	C	68	53	0.92	0.956	0.364	0.093	0.094	-	-	11.6	1.7	5.0		10.1	33.1	38.5
Aotus vociferans	B	17	17	0.97	0.940	0.298	0.166	0.176	2.2	1.1	9.0	<1	35.7	42.6	-	9.3	-
Aotus zonalis	E	20	19	0.98	0.991	0.131	0.046	0.053	-	-	<1	11.7	<1	7.0	5.7	8.9	66.8
Ateles belzebuth belzebuth	E	41	31	0.99	0.961	0.095	0.096	0.097	-	-	<1	<1	<1	23.3	<1	8.6	68.1
Ateles fusciceps rufiventris	C	31	25	0.99	0.979	0.270	0.060	0.040	-	-	<1	<1	<1	-	3.8	26.0	70.2
*Ateles hybridus*brunneus***	E	24	24	0.96	0.986	0.221	0.047	0.042	-	-	<1	<1	<1	26.2	<1	12.9	60.9
Ateles hybridus hybridus	C	25	25	0.99	0.976	0.161	0.108	0.000	-	-	6.7	<1	<1	-	1.9	26.0	65.4
Cacajao ouakary	C	18	18	0.93	0.948	0.558	0.111	0.111	-	-	<1	<1	<1	-	3.3	19.1	77.6
*Plecturocebus caquetensis**	E	18	18	0.82	0.998	0.473	0.004	0.000	-	-	3.4	<1	1.7	17.5	<1	23.2	54.2
Plecturocebus ornatus	C	32	25	0.95	0.987	0.303	0.037	0.040	-	-	1.0	<1	<1	-	5.4	10.9	82.6
Cheracebus lucifer	E	10	10	0.99	0.990	0.219	0.042	0.000	-	-	6.6	<1	2.6	10.3	19.5	<1	61.0
Cheracebus lugens	D	23	23	0.99	0.915	0.384	0.180	0.174	-	-	16.0	<1	1.4	30.7	8.5	-	43.4
Cebuella pygmaea pygmaea	E	12	11	1.0	0.976	0.104	0.091	0.091	-	-	<1	<1	4.3	35.2	1.3	14.5	44.7
Cebus albifrons albifrons	E	37	29	0.97	0.930	0.271	0.135	0.138	-	-	<1	<1	<1	51.2	7.6	20.5	20.7
*Cebus albifrons cesarae***	C	13	13	0.99	0.995	0.173	0.015	0.000	-	-	<1	<1	<1	-	<1	29.9	70.1
*Cebus albifrons versicolor***	E	59	47	0.95	0.969	0.202	0.083	0.085	-	-	<1	<1	<1	38.1	-	36.7	25.3

Cebus apella fatuellus	D	102	81	0.91	0.876	0.339	0.185	0.185	-	-	<1	<1	2.3	48.1	<1	-	49.6
Cebus capucinus	E	53	42	0.98	0.969	0.256	0.077	0.071	-	-	<1	<1	<1	18.2	<1	23.5	58.3
Lagothrix l. lagotricha	D	64	51	0.90	0.910	0.327	0.171	0.176	-	-	1.0	<1	11.6	49.6	6.2	-	31.5
*Lagothrix l. lugens***	F	56	45	0.99	0.940	0.293	0.136	0.133	-	-	-	-	-	20.3	-	18.0	61.6
Pithecia hirsuta	D	12	12	0.97	0.980	0.316	0.065	0.083	-	-	<1	<1	28.1	16.6	19.1	-	36.2
Pithecia milleri	D	21	18	0.91	0.956	0.178	0.100	0.056	-	-	<1	<1	<1	27.3	<1	-	72.7
Leontocebus fuscus	F	33	26	0.99	0.966	0.401	0.084	0.077	-	-	-	-	-	31.4	-	7.0	61.6
Saguinus geoffroyi	C	13	12	0.94	0.993	0.158	0.030	0.000	-	-	<1	6.2	2.2	-	1.2	10.7	79.7
Saguinus inustus	C	16	16	0.98	0.941	0.366	0.130	0.125	-	-	15.8	<1	12.4	-	2.4	5.7	63.7
*Saguinus leucopus**	F	78	61	0.87	0.972	0.201	0.072	0.066	-	-	-	-	-	16.1	-	11.3	72.6
Leontocebus n. nigricollis	D	12	12	0.90	0.998	0.300	0.004	0.000	-	-	14.7	1.4	1.5	22.5	6.3	-	53.8
*Saguinus oedipus**	F	55	38	1.0	0.986	0.185	0.054	0.026	-	-	-	-	-	3.0	-	11.1	85.9
*Saimiri sciureus albigena***	F	35	28	0.91	0.976	0.178	0.073	0.071	-	-	-	-	-	9.3	-	8.4	82.3
Saimiri s. cassiquiarensis	E	21	21	0.93	0.965	0.291	0.089	0.095	-	-	<1	<1	<1	32.1	3.3	3.3	61.3
Saimiri sciureus macrodon	E	29	28	0.84	0.953	0.350	0.107	0.107	-	-	<1	<1	7.2	19.1	1.1	<1	72.6

M: Selected Model; **Obs**: Number of observations; **OTr**: Number of observations for training; **POc**: Probability of occurrence; **AUC**: Training AUC value; **LT**: Logistic Threshold; **FPA**: Fractional Predicted Area; **TOR**: Training Omission Rate; **PTC**: Percent Tree Cover; **Can**: Forest Canopy Height; **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range (BIO5: Maximum Temperature of Warmest Month - BIO6: Minimum Temperature of Coldest Month); **BIO15**: Precipitation Seasonality (Coefficient of Variation); **Bio**: Biomes; **Elev**: Elevation (DEM); **Land**: Land Cover; **Wat**: Watershed.*Endemic ** Distribution restricted to Colombia.

2.7 Figures

Figure 2.1 Map of Colombia and its location in South America.

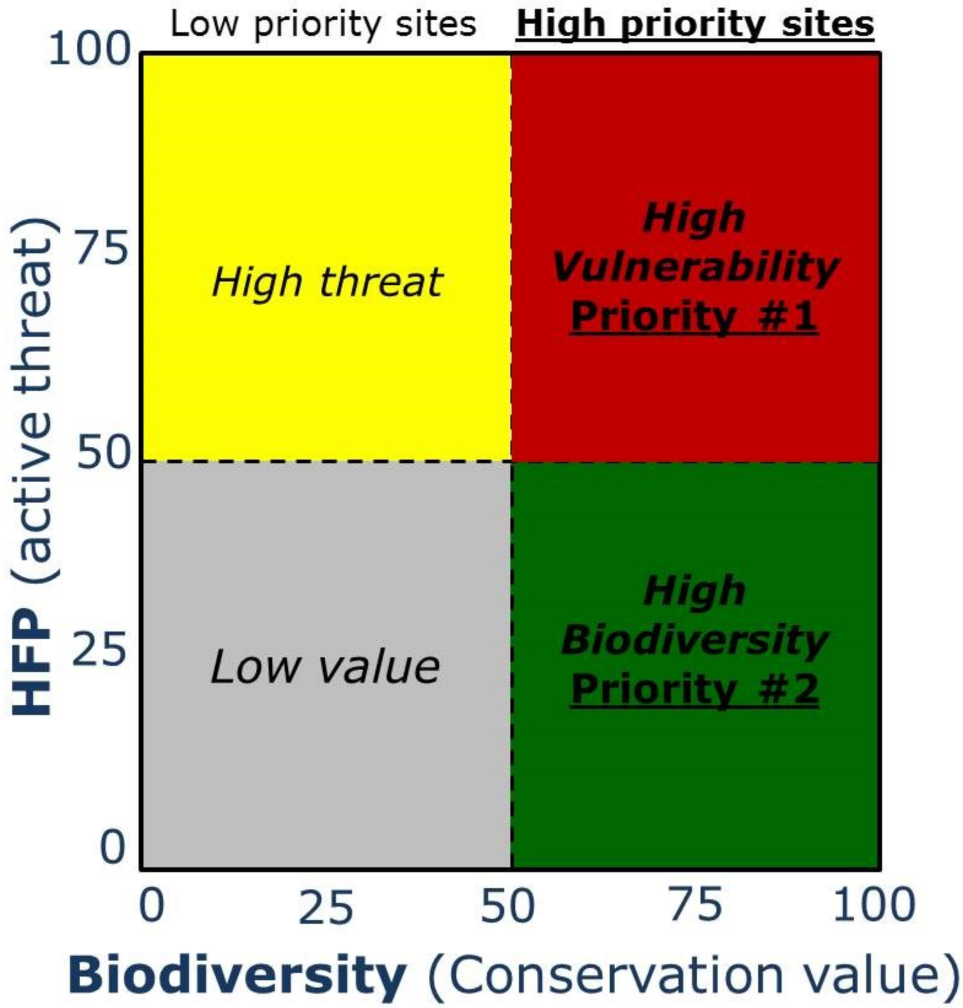


Figure 2.2 Two-dimensional vulnerability matrix used to identify regional conservation priorities, based on levels of irreplaceability value relative to threats and conservation value. Conservation value (horizontal axis) denotes the priority rank of a site accordingly to occurrence of species and habitat quality (zonation rank), whereas human footprint index (HFP, vertical axis) representing percentage of the human influence on the land. Adapted from Margules and Pressey (2000).

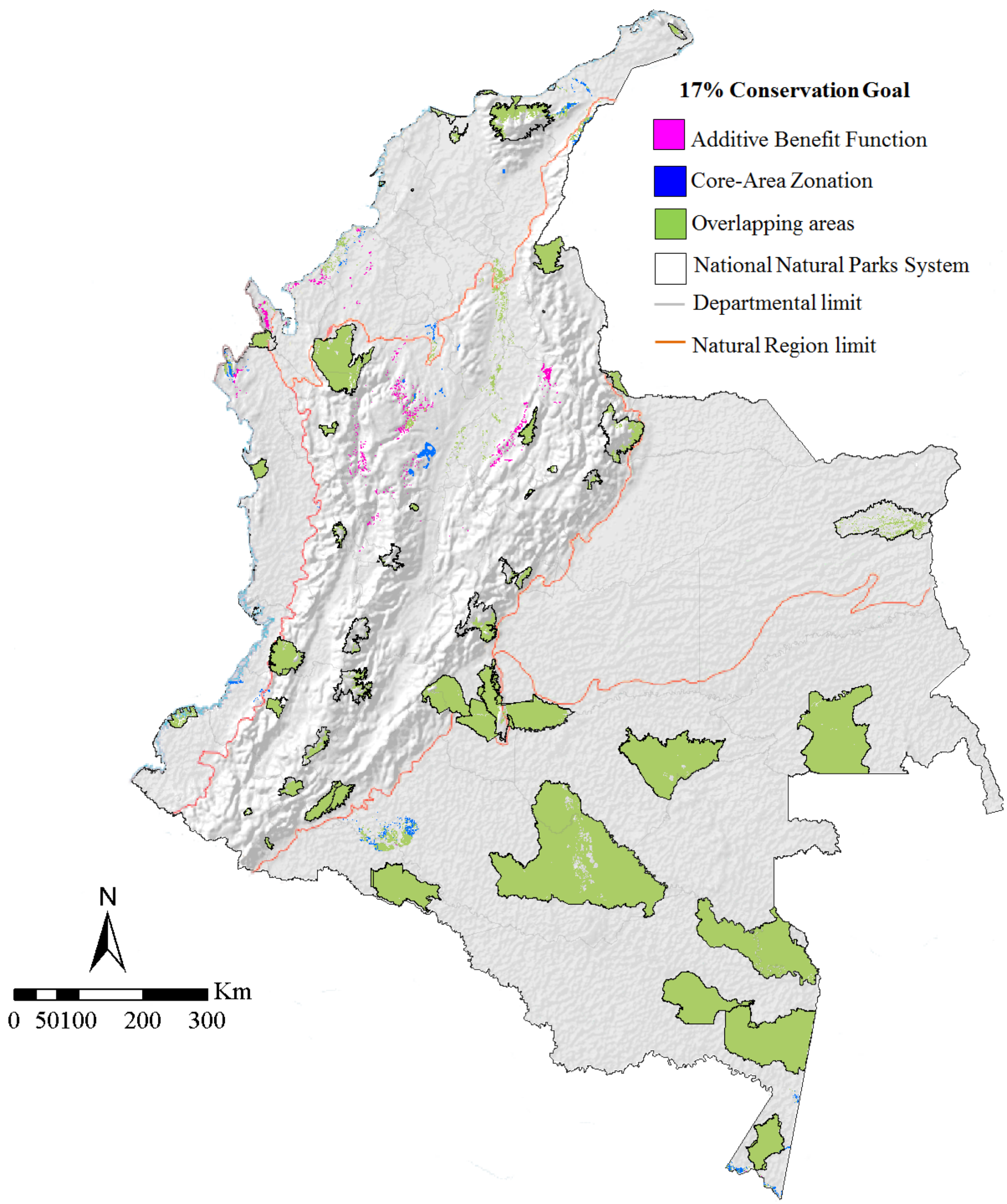


Figure 2.3 Prioritized conservation areas in Colombia for the 17% conservation goal. Two main cell removal rules, the Additive Benefit Function and the Core-Area Zonation, were used to select the most important areas to improve representation of suitable areas for primates in Colombia. Overlapping areas: selected areas where the two rules converge.

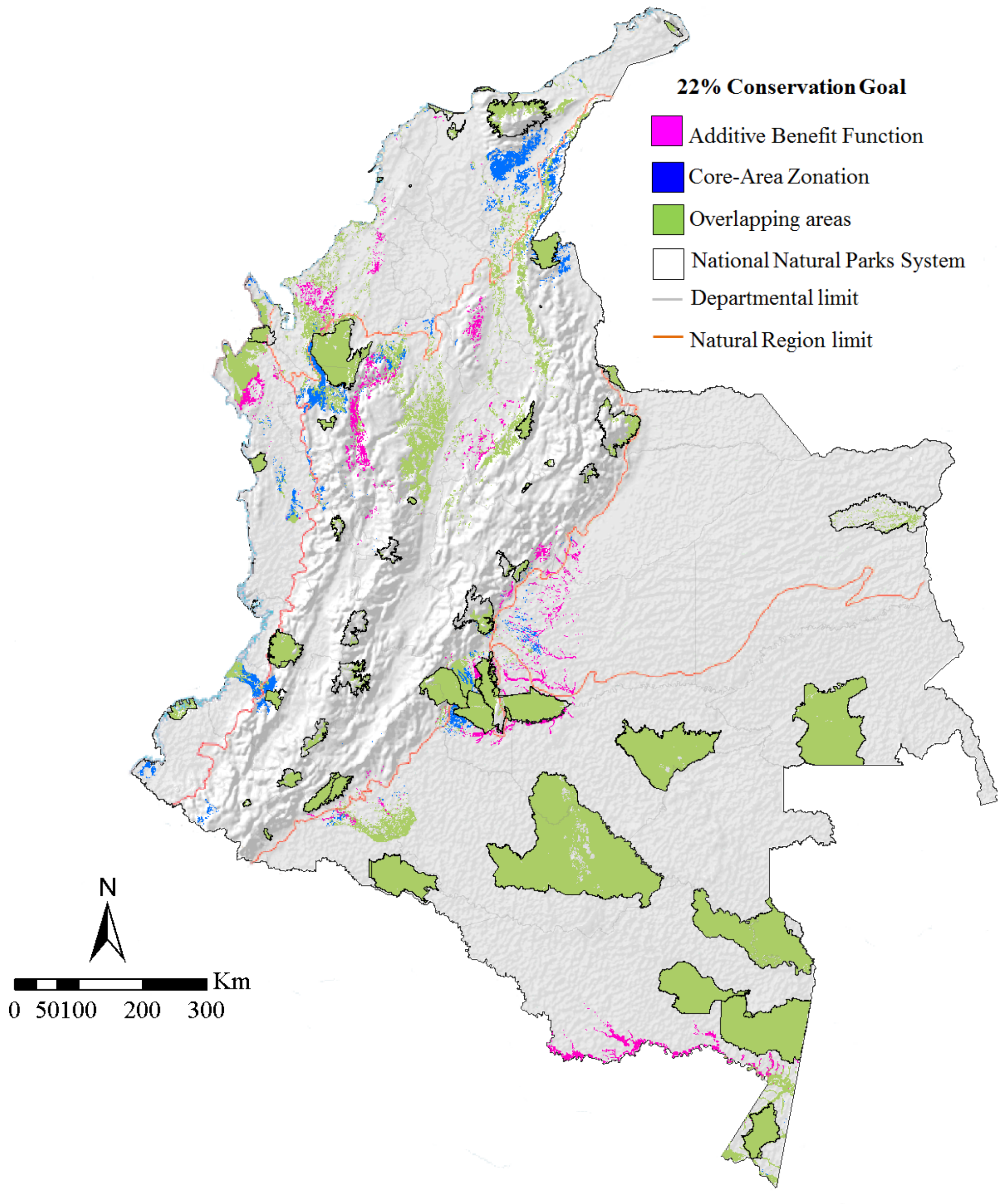


Figure 2.4 Prioritized conservation areas in Colombia for the 22% conservation goal. Two main cell removal rules, the Additive Benefit Function and the Core-Area Zonation, were used to select the most important areas to improve representation of suitable areas for primates in Colombia. Overlapping areas: selected areas where the two rules converge.

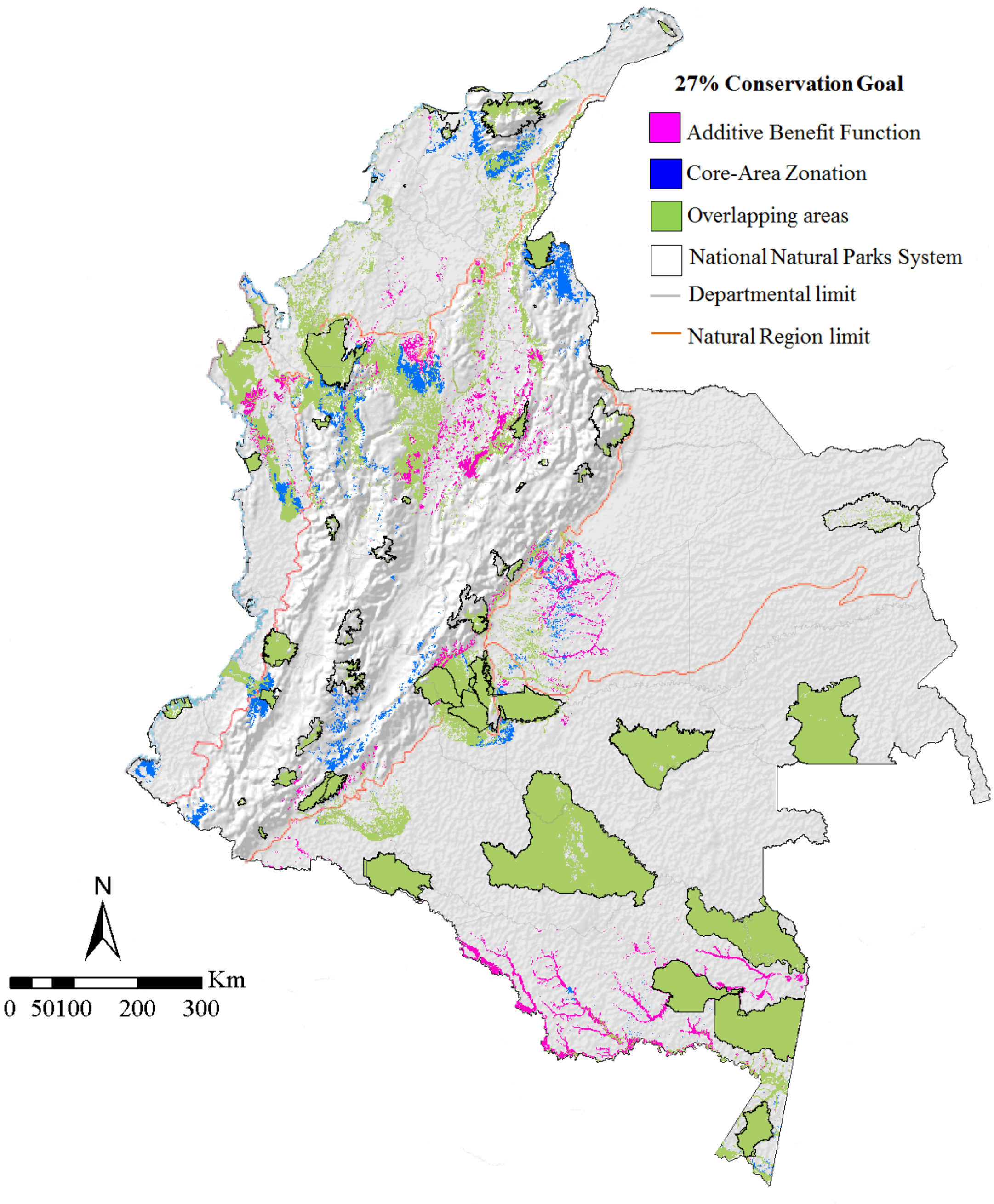


Figure 2.5 Prioritized conservation areas in Colombia for the 27% conservation goal. Two main cell removal rules, the Additive Benefit Function and the Core-Area Zonation, were used to select the most important areas to improve representation of suitable areas for primates in Colombia. Overlapping areas: selected areas where the two rules converge.

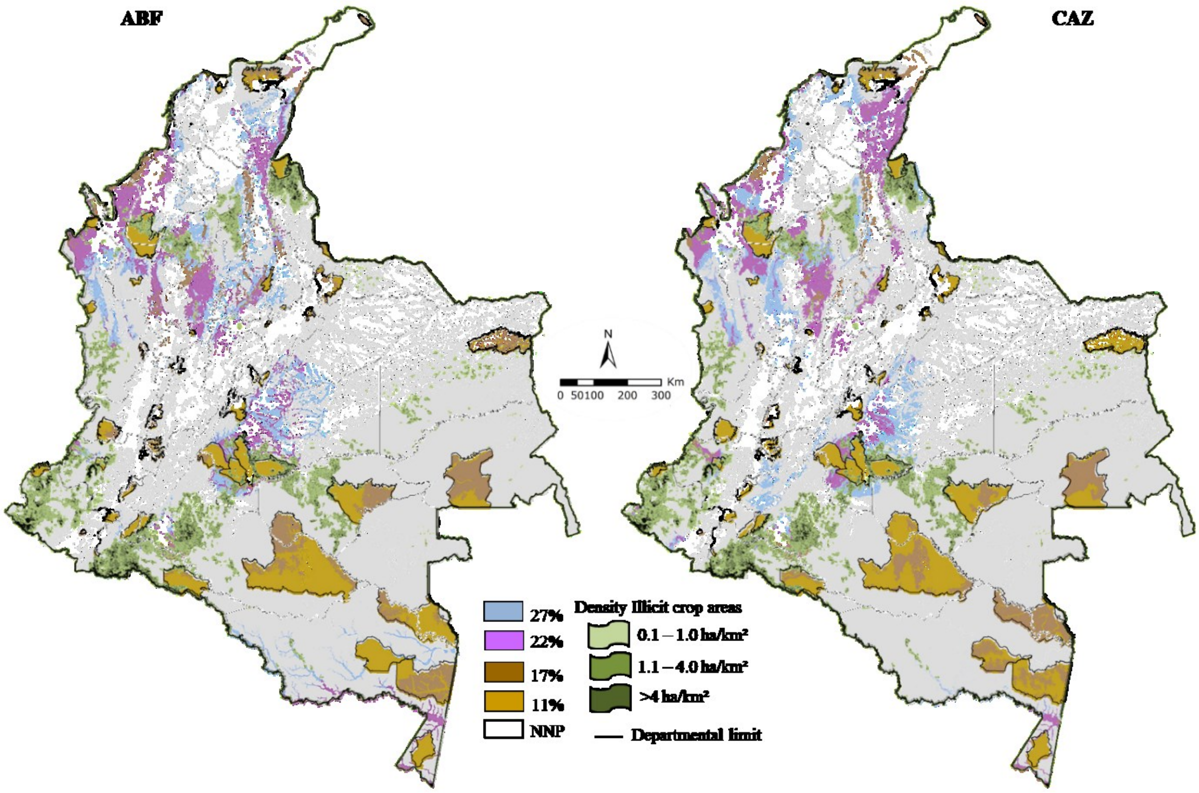


Figure 2.6 Potential threats associated to priority conservation zones at different protection targets. Density of Illicit crop areas (UNODC 2014) were overlaid to scenarios using two main cell removal rules, the Additive Benefit Function (ABF) and the Core-Area Zonation (CAZ), in order to identify areas of high vulnerability. NNP: current National Natural Park system.

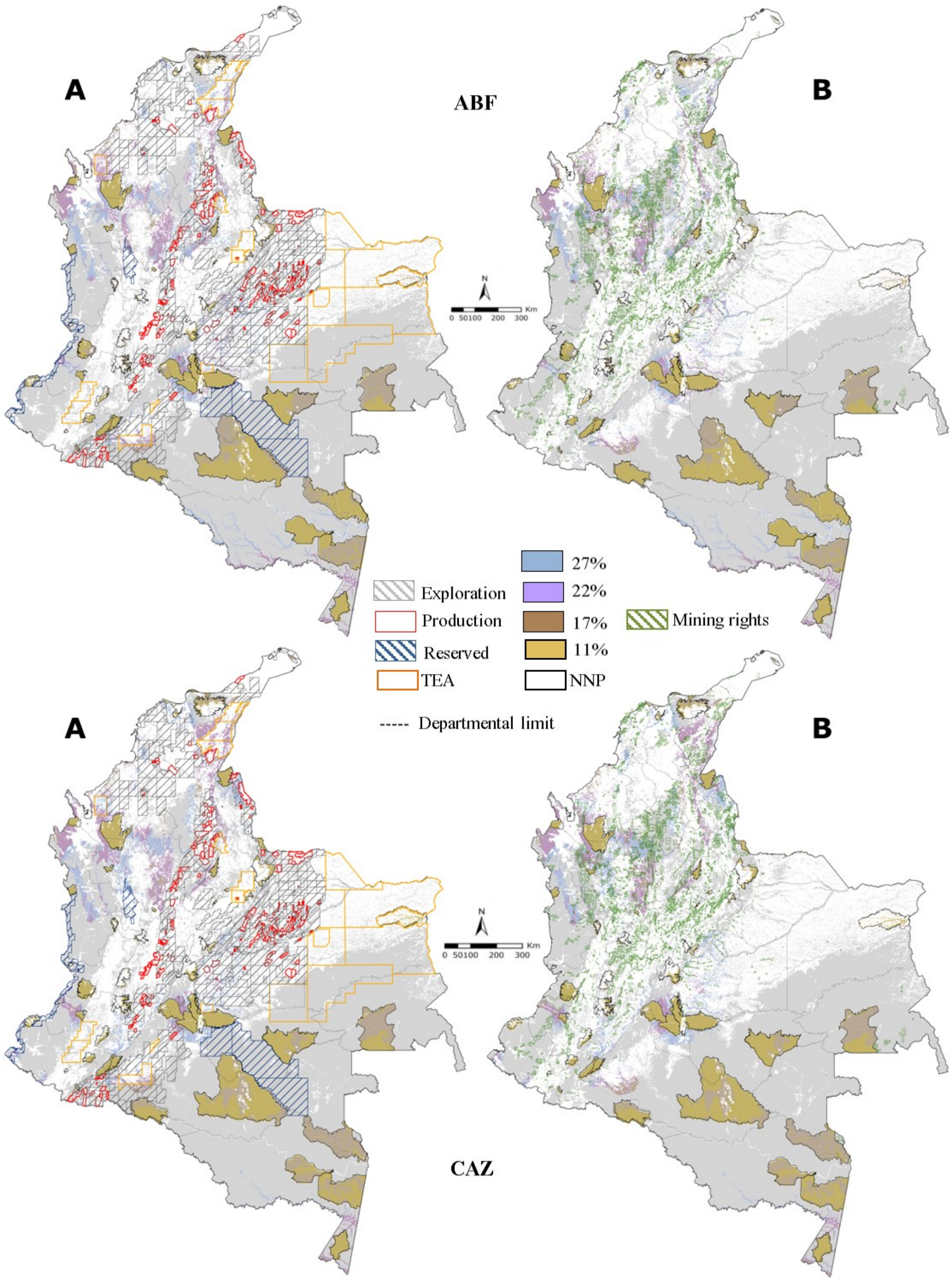


Figure 2.7 Potential threats associated to priority conservation zones at different protection targets. Oil concession areas (A) and mining rights (B) were overlaid to Additive Benefit Function (ABF) and Core-Area Zonation (CAZ) scenarios to identify vulnerability priorities to consider in the expansion process of the current reserve network. NNP: current National Natural Park system

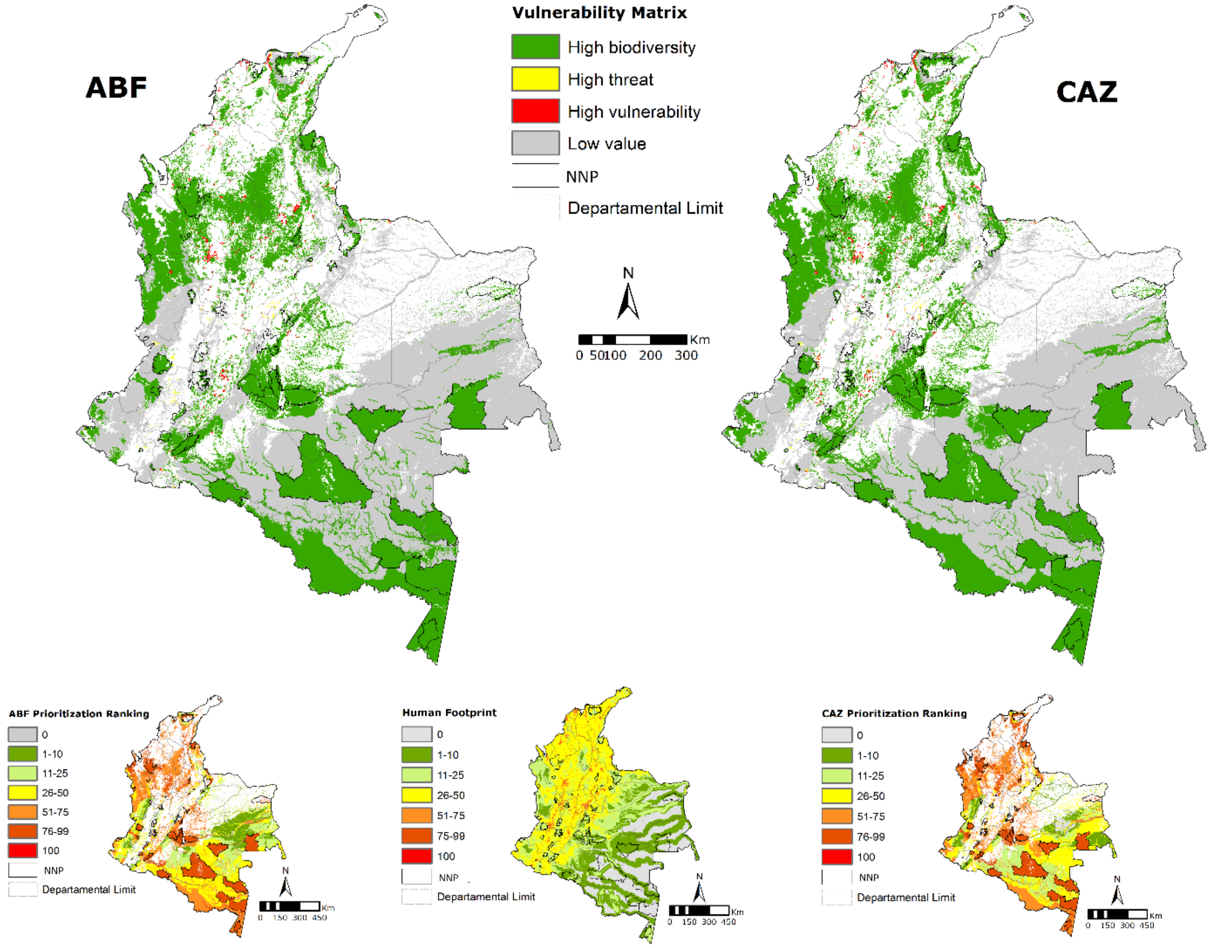


Figure 2.8a Irreplaceability-vulnerability ranking based on the Human Footprint Index and reclassified Additive Benefit Function (ABF) and the Core-Area Zonation (CAZ) priority rank scenarios. Regional conservation priorities are identified in terms of high vulnerability value (High biodiversity and high threat) using a two-dimensional vulnerability matrix. NNP: current National Natural Park System.

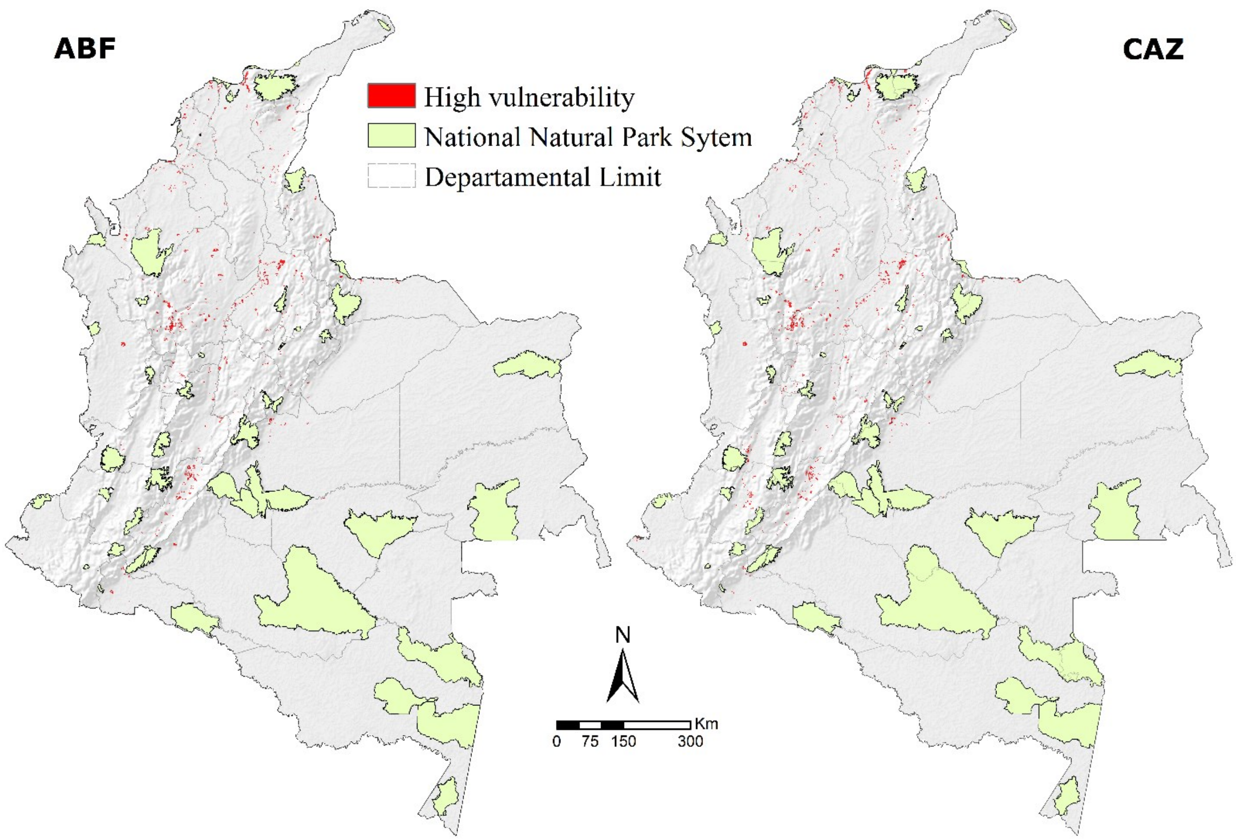


Figure 2.8b Regional conservation priorities of high vulnerability value (High biodiversity and high threat) derived from the irreplaceability-vulnerability approach using a two-dimensional vulnerability matrix to pair the zonation rank (conservation values) with the percentage of threat relative to human Influence on the land (biomes). ABF: Additive Benefit Function; CAZ: Core-Area Zonation. Green areas represent the current National Natural Park System.

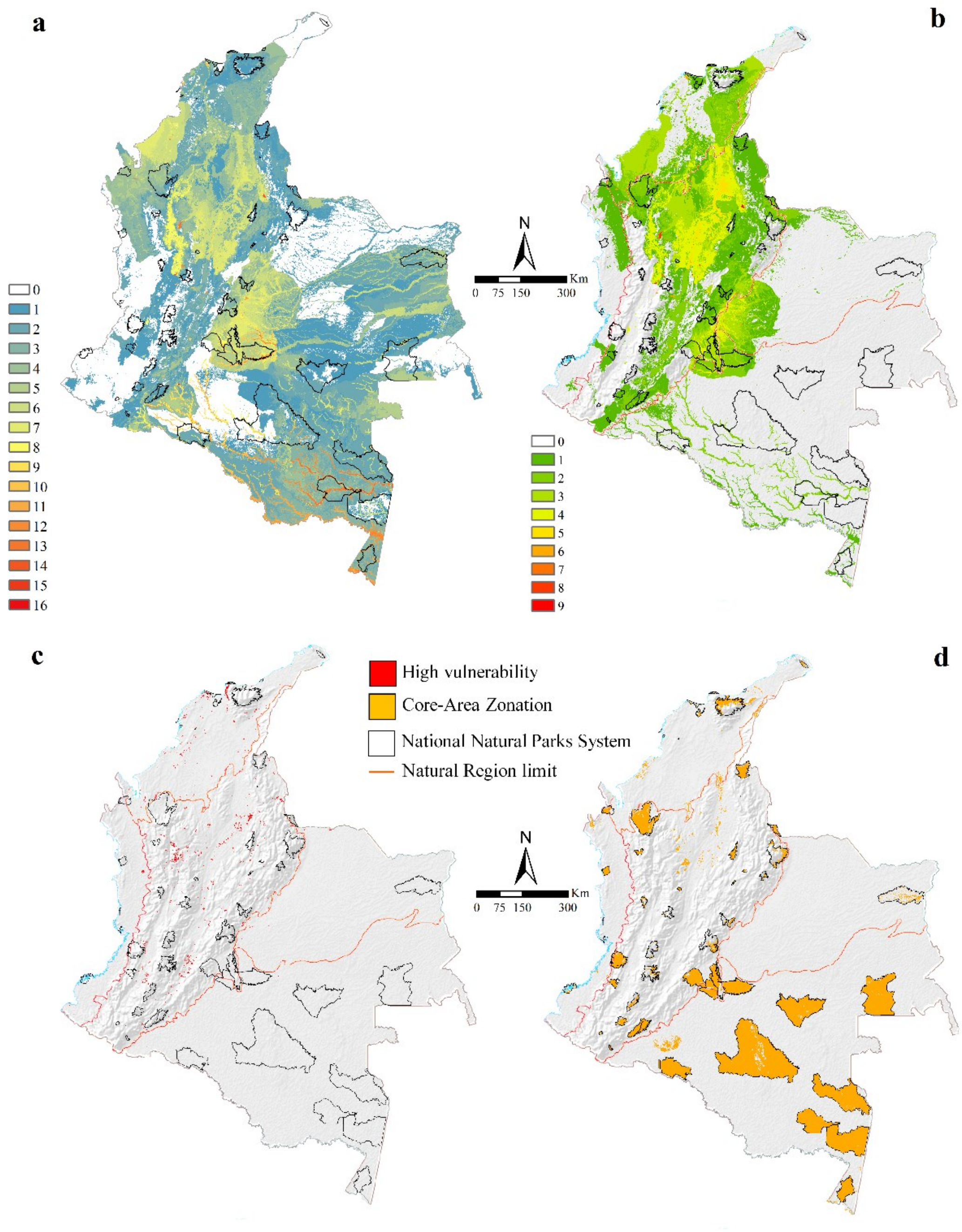


Figure 2.9 Primate richness in Colombia (a) -cold to warm colors represent increase in number of species. Incidence of species of concern (b) -endemic, rare and highly threatened, red color represents higher occurrences. Priorities of high vulnerability value using the Core-Area Zonation cell removal rule (c). Core-Area Zonation ranking under the 17% conservation goal (d).

3. Protecting primates in Colombia: from fine to coarse perspectives in conservation needs

3.1 Implications

This thesis provided both an assessment of conservation gaps and prioritized sites for future protection, as well as new geographic distribution maps (ranges and suitable habitat) for 39 taxa of primates. This is especially valuable for species that do not have contemporary distribution models including species in the families of Aotidae, Pitheciidae, Cebidae, and most of the species in Callitrichinae. Modeled potential distribution of primates provide the capacity for better assessing population status and development of sites to target for verifying occurrence (Hipólito et al. 2015 and Maestri & Patterson 2016) and monitoring of populations for not only endangered species, but also poorly known species where conservation assessments are needed. For example, monitoring activities are recommended for spider monkeys and woolly monkeys (Palacios & Peres 2005, Link et al. 2010 and Lizcano et al. 2014) given the rate of habitat fragmentation in areas where these species occur (Armenteras & Villareal 2003). These species have diet requirements and body size features, making them more susceptible to fragmentation (Cowlishaw & Dunbar 2000, Peres 2000, Palacios & Peres 2005, Defler 2010 and Link et al. 2010), along with the risk of becoming a regular prey for hunting. Likewise, the taxonomic arrangement, geographic ranges, and conservation needs for night monkeys in the Andes and Amazon regions need to be better addressed (Defler & Bueno 2007).

Conservation planning needs to consider the social dimension with conservation strategies ensuring the quality and well-being of not only non-human species, but also opportunity to coexist with humans by allowing responsible traditional use of the different resources. This is even more important when settlements overlap with forested areas that harbor high biodiversity values or sensitive species. Thus, one of the main goals in the current paradigm of conservation planning is the maintenance of ecosystem functions and services, while also ensuring traditional ways of living. New conservation sites in areas where African decent and indigenous communities occur (Figure 3.2) should therefore be integrated with ongoing conservation programs in the country. This includes the policy of social participation in conservation ‘’Parques con la gente’’ (parks with people), special management regimes with indigenous peoples formulated by the SNNP (Paredes 2011), and the multiple community-based strategies led by different NGOs providing support in the formulation of management plans of natural resources with active participation of stakeholders. This includes the use of traditional knowledge to ensure protection of primary forests and sacred sites (e.g., PNN Yaigoje-Apaporis and native reserves in the Amazon region, Conservation International Colombia (pers. obs.)). Indeed, Corzo (2008) considers such approaches to be advantageous ("oportunas") since communities can help to conserve strategic ecosystems while limiting the pressure of human development. Likewise, Armenteras et al. (2009) pointed out the value of indigenous reserves to mitigate deforestation. These strategies benefit species of spider monkeys in the Andean and Chocó bio-geographic region, as some other vulnerable species present in new proposed conservation areas in the Amazon piedmont and Pacific region.

Likewise, the conservation category of rural reserve ("reserva campesina", Corzo 2008) could be used to set protection actions in rural areas where critically endangered species of monkeys occur (e.g., the Caqueta titi monkey), while occurring in areas of high habitat fragmentation. Similarly, social based conservation projects on reforestation and sustainable resource use occurring in areas of high coca crop incidence have demonstrated to be effective in providing alternative economic options, while increasing awareness and values of restoring forests and associated ecosystem services (Giraldo-Benavides et al. 2007 and Baena 2016).

Finally, primates represent highly charismatic species that have value in being used as flagship species to gain public and international interest and funding for conservation programs (Leader-Williams & Dublin 2000). This includes assembly alliances with different players (communities, government, NGO, universities, etc.) and finding ways to generate incentives (Supriatna & Ario 2105). Use of primates as flagship species for conservation in areas of high vulnerability may provide substantial benefits for both communities and habitats (biodiversity). Home et al. (2009) noted that a combination of charisma and ecological importance is an important criterion for the selection of flagship species and for successful conservation programs. These features are clearly exhibited by primates (their role in the maintenance and functioning of the ecosystems, along with the sympathy that they generate in the public). Currently, species-based conservation programs in Colombia aim at protecting populations of the cotton-top tamarin (*Saguinus Oedipus*), spider monkeys (*Ateles hybridus*), and woolly monkeys (*Lagothrix l. lagothricha*) and can be replicated and/or adjusted to include other under-protected vulnerable species such as the white-footed tamarin (*Saguinus leucopus*) and Caqueta titi monkey (*Callicebus caquetensis*).

3.2 Limitations

Given that the number of location records for some taxa in this study were small, there is still uncertainty in both their environmental niche (Zhang & Zhang 2012) and their geographic distribution/suitable habitat. This identifies the need for prioritizing collection and reporting of occurrence records, especially for those species with less than ten observations (e.g., *Saguinus n. graellsi, S. n. hernandezi, Callimico goeldii, Cebus a. malitiosus*) or with unknown occurrence records such as the shock-headed capuchin (*Cebus albifrons cuscinus*). Censuses for some taxa are still needed such as the Hernández-Camacho's night monkey, a newly described species for Colombia (Defler & Bueno 2007) based on only one museum specimen and no record of locality (i.e., found in captivity), although supposedly captured in the NNP-Los Nevados (Andean region) (Table 2.1, Main Chapter). This limits identification of geographic distribution and conservation status.

Furthermore, to improve the knowledge on national conservation needs and for a more precise definition of distribution ranges for the Aotidae family in the country, there is the need to confirm the presence of the Brumback's night monkey (*Aotus brumbacki*) at northeastern parts of the Orinoco region, to clarify whether the Northern Night Monkey (*A. trivirgatus*) occurs in the country, and to include confirmed records for a new species for Colombia the Nancy Ma's Night Monkey (*A. nancymaae*) (IGUN 2012), which report was found after the distributions maps were made.

For the Brumback's night monkey, most records are limited to localities in the western parts of the Orinoco region with an unsuccessful attempt to clarify the extent of its geographic distribution in forested areas of savannas in the eastern side of this region (Castillo-Ayala & Nielsen 2013). Increasing regional efforts for sampling are essential given the vulnerability/status of this night monkey and the level of threat due to deforestation for illicit crops in the Orinoco region (Armenteras et al. 2013).

A recent update of the list of primates in Colombia includes the northern night monkey (*A. trivirgatus*) (APC 2016), while Veiga & Rynalds (2008) does not recognize Colombia as native for this species. There is also uncertainty about determining if a specimen from a locality in the Orinoco basin in Colombia is either *A. trivirgatus*, *A. brumbacki*, or even a new species highlighting the need to resolve the phylogenetic arrangement for the species of night monkeys within the eastern localities of Colombia (Defler & Bueno 2007).

Lack of national high-resolution environmental data (e.g., soil fertility, tree species composition and dominance, forest productivity and structure, etc.) limits fine-scale predictions of geographic distribution and a full understanding of ecological niches. Regionally-derived environmental data would also increase the level of confidence in conservation planning assessments, as well as allowing better assessments of landscape connectivity (Lehtomäki et al 2009). As an example, Lawley et al. (2016) remarked about the capacity of integrating data from both site-based and remote sensing platforms in order to monitor vegetation condition and thus inform management decisions. Such monitoring would be highly valuable. Open access to spatial data in Colombia is critical but limited for scientists and conservation organizations (Brito 2013).

Likewise, improvements are needed in further prioritization of protected areas and assessments of vulnerability as more information becomes available and sites are protected. Updated spatial datasets on contemporary forest and land use cover type for the country would be especially valuable (as the models generated by Armenteras et al. 2002, Armenteras et al. 2003, Etter et al. 2006 and Rodríguez Eraso et al. 2013). Other important data sets include the occurrence and/or density of illicit crops, human population density, forest industry, farming, and ranching. For instance, the information derived from the spatial footprint index developed by Etter et al. (2011) could be an effective tool for identifying vulnerable areas across the geographic ranges of primates in Colombia since it integrates important variables such land use intensity, intervention time, and biophysical variability.

3.3 Recommendations

In spite of limitations described above, this study offers the first attempt to address major conservation needs for primates at a national, multi-specific level. It also contributes to providing a consistent dataset and approach to defining the geographic ranges for most primates in Colombia. However, connectivity assessments also need to be carried out. Connectivity analyses would allow evaluation of the condition of forested areas within national natural parks and to select in an objective manner new conservation areas that link remnant patches of forest with current protected areas. Protection costs could also decrease if new conservation areas are located near existing areas (Moilanen et al. 2009).

Finally, it is critical to consider other threats (e.g., deforestation and agriculture patterns) in order to have more diverse array of scenarios for prioritizing conservation areas and helping with decision-making. This could follow the form of irreplaceability-vulnerability analysis (Lawler et al. 2003), opportunity cost modeling (Naidoo & Adamowicz 2006) using probabilities of land conversion and estimates of economic gain, or by considering the impacts as surrogates for cost, mainly those related with land uses. This last approach has the benefit of setting conservation priorities in areas with low incidence of human development and lower land purchasing cost. However, caution is needed in settling on the right costs and conservation targets since it can lead to the inadequate selection of areas to protect (Possingham et al. 2009).

3.4. Figures

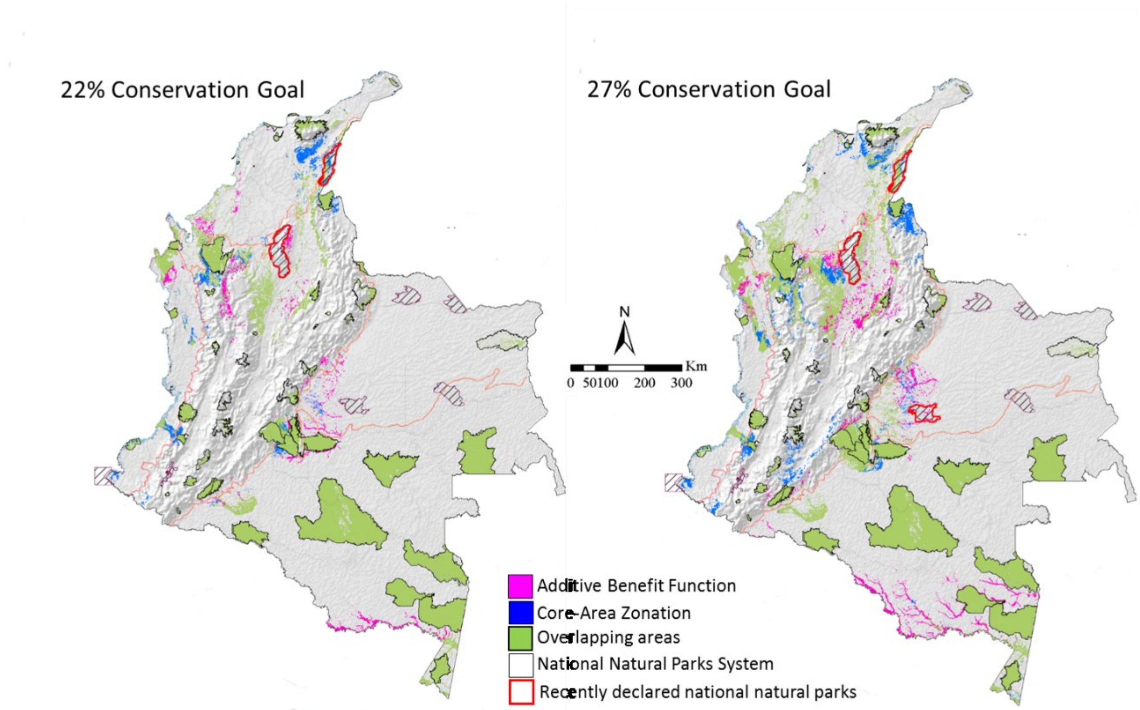


Figure 3.1 National Natural Parks recently declared in relation with merged scenarios using two main cell removal rules, the Additive Benefit Function (ABF) and the Core-Area Zonation (CAZ) at 22 and 27% protection targets.

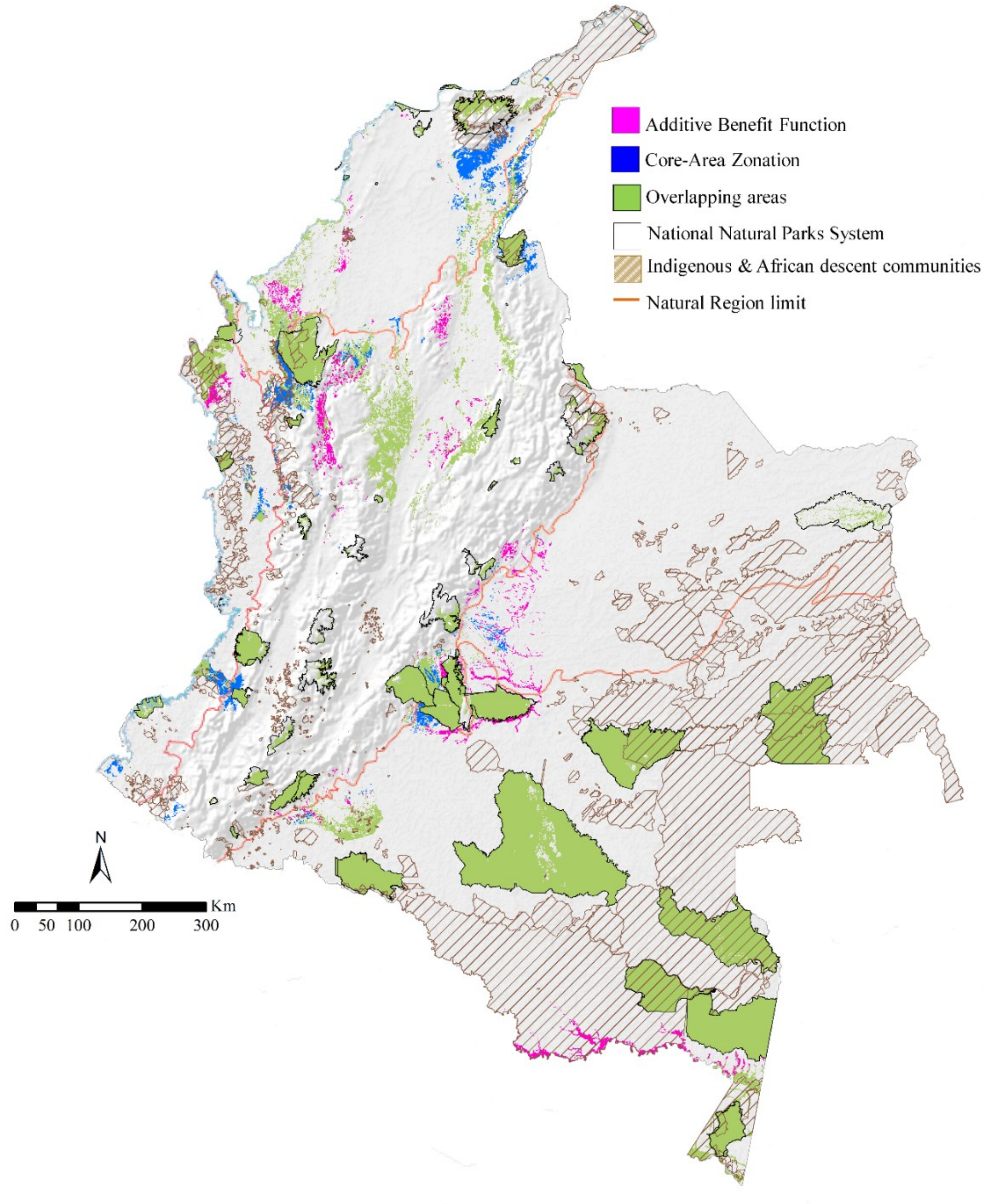


Figure 3.2 Indigenous reserves and African descent communities associated to priority conservation zones using two main cell removal rules, the Additive Benefit Function (ABF) and the Core-Area Zonation (CAZ) at 22% protection goal.

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Appendices

Appendix A. Map of the geographic sub-areas within the five inland natural regions in Colombia. Downloaded from IGAC (Instituto Geográfico Agustín Codazzi. Bogotá, Colombia): http://geoportal.igac.gov.co/mapas_de_colombia/IGAC/Tematicos2012/RegionesGeograficas.pdf

Appendix B. List of databases and references used to get information on species occurrences.

Main source:

Rodríguez-Mahecha, J. V., Arjona-Hincapié F., Muto T., Urbina Cardona J. N., Bejarano-Mora P., Ruiz-Agudelo C., Díaz Granados M. C., Palacios E., Moreno M. I., Gómez A., &. Geothinking Ltda. 2013. Ara Colombia. Sistema de Información Geográfica para el Análisis de la Gestión Institucional Estatal (Módulo OtusColombia) y la Afectación a la Biodiversidad sensible y al Patrimonio Cultural (Módulo TremarctosColombia). Versión 2.0.

Additional sources:

GIBF- Global Biodiversity Information Facility, http://www.gbif.org/occurrence/search:

a. Field Museum of Natural History (Zoology): FMNH Mammal Collection. Accessed via http://www.gbif.org/dataset/41fc5c40-5e81-496f-9733-6b5681b3b7a5

b. Royal Ontario Museum: Mammalogy Collection - Royal Ontario Museum. Accessed via http://www.gbif.org/dataset/c5c4a23e-2035-4416-ab64-032d6df52ddb

c. Museum of Vertebrate Zoology: MVZ Mammal Collection (Arctos). Accessed via http://www.gbif.org/dataset/0daed095-478a-4af6-abf5-18acb790fbb2

d. University of Washington Burke Museum: UWBM Mammalogy Collection. Accessed via http://www.gbif.org/dataset/830eb5d0-f762-11e1-a439-00145eb45e9a

e. Museum of Comparative Zoology, Harvard University: MCZ Mammalogy Collection. Accessed via http://www.gbif.org/dataset/84873266-f762-11e1-a439-00145eb45e9a

f. National Museum of Natural History, Smithsonian Institution: NMNH occurrence DwC-A. Accessed via http://www.gbif.org/dataset/5df38344-b821-49c2-8174-cf0f29f4df0d

SIB – Sistema de información sobre biodiversidad de Colombia, http://data.sibcolombia.net/

Catalogue of the biodiversity of Colombia, coordinated by the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (**IAVH**), and supported by the Ministerio de Ambiente y Desarrollo Sostenible, Instituto Amazónico de Investigaciones Científicas **Sinchi**, Instituto de Hidrología, Meteorología y Estudios Ambientales **IDEAM**, Instituto de Investigaciones Marinas y Costeras "José Benito Vives de Andreis", Instituto de Investigaciones Ambientales del Pacífico, and the Universidad Nacional de Colombia.

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Appendix C. An example of the final Excel data sheet that includes relevant information on species occurrences. This format was adapted from the primate species data base proportioned by Conservation International Colombia.

ID #	Source	Cientific_Name	Dpto	Munici	Locality	Latitude	Longitude	MET_GEOREF_rev	METADATO_URL_re	Date	Type_Rec	Museum_Code	Catalogue #	Collector	Additional_URL
500	ARA	*Saguinus oedipus*	Córdoba	Tierralta	Urrá	7.7013142	-75.9809942	Google Earth		Desconocida					
501	ARA	*Saguinus oedipus*	Córdoba	Tierralta	Urrá	7.9114025	-75.9753836	Google Earth		Desconocida					http://data.gbif.org/ws/rest/
502	ARA	*Saguinus oedipus*	Córdoba	Tierralta	Urrá	8.0287689	-75.9666036	Google Earth		Desconocida					
503	GBIF	*Aotus griseimembra*	Córdoba		Catival, upper	8.2833333	-75.6833333		http://data.gbif.org/occurrences/61811389	Desconocida	Specimen	FMNH-Mammals	68858	P. Hershkovitz	
504	ARA	*Cebus capucinus*	Córdoba		Paramillo PN	7.5333333	-76.1166667			Desconocida					
505	ARA	*Saguinus oedipus*	Córdoba		Paramillo PN	7.5333333	-76.1166667			Desconocida					
506	ARA	*Saguinus oedipus*	Córdoba		Puerto Zapote	9.4166667	-75.7500000			Desconocida					http://data.gbif.org/ws/rest/
507	ARA	*Alouatta palliata aequatorialis*	Chocó	Nuquí	El Amargal E	5.5666670	-77.5061110	Ramírez & Sánchez 2005. Primer Censo del Mono Aullador Negro Alouatta pa		Desconocida		ICN-Mamíferos			http://data.gbif.org/ws/rest/
515	ARA	*Alouatta palliata aequatorialis*	Atlántico	Luruaco	Los Pendales	10.6181200	-75.2057900	Google Earth+Genames+DIVIPOL	Compilacion-CI-2009 (J.Gualdron)	Desconocida		IAVH - 8200001422-01			http://data.gbif.org/ws/rest/
516	ARA	*Saguinus geoffroyi*	Chocó	Acandí	Acandí rio, ce	8.5139870	-77.2815800	Google Earth	ICN - Catalogo Mamíferos (YMS 20100419	19590112	Piel, otros	ICN-Mamíferos	1788		
517	ARA	*Aotus zonalis*	Chocó	Acandí	Acandí rio, ce	8.5139870	-77.2815800	Google Earth	Compilacion-CI-2009 (J.Gualdron)	Desconocida					
518	ARA	*Aotus zonalis*	Chocó	Acandí	Gilgal corregir	8.1902300	-77.0814810	Geoportal IGAC	IAVH-M_Base de datos coleccion de mam	Desconocida	Espécimen	IAVH - 8200001422-01	2673	Rodriguez J	
519	ARA	*Ateles geoffroyi rufiventris*	Chocó	Bahia Solano	Cupica rio	6.7172080	-77.4633060	Geoportal IGAC	Compilacion-CI-2009 (J.Gualdron)	Desconocida					
520	ARA	*Alouatta palliata aequatorialis*	Córdoba	Chimá	Pimental	9.0923170	-75.7096330	Fuente		17-NOV-11 7:	Observaciones				
521	ARA	*Alouatta palliata aequatorialis*	Córdoba	Lorica	Ceiba pareja	9.1598000	-75.9100500	Fuente		05-Oct-11	Observaciones				
522	ARA	*Alouatta palliata aequatorialis*	Córdoba	Lorica	Cotocá	9.0944830	-75.8642000	Fuente		11-OCT-11 1:0	Observaciones				
523	ARA	*Alouatta palliata aequatorialis*	Córdoba	Lorica	Cotocá	9.1128830	-75.8361830	Fuente		11-OCT-11 10:	Observaciones				
524	ARA	*Alouatta palliata aequatorialis*	Córdoba	San Pelayo	La Pacha	9.0047000	-75.8611670	Fuente		26-SEP-11 11	Observaciones				
525	ARA	*Saguinus geoffroyi*	Chocó	Riosucio	El Tilupo alto	7.8666667	-77.1166667	Geonames + Geoportal IGAC		Desconocida					
526	ARA	*Alouatta palliata aequatorialis*	Córdoba	San Pelayo	La Pacha	9.0078330	-75.8712170	Fuente		27-SEP-11 1:0	Observaciones				
527	ARA	*Alouatta palliata aequatorialis*	Córdoba	San Pelayo	La Pacha	9.0210500	-75.8512170	Fuente		25-SEP-11 10	Observaciones				http://data.gbif.org/ws/rest/
528	ARA	*Alouatta palliata aequatorialis*	Córdoba	San Pelayo	La Pacha	9.0211170	-75.8607170	Fuente		25-SEP-11 4:4	Observaciones				
529	ARA	*Alouatta palliata aequatorialis*	Córdoba	San Pelayo	La Pacha	9.0211500	-75.8603000	Fuente		26-SEP-11 1:0	Observaciones				
530	ARA	*Alouatta palliata aequatorialis*	Chocó	Riosucio	Los Katíos PN	7.8381440	-77.1422940	Geoportal IGAC		Desconocida	Espécimen	IAVH - 8200001422-01	6083	Rodríguez, J. V.	
531	ARA	*Aotus zonalis*	Chocó	Riosucio	Los Katíos PN	7.9095690	-77.0996140	Geoportal IGAC		Desconocida	Espécimen	IAVH - 8200001422-01	3092	Echeverri, H., & A. Perea	http://data.gbif.org/ws/rest/
532	ARA	*Aotus zonalis*	Chocó	Riosucio	Los Katíos PN	7.7461810	-77.1500280	Geoportal IGAC		Desconocida	Espécimen	IAVH - 8200001422-01	2676	Rodríguez M., J.V.	
533	ARA	*Saguinus geoffroyi*	Chocó	Unguía	Tanela corregi	8.2166400	-77.0484060	DIVIPOLA + Geonames + Google Earth		Desconocida	Espécimen	IAVH - 8200001422-01	2670	Rodriguez, José V., H. Pavas & A. Perea	
534	Thomas Defler	*Saguinus geoffroyi*	Chocó	Unguía	Unguía	8.0522250	-77.1021870	Google Earth		09/03/1950	skin, skull	FMNH-Mammals	FMNH69947	P. Hershkovitz	
535	GBIF	*Aotus zonalis*	Chocó	Unguía	Unguía	8.0522250	-77.1021870	Google Earth	http://data.gbif.org/occurrences/61811399	Desconocida		FMNH-Mammals	69611	P. Hershkovitz	
536	ARA	*Alouatta seniculus*	Chocó	Unguía	Unguía	8.0522250	-77.1021870	Google Earth		Desconocida		FMNH-Mammals	69591	P. Hershkovitz	http://data.gbif.org/ws/rest/
537	ARA	*Aotus zonalis*	Chocó	Unguía	Unguía, area	8.3163810	-77.2166310	DIVIPOLA + Geonames + Google Earth		Desconocida					http://data.gbif.org/ws/rest/
538	ARA	*Saguinus geoffroyi*	Chocó	Unguia	Darien Serran	8.0620600	-77.2000900	Geoportal IGAC		Desconocida					http://data.gbif.org/ws/rest/
539	GBIF	*Alouatta seniculus*	Chocó	Novita	Novita (400 ft)	4.9492910	-76.6098410	DIVIPOLA (Dane) + Google Earth	http://data.gbif.org/occurrences/213089530	Desconocida		AMNH-Mammalia	33062	L. E. Miller	
540	ARA	*Alouatta seniculus*	Cesar	Chiriguaná	Carbonero, ca	9.3333300	-73.6333300	Google Earth+Geoportal IGAC+ Geonames		19770216		ICN-Mamíferos	6890		http://data.gbif.org/ws/rest/
1322	Thomas Defler	*Alouatta seniculus*	Magdalena	Santa Marta	Buritaca	11.2604820	-73.7714920	Google Earth		April 1899		AMNH-Mammalia	23334	H. H. Smith	http://data.gbif.org/ws/rest/
1323	Thomas Defler	*Alouatta seniculus*	Magdalena	Santa Marta	Cacagualito (1	11.2742560	-74.0518810	Geoportal IGAC + Google Earth		Desconocida		AMNH-Mammalia	23330	H. H. Smith	
1324	Thomas Defler	*Cebus albifrons malitiousus*	Magdalena	Santa Marta	Cacagualito (1	11.2742560	-74.0518810	Geoportal IGAC + Google Earth		28/04/1899		AMNH-Mammalia	23399	H. H. Smith	http://data.gbif.org/ws/rest/
1325	Thomas Defler	*Alouatta seniculus*	Magdalena	Santa Marta	Calabazo	11.2834920	-74.0028010	DIVIPOLA + Geoportal IGAC + Google Earth		April 1899		AMNH-Mammalia	23335	H. H. Smith	
1326	Thomas Defler	*Aotus griseimembra*	Magdalena	Santa Marta	Cincinati	11.1000250	-74.0833361	Google Earth		20 July 1911		AMNH-Mammalia	32665	M. A. Carriker	
1327	Thomas Defler	*Alouatta seniculus*	Magdalena	Santa Marta	Guairaca	11.2953250	-74.0605420	Geoportal IGAC		3 Feb. 1900		AMNH-Mammalia	23377	H. H. Smith	http://data.gbif.org/ws/rest/
1328	Thomas Defler	*Alouatta seniculus*	Magdalena	Santa Marta	Jordan	11.2835972	-73.9833611	Google Earth		Feb. 1899	Specimen	AMNH-Mammalia	23332	H. H. Smith	http://data.gbif.org/ws/rest/
1329	Thomas Defler	*Alouatta seniculus*	Magdalena	Santa Marta	Los Naranjos	11.2990917	-73.9000111	Google Earth		May 1898		AMNH-Mammalia	23353	H. H. Smith	http://data.gbif.org/ws/rest/
1793	NP_2010_17(2)	*Callicebus caquetensis*	Caquetá	Valparaiso	Finca Libardo	1.1067639	-75.6196722			20/04/2012	Obsevation			Defler, T., M.L Bueno & J. G	Defler, T., M.L Bueno & J. (
1794	NP_2010_17(2)	*Callicebus caquetensis*	Caquetá	Valparaiso	Finca Libardo	1.1034083	-75.6163333			20/04/2012	Obsevation			Defler, T., M.L Bueno & J. G	Defler, T., M.L Bueno & J. (
1795	NP_2010_17(2)	*Callicebus caquetensis*	Caquetá	Valparaiso	Finca Bello Di	1.0203028	-75.6181278			20/04/2012	Obsevation			Defler, T., M.L Bueno & J. G	Defler, T., M.L Bueno & J. (
1796	NP_2012_19(1)	*Ateles hybridus brunneus*	Caldas	Samaná	P.N.N. Selva (	5.4952778	-75.1155556	UTM_Conversion_ExcelSheet		2011	Obsevation			Roncancio-Duque, Nestor. A record of Variegated Spide	
1797	NP_2011_18(1)	*Saguinus oedipus*	Bolívar	San Juan de N	La Reserva	10.0402028	-74.9749444	UTM_Conversion_ExcelSheet		2011	Obsevation			Dechner, A. Searching for A. palliata in Northen Colomb	
1798	NP_2011_18(1)	*Saguinus oedipus*	Bolívar	Calamar	El Acueducto	10.1147722	-74.9447917	UTM_Conversion_ExcelSheet		2011	Obsevation			Dechner, A. Searching for A. palliata in Northen Colomb	
1799	NP_2008_15(1)	*Aotus lemurinus*	Quindío	Quimbaya	La Montaña d	4.5893889	-75.8741667	UTM_Conversion_ExcelSheet		2006	Obsevation			Martin-Gomez, O. H. Consumo de nectar por Aotus lem	
1800	NP_2014_21(1)	*Pithecia hirsuta*	Amazonas	La Pedrera	Caño Esperan	-1.8397222	-69.7275000	UTM_Conversion_ExcelSheet		2001-2012	Obsevation			Palacios Erwin_CI-Col/ Marsh L. K. 2014. Taxonomic re	
1801	NP_2014_21(1)	*Pithecia hirsuta*	Amazonas	La Pedrera	Quebradon El	-1.5866389	-69.5276944	UTM_Conversion_ExcelSheet		2001-2012	Obsevation			Palacios Erwin_CI-Col/ Marsh L. K. 2014. Taxonomic re	
1802	NP_2014_21(1)	*Pithecia hirsuta*	Amazonas	La Pedrera	Caño Curare/	-1.3347222	-69.8227778	UTM_Conversion_ExcelSheet		2001-2012	Obsevation			Palacios Erwin_CI-Col/ Marsh L. K. 2014. Taxonomic re	
1803	NP_2014_21(1)	*Pithecia hirsuta*	Amazonas	La Pedrera	Caño Agua Bl	-1.3266667	-69.7672222	UTM_Conversion_ExcelSheet		2001-2012	Obsevation			Palacios Erwin_CI-Col/ Marsh L. K. 2014. Taxonomic re	
1804	NP_2014_21(1)	*Pithecia hirsuta*	Amazonas	La Pedrera	Caño El Bolivi	-1.4116667	-69.5827778	UTM_Conversion_ExcelSheet		2001-2012	Obsevation			Palacios Erwin_CI-Col/ Marsh L. K. 2014. Taxonomic re	

From left to right: ID number, Scientific Name, Source, Department (similar to Province in Canada), Municipality, Locality, Latitude Coordinates, Longitude Coordinates, Method of Geo-referencing, Metadata_URL, Date of the record, Type of record (skull, skin, direct observation, etc.), Museum Code, Catalogue Number, Collector name, and additional URL link.

Appendix D. List of environmental variables considered for the modelling processes. Description of variables, layers resolution and acquisition sources are enumerated. Variables **in bold** correspond to selected environmental predictors used in all final environmental niche models. Bioclimatic variables defined as in WorldClim (2015), as well as for **(*)**: "Extreme or limiting environmental factors". Note: 30 arc-seconds equal approx. 920 meters at Equator, and 1 arc-second equals approx. 30 meters at Equator.

CLIMATE MODELS						
Variable Name	**Year**	**Description**	**File Name**	**Resolution**	**Source**	**URL**
BIO1	2005	Annual Mean Temperature	bio_ res_01	30 arc-seconds GeoTIFF	WorldClim/ Hijmans et al. 2005[1]	http://www.worldclim.org/
BIO2		Mean Diurnal Range (Mean of monthly (max temp-min temp))	bio_ res_02			
BIO3		Isothermality (BIO2/BIO7) (* 100)	bio_ res_03			
BIO4		**T° Seasonality (standard deviation *100)**	bio_ res_04			
BIO5*		Max Temperature of Warmest Month	bio_ res_05			
BIO6*		Min Temperature of Coldest Month	bio_ res_06			
BIO7		**T° Annual Range (BIO5-BIO6)**	bio_ res_07			
BIO8*		Mean Temperature of Wettest Quarter	bio_ res_08			
BIO9*		Mean Temperature of Driest Quarter	bio_ res_09			
BIO10*		Mean Temperature of Warmest Quarter	bio_ res_10			

BIO11*	2005	Mean Temperature of Coldest Quarter	bio_ res_11	30 arc-seconds GeoTIFF	WorldClim/ Hijmans et al. 2005[1]	http://www.worldclim.org/
BIO12*		Annual Precipitation	bio_ res_12			
BIO13*		Precipitation of Wettest Month	bio_ res_13			
BIO14*		Precipitation of Driest Month	bio_ res_14			
BIO15		**Precipitation Seasonality (Coefficient of Variation)**	bio_ res_15			
BIO16*		Precipitation of Wettest Quarter	bio_ res_16			
BIO17*		Precipitation of Driest Quarter	bio_ res_17			
BIO18*		Precipitation of Warmest Quarter	bio_ res_18			
BIO19*		Precipitation of Coldest Quarter	bio_ res_19			
VEGETATION MODELS						
Net Primary Productivity (NPP)	2010	**Amount of atmospheric carbon fixed by plants and accumulated as biomass (Multi Year average)**	npp_col	1 Km Tiff Image	UNEP -United Nations Environment Programme[2]	http://geodata.grid.unep.ch/results.php
Forest Canopy Height	2005	**Global Forest Canopy Height**	canopy_col	1 Km Tiff Image	SDAT_ORNL DAAC[3]/ Simard et al. 2011[4]	http://webmap.ornl.gov/wcsdown/dataset.jsp?ds_id=10023

Tree Cover	2003	**Percent tree cover**	ptc_1km2	30 arc-seconds GeoTIFF	ISC GM[5] (Version 1)/ MODIS data 2003 (Terra)	http://www.iscgm.org/gm/ptc.html
SOIL MODELS						
Actual evapo-transpiration	1950-2000	Soil-water balance (yearly average)	aet_col	30 arc-seconds ESRI Grid	Trabucco & Zomer 2010_CGIAR-CSI[6]	http://www.cgiar-csi.org/data/global-high-resolution-soil-water-balance
BulkDensity_0-5mean	2013	Bulk density in kg /m^3 (mean estimate) for 2.5 cm depth	bld_m_ col	1 Km SoilGrid	Hengl et al. 2014 – ISRIC[7]	http://soilgrids.org/
Clay_ 0-5mean	2013	Soil texture fraction clay in percent (mean estimate) for 2.5 cm depth	clay_m_ col	1 Km SoilGrid		
Organic_ Carbon_ 0-5mean	2013	Soil organic carbon content (fine earth fraction) in per miles (mean estimate) for 2.5 cm depth	oc_m_col	1 Km SoilGrid		
pH_ 0-5mean	2013	Soil pH x 10 in H2O (mean estimate) for 2.5 cm depth	ph1_m_ col	1 Km SoilGrid		
Sand_ 0-5mean	2013	Soil texture fraction sand in percent (mean estimate) for 2.5 cm depth	sd1_m_col	1 Km SoilGrid		
PHYSICAL MODELS						
Elevation	From 2001	**ASTER -Global Digital Elevation Model (GDEM) Version 2.**	Dem_col_ clip	1 arc-second GeoTIFF	LP DAAC[8]	http://gdex.cr.usgs.gov/gdex/ https://lpdaac.usgs.gov/products/aster_products_table/astgtm

Land Cover Relates five main cover types: vegetation, wastelands (rocky outcrops, eroded land, etc.), anthropic (crops), hydric and built (Urban and industrial areas) (IGAC 2007[9])	2008	**19 Classes**	Landcover_pj	Shape file	SIG-OT-IGAC[10]	http://sigotn.igac.gov.co/sigotn/
		Heterogeneous agricultural areas	Areas that present mix of different types of crops, as a mosaic of annual and perennial crops; pasture and crops; crops, pastures and natural areas.			
		Areas mostly affected	Areas of mining, oil drilling, coal mining, gold, and other building materials, waste dumps and landfills.			
		Urban areas	Urban and suburban areas, population centers, communication networks, industrial or commercial areas, roads, railways and associated land, port areas, airports, water pipeline, construction sites, transformed natural areas			
		Natural inland waters	Rivers, ponds, lakes or flooded areas.			
		Shrub lands	Shrubs as prevailing woody elements. It includes shrub of "paramo", savannah and xerophytic.			
		Artificial inland waters	Water surfaces built by man as reservoirs or dams.			
		Rocky outcrops	It refers to areas where rock is exposed and there is no vegetation. In this exercise, due to the scale of work, the rocky outcrops were integrated into adjacent coverages, mainly bare areas and grasslands.			
		Natural forests	Plant communities dominated by trees higher than 5-meter height with average treetops density greater than 70%, and with an area greater than 50 ha. It includes dense forests, fragmented, of gallery or riparian, and mangroves.			
		Annual or transitional crops	Crops whose growing cycle lasts one year or less, or few months. Mainly characterized, after harvest, it is necessary to plant to continue producing.			
		Planted Forests	Planted hardwood forests and conifers.			
		Semi-permanent and permanent crops	Land devoted to crops whose growth cycle is longer than one year and where several crops are produced without replanting. Permanent crops such as sugarcane, panela cane, banana and plantain are presented			
		Continental aquatic vegetation	It is associated with aquatic ecosystems in the emerged part or aquatic vegetation belts. It contains herbaceous vegetation in wet inland areas, swamps, marshes, etc.			

Land Cover Relates five main cover types: vegetation, wastelands (rocky outcrops, eroded land, etc.), anthropic (crops), hydric and built (Urban and industrial areas) (IGAC 2007[9])	2008	Glaciers and snow	Areas covered by ice or snow.
		Grasslands	Vegetation dominated by herbs and grasses. Grasslands may have trees and bushes. This class includes grasslands associated to "paramo", savannah and xerophytic areas.
		Herbaceous and shrub coastal	It contains herbaceous and shrub vegetation in the intertidal zone, coastal and floodplain with marine influence.
		Bare areas with no or little vegetation	These zones correspond to the sands, beaches and dunes, or areas with sparse vegetation, such as "super-paramos".
		Pastures	Planted herbaceous species, generally used for livestock activities. Can be pastures, woody, weedy or "enrastrojados"
		Coastal lagoons	The coastal lagoons are depressions formed in the bays or in the terminal parts of the floodplain of rivers. Some are of tectonic origin and others are formed by the accumulation of sediments carried by ocean currents
		Secondary vegetation	Low-lying vegetation that is usually product of the process of succession of pastures or crops to tree cover. "Rastrojos" and vegetation in early successional state.
Biomes Set of ecosystems characterized by species and a variety of plants, weather condition and land cover characteristic (INVEMAR et al. 2007[11]).	2008	**32 classes**	Biome_pj	Shapefile	SIG-OT-IGAC[10]	http://sigotn.igac.gov.co/sigot/
		Halobiome of the Caribbean coast	Marine fluvial plains with poor to very poor drainage, in the Caribbean Coast. Tropical dry forest.
		Halobiome of the Pacific coast	Marine fluvial plains with poor to very poor drainage, in the Pacific Coast. Tropical rain forest.
		Helobioma of the Guajira	Dry and very dry warm climates in alluvial valleys with poor to very poor drainage in the Guajira Peninsula. Tropical Forest Desert.
		Andean Helobiomes	Very dry cold and dry cold climates; Floodplains poor to very poorly drained, in the valleys of Suarez and Bogota rivers. Tropical rain forest.
		Helobiomes of the Amazon-Orinoco basins	Poor to very poorly drained valleys in the Amazon and Orinoco region. Tropical rain forest.
		Helobiomes of the Magdalena and Caribe	Valleys, plains and foothills; with poor to very poor drainage in the Caribbean and Magdalena region. Tropical rain forest.

Biomes Set of ecosystems characterized by species and a variety of plants, weather condition and land cover characteristic (INVEMAR et al. 2007[11]).	2008	Helobiomes of the Pacific and Atrato	Poor to very poorly drained alluvial valleys and floodplains in the Atrato and pacific. Tropical rain forest.
		Helobiomes of the Zulia river	Poor to very poorly drained alluvial valleys in the Zulia river. Tropical rain forest.
		Helobiomes of Valle del Cauca	Temperate too dry to humid temperate climates in poor to very poorly drained plains in Valle del Cauca. Tropical dry forest.
		Litobiomes of the Amazon-Orinoco basins	Residual flattening surfaces (Peniplanicies). Excessively to deficiently drained in the Amazon and Orinoco region. Tropical rain forest.
		High Orobiome of de Santa Marta	Very dry to dry cold snowy climate in Sierra Nevada de Santa Marta. Tropical rain forest.
		Low Orobiome of Santa Marta and Macuira	Warm arid climate to very humid temperate climate; mountain climate. Sierra Nevada de Santa Marta and, Serranía de Macuira, Jarara and Cocinas.
		Orobiome of the La Macarena	Warm humid to very humid temperate climate. Hill and mountain climate. Serrania de La Macarena. Tropical rain forest.
		Orobiome of the San Lucas	Dry warm climate to very humid temperate climate. Mountain climate. Serrania San Lucas. Tropical rain forest.
		Orobiome of the Baudo and Darien	Warm humid climate to very humid temperate climate. Mountain climate. Serrania Baudo and Darien. Tropical rain forest.
		Middle Orobiome of Santa Marta	Dry cold climate to very cold humid climate. Mountain climate. Sierra Nevada de Santa marta. Tropical rain forest.
		High Orobiomes Andean region	Very dry cold climate to dry snowy climate. Plains, foothill, hills and mountains excessively to deficiently drained in the Andean region. Tropical rain forest
		Azonal Orobiomes of Cucuta	Very dry warm climate to dry temperate climate. Valleys, plains, hills and mountains excessively to deficiently drained around Cucuta. Tropical rain forest.
		Azonal Orobiomes of Sogamoso river	Very dry warm climate to dry temperate climate. Valleys, hills and mountains excessively to deficiently drained in the Sogamoso river (Chicamocha and Suarez). Tropical rain forest.

		Azonal Orobiomes of Patia valley	Warm dry climate to humid temperate. Plains, foothills, hills and mountains (principally) excessively to deficiently drained in the Patia river. Tropical rain forest.
Biomes Set of ecosystems characterized by species and a variety of plants, weather condition and land cover characteristic (INVEMAR et al. 2007[11]).	2008	Azonal Orobiomes Dagua river	Warm dry climate and dry temperate. Mountains of the Dagua river, covered by grasslands. Tropical rain forest.
		Low Orobiomes Andean region	Very dry and warm climate to rainy temperate climate. Plains, foothills, upland, hills and mountains excessively to deficiently drained in the Andes. Tropical rain forest.
		Middle Orobiomes Andean region	Dry temperate climate to very humid cold climate. Plains, foothills, upland, hills and mountains excessively to deficiently drained in the Andes. Tropical rain forest.
		Peinobiomes of the Amazon-Orinoco basins	Dry warm climate to very humid temperate climate. Aeolian plains, foothills, uplands, eroded hills in the Amazon and Orinoco region. Tropical rain forest.
		"Alternohigrico" and/or tropical sub-xerophytic Zonobiome of the Alto Magdalena	Very dry and warm climate to dry cold climate. Valleys, hills, plains, foothills, uplands excessively to deficiently drained in the Alto Magdalena region. Tropical dry forest.
		"alternohigrico" and/or tropical sub-xerophytic Zonobiome of the Cauca Valley	Very dry and warm climate to dry cold climate. Valleys, hills, plains, foothills, uplands excessively to deficiently drained in the Cauca Valley. Tropical dry forest.
		Tropical desert Zonobiome of La Guajira and Santa Marta	Warm arid climate, very dry and dry in plains, foothills and hills excessively to deficiently drained in the Guajira peninsula and around Santa Marta. Tropical forest wilderness.
		Tropical wet Zonobiome of the Amazon-Orinoco basins	Dry warm climate too very humid temperate climate. Valleys, plains, foothills, hills, flattening surfaces excessively to deficiently drained in the Amazon and Orinoco region. Tropical rain forest.
		Tropical wet Zonobiome of the Catatumbo	Dry warm climates to humid temperate climates. Valleys, hills, plains, foothills excessively to deficiently drained in the Catatumbo. Tropical rain forest.
		Tropical wet Zonobioma of the Magdalena and Caribbean	Dry warm climates to very humid temperate climates. Valleys, hills, plains, foothills excessively to deficiently drained in the Magdalena and Caribbean region. Tropical rain forest.

		Tropical wet Zonobioma of the Pacific and Atrato river	Humid warm climate to pluvial temperate. Valleys, hills, plains, foothills excessively to deficiently drained in the Pacific and Atrato. Tropical rain forest.				
		Tropical dry Zonobioma of the Caribbean	Very dry warm climates and dry temperate climate in valleys, plains, foothills and hills excessively to deficiently drained in the Caribbean. Tropical dry forest.				
Watershed Piece of land drained by a single natural drainage system (IDEAM 2002[12]).	2002	**45 watersheds**	Hydro_pj	Shapefile	SIG-OT-IGAC[10]	http://sigotn.igac.gov.co/sigot/	
		Alto Patía					
		Baudó – Directos river					
		Mira-Guiza river					
		Micay river					
		Sanguianga - Patía Norte river					
		Bajo Patía					
		Coyanero – Dagua river					
		Low Guaviare					
		San Juan river					
		North Sierra Nevada de Santa Marta					
		Low Guajira					
		West Sierra Nevada de Santa Marta					
		Middle Cauca					
		Middle Magdalena					
		Sogamoso river					
		Savannah of Bogotá					
		Atrato river					

		Upper Cauca
		Low Cauca
Watershed Piece of land drained by a single natural drainage system (IDEAM[12]).	2002	Sinú - Caribe
		Upper Guajira
		Low Magdalena
		Cesar river
		Catatumbo river
		Low Caquetá
		Apaporis river
		Upper Magdalena
		Nechi river
		Arauca river
		Low Meta
		Bita river
		Inírida river
		Guainía river
		Putumayo river
		Tolo river
		Atabajo river
		Puré river
		Vaupés river

		Upper Guaviare
		Middle Guaviare
Watershed Piece of land drained by a single natural drainage system (IDEAM[12]).	2002	Tomo – Tuparru river
		Upper Meta
		Vichada river

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Appendix E. Matrix of Pearson's correlation coefficient values among nominated predictor variables of environmental models to estimate probability of occurrence of species of primates in Colombia. Highly and significant correlated coefficient values are highlighted with dark and clear orange respectively. Extreme and limiting environmental factors are not included.

MODEL	VARIABLE	bulk	clay	org	pH	sand	aet	can	NPP	ptc	bio3	bio7	bio2	bio15	bio4	bio12	bio1	DEM
Soil	bulk	1																
	clay	0.41	1															
	org	-0.62	-0.23	1														
	pH	0.20	-0.23	-0.06	1													
	sand	0.23	-0.53	-0.21	0.24	1												
	aet	0.08	0.33	-0.01	-0.64	-0.10	1											
Vegetation	can	-0.20	0.10	0.20	-0.43	-0.13	0.44	1										
	NPP	0.08	0.03	-0.07	-0.23	0.11	0.10	0.09	1									
	ptc	-0.20	0.06	0.28	-0.52	-0.08	0.47	0.68	0.18	1								
Climate	bio3	-0.40	-0.17	0.43	-0.02	-0.24	0.15	0.25	-0.12	0.16	1							
	bio7	0.37	0.01	-0.40	0.32	0.30	-0.07	-0.30	-0.06	-0.31	-0.41	1						
	bio2	0.08	-0.17	-0.11	0.35	0.15	0.03	-0.14	-0.17	-0.23	0.23	0.75	1					
	bio15	0.36	-0.06	-0.36	0.53	0.23	-0.52	-0.59	-0.17	-0.54	-0.47	0.59	0.27	1				
	bio4	0.50	0.28	-0.52	-0.08	0.28	0.04	-0.19	0.18	-0.09	-0.79	0.55	-0.07	0.48	1			
	bio12	-0.26	0.29	0.28	-0.77	-0.40	0.63	0.35	0.06	0.39	0.27	-0.35	-0.22	-0.49	-0.14	1		
	bio1	0.61	0.45	-0.50	-0.28	-0.05	0.46	-0.06	0.10	0.01	-0.21	0.29	0.10	0.21	0.46	0.24	1	
Physical	DEM	-0.58	-0.45	0.48	0.37	0.07	-0.49	0.02	-0.13	-0.06	0.27	-0.15	0.05	-0.12	-0.42	-0.29	-0.96	1

Bulk: mean bulk density in kg/m^3; **clay**: soil texture fraction in clay (%, mean estimate); **org**: soil organic carbon content in per miles(mean estimate); **pH**: Soil pH x 10 in H2O (mean estimate); **sand**: Soil texture fraction sand (%, mean estimate); **aet**: actual evapo-transpiration; **can**: forest canopy height; **NPP**: Net Primary Productivity; **ptc**: percent tree cover; **bio3**: Isothermality; **bio7**: temperature annual range (BIO5: Maximum Temperature of Warmest Month - BIO6: Minimum Temperature of Coldest Month); **bio2**: mean diurnal range; **bio15**: precipitation seasonality; **bio4**: temperature seasonality; **bio12**: annual precipitation; **bio1**: annual mean temperature; **DEM**: digital elevation model.

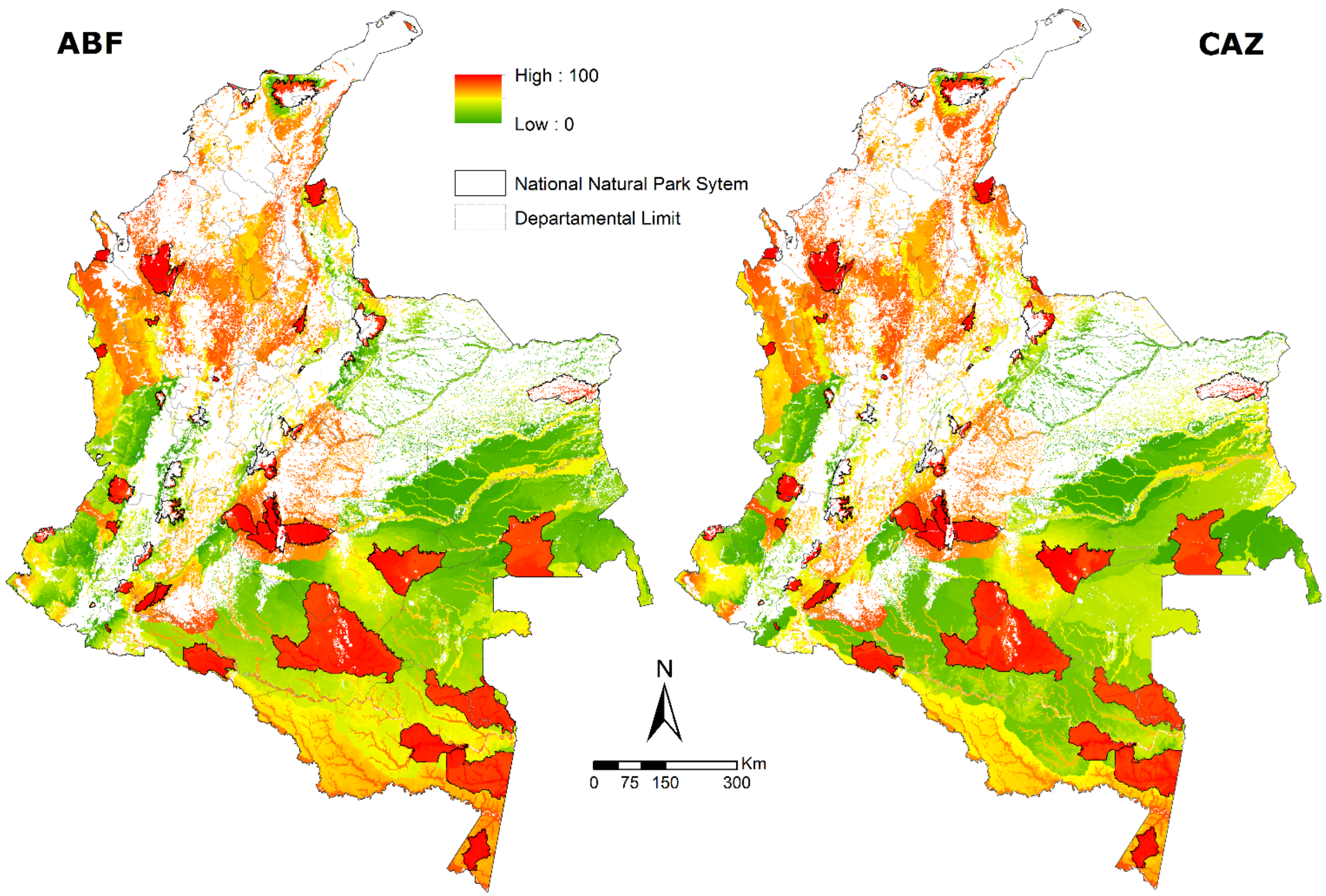
Appendix F. List of 39 different models run to assess model fit and predictive performance in the estimation of distribution ranges of species with more than 50 locations. Combination of variables **in Bold** correspond to the second set of models used to model final environmental niche models; of them, only one model with the best performance was selected for each species to be used in subsequent Zonation analyses.

MODEL	Combination of Variables															
	CLIMATE			VEGETATION			SOIL						PHYSICAL			
1	BIO4	BIO7	BIO15	PTC	Canp									Elev	Land	
2	**BIO4**	**BIO7**	**BIO15**										**Bio**	**Elev**	**Land**	
3	**BIO4**	**BIO7**	**BIO15**	**PTC**	**Canp**								**Bio**		**Land**	
4	BIO4	BIO7	BIO15	PTC	Canp								Bio	Elev		
5	BIO4	BIO7	BIO15	PTC	Canp								Bio	Elev	Land	
6	**BIO4**	**BIO7**	**BIO15**											**Elev**	**Land**	**Wat**
7													Bio	Elev	Land	
8														Elev	Land	Wat
9	**BIO4**	**BIO7**	**BIO15**										**Bio**	**Elev**		**Wat**
10	BIO4	BIO7	BIO15										Bio			Wat
11	**BIO4**	**BIO7**	**BIO15**										**Bio**	**Elev**	**Land**	**Wat**
12													**Bio**		**Land**	**Wat**
13	BIO4	BIO7	BIO15	PTC	Canp								Bio			Wat
14	**BIO4**	**BIO7**	**BIO15**	**PTC**	**Canp**									**Elev**		**Wat**
15	BIO4	BIO7	BIO15	PTC	Canp								Bio			
16	BIO4	BIO7	BIO15											Elev		Wat
17	BIO4	BIO7	BIO15											Elev	Land	
18	BIO4	BIO7	BIO15										Bio		Land	
19	BIO4	BIO7	BIO15	PTC	Canp									Elev		
20	BIO4	BIO7	BIO15	PTC	Canp											Wat
21	BIO4	BIO7	BIO15	PTC	Canp	NPP										
22				PTC	Canp									Elev		
23				PTC		NPP							Bio	Elev	Land	Wat

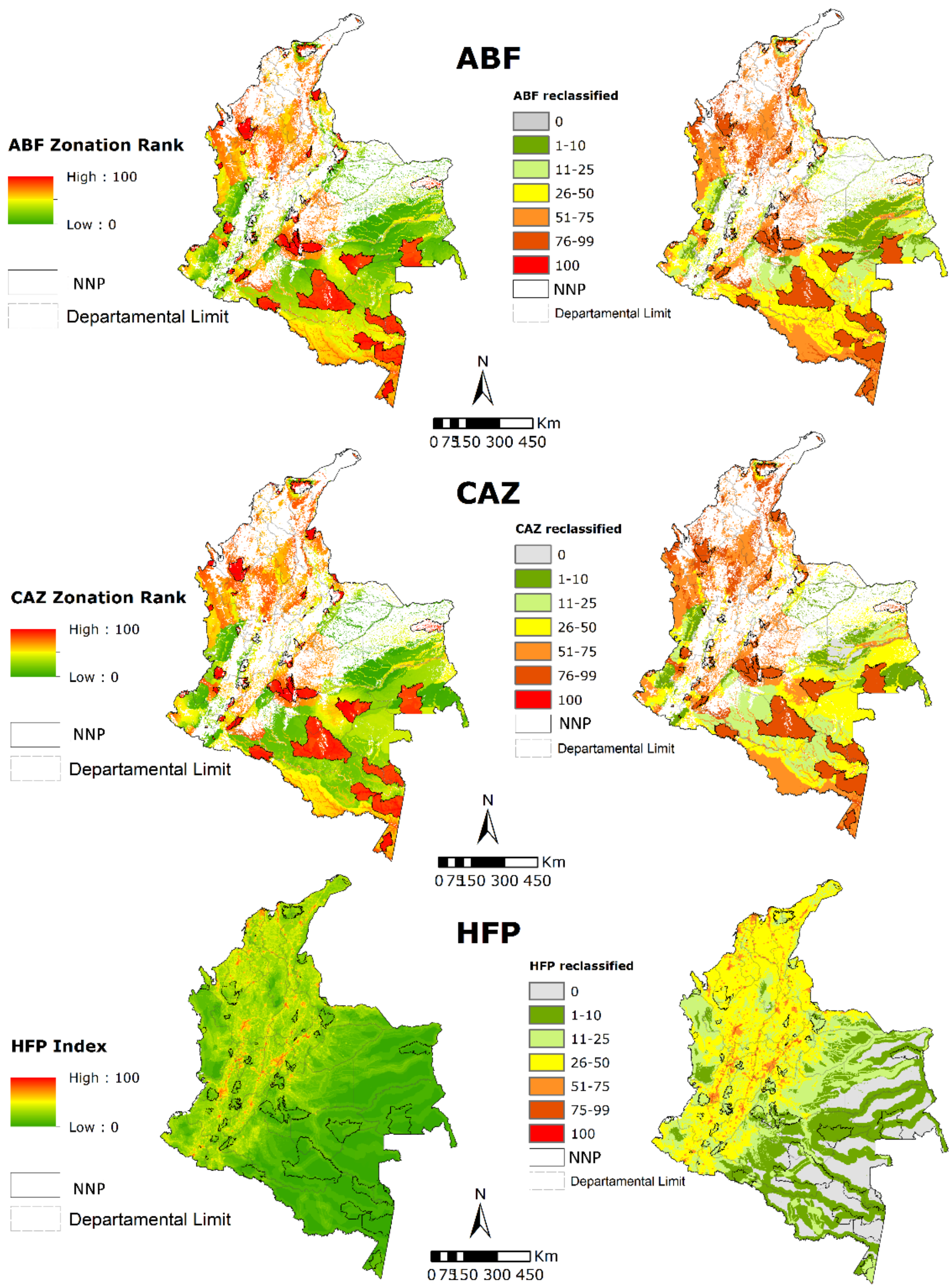
24					Canp	NPP							Bio	Elev	Land	Wat
25				PTC									Bio	Elev	Land	Wat
26					Canp								Bio	Elev	Land	Wat
27						NPP							Bio	Elev	Land	Wat
28				PTC	Canp	NPP	AET	Bulk	Clay	Org	pH	Sand				
29	BIO4	BIO7	BIO15				AET	Bulk	Clay	Org	pH	Sand				
30	BIO4	BIO7	BIO15				AET	Bulk	Clay							
31	BIO4	BIO7	BIO15							Org	pH	Sand				
32							AET	Bulk	Clay	Org	pH	Sand	Bio			
33							AET	Bld	Clay	Org	pH	Sand		Elev		
34							AET	Bulk	Clay	Org	pH	Sand			Land	
35							AET	Bulk	Clay	Org	pH	Sand				Wat
36							AET	Bulk	Clay	Org	pH	Sand	Bio	Elev	Land	Wat
37							AET	Bulk	Clay				Bio	Elev	Land	Wat
38										Org	pH	Sand	Bio	Elev	Land	Wat
39	BIO4	BIO7	BIO15	PTC	Canp	NPP	AET	Bulk	Clay	Org	pH	Sand				

Bio4: temperature seasonality; **Bio7**: temperature annual range (BIO5: Maximum Temperature of Warmest Month - BIO6: Minimum Temperature of Coldest Month); **Bio15**: precipitation seasonality; **PTC**: percent tree cover; **Canp**: forest canopy height; **NPP**: Net Primary Productivity; **AET**: actual evapo-transpiration; **Bulk**: mean bulk density in kg/m^3; **Clay**: soil texture fraction in clay (%, mean estimate); **Org**: soil organic carbon content in per miles(mean estimate); **pH**: Soil pH x 10 in H2O (mean estimate); **Sand**: Soil texture fraction sand (%, mean estimate); **Bio**: Biome; **Elev**: Elevation (DEM); **Land**: Land Cover; **Wat**: Watershed.

Appendix G. Classic Zonation ranking for each cell removal rule. Biological value of areas is expressed in percentages from zero (0) or the least conservation value to 100% or high conservation value, with 83 indicating the top 17% of the landscape to be protected. **ABF:** Additive Benefit Function cell removal rule. **CAZ:** Core-Area Zonation removal rule.



Appendix H. Reclassified raster's layers relating the Human Footprint Index (HFP) and the zonation priority rank for scenarios using two different removal rules (Additive Benefit Function (ABF) and Core-Area Zonation (CAZ)), in order to generate an irreplaceability-vulnerability analysis based on a two-dimensional vulnerability matrix. NNP: current National Natural Park System.



Appendix I. Percent contribution of environmental variables, AUC (Area Under the Curve) values and main statistics of seven selected distribution models for each of the species of primates in Colombia. Model with the best performance is highlighted with red. Description for each model as follows:

MODEL	VARIABLES								
	CLIMATE			VEGETATION		PHYSICAL			
A	BIO4	BIO7	BIO15			Bio	Elev	Land	
B	BIO4	BIO7	BIO15	PTC	Canp	Bio		Land	
C	BIO4	BIO7	BIO15				Elev	Land	Wat
D	BIO4	BIO7	BIO15			Bio	Elev		Wat
E	BIO4	BIO7	BIO15			Bio	Elev	Land	Wat
F						Bio		Land	Wat
G	BIO4	BIO7	BIO15	PTC	Canp		Elev		Wat

BIO4: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range (BIO5: Maximum Temperature of Warmest Month - BIO6: Minimum Temperature of Coldest Month); **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height; **Bio**: Biomes; **Elev**: Elevation (DEM); **Land**: Land Cover; **Wat**: Watershed.

Appendix I.a. *Species with more than 10 occurrence records*:

Alouatta palliata aequatorialis / South Pacific blackish howler monkey							
Status: IUCN_**VU** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**G**	**H**
# Observations	26						
Obs_Train	**23**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.986**	**0.984**	**0.987**	**0.988**	**0.991**	**0.987**	**0.991**
Test AUC							
Logis_Tresh	0.101	0.100	0.200	0.101	0.094	0.113	0.128
Fract_Pred_Area	0.053	0.059	0.043	0.046	0.044	0.052	0.042
Train_Omis_Rate	0.043	0.043	0.043	0.043	0.043	0.043	0.048
Percent Contribution							
PTC		<1					4.1
Canp		<1					<1
BIO4	1.1	1.0	3.4	<1	<1		4.0
BIO7	24.9	25.5	2.5	8.3	5.3		3.1
BIO15	1.6	2.3	4.7	2.3	1.2		11.9
Biome	55.1	55.4		39.8	37.0	10.1	
Elevation	1.7		<1	<1	<1		<1
Landcover	15.7	15.2	11.8		8.4	38.3	
Watershed			77.7	49.6	48.0	51.6	76.8

Alouatta seniculus seniculus / Red howler monkey							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	266						
Obs_Train	205	203	205	205	205	205	203
Obs_Test	51	50	51	51	51	51	50
Training AUC	**0.765**	**0.764**	**0.789**	**0.793**	**0.814**	**0.804**	**0.778**
Test AUC	0.703	0.707	0.776	0.767	0.781	0.772	0.753
Logis_Tresh	0.380	0.384	0.374	0.410	0.354	0.368	0.425
Fract_Pred_Area	0.298	0.290	0.278	0.272	0.261	0.253	0.286
Train_Omis_Rate	0.298	0.291	0.278	0.273	0.263	0.268	0.286
Percent Contribution							
PTC		11.5					22.3
Canp		2.4					9.9
BIO4	1.0	1.4	<1	2.4	<1		3.5
BIO7	1.5	1.4	<1	<1	<1		<1
BIO15	1.9	4.0	1.8	2.5	1.5		3.0
Biome	32.7	32.1		41.6	21.0	23.0	
Elevation	5.0		2.1	3.1	2.1		5.0
Landcover	57.9	47.1	54.4		43.6	46.3	
Watershed			41.7	50.3	31.8	30.7	56.4

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate.

***Aotus brumbacki** / Brumback's night monkey**							
Status: IUCN_**VU** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				10			
Obs_Train				**10**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.923**	**0.924**	**0.986**	**0.984**	**0.995**	**0.989**	**0.977**
Test AUC							
Logis_Tresh	0.292	0.297	0.520	0.149	0.638	0.447	0.195
Fract_Pred_Area	0.192	0.181	0.041	0.086	0.010	0.030	0.098
Train_Omis_Rate	0.100	0.200	0.000	0.100	0.000	0.000	0.100
Percent Contribution							
PTC		<1					<1
Canp		1.6					<1
BIO4	<1	<1	<1	4.9	2.0		2.6
BIO7	<1	<1	<1	<1	<1		<1
BIO15	<1	<!	<1	<1	<1		<1
Biome	53.7	53.5		20.5	17.1	19.5	
Elevation	<1		5.6	1.1	1.2		5.4
Landcover	46.3	44.9	21.4		18.6	23.4	
Watershed			73.0	73.5	61.2	57.1	92.0

***Aotus griseimembra* / Grey-handed night monkey**							
Status: IUCN_**VU** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations			70				
Obs_Train			**56**				53
Obs_Test			14				13
Training AUC	**0.938**	**0.927**	**0.948**	**0.949**	**0.957**	**0.958**	**0.951**
Test AUC	0.941	0.931	0.927	0.912	0.926	0.925	0.840
Logis_Tresh	0.309	0.370	0.234	0.164	0.228	0.285	0.291
Fract_Pred_Area	0.152	0.153	0.142	0.192	0.107	0.108	0.107
Train_Omis_Rate	0.143	0.161	0.143	0.018	0.107	0.107	0.113
Percent Contribution							
PTC		<1					3.4
Canp		<1					3.9
BIO4	<1	<1	2.6	<1	<1		7.9
BIO7	2.4	<1	<1	<1	<1		<1
BIO15	<1	<1	<1	<1	<1		<1
Biome	59.7	62.5		44.1	28.7	31.7	
Elevation	2.8		6.2	4.1	5.4		8.1
Landcover	35.1	37.5	30.1		24.2	31.5	
Watershed			61.0	51.8	41.7	36.8	76.6

***Aotus lemurinus* / Colombian night monkey**							
Status: IUCN_**VU** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				68			
Obs_Train				**53**			
Obs_Test				13			
Training AUC	**0.935**	**0.935**	**0.956**	**0.947**	**0.957**	**0.955**	**0.953**
Test AUC	0.923	0.923	0.942	0.941	0.944	0.948	0.941
Logis_Tresh	0.319	0.319	0.364	0.436	0.357	0.344	0.372
Fract_Pred_Area	0.149	0.149	0.093	0.100	0.107	0.102	0.109
Train_Omis_Rate	0.151	0.151	0.094	0.094	0.113	0.094	0.113
Percent Contribution							
PTC		<1					1.4
Canp		<1					1.5
BIO4	3.4	3.4	11.6	<1	<1		8.9
BIO7	<1	<1	1.7	<1	<1		<1
BIO15	<1	<1	5.0	<1	<1		<1
Biome	70.7	70.7		69.1	58.1	50.5	
Elevation	<1		10.1	<1	<1		39.4
Landcover	25.9	25.9	33.1		23.0	26.1	
Watershed			38.5	30.9	19.0	23.4	48.7

***Aotus vociferans* / Spix's night monkey**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				17			
Obs_Train				**17**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.920**	**0.940**	**0.948**	**0.920**	**0.931**	**0.927**	**0.935**
Test AUC							
Logis_Tresh	0.285	0.298	0.274	0.304	0.212	0.231	0.305
Fract_Pred_Area	0.176	0.166	0.118	0.123	0.123	0.157	0.143
Train_Omis_Rate	0.176	0.176	0.118	0.118	0.118	0.176	0.118
Percent Contribution							
PTC		2.2					<1
Canp		1.1					<1
BIO4	9.7	9.0	4.2	<1	1.2		4.6
BIO7	<1	<1	<1	<1	<1		<1
BIO15	33.6	35.7	3.7	<1	<1		5.9
Biome	38.9	42.6		31.5	30.0	31.7	
Elevation	4.8		13.3	6.1	5.3		11.8
Landcover	13.0	9.3	12.8		6.0	8.6	
Watershed			66.0	62.5	57.6	59.7	77.8

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

***Aotus zonalis* / Panamanian night monkey**							
Status: IUCN_**DD** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	20						
Obs_Train	**19**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.976**	**0.953**	**0.989**	**0.990**	**0.991**	**0.985**	**0.986**
Test AUC							
Logis_Tresh	0.229	0.104	0.116	0.190	0.131	0.215	0.115
Fract_Pred_Area	0.070	0.158	0.053	0.052	0.046	0.052	0.053
Train_Omis_Rate	0.053	0.158	0.053	0.053	0.053	0.053	0.053
Percent Contribution							
PTC		2.2					3.7
Canp		<1					<1
BIO4	15.3	19.0	2.2	1.4	<1		<1
BIO7	4.1	6.0	10.6	14.3	11.7		15.1
BIO15	5.2	3.1	1.4	<1	<1		<1
Biome	46.7	54.4		8.5	7.0	11.3	
Elevation	15.2		6.6	6.3	5.7		5.3
Landcover	13.6	15.3	9.9		8.9	10.3	
Watershed			69.2	69.5	66.8	78.4	75.9

***Ateles belzebuth belzebuth* / Long-haired spider monkey**							
Status: IUCN_**EN** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	41						
Obs_Train	**31**						
Obs_Test	7						
Training AUC	**0.937**	**0.934**	**0.944**	**0.959**	**0.961**	**0.961**	**0.940**
Test AUC	0.835	0.849	0.885	0.911	0.892	0.892	0.884
Logis_Tresh	0.233	0.227	0.106	0.103	0.095	0.095	0.135
Fract_Pred_Area	0.127	0.129	0.147	0.097	0.096	0.096	0.163
Train_Omis_Rate	0.129	0.129	0.161	0.097	0.097	0.097	0.161
Percent Contribution							
PTC		<1					<1
Canp		3.3					<1
BIO4	<1	<1	1.0	1.3	<1		1.5
BIO7	2.5	4.0	<1	<1	<1		<1
BIO15	12.3	10.2	<1	<1	<1		<1
Biome	64.6	63.8		22.5	23.3	23.3	
Elevation	2.7		2.7	<1	<1		4.2
Landcover	17.8	18.8	10.5		8.6	8.6	
Watershed			85.8	76.3	68.1	68.1	94.3

***Ateles fusciceps rufiventris* / Colombian black spider monkey**							
Status: IUCN_**CR** / National_**EN**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	31						
Obs_Train	**25**						
Obs_Test	6						
Training AUC	**0.917**	**0.917**	**0.979**	**0.970**	**0.981**	**0.980**	**0.965**
Test AUC	0.883	0.883	0.969	0.942	0.941	0.963	0.969
Logis_Tresh	0.243	0.243	0.270	0.221	0.148	0.191	0.324
Fract_Pred_Area	0.174	0.174	0.060	0.078	0.080	0.067	0.087
Train_Omis_Rate	0.160	0.160	0.040	0.080	0.080	0.080	0.080
Percent Contribution							
PTC		<1					<1
Canp		<1					3.2
BIO4	8.0	8.0	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	<1	<1	<1	<1	<1		<1
Biome	45.9	45.9		31.3	25.9	20.2	
Elevation	<1		3.8	<1	<1		4.3
Landcover	46.1	46.1	26.0		22.7	26.7	
Watershed			70.2	68.7	51.5	53.0	92.5

***Ateles hybridus**brunneus** / Brown spider monkey**							
Status: IUCN_**CR** / National_**CR**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	24						
Obs_Train	**24**	**23**	**23**	**24**	**24**	**24**	**23**
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.956**	**0.960**	**0.980**	**0.979**	**0.986**	**0.986**	**0.973**
Test AUC							
Logis_Tresh	0.209	0.268	0.382	0.180	0.221	0.221	0.152
Fract_Pred_Area	0.125	0.103	0.049	0.059	0.047	0.047	0.077
Train_Omis_Rate	0.125	0.087	0.042	0.042	0.042	0.042	0.087
Percent Contribution							
PTC		19.3					16.1
Canp		<1					<1
BIO4	<1	1.3	<1	<1	<1		<1
BIO7	2.1	2.3	<1	<1	<1		<1
BIO15	<1	<1	<1	<1	<1		<1
Biome	64.4	55.3		30.5	26.2	26.2	
Elevation	<1		1.2	<1	<1		1.4
Landcover	33.5	21.8	22.4		12.9	12.9	
Watershed			76.4	69.5	60.9	60.9	82.4

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

***Ateles hybridus hybridus* / Variegated spider monkey**							
Status: IUCN_**CR** / National_**CR**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	25						
Obs_Train	**25**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.928**	**0.940**	**0.976**	**0.972**	**0.977**	**0.970**	**0.970**
Test AUC							
Logis_Tresh	0.253	0.195	0.161	0.270	0.169	0.158	0.270
Fract_Pred_Area	0.160	0.159	0.108	0.084	0.084	0.091	0.099
Train_Omis_Rate	0.160	0.160	0.000	0.080	0.080	0.080	0.080
Percent Contribution							
PTC		<1					<1
Canp		2.1					<1
BIO4	<1	<1	6.7	5.2	2.8		10.9
BIO7	<1	<1	<1	<1	<1		<1
BIO15	3.7	3.5	<1	<1	<1		<1
Biome	56.5	53.8		24.8	20.4	19.3	
Elevation	<1		1.9	<1	<1		3.2
Landcover	39.9	40.5	26.0		22.4	23.5	
Watershed			65.4	70.0	54.4	57.3	85.9

***Cacajao ouakary* / Golden-backed Black Uakary monkey**							
Status: IUCN_**LC** / National_**NT**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	18						
Obs_Train	**18**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.845**	**0.887**	**0.948**	**0.939**	**0.946**	**0.938**	**0.940**
Test AUC							
Logis_Tresh	0.490	0.489	0.558	0.509	0.466	0.413	0.549
Fract_Pred_Area	0.278	0.201	0.111	0.142	0.138	0.156	0.105
Train_Omis_Rate	0.278	0.222	0.111	0.167	0.111	0.167	0.111
Percent Contribution							
PTC		40.9					20.8
Canp		4.6					4.6
BIO4	9.8	12.7	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	1.5	4.1	<1	<1	<1		<1
Biome	29.1	18.1		8.4	2.8	3.4	
Elevation	6.6		3.3	1.8	2.7		2.8
Landcover	53.1	19.5	19.1		18.8	18.1	
Watershed			77.6	89.8	45.6	78.5	71.8

***Plecturocebus caquetensis** / Caquetá tití monkey**							
Status: IUCN_**CR** / National_**CR**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	18						
Obs_Train	**18**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.997**	**0.998**	**0.998**	**0.997**	**0.998**	**0.998**	**0.998**
Test AUC							
Logis_Tresh	0.503	0.443	0.464	0.300	0.473	0.217	0.231
Fract_Pred_Area	0.005	0.005	0.004	0.006	0.004	0.005	0.008
Train_Omis_Rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Percent Contribution							
PTC		1.4					7.8
Canp		1.8					<1
BIO4	7.7	5.9	6.2	3.0	3.4		5.7
BIO7	6.9	8.1	<1	<1	<1		<1
BIO15	5.7	5.0	4.0	1.4	1.7		4.6
Biome	32.6	31.6		25.3	17.5	20.3	
Elevation	<1		7.5	1.0	<1		15.2
Landcover	47.1	46.2	26.2		23.2	26.6	
Watershed			56.1	69.3	54.2	53.1	66.8

***Plectorucebus ornatus* / Ornate tití monkey**							
Status: IUCN_**VU** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	32						
Obs_Train	**25**						
Obs_Test	6						
Training AUC	**0.952**	**0.965**	**0.987**	**0.988**	**0.987**	**0.988**	**0.984**
Test AUC	0.954	0.938	0.980	0.989	0.974	0.972	0.978
Logis_Tresh	0.182	0.171	0.303	0.281	0.325	0.210	0.369
Fract_Pred_Area	0.137	0.120	0.037	0.040	0.043	0.041	0.040
Train_Omis_Rate	0.120	0.120	0.040	0.040	0.040	0.040	0.040
Percent Contribution							
PTC		18.8					7.1
Canp		5.5					2.7
BIO4	<1	2.6	1.0	3.2	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	11.7	5.4	<1	<1	<1		<1
Biome	48.2	38.3		6.7	5.1	15.4	
Elevation	3.1		5.4	5.0	5.0		3.8
Landcover	37.0	29.4	10.9		10.7	12.6	
Watershed			82.6	85.1	79.2	72.0	86.4

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

Cheracebus lucifer **/ Yellow-handed Titi Monkey**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				10			
Obs_Train				**10**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.973**	**0.932**	**0.986**	**0.989**	**0.990**	**0.973**	**0.986**
Test AUC							
Logis_Tresh	0.257	0.297	0.289	0.195	0.219	0.191	0.289
Fract_Pred_Area	0.078	0.158	0.040	0.046	0.042	0.077	0.040
Train_Omis_Rate	0.100	0.200	0.000	0.000	0.000	0.100	0.000
Percent Contribution							
PTC		2.8					<1
Canp		<1					<1
BIO4	2.5	<1	5.2	6.8	6.6		5.2
BIO7	<1	<1	<1	<1	<1		<1
BIO15	53.5	71.4	4.8	2.8	2.6		4.8
Biome	17.6	25.8		10.1	10.3	12.6	
Elevation	26.3		21.8	19.8	19.5		21.8
Landcover	<1	<1	<1		<1	1.5	
Watershed			68.1	60.2	61.0	85.8	68.1

Cheracebus lugens **/ Collared titi monkey**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				23			
Obs_Train				**23**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.876**	**0.871**	**0.908**	**0.915**	**0.917**	**0.886**	**0.912**
Test AUC							
Logis_Tresh	0.330	0.297	0.358	0.384	0.357	0.388	0.353
Fract_Pred_Area	0.217	0.255	0.193	0.180	0.188	0.224	0.211
Train_Omis_Rate	0.217	0.261	0.174	0.174	0.174	0.174	0.217
Percent Contribution							
PTC		<1					<1
Canp		1.6					4.4
BIO4	18.7	17.1	25.8	16.0	15.3		26.1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	11.4	12.3	1.4	1.4	<1		7.0
Biome	38.4	46.3		30.7	24.8	37.3	
Elevation	9.8		11.6	8.5	6.3		14.0
Landcover	21.6	22.7	23.1		15.7	14.3	
Watershed			38.2	43.4	37.9	48.5	48.4

Cebuella pygmaea pygmaea **/ Western pygmy marmoset**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				12			
Obs_Train				**11**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.958**	**0.954**	**0.963**	**0.959**	**0.976**	**0.968**	**0.962**
Test AUC							
Logis_Tresh	0.114	0.117	0.173	0.109	0.104	0.136	0.288
Fract_Pred_Area	0.091	0.092	0.126	0.117	0.091	0.090	0.099
Train_Omis_Rate	0.091	0.091	0.091	0.091	0.091	0.091	0.091
Percent Contribution							
PTC		<1					<1
Canp		<1					6.2
BIO4	<1	<1	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	34.6	35.8	6.3	5.0	4.3		10.8
Biome	45.4	45.8		41.9	35.2	34.7	
Elevation	3.0		4.5	<1	1.3		6.4
Landcover	17.0	18.4	28.6		14.5	15.9	
Watershed			60.5	53.1	44.7	49.4	76.6

Cebus albifrons albifrons **/ White-fronted capuchin**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				37			
Obs_Train				**29**			
Obs_Test				7			
Training AUC	**0.910**	**0.877**	**0.910**	**0.921**	**0.930**	**0.912**	**0.890**
Test AUC	0.798	0.724	0.943	0.868	0.857	0.752	0.910
Logis_Tresh	0.330	0.280	0.382	0.304	0.271	0.227	0.471
Fract_Pred_Area	0.158	0.426	0.172	0.158	0.135	0.169	0.207
Train_Omis_Rate	0.172	0.310	0.172	0.172	0.138	0.172	0.207
Percent Contribution							
PTC		<1					<1
Canp		<1					<1
BIO4	<1	<1	<1	1.4	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	<1	<1	<1	<1	<1		<1
Biome	66.1	77.3		69.9	51.2	57.2	
Elevation	11.8		20.1	4.9	7.6		38.6
Landcover	21.6	22.7	39.8		20.5	9.7	
Watershed			40.1	23.8	20.7	33.1	61.4

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

*Cebus albifrons cesarae*** / Río Cesar white-fronted capuchin							
Status: IUCN_**DD** / National_**NT**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				13			
Obs_Train				**13**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.988**	**0.988**	**0.995**	**0.988**	**0.995**	**0.995**	**0.986**
Test AUC							
Logis_Tresh	0.226	0.226	0.173	0.098	0.208	0.208	0.096
Fract_Pred_Area	0.049	0.049	0.015	0.052	0.022	0.022	0.054
Train_Omis_Rate	0.077	0.077	0.000	0.077	0.000	0.000	0.077
Percent Contribution							
PTC		<1					<1
Canp		<1					<1
BIO4	<1	<1	<1	<1	<1		<1
BIO7	7.4	7.4	<1	<1	<1		<1
BIO15	11.9	11.9	<1	<1	<1		<1
Biome	40.0	40.0		11.9	6.6	6.6	
Elevation	<1		<1	<1	<1		1.1
Landcover	40.7	40.7	29.9		26.8	26.8	
Watershed			70.1	88.1	66.6	66.6	98.9

*Cebus albifrons versicolor*** / Varied white-fronted capuchin							
Status: IUCN_**EN** / National_**NT**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				59			
Obs_Train				**47**			
Obs_Test				11			
Training AUC	**0.952**	**0.946**	**0.965**	**0.959**	**0.969**	**0.973**	**0.956**
Test AUC	0.908	0.921	0.952	0.954	0.961	0.941	0.963
Logis_Tresh	0.309	0.349	0.219	0.465	0.202	0.177	0.312
Fract_Pred_Area	0.108	0.118	0.100	0.087	0.083	0.088	0.113
Train_Omis_Rate	0.106	0.128	0.106	0.064	0.085	0.106	0.106
Percent Contribution							
PTC		<1					10.7
Canp		<1					2.1
BIO4	1.7	1.2	<1	<1	<1		8.8
BIO7	<1	<1	<1	<1	<1		<1
BIO15	<1	<1	5.4	<1	<1		<1
Biome	53.6	54.9		54.2	38.1	39.2	
Elevation	1.4		4.9	<1			6.5
Landcover	43.1	43.9	42.1		36.7	33.1	
Watershed			47.6	45.8	25.3	27.7	71.9

Cebus apella fatuellus / Tufted capuchin							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				102			
Obs_Train				**81**			
Obs_Test				20			
Training AUC	**0.799**	**0.804**	**0.850**	**0.876**	**0.882**	**0.884**	**0.856**
Test AUC	0.811	0.826	0.845	0.902	0.905	0.763	0.850
Logis_Tresh	0.335	0.326	0.359	0.339	0.335	0.311	0.348
Fract_Pred_Area	0.285	0.284	0.234	0.185	0.189	0.184	0.247
Train_Omis_Rate	0.284	0.284	0.235	0.185	0.185	0.185	0.247
Percent Contribution							
PTC		<1					1.8
Canp		5.6					4.5
BIO4	<1	<1	<1	<1	<1		1.9
BIO7	<1	<1	<1	<1	<1		<1
BIO15	3.9	6.7	8.1	2.3	1.4		6.8
Biome	84.0	78.6		48.1	45.1	54.0	
Elevation	<1		5.8	<1	<1		10.3
Landcover	12.1	9.1	11.6		5.4	4.9	
Watershed			74.4	49.6	48.0	41.0	74.7

Cebus capucinus capucinus / Colombian white-throated capuchin							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				53			
Obs_Train	**42**	**41**			**42**		**41**
Obs_Test				10			
Training AUC	**0.924**	**0.924**	**0.967**	**0.962**	**0.969**	**0.970**	**0.954**
Test AUC	0.845	0.845	0.918	0.837	0.834	0.935	0.872
Logis_Tresh	0.258	0.258	0.327	0.308	0.256	0.200	0.457
Fract_Pred_Area	0.165	0.165	0.085	0.096	0.077	0.092	0.103
Train_Omis_Rate	0.167	0.167	0.098	0.095	0.071	0.095	0.098
Percent Contribution							
PTC		<1					<1
Canp		<1					<1
BIO4	11.0	11.0	1.1	<1	<1		1.1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	<1	<1	<1	<1	<1		<1
Biome	51.8	51.8		27.7	18.2	16.3	
Elevation	<1		1.4	<1	<1		2.7
Landcover	37.2	37.2	24.2		23.5	25.9	
Watershed			73.3	72.3	58.3	57.8	96.2

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

***Lagothrix lagotricha lagotricha* / Humboldt's woolly monkey**

Status: IUCN_**VU** / National_**NT**

SDM	A	B	C	D	E	F	G
# Observations				64			
Obs_Train				**51**			
Obs_Test				12			
Training AUC	**0.893**	**0.893**	**0.881**	**0.910**	**0.910**	**0.888**	**0.896**
Test AUC	0.913	0.880	0.795	0.851	0.846	0.893	0.847
Logis_Tresh	0.374	0.336	0.438	0.327	0.316	0.341	0.410
Fract_Pred_Area	0.182	0.196	0.197	0.171	0.176	0.196	0.196
Train_Omis_Rate	0.176	0.196	0.196	0.176	0.176	0.196	0.196
Percent Contribution							
PTC		7.7					18.2
Canp		<1					4.0
BIO4	4.7	1.6	2.5	1.0	1.0		2.3
BIO7	2.5	2.1	<1	<1	<1		<1
BIO15	12.9	10.2	5.6	11.6	3.6		10.2
Biome	51.8	57.8		49.6	46.2	52.3	
Elevation	4.8		20.5	6.2	5.0		18.9
Landcover	23.3	20.6	34.3		21.0	23.7	
Watershed			37.1	31.5	23.2	24.1	46.4

Lagothrix lagotricha lugens** / Colombian woolly monkey

Status: IUCN_**CR** / National_**VU**

SDM	A	B	C	D	E	F	G
# Observations				56			
Obs_Train				**45**			
Obs_Test				11			
Training AUC	**0.841**	**0.844**	**0.921**	**0.931**	**0.936**	**0.940**	**0.909**
Test AUC	0.787	0.806	0.953	0.936	0.936	0.862	0.959
Logis_Tresh	0.337	0.354	0.259	0.258	0.224	0.293	0.279
Fract_Pred_Area	0.243	0.244	0.178	0.156	0.156	0.136	0.193
Train_Omis_Rate	0.244	0.244	0.178	0.156	0.156	0.133	0.200
Percent Contribution							
PTC		7.9					6.3
Canp		<1					<1
BIO4	2.4	2.6	4.5	5.0	1.9		10.6
BIO7	<1	<1	<1	<1	<1		<1
BIO15	1.8	4.8	3.5	3.7	3.6		<1
Biome	62.1	60.9		24.8	22.8	20.3	
Elevation	3.4		4.9	3.8	2.6		7.3
Landcover	30.3	23.7	14.9		13.6	18.0	
Watershed			72.2	62.7	55.5	61.6	75.8

***Pithecia hirsuta* / Hairy saki**

Status: IUCN_**Not Listed** / National_**LC**

SDM	A	B	C	D	E	F	G
# Observations				12			
Obs_Train				**12**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.960**	**0.946**	**0.976**	**0.980**	**0.980**	**0.956**	**0.982**
Test AUC							
Logis_Tresh	0.272	0.313	0.432	0.316	0.316	0.425	0.353
Fract_Pred_Area	0.106	0.110	0.061	0.065	0.065	0.083	0.070
Train_Omis_Rate	0.083	0.083	0.083	0.083	0.083	0.250	0.083
Percent Contribution							
PTC		32.8					26.8
Canp		1.6					2.7
BIO4	<1	<1	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	56.3	40.4	29.4	28.1	28.1		18.1
Biome	22.9	25.2		16.6	16.6	23.8	
Elevation	19.7		24.9	19.1	19.1		16.8
Landcover	1.0	<1	1.6		<1	1.4	
Watershed			44.1	36.2	36.2	74.8	35.6

***Pithecia milleri* / Miller's saki**

Status: IUCN_**DD** / National_**VU**

SDM	A	B	C	D	E	F	G
# Observations				21			
Obs_Train				**18**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.953**	**0.953**	**0.966**	**0.956**	**0.971**	**0.971**	**0.962**
Test AUC							
Logis_Tresh	0.198	0.198	0.144	0.178	0.131	0.131	0.212
Fract_Pred_Area	0.126	0.126	0.135	0.100	0.104	0.104	0.111
Train_Omis_Rate	0.111	0.111	0.111	0.056	0.111	0.111	0.111
Percent Contribution							
PTC		<1					<1
Canp		<1					2.4
BIO4	2.4	2.4	3.9	<1	<1		5.3
BIO7	<1	<1	<1	<1	<1		<1
BIO15	34.0	34.0	4.3	<1	<1		4.6
Biome	40.6	40.6		27.3	23.5	23.5	
Elevation	<1		3.4	<1	<1		5.5
Landcover	23.1	23.1	18.2		15.5	15.5	
Watershed			70.2	72.7	61.1	61.1	82.2

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

***Leontocebus fuscus* / Saddle-backed tamarin**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	33						
Obs_Train	**26**						
Obs_Test	6						
Training AUC	**0.938**	**0.950**	**0.928**	**0.960**	**0.960**	**0.966**	**0.949**
Test AUC	0.921	0.957	0.962	0.945	0.947	0.924	0.972
Logis_Tresh	0.320	0.299	0.371	0.308	0.280	0.401	0.359
Fract_Pred_Area	0.153	0.115	0.143	0.113	0.115	0.084	0.116
Train_Omis_Rate	0.154	0.115	0.154	0.115	0.115	0.077	0.115
Percent Contribution							
PTC		5.4					2.7
Canp		4.1					5.9
BIO4	<1	<1	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	35.1	29.4	11.3	8.0	7.8		5.0
Biome	53.6	50.8		35.9	35.0	31.4	
Elevation	<1		13.7	1.7	1.4		13.5
Landcover	11.3	10.2	6.9		4.1	7.0	
Watershed			68.0	54.4	51.6	61.6	72.9

***Saguinus geoffroyi* / Geoffroy's tamarin**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	13						
Obs_Train	**12**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.966**	**0.960**	**0.993**	**0.992**	**0.992**	**0.990**	**0.993**
Test AUC							
Logis_Tresh	0.044	0.159	0.158	0.151	0.142	0.057	0.140
Fract_Pred_Area	0.083	0.083	0.030	0.036	0.035	0.042	0.033
Train_Omis_Rate	0.083	0.083	0.000	0.000	0.000	0.083	0.000
Percent Contribution							
PTC		<1					2.1
Canp		<1					<1
BIO4	1.9	2.2	<1	<1	<1		<1
BIO7	<1	<1	6.2	8.9	6.1		9.7
BIO15	<1	<1	2.2	2.7	1.5		2.9
Biome	77.1	79.7		4.4	5.1	9.8	
Elevation	1.4		1.2	<1			<1
Landcover	19.6	18.2	10.7		6.4	12.9	
Watershed			79.7	83.9	80.9	77.3	85.3

***Saguinus inustus* / Mottled-faced tamarin**							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	16						
Obs_Train	**16**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.880**	**0.880**	**0.941**	**0.932**	**0.945**	**0.924**	**0.931**
Test AUC							
Logis_Tresh	0.372	0.372	0.366	0.304	0.352	0.394	0.319
Fract_Pred_Area	0.250	0.250	0.130	0.178	0.134	0.179	0.173
Train_Omis_Rate	0.250	0.250	0.125	0.188	0.125	0.062	0.188
Percent Contribution							
PTC		<1					<1
Canp		<1					<1
BIO4	35.4	35.4	15.8	15.2	13.7		14.6
BIO7	<1	<1	<1	<1	<1		
BIO15	18.5	18.5	12.4	8.4	9.4		10.0
Biome	40.4	40.4		14.3	14.3	20.9	
Elevation	<1		2.4	<1	<1		2.3
Landcover	5.7	5.7	5.7		4.0	5.9	
Watershed			63.7	62.1	58.7	73.2	73.1

***Saguinus leucopus** * / White-footed tamarin**							
Status: IUCN_**EN** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	78						
Obs_Train	**61**						
Obs_Test	15						
Training AUC	**0.954**	**0.953**	**0.961**	**0.971**	**0.970**	**0.972**	**0.965**
Test AUC	0.950	0.940	0.978	0.954	0.963	0.973	0.956
Logis_Tresh	0.284	0.344	0.231	0.199	0.128	0.201	0.238
Fract_Pred_Area	0.115	0.098	0.082	0.068	0.082	0.072	0.082
Train_Omis_Rate	0.115	0.098	0.082	0.082	0.082	0.066	0.082
Percent Contribution							
PTC		<1					<1
Canp		1.5					<1
BIO4	2.0	1.5	<1	<1	<1		<1
BIO7	2.4	3.5	<1	<1	<1		<1
BIO15	<1	1.7	<1	<1	<1		<1
Biome	70.4	69.0		30.0	26.0	16.1	
Elevation	1.9		4.8	<1	<1		4.6
Landcover	23.2	22.8	13.8		9.9	11.3	
Watershed			81.4	70.0	64.1	72.6	95.4

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

Leontocebus nigricollis nigricollis / Spix's black mantle tamarin							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				12			
Obs_Train				**12**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.997**	**0.994**	**0.998**	**0.998**	**0.999**	**0.992**	**0.998**
Test AUC							
Logis_Tresh	0.127	0.101	0.371	0.300	0.292	0.118	0.441
Fract_Pred_Area	0.013	0.026	0.006	0.004	0.004	0.050	0.005
Train_Omis_Rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Percent Contribution							
PTC		<1					<1
Canp		<1					<1
BIO4	36.2	38.2	17.9	14.7	13.6		17.4
BIO7	1.6	<1	2.4	1.4	1.6		3.0
BIO15	1.6	1.9	<1	1.5	1.3		<1
Biome	38.5	47.6		22.5	22.6	28.0	
Elevation	12.0		18.1	6.3	5.7		16.2
Landcover	10.1	12.3	1.1		2.4	2.6	
Watershed			60.5	53.8	52.8	69.4	63.4

*Saguinus oedipus** / Cotton-top tamarin							
Status: IUCN_**CR** / National_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				55			
Obs_Train	**38**	**35**		**38**			**35**
Obs_Test	9	8		9			8
Training AUC	**0.950**	**0.958**	**0.980**	**0.977**	**0.981**	**0.986**	**0.978**
Test AUC	0.920	0.926	0.988	0.993	0.992	0.978	0.985
Logis_Tresh	0.322	0.312	0.324	0.381	0.269	0.185	0.302
Fract_Pred_Area	0.114	0.104	0.063	0.064	0.062	0.054	0.061
Train_Omis_Rate	0.105	0.114	0.053	0.053	0.053	0.026	0.057
Percent Contribution							
PTC		3.5					1.3
Canp		<1					<1
BIO4	6.8	5.9	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	1.4	5.1	<1	<1	<1		2.2
Biome	70.0	65.2		2.8	3.2	3.0	
Elevation	3.1		1.7	2.3	1.8		2.4
Landcover	18.8	20.2	7.0		7.3	11.1	
Watershed			91.3	94.9	87.8	85.9	94.1

*Saimiri sciureus albigena*** / Colombian squirrel monkey							
Status: IUCN_**NT** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				35			
Obs_Train				**28**			
Obs_Test				7			
Training AUC	**0.908**	**0.926**	**0.977**	**0.974**	**0.978**	**0.976**	**0.977**
Test AUC	0.967	0.880	0.986	0.992	0.990	0.972	0.978
Logis_Tresh	0.424	0.321	0.308	0.272	0.267	0.178	0.230
Fract_Pred_Area	0.191	0.143	0.067	0.074	0.071	0.073	0.071
Train_Omis_Rate	0.179	0.143	0.071	0.071	0.071	0.071	0.071
Percent Contribution							
PTC		38.2					10.4
Canp		19.8					7.0
BIO4	<1	<1	2.6	3.1	1.9		1.0
BIO7	<1	<1	<1	<1	<1		<1
BIO15	1.2	<1	<1	<1	<1		<1
Biome	56.7	27.6		5.6	4.9	9.3	
Elevation	6.4		4.9	4.8	3.2		4.8
Landcover	35.8	14.4	7.9		7.1	8.4	
Watershed			84.7	86.6	82.9	82.3	76.7

Saimiri sciureus cassiquiarensis / Humboldt's squirrel monkey							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				21			
Obs_Train				**21**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.880**	**0.880**	**0.955**	**0.964**	**0.965**	**0.955**	**0.951**
Test AUC							
Logis_Tresh	0.317	0.317	0.241	0.293	0.291	0.317	0.268
Fract_Pred_Area	0.205	0.238	0.115	0.091	0.089	0.106	0.116
Train_Omis_Rate	0.190	0.238	0.095	0.095	0.095	0.095	0.095
Percent Contribution							
PTC		1.4					<1
Canp		3.0					<1
BIO4	6.5	10.4	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	<1	<1	<1	<1	<1		<1
Biome	74.1	70.8		32.7	32.1	35.5	
Elevation	4.9		11.7	4.0	3.3		12.3
Landcover	14.5	14.3	5.1		3.3	1.7	
Watershed			83.2	63.4	61.3	62.8	87.7

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

Saimiri sciureus macrodon / Ecuadorian squirrel monkey							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations				29			
Obs_Train				**28**			
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.925**	**0.929**	**0.947**	**0.953**	**0.953**	**0.944**	**0.950**
Test AUC							
Logis_Tresh	0.316	0.347	0.396	0.304	0.350	0.320	0.413
Fract_Pred_Area	0.166	0.152	0.128	0.128	0.107	0.167	0.107
Train_Omis_Rate	0.179	0.143	0.143	0.143	0.107	0.036	0.107
Percent Contribution							
PTC		14.9					6.5
Canp		1.3					2.7
BIO4	1.5	4.8	3.1	2.4	<1		2.6
BIO7	<1	<1	<1	<1	<1		<1
BIO15	50.1	34.5	2.2	4.1	7.2		1.2
B**iome**	45.6	43.1		19.0	19.1	17.3	
Elevation	<1		5.7	2.2	1.1		4.9
Landcover	2.8	1.2	3.1		<1	1.3	
Watershed			85.9	72.4	72.6	81.4	82.0

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

Appendix I.b. *Species with less than 10 occurrence records*:

***Cheracebus medemi* / Colombian Black-handed Titi**							
Status: IUCN_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	7						
Obs_Train	**6**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.978**	**0.980**	**0.934**	**0.985**	**0.987**	**0.984**	**0.949**
Test AUC							
Logis_Tresh	0.518	0.482	0.179	0.486	0.441	0.412	0.205
Fract_Pred_Area	0.032	0.033	0.251	0.029	0.032	0.038	0.167
Train_Omis_Rate	0.000	0.000	0.000	0.000	0.000	0.000	0.167
Percent Contribution							
PTC		<1					
Canp		1.1					10.4
BIO4	<1	<1	<1	<1	<1		<1
BIO7	<1	<1	<1	<1	<1		<1
BIO15	46.8	48.7	24.5	18.8	19.6		24.4
Biome	44.2	44.0		36.0	34.8	41.3	
Elevation	2.0		9.4	2.4	1.9		8.4
Landcover	7.0	6.2	5.0		3.3	2.7	
Watershed			61.0	42.8	40.4	56.0	56.7

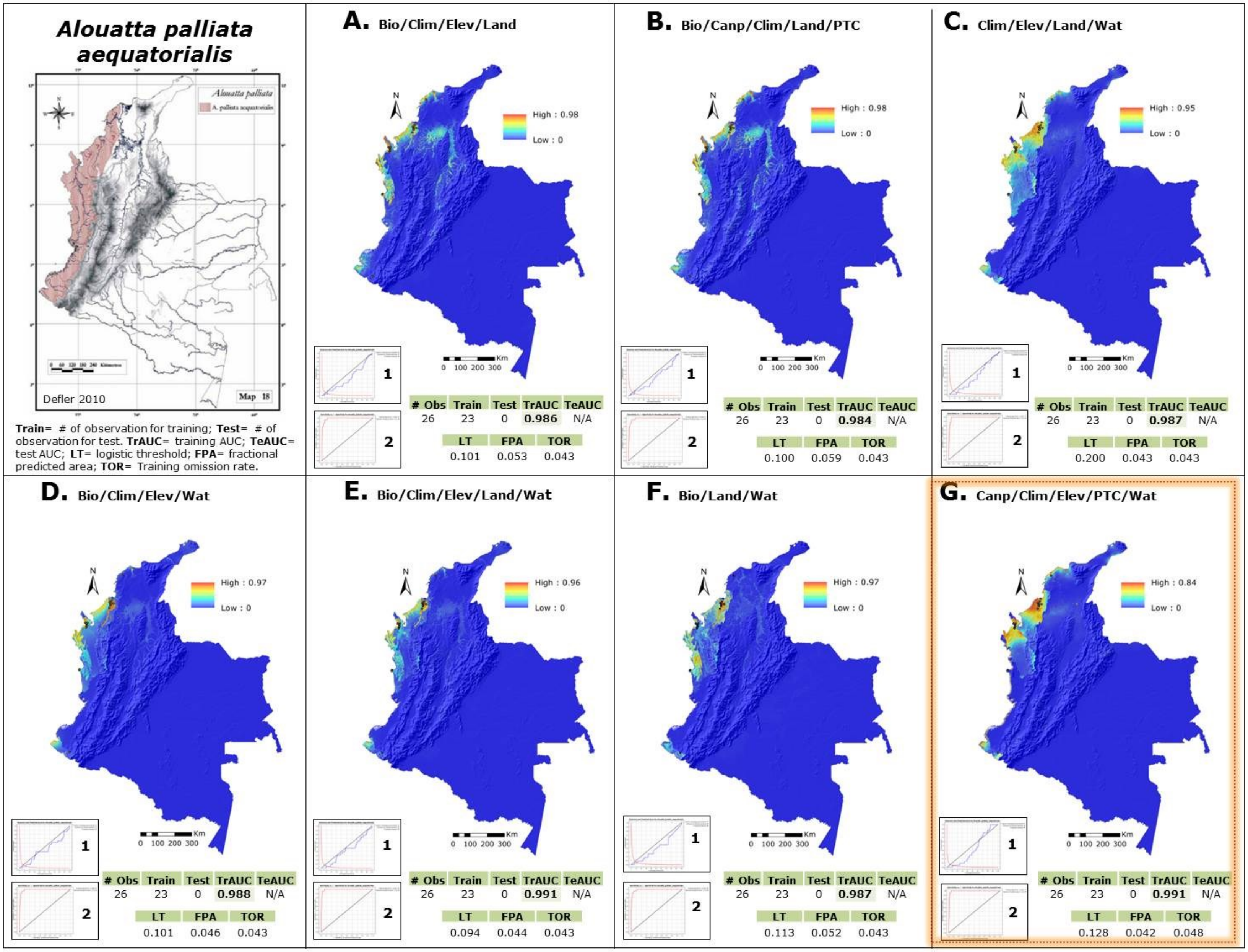
***Callimico goeldii* / Goeldi's marmoset**							
Status: IUCN_**VU**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	7						
Obs_Train	**7**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.985**	**0.985**	**0.967**	**0.987**	**0.990**	**0.985**	**0.976**
Test AUC							
Logis_Tresh	0.260	0.273	0.298	2.880	0.326	0.348	0.291
Fract_Pred_Area	0.049	0.044	0.100	0.039	0.027	0.069	0.079
Train_Omis_Rate	0.000	0.000	0.143	0.000	0.000	0.000	0.143
Percent Contribution							
PTC		5.3					<1
Canp		<1					3.2
BIO4	1.8	2.7	1.5	<1	<1		1.3
BIO7	<1	<1	<1	<1	<1		<1
BIO15	54.7	46.8	17.2	12.4	12.1		18.0
Biome	41.2	43.9		34.6	34.1	35.8	
Elevation	1.0		4.0	1.3	1.2		5.2
Landcover	1.3	1.4	2.0		1.5	1.6	
Watershed			75.3	51.7	51.0	62.6	72.3

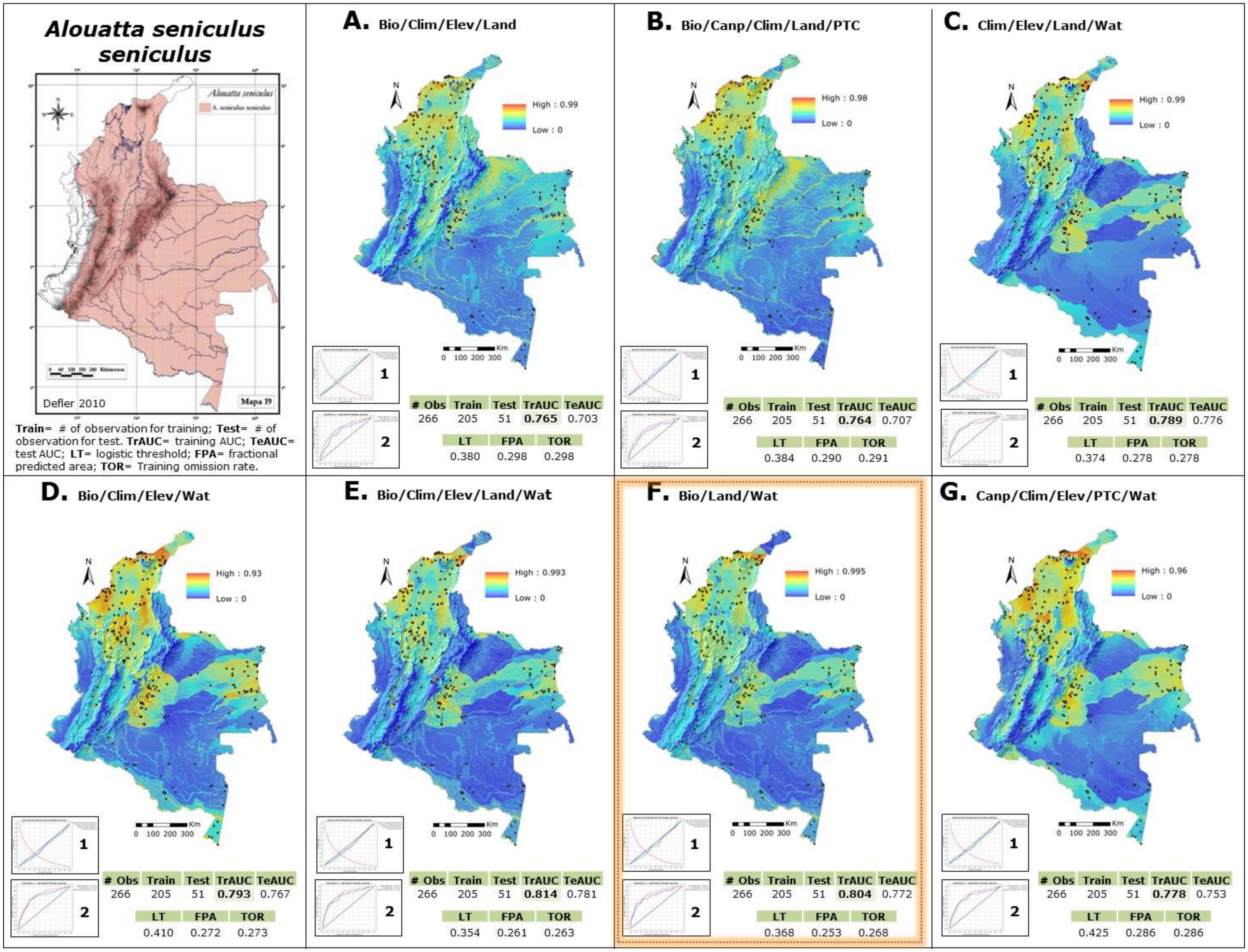
Cebus albifrons malitiosus** **/ Santa Marta white-fronted capuchin**							
Status: IUCN_**EN** / National_**NT**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	7						
Obs_Train	**7**	**6**	**6**	**7**	**7**	**7**	**6**
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.999**	**0.999**	**0.999**	**1.000**	**1.000**	**1.000**	**0.999**
Test AUC							
Logis_Tresh	0.609	0.752	0.608	0.414	0.553	0.649	0.633
Fract_Pred_Area	0.003	0.002	0.001	0.001	0.001	0.000	0.001
Train_Omis_Rate	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Percent Contribution							
PTC		<1					<1
Canp		2.0					<1
BIO4	<1	1.3	<1	<1	<1		<1
BIO7	<1	<1	3.2	<1	<1		3.9
BIO15	28.2	31.4	2.6	2.9	2.8		2.6
Biome	44.8	37.5		9.4	8.8	6.1	
Elevation	<1		1.7	<1	<1		3.3
Landcover	26.9	27.8	2.7		3.3	11.4	
Watershed			89.2	87.6	85.1	82.5	90.2

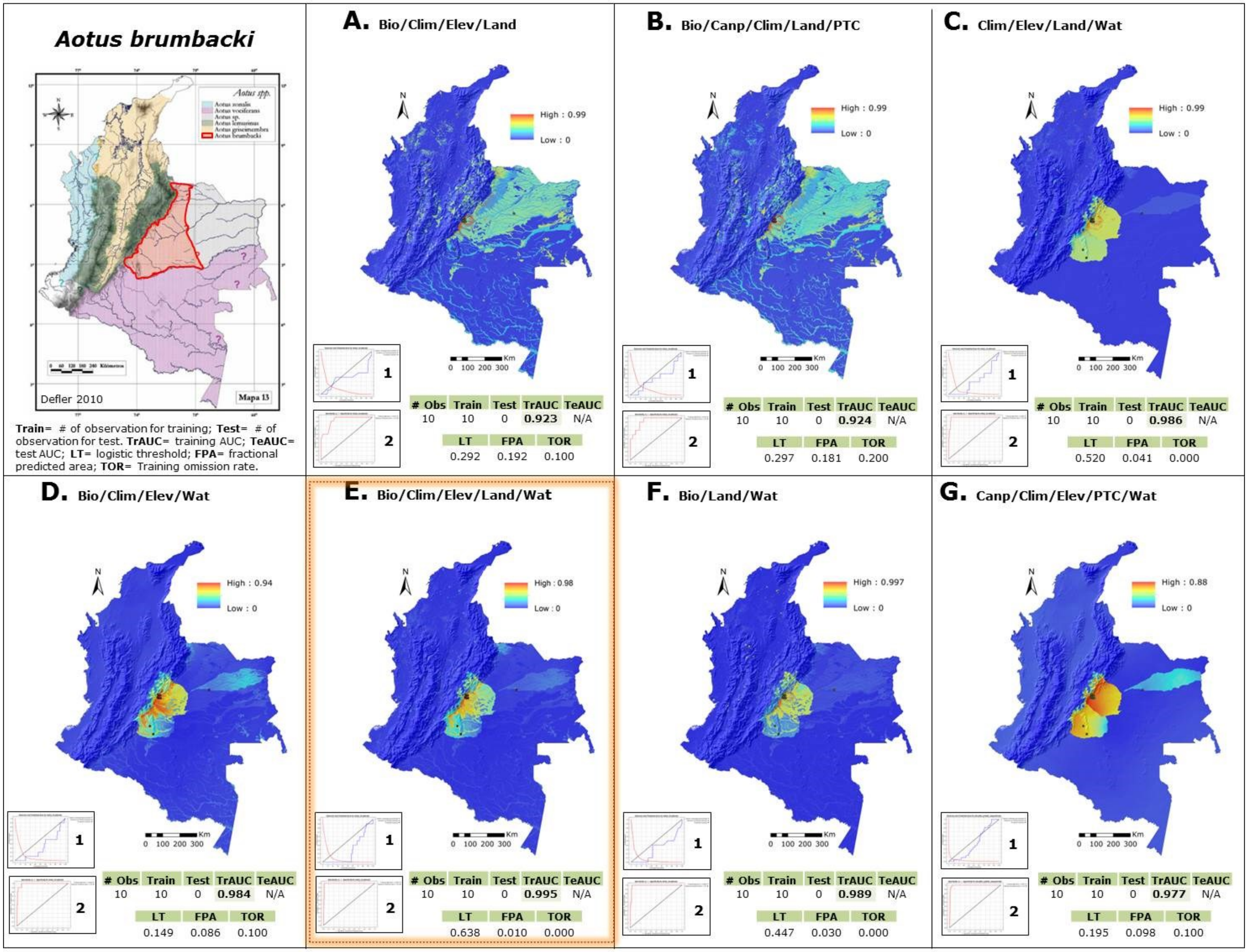
Leontocebus nigricollis hernandezi** / Hernández-camacho's black ma							
Status: IUCN_**LC** / National_**LC**							
SDM	**A**	**B**	**C**	**D**	**E**	**F**	**G**
# Observations	7						
Obs_Train	**7**						
Obs_Test	0	0	0	0	0	0	0
Training AUC	**0.910**	**0.909**	**0.947**	**0.970**	**0.970**	**0.964**	**0.947**
Test AUC							
Logis_Tresh	0.392	0.393	0.319	0.433	0.433	0.447	0.319
Fract_Pred_Area	0.172	0.172	0.129	0.073	0.073	0.121	0.129
Train_Omis_Rate	0.143	0.143	0.143	0.143	0.143	0.000	0.143
Percent Contribution							
PTC		<1					<1
Canp		3.2					<1
BIO4	17.4	14.4	7.4	4.4	4.4		7.4
BIO7	<1	<1	<1	<1	<1		<1
BIO15	18.5	17.9	<1	<1	<1		<1
Biome	50.1	53.9		23.3	23.3	23.6	
Elevation	2.8		<1	<1	<1		<1
Landcover	11.2	10.6	<1		<1	<1	
Watershed			92.6	72.3	72.3	76.4	92.6

Obs_Train: Number of training observations; **Obs_Test**: Number of testing observations; **Logis_Tresh**: Logistic Threshold; **Fract_Pred_Area**: Fractional Predicted Area; **Train_Omis_Rate**: Training Omission Rate. **BIO4**: Temperature Seasonality (standard deviation *100); **BIO7**: Temperature Annual Range; **BIO15**: Precipitation Seasonality (Coefficient of Variation); **PTC**: Percent Tree Cover; **Canp**: Forest Canopy Height.

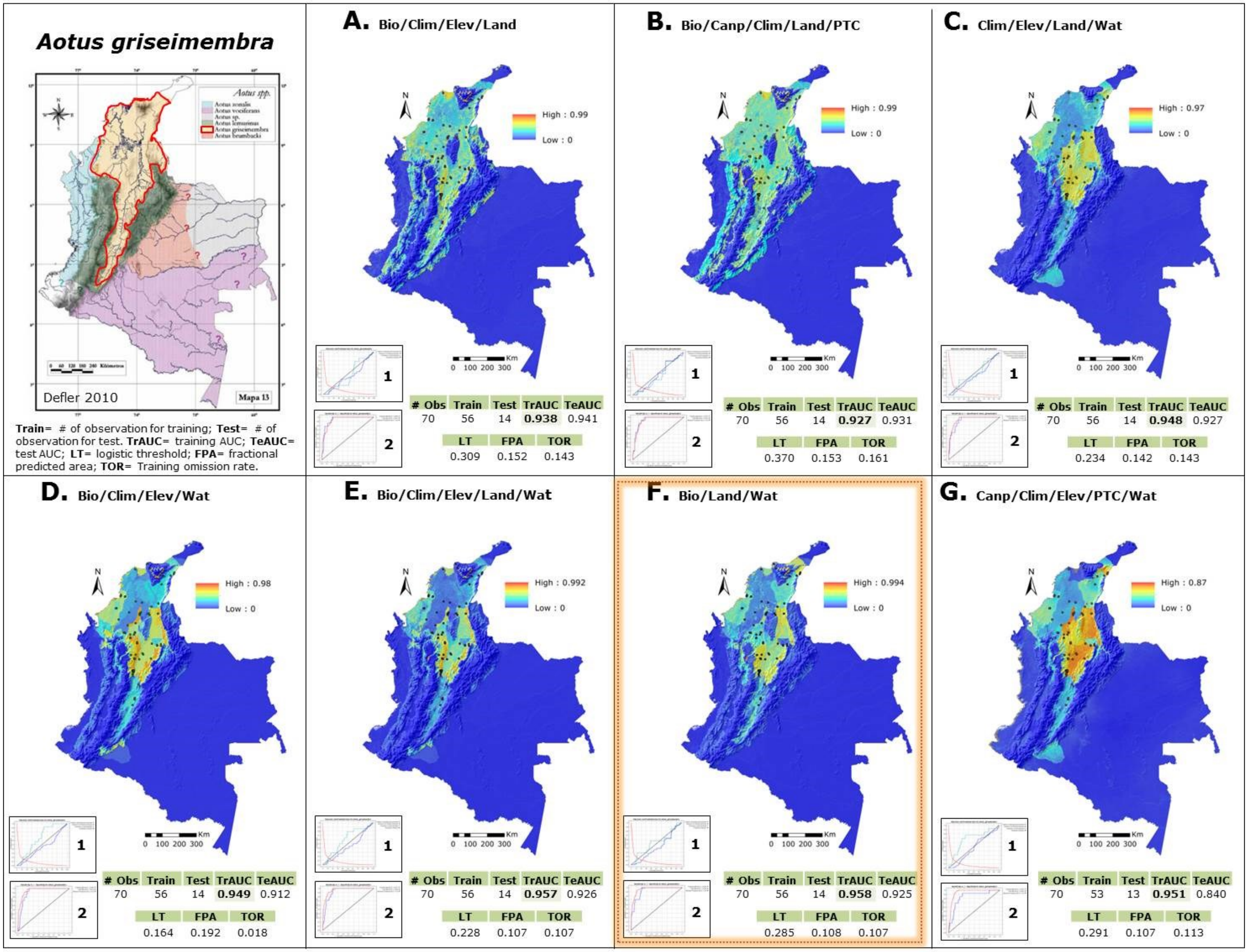
Appendix J. Species distribution models for species of primates in Colombia. A single predictive model with the best performance (highlighted with orange) was selected for each species through a comparative analysis. Selection involved spatial comparison, the relation among AUC values and the fractional predicted area. Parsimonious models account lower fractional predicted area values and reduced omission errors. To visualize predictive power, plots depicting the variation of sensitivity (1 - omission rate) and 1 - specificity (predicted area) in relation with the cumulative threshold, and the ROC (AUC) curve are also included. *Species with less than 10 occurrence records.


Alouatta palliata aequatorialis
Alouatta palliata
A. palliata aequatorialis
Map 18
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.98
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.986 N/A
LT FPA TOR
0.101 0.053 0.043
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.984 N/A
LT FPA TOR
0.100 0.059 0.043
C. Clim/Elev/Land/Wat
High : 0.95
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.987 N/A
LT FPA TOR
0.200 0.043 0.043
D. Bio/Clim/Elev/Wat
High : 0.97
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.988 N/A
LT FPA TOR
0.101 0.046 0.043
E. Bio/Clim/Elev/Land/Wat
High : 0.96
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.991 N/A
LT FPA TOR
0.094 0.044 0.043
F. Bio/Land/Wat
High : 0.97
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.987 N/A
LT FPA TOR
0.113 0.052 0.043
G. Canp/Clim/Elev/PTC/Wat
High : 0.84
Low : 0
Km
0 100 200 300
1
2
Obs Train Test TrAUC TeAUC
26 23 0 0.991 N/A
LT FPA TOR
0.128 0.042 0.048


Alouatta seniculus seniculus
Alouatta seniculus
A. seniculus seniculus
Defler 2010
Mapa 19
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
0 100 200 300 Km
1
2
Obs 266 Train 205 Test 51 TrAUC 0.765 TeAUC 0.703
LT 0.380 FPA 0.298 TOR 0.298
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs 266 Train 205 Test 51 TrAUC 0.764 TeAUC 0.707
LT 0.384 FPA 0.290 TOR 0.291
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs 266 Train 205 Test 51 TrAUC 0.789 TeAUC 0.776
LT 0.374 FPA 0.278 TOR 0.278
D. Bio/Clim/Elev/Wat
High : 0.93
Low : 0
Obs 266 Train 205 Test 51 TrAUC 0.793 TeAUC 0.767
LT 0.410 FPA 0.272 TOR 0.273
E. Bio/Clim/Elev/Land/Wat
High : 0.993
Low : 0
Obs 266 Train 205 Test 51 TrAUC 0.814 TeAUC 0.781
LT 0.354 FPA 0.261 TOR 0.263
F. Bio/Land/Wat
High : 0.995
Low : 0
Obs 266 Train 205 Test 51 TrAUC 0.804 TeAUC 0.772
LT 0.368 FPA 0.253 TOR 0.268
G. Canp/Clim/Elev/PTC/Wat
High : 0.96
Low : 0
Obs 266 Train 205 Test 51 TrAUC 0.778 TeAUC 0.753
LT 0.425 FPA 0.286 TOR 0.286

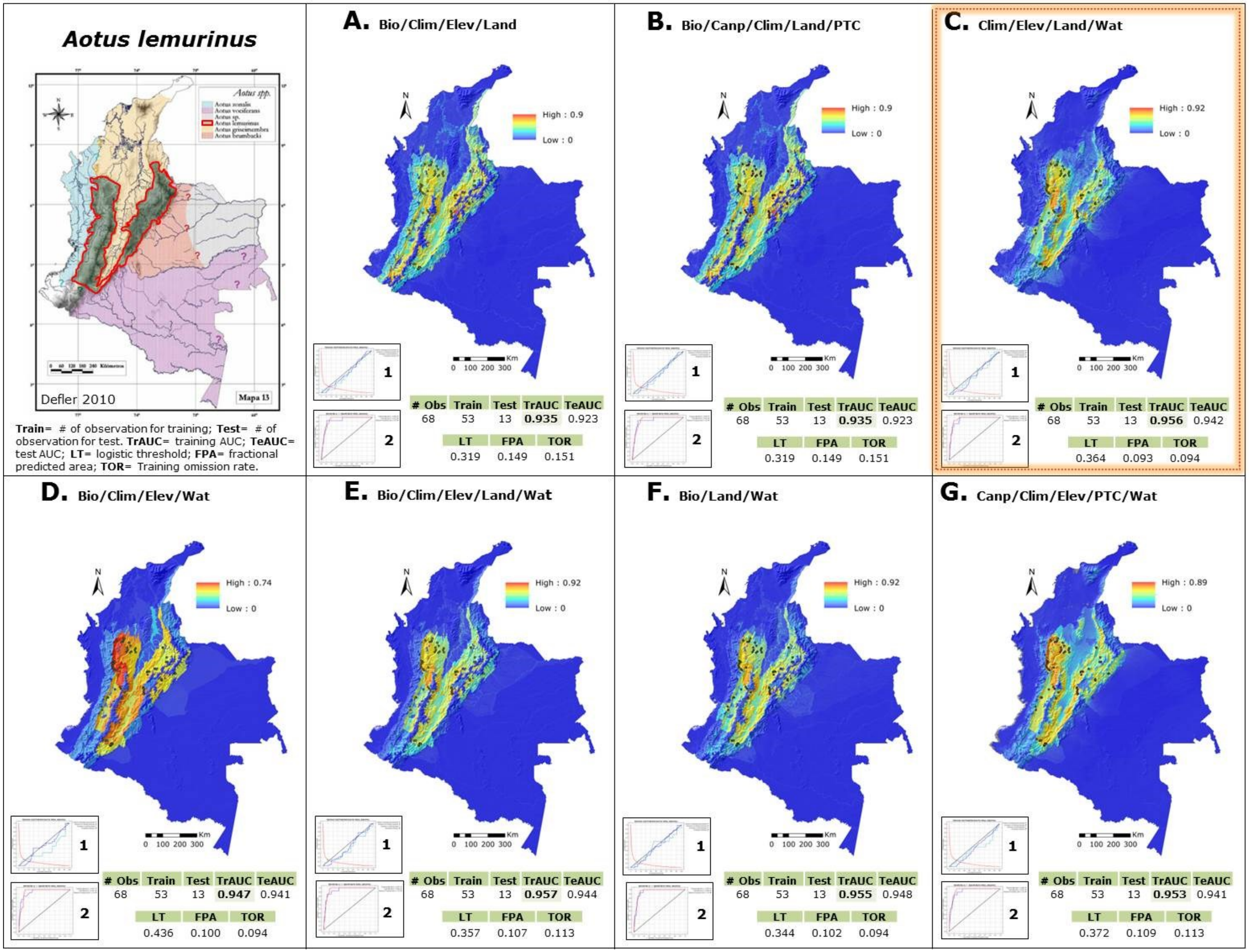


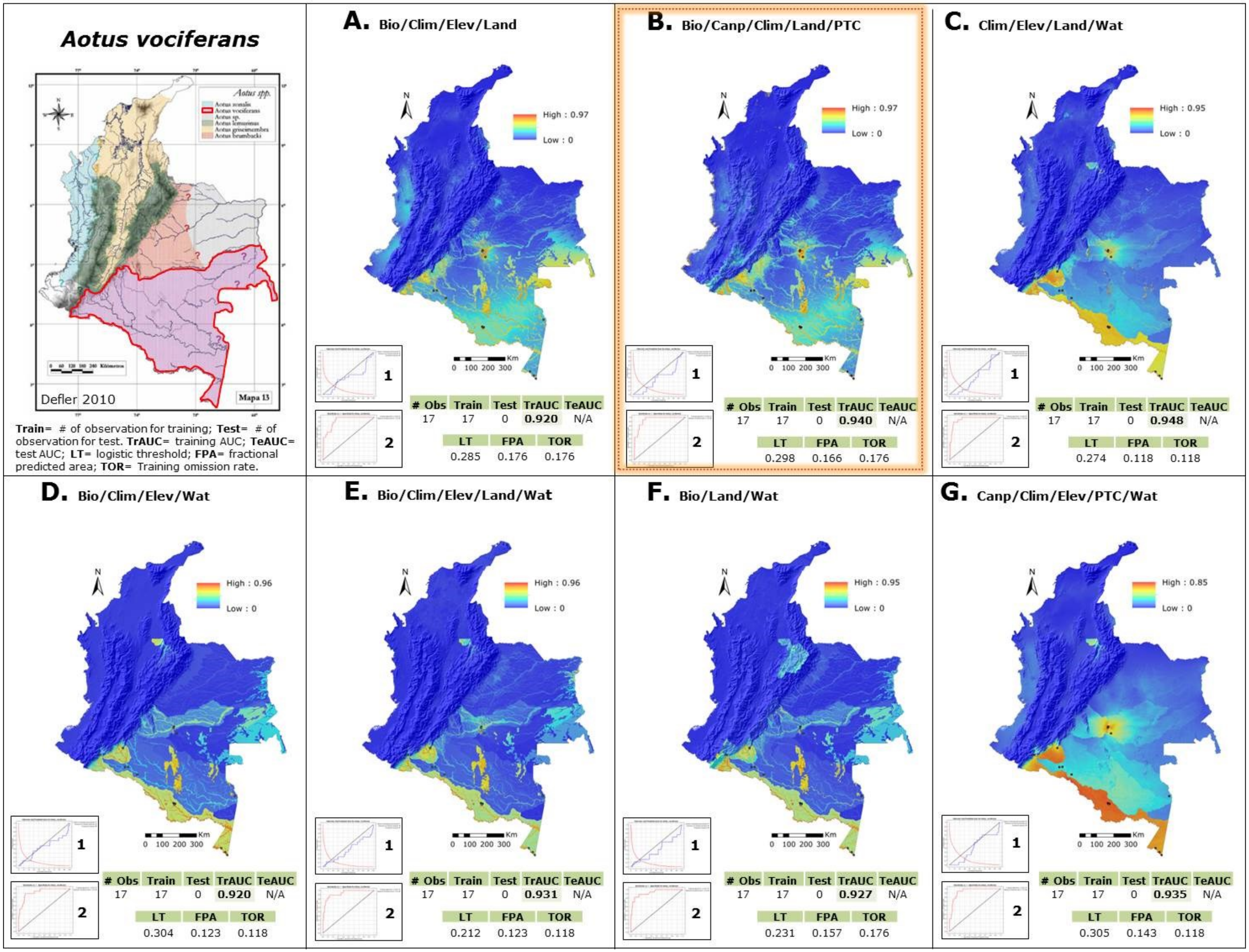
Train= # of observation for training; **Test**= # of observation for test. **TrAUC**= training AUC; **TeAUC**= test AUC; **LT**= logistic threshold; **FPA**= fractional predicted area; **TOR**= Training omission rate.

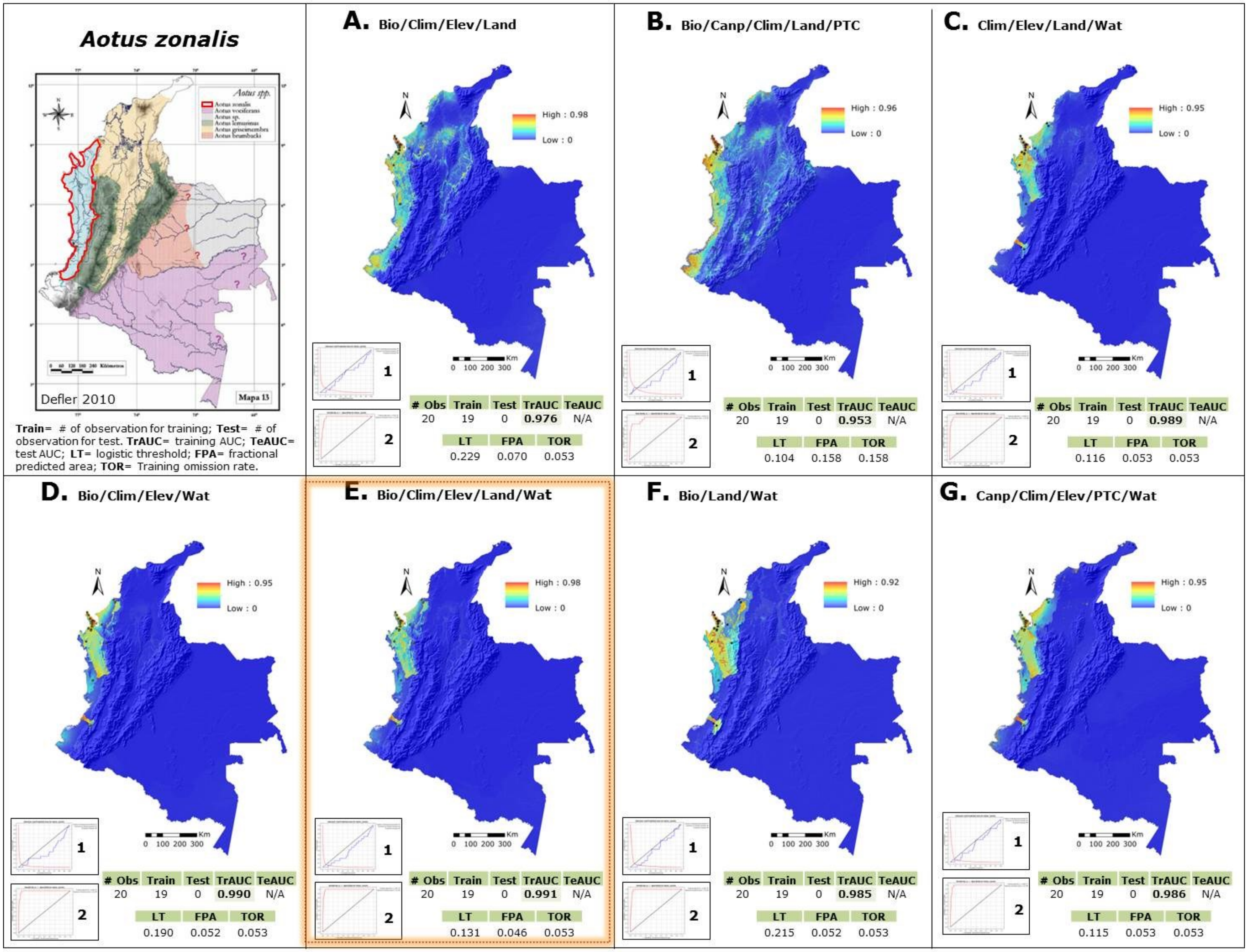


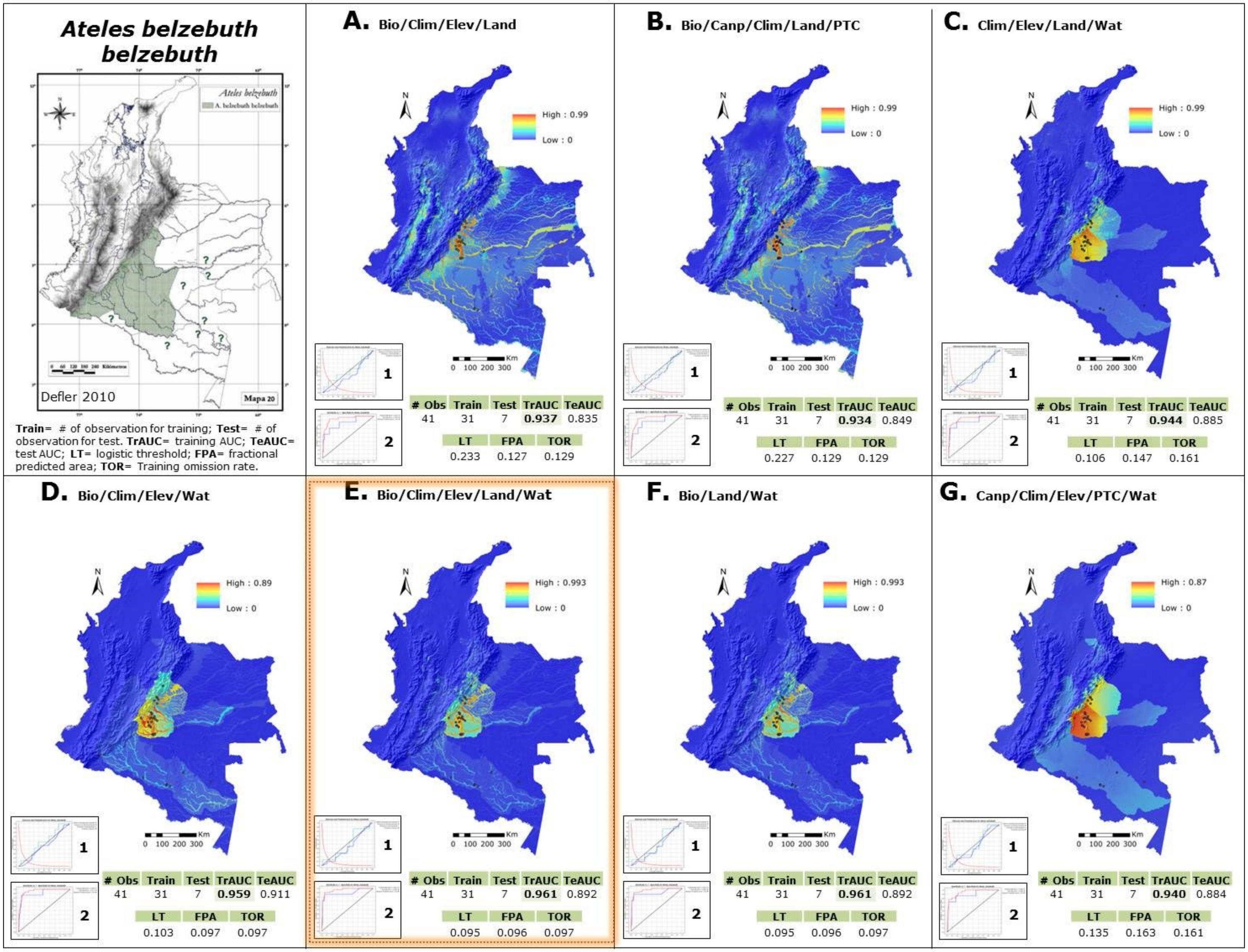
Model	# Obs	Train	Test	TrAUC	TeAUC	LT	FPA	TOR
A. Bio/Clim/Elev/Land	70	56	14	**0.938**	0.941	0.309	0.152	0.143
B. Bio/Canp/Clim/Land/PTC	70	56	14	**0.927**	0.931	0.370	0.153	0.161
C. Clim/Elev/Land/Wat	70	56	14	**0.948**	0.927	0.234	0.142	0.143
D. Bio/Clim/Elev/Wat	70	56	14	**0.949**	0.912	0.164	0.192	0.018
E. Bio/Clim/Elev/Land/Wat	70	56	14	**0.957**	0.926	0.228	0.107	0.107
F. Bio/Land/Wat	70	56	14	**0.958**	0.925	0.285	0.108	0.107
G. Canp/Clim/Elev/PTC/Wat	70	53	13	**0.951**	0.840	0.291	0.107	0.113

Train= # of observation for training; **Test**= # of observation for test. **TrAUC**= training AUC; **TeAUC**= test AUC; **LT**= logistic threshold; **FPA**= fractional predicted area; **TOR**= Training omission rate.

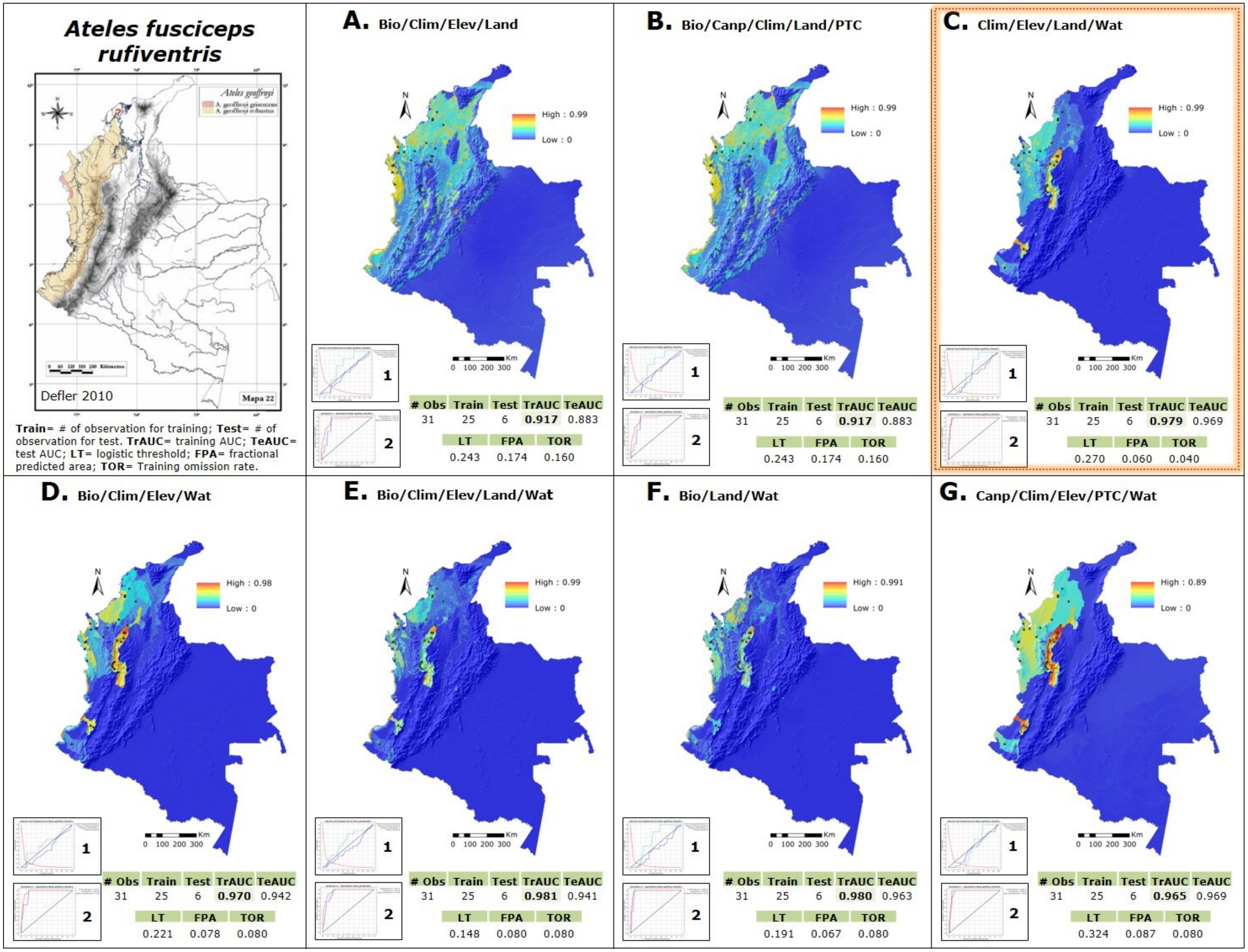

Aotus lemurinus
Aotus spp.
Aotus zonalis
Aotus vociferans
Aotus sp.
Aotus lemurinus
Aotus griseimembra
Aotus brumbacki
Mapa 13
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.9
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.935 TeAUC 0.923
LT 0.319 FPA 0.149 TOR 0.151
B. Bio/Canp/Clim/Land/PTC
High : 0.9
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.935 TeAUC 0.923
LT 0.319 FPA 0.149 TOR 0.151
C. Clim/Elev/Land/Wat
High : 0.92
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.956 TeAUC 0.942
LT 0.364 FPA 0.093 TOR 0.094
D. Bio/Clim/Elev/Wat
High : 0.74
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.947 TeAUC 0.941
LT 0.436 FPA 0.100 TOR 0.094
E. Bio/Clim/Elev/Land/Wat
High : 0.92
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.957 TeAUC 0.944
LT 0.357 FPA 0.107 TOR 0.113
F. Bio/Land/Wat
High : 0.92
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.955 TeAUC 0.948
LT 0.344 FPA 0.102 TOR 0.094
G. Canp/Clim/Elev/PTC/Wat
High : 0.89
Low : 0
Obs 68 Train 53 Test 13 TrAUC 0.953 TeAUC 0.941
LT 0.372 FPA 0.109 TOR 0.113
Km
0 100 200 300
1
2


Aotus vociferans
Aotus spp.
Aotus zonalis
Aotus vociferans
Aotus sp.
Aotus lemurinus
Aotus griseimembra
Aotus brumbacki
Defler 2010
Mapa 13
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.920 N/A
LT FPA TOR
0.285 0.176 0.176
B. Bio/Canp/Clim/Land/PTC
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.940 N/A
LT FPA TOR
0.298 0.166 0.176
C. Clim/Elev/Land/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.948 N/A
LT FPA TOR
0.274 0.118 0.118
D. Bio/Clim/Elev/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.920 N/A
LT FPA TOR
0.304 0.123 0.118
E. Bio/Clim/Elev/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.931 N/A
LT FPA TOR
0.212 0.123 0.118
F. Bio/Land/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.927 N/A
LT FPA TOR
0.231 0.157 0.176
G. Canp/Clim/Elev/PTC/Wat
High : 0.85
Low : 0
Obs Train Test TrAUC TeAUC
17 17 0 0.935 N/A
LT FPA TOR
0.305 0.143 0.118
N
0 100 200 300 Km
1
2

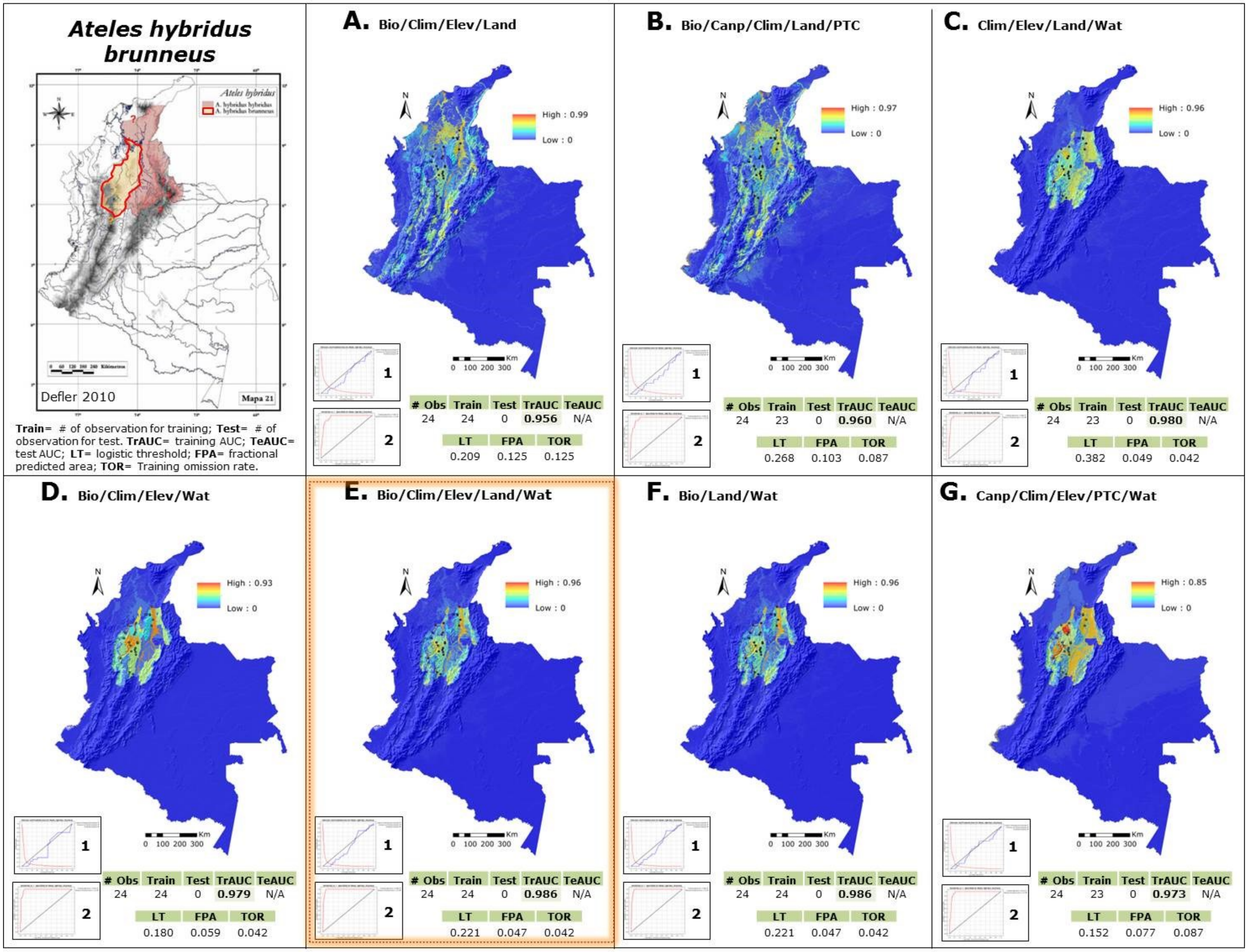

Aotus zonalis
Aotus spp.
Aotus zonalis
Aotus vociferans
Aotus sp.
Aotus lemurinus
Aotus griseimembra
Aotus brumbacki
Defler 2010
Mapa 13
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.98
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.976 | TeAUC N/A
LT 0.229 | FPA 0.070 | TOR 0.053
B. Bio/Canp/Clim/Land/PTC
High : 0.96
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.953 | TeAUC N/A
LT 0.104 | FPA 0.158 | TOR 0.158
C. Clim/Elev/Land/Wat
High : 0.95
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.989 | TeAUC N/A
LT 0.116 | FPA 0.053 | TOR 0.053
D. Bio/Clim/Elev/Wat
High : 0.95
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.990 | TeAUC N/A
LT 0.190 | FPA 0.052 | TOR 0.053
E. Bio/Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.991 | TeAUC N/A
LT 0.131 | FPA 0.046 | TOR 0.053
F. Bio/Land/Wat
High : 0.92
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.985 | TeAUC N/A
LT 0.215 | FPA 0.052 | TOR 0.053
G. Canp/Clim/Elev/PTC/Wat
High : 0.95
Low : 0
Obs 20 | Train 19 | Test 0 | TrAUC 0.986 | TeAUC N/A
LT 0.115 | FPA 0.053 | TOR 0.053
0 100 200 300 Km

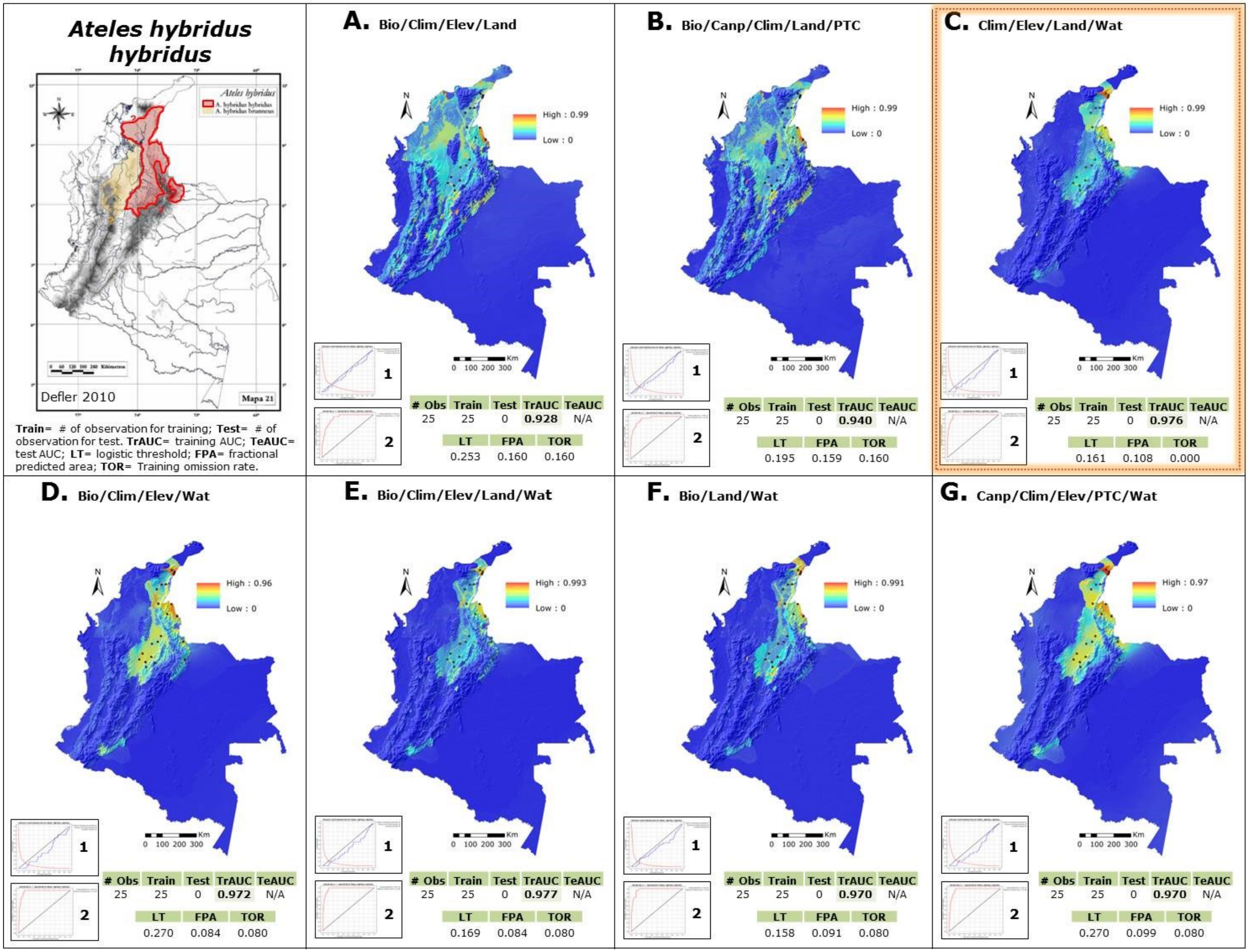


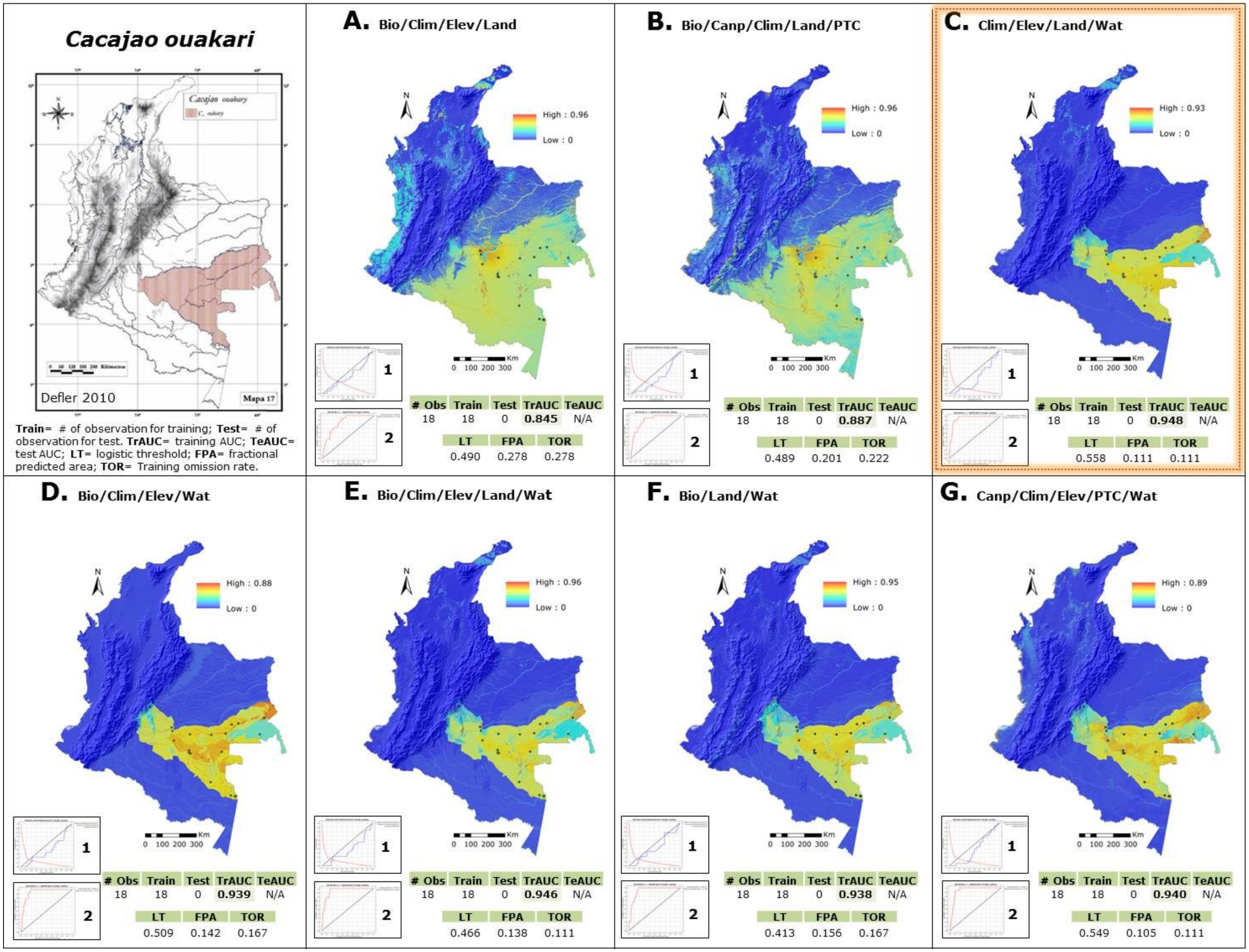
Ateles belzebuth belzebuth
Ateles belzebuth
A. belzebuth belzebuth
Defler 2010
Mapa 20
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.937 0.835
LT FPA TOR
0.233 0.127 0.129
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.934 0.849
LT FPA TOR
0.227 0.129 0.129
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.944 0.885
LT FPA TOR
0.106 0.147 0.161
D. Bio/Clim/Elev/Wat
High : 0.89
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.959 0.911
LT FPA TOR
0.103 0.097 0.097
E. Bio/Clim/Elev/Land/Wat
High : 0.993
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.961 0.892
LT FPA TOR
0.095 0.096 0.097
F. Bio/Land/Wat
High : 0.993
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.961 0.892
LT FPA TOR
0.095 0.096 0.097
G. Canp/Clim/Elev/PTC/Wat
High : 0.87
Low : 0
Obs Train Test TrAUC TeAUC
41 31 7 0.940 0.884
LT FPA TOR
0.135 0.163 0.161
Km
0 100 200 300
1
2

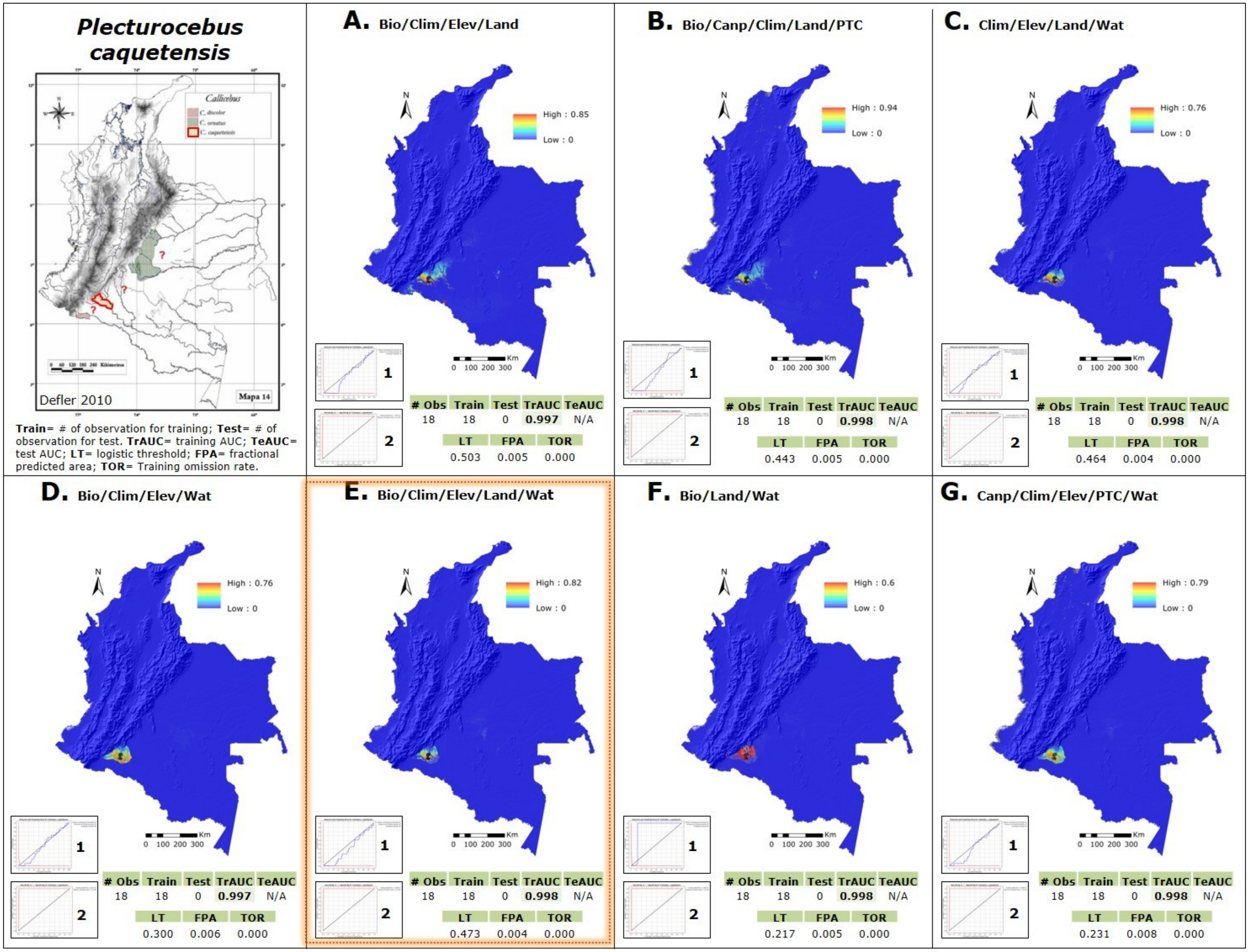


Ateles fusciceps rufiventris
Ateles geoffroyi
A. geoffroyi grisescens
A. geoffroyi robustus
Kilómetros
Mapa 22
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.917 0.883
LT FPA TOR
0.243 0.174 0.160
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.917 0.883
LT FPA TOR
0.243 0.174 0.160
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.979 0.969
LT FPA TOR
0.270 0.060 0.040
D. Bio/Clim/Elev/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.970 0.942
LT FPA TOR
0.221 0.078 0.080
E. Bio/Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.981 0.941
LT FPA TOR
0.148 0.080 0.080
F. Bio/Land/Wat
High : 0.991
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.980 0.963
LT FPA TOR
0.191 0.067 0.080
G. Canp/Clim/Elev/PTC/Wat
High : 0.89
Low : 0
Obs Train Test TrAUC TeAUC
31 25 6 0.965 0.969
LT FPA TOR
0.324 0.087 0.080
N
Km
0 100 200 300
1
2

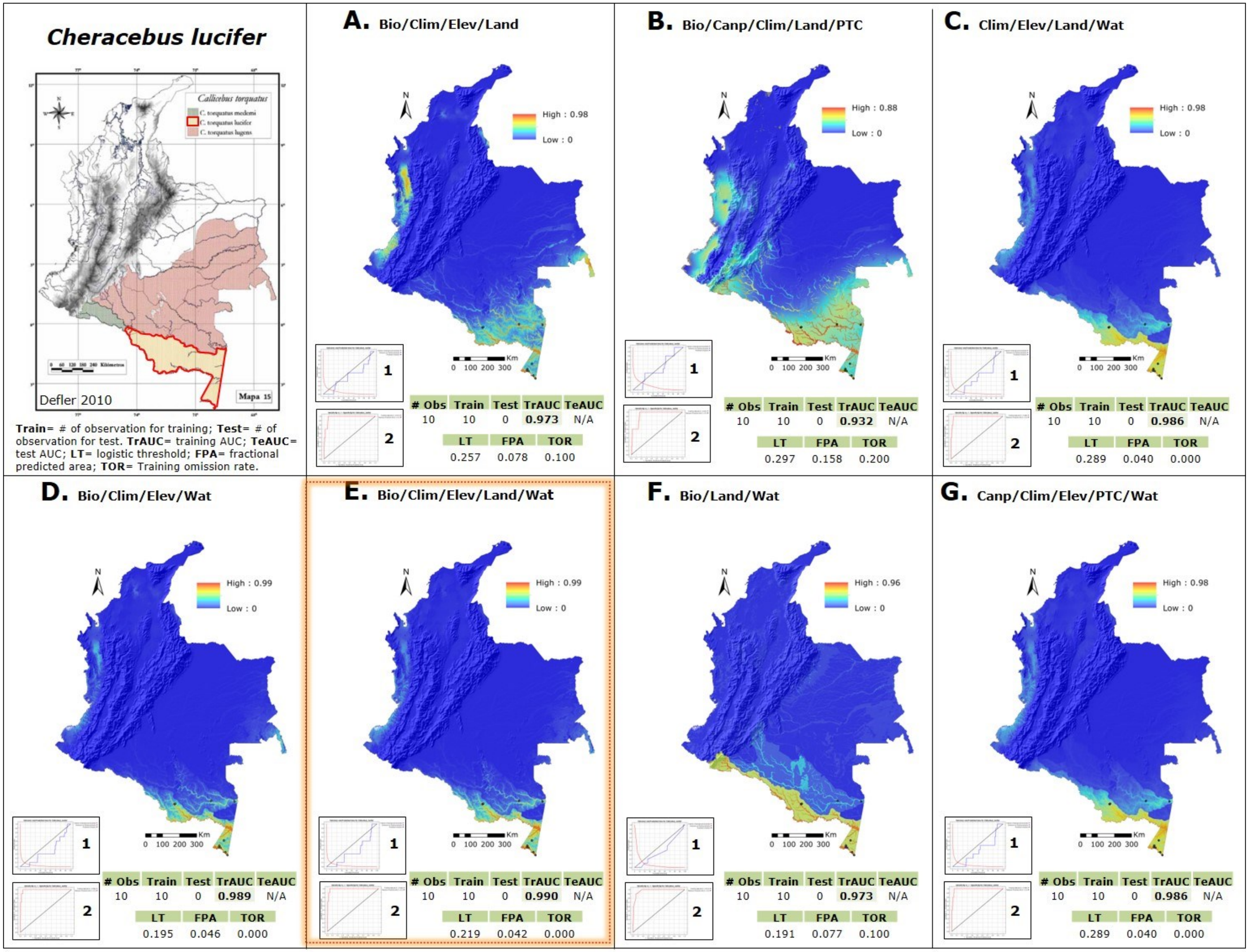

Ateles hybridus brunneus
Ateles hybridus
A. hybridus hybridus
A. hybridus brunneus
Defler 2010
Mapa 21
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
24 24 0 0.956 N/A
LT FPA TOR
0.209 0.125 0.125
B. Bio/Canp/Clim/Land/PTC
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
24 23 0 0.960 N/A
LT FPA TOR
0.268 0.103 0.087
C. Clim/Elev/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
24 23 0 0.980 N/A
LT FPA TOR
0.382 0.049 0.042
D. Bio/Clim/Elev/Wat
High : 0.93
Low : 0
Obs Train Test TrAUC TeAUC
24 24 0 0.979 N/A
LT FPA TOR
0.180 0.059 0.042
E. Bio/Clim/Elev/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
24 24 0 0.986 N/A
LT FPA TOR
0.221 0.047 0.042
F. Bio/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
24 24 0 0.986 N/A
LT FPA TOR
0.221 0.047 0.042
G. Canp/Clim/Elev/PTC/Wat
High : 0.85
Low : 0
Obs Train Test TrAUC TeAUC
24 23 0 0.973 N/A
LT FPA TOR
0.152 0.077 0.087
Km
0 100 200 300

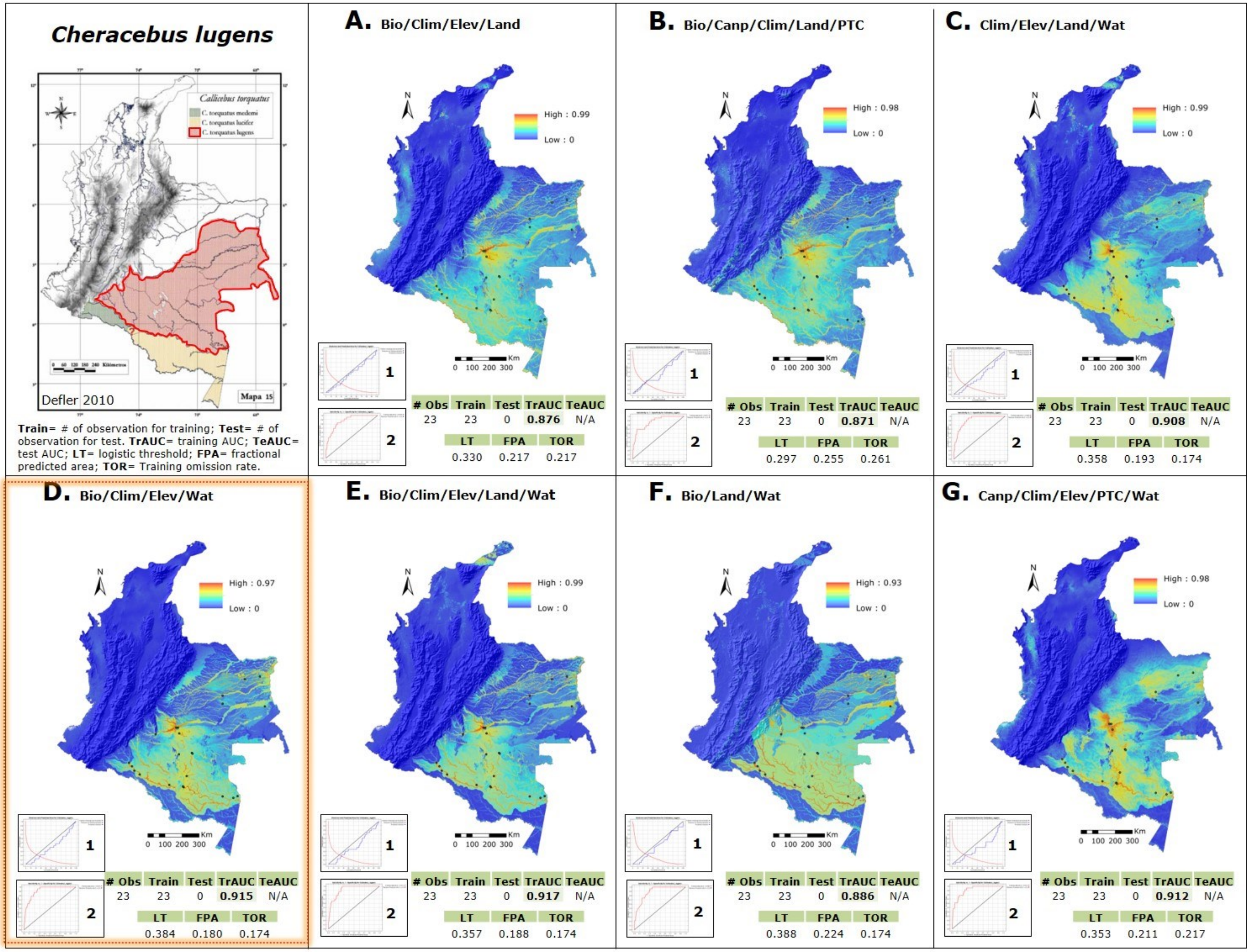

Ateles hybridus hybridus
Ateles hybridus
A. hybridus hybridus
A. hybridus brunneus
Mapa 21
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.928 TeAUC N/A
LT 0.253 FPA 0.160 TOR 0.160
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.940 TeAUC N/A
LT 0.195 FPA 0.159 TOR 0.160
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.976 TeAUC N/A
LT 0.161 FPA 0.108 TOR 0.000
D. Bio/Clim/Elev/Wat
High : 0.96
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.972 TeAUC N/A
LT 0.270 FPA 0.084 TOR 0.080
E. Bio/Clim/Elev/Land/Wat
High : 0.993
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.977 TeAUC N/A
LT 0.169 FPA 0.084 TOR 0.080
F. Bio/Land/Wat
High : 0.991
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.970 TeAUC N/A
LT 0.158 FPA 0.091 TOR 0.080
G. Canp/Clim/Elev/PTC/Wat
High : 0.97
Low : 0
Obs 25 Train 25 Test 0 TrAUC 0.970 TeAUC N/A
LT 0.270 FPA 0.099 TOR 0.080
Km
0 100 200 300
1
2

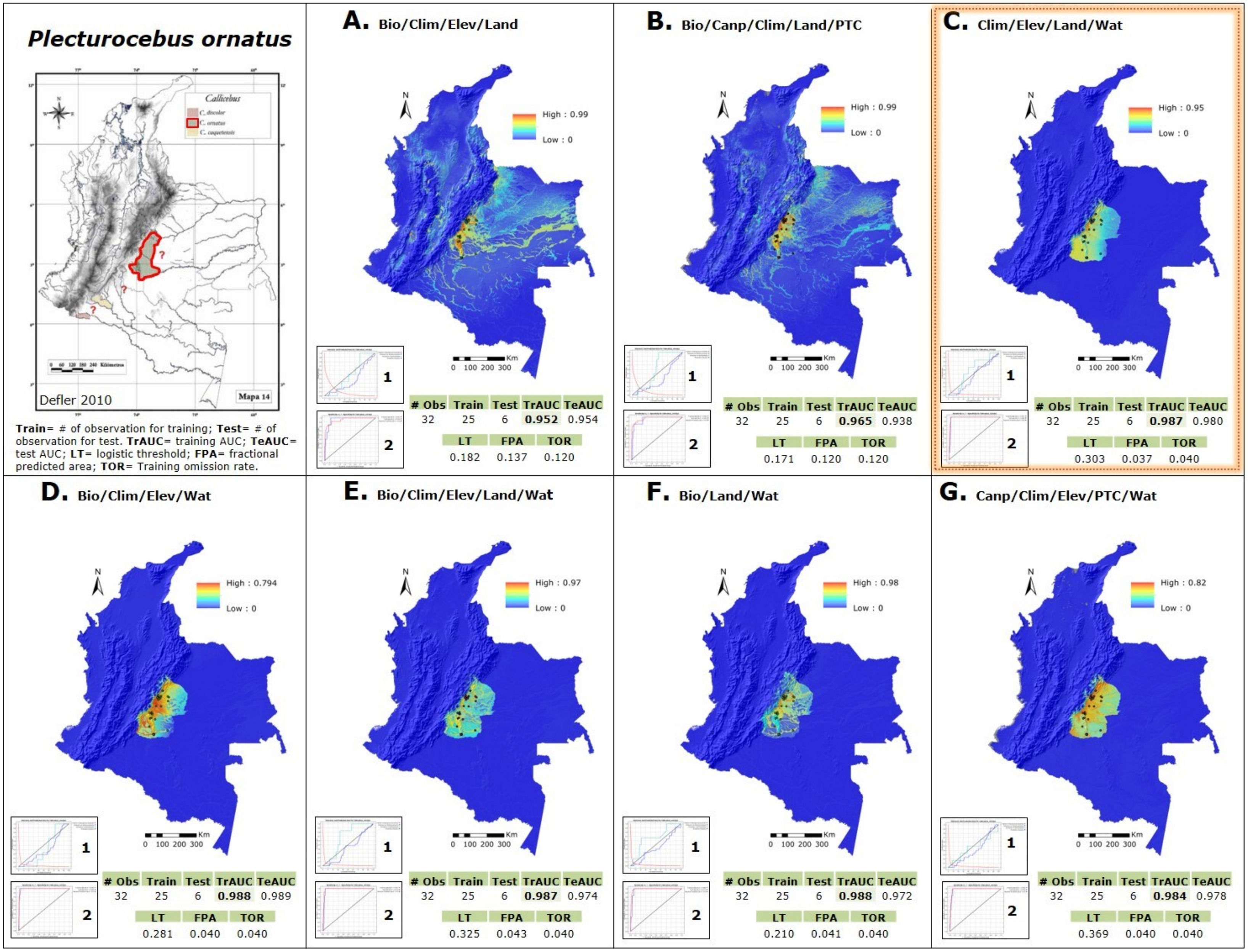

Cacajao ouakari
Cacajao ouakary
C. oukary
Defler 2010
Mapa 17
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.96
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.845 | N/A
LT | FPA | TOR
0.490 | 0.278 | 0.278
B. Bio/Canp/Clim/Land/PTC
High : 0.96
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.887 | N/A
LT | FPA | TOR
0.489 | 0.201 | 0.222
C. Clim/Elev/Land/Wat
High : 0.93
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.948 | N/A
LT | FPA | TOR
0.558 | 0.111 | 0.111
D. Bio/Clim/Elev/Wat
High : 0.88
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.939 | N/A
LT | FPA | TOR
0.509 | 0.142 | 0.167
E. Bio/Clim/Elev/Land/Wat
High : 0.96
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.946 | N/A
LT | FPA | TOR
0.466 | 0.138 | 0.111
F. Bio/Land/Wat
High : 0.95
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.938 | N/A
LT | FPA | TOR
0.413 | 0.156 | 0.167
G. Canp/Clim/Elev/PTC/Wat
High : 0.89
Low : 0
Obs | Train | Test | TrAUC | TeAUC
18 | 18 | 0 | 0.940 | N/A
LT | FPA | TOR
0.549 | 0.105 | 0.111
0 100 200 300 Km

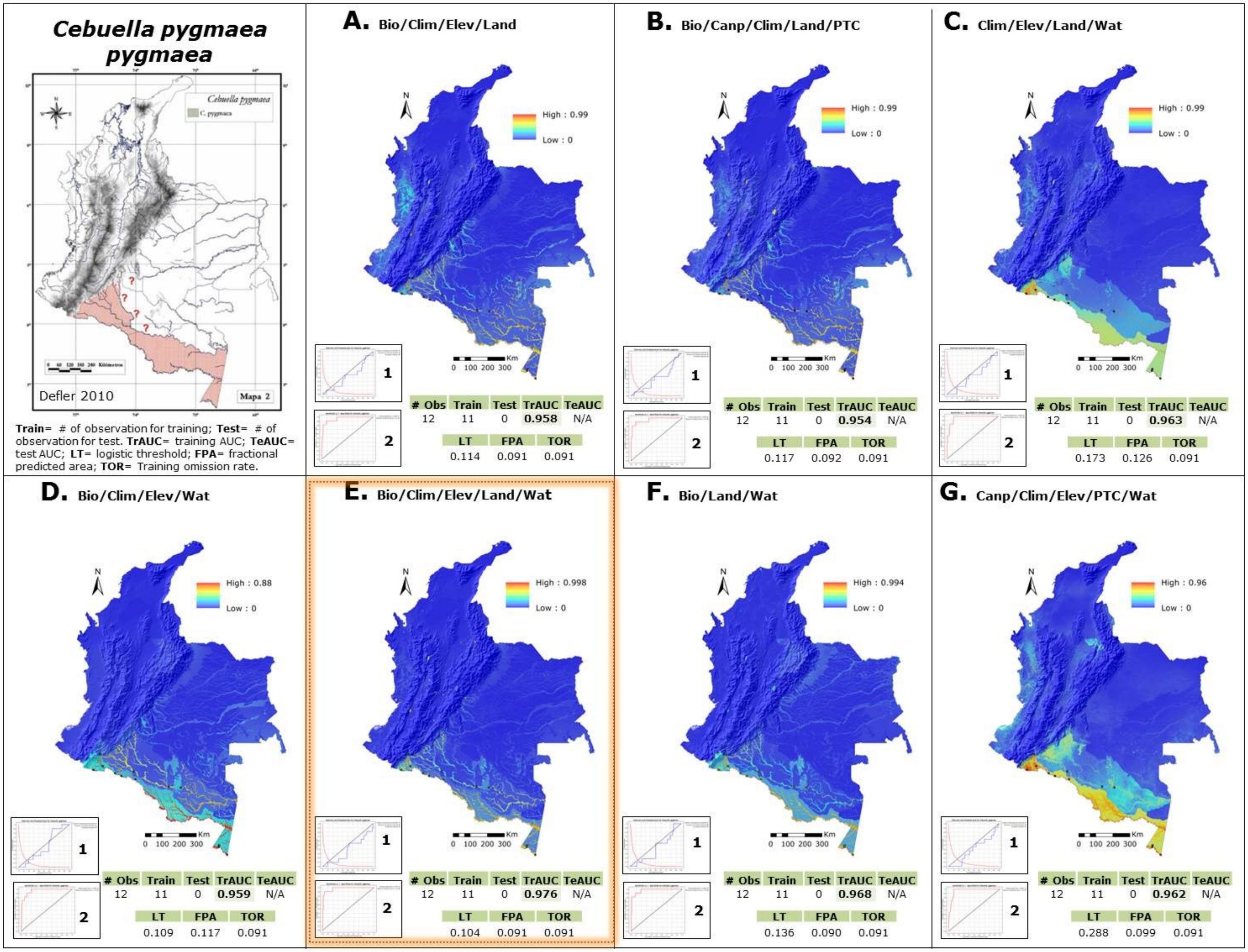


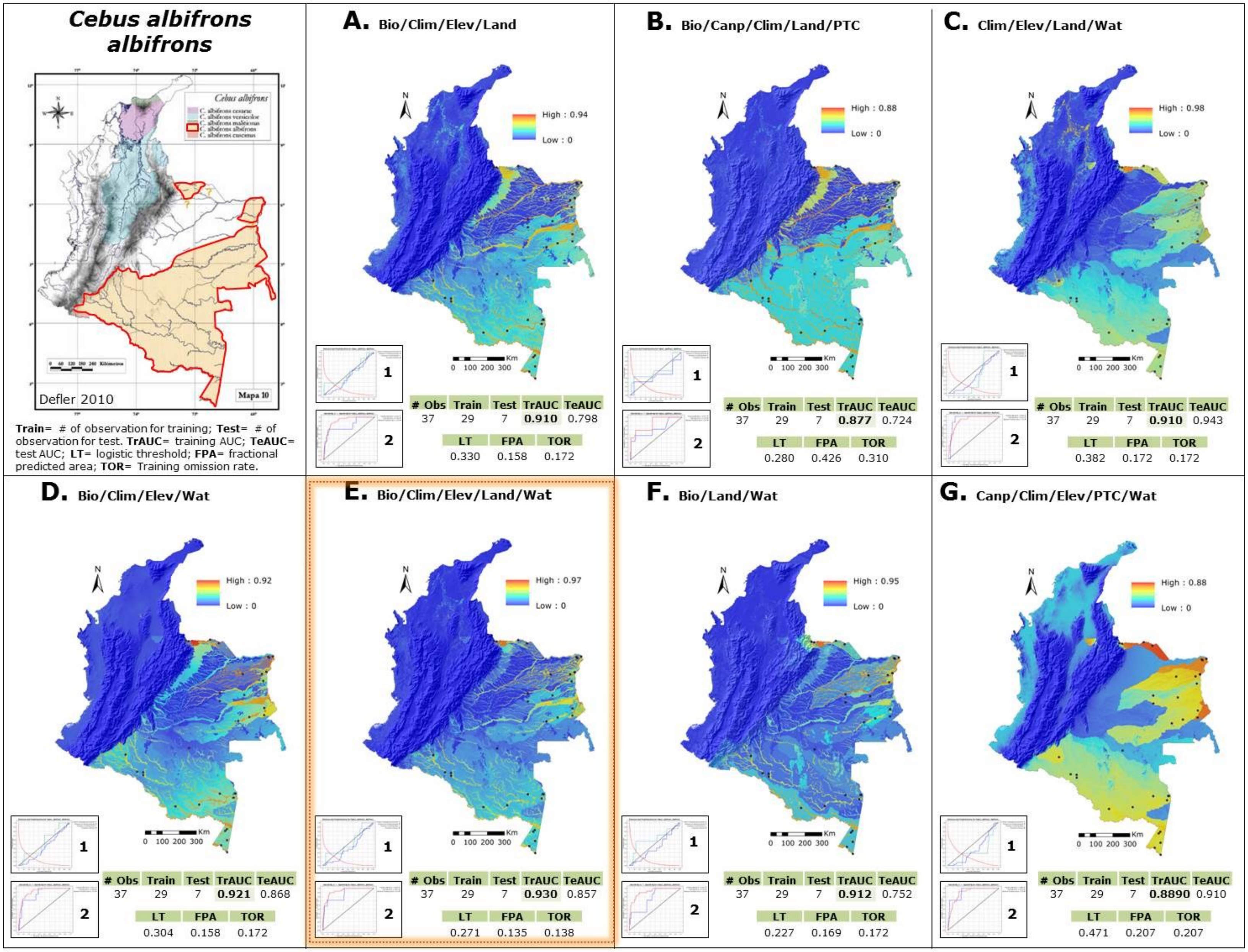
Train= # of observation for training; **Test**= # of observation for test. **TrAUC**= training AUC; **TeAUC**= test AUC; **LT**= logistic threshold; **FPA**= fractional predicted area; **TOR**= Training omission rate.

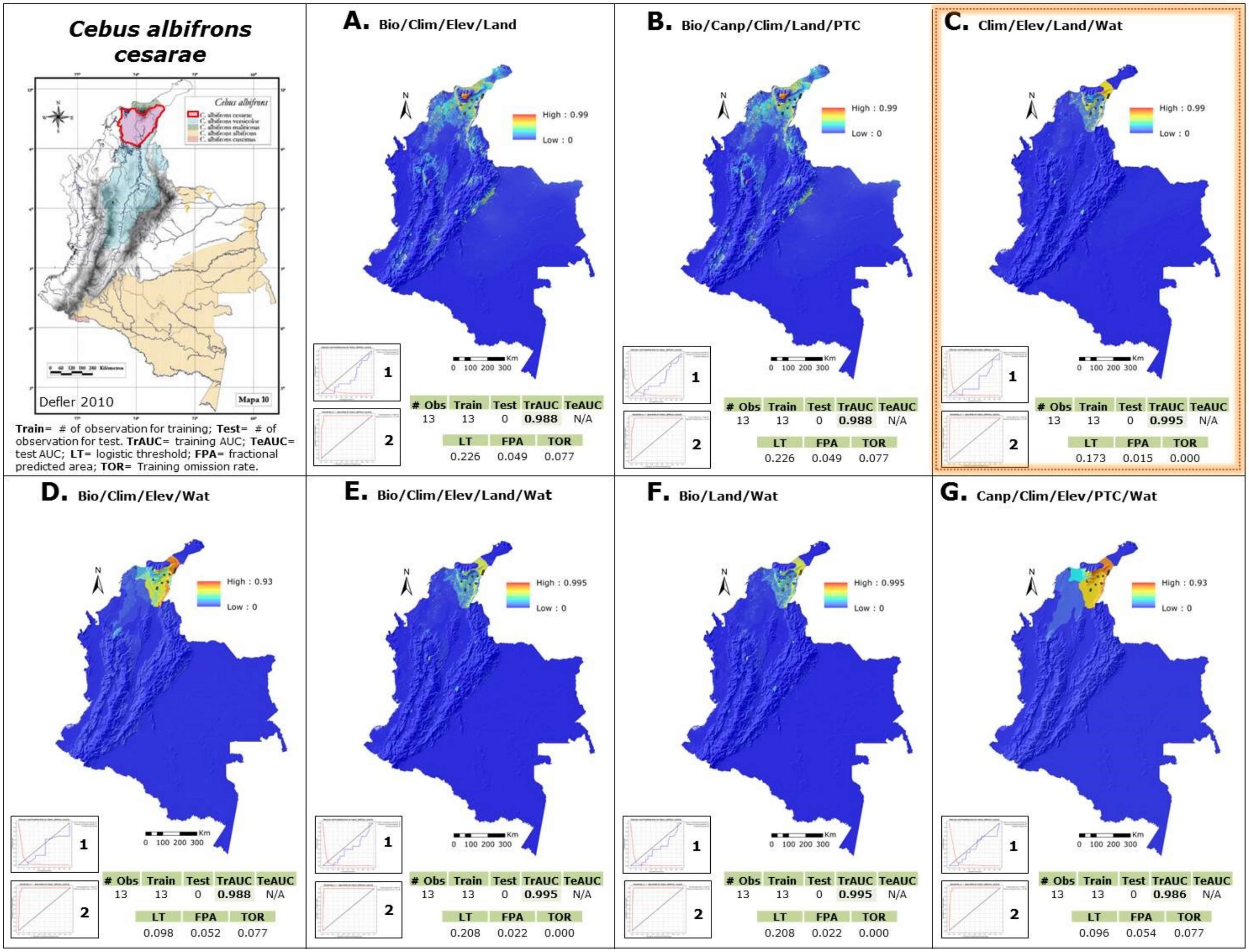

Cheracebus lucifer
Callicebus torquatus
C. torquatus medemi
C. torquatus lucifer
C. torquatus lugens
Mapa 15
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.98
Low : 0
0 100 200 300 Km
Obs Train Test TrAUC TeAUC
10 10 0 0.973 N/A
LT FPA TOR
0.257 0.078 0.100
B. Bio/Canp/Clim/Land/PTC
High : 0.88
Low : 0
Obs Train Test TrAUC TeAUC
10 10 0 0.932 N/A
LT FPA TOR
0.297 0.158 0.200
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
10 10 0 0.986 N/A
LT FPA TOR
0.289 0.040 0.000
D. Bio/Clim/Elev/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
10 10 0 0.989 N/A
LT FPA TOR
0.195 0.046 0.000
E. Bio/Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
10 10 0 0.990 N/A
LT FPA TOR
0.219 0.042 0.000
F. Bio/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
10 10 0 0.973 N/A
LT FPA TOR
0.191 0.077 0.100
G. Canp/Clim/Elev/PTC/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
10 10 0 0.986 N/A
LT FPA TOR
0.289 0.040 0.000


Cheracebus lugens
Callicebus torquatus
C. torquatus medemi
C. torquatus lucifer
C. torquatus lugens
Mapa 15
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
0 100 200 300 Km
Obs Train Test TrAUC TeAUC
23 23 0 0.876 N/A
LT FPA TOR
0.330 0.217 0.217
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
23 23 0 0.871 N/A
LT FPA TOR
0.297 0.255 0.261
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
23 23 0 0.908 N/A
LT FPA TOR
0.358 0.193 0.174
D. Bio/Clim/Elev/Wat
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
23 23 0 0.915 N/A
LT FPA TOR
0.384 0.180 0.174
E. Bio/Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
23 23 0 0.917 N/A
LT FPA TOR
0.357 0.188 0.174
F. Bio/Land/Wat
High : 0.93
Low : 0
Obs Train Test TrAUC TeAUC
23 23 0 0.886 N/A
LT FPA TOR
0.388 0.224 0.174
G. Canp/Clim/Elev/PTC/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
23 23 0 0.912 N/A
LT FPA TOR
0.353 0.211 0.217

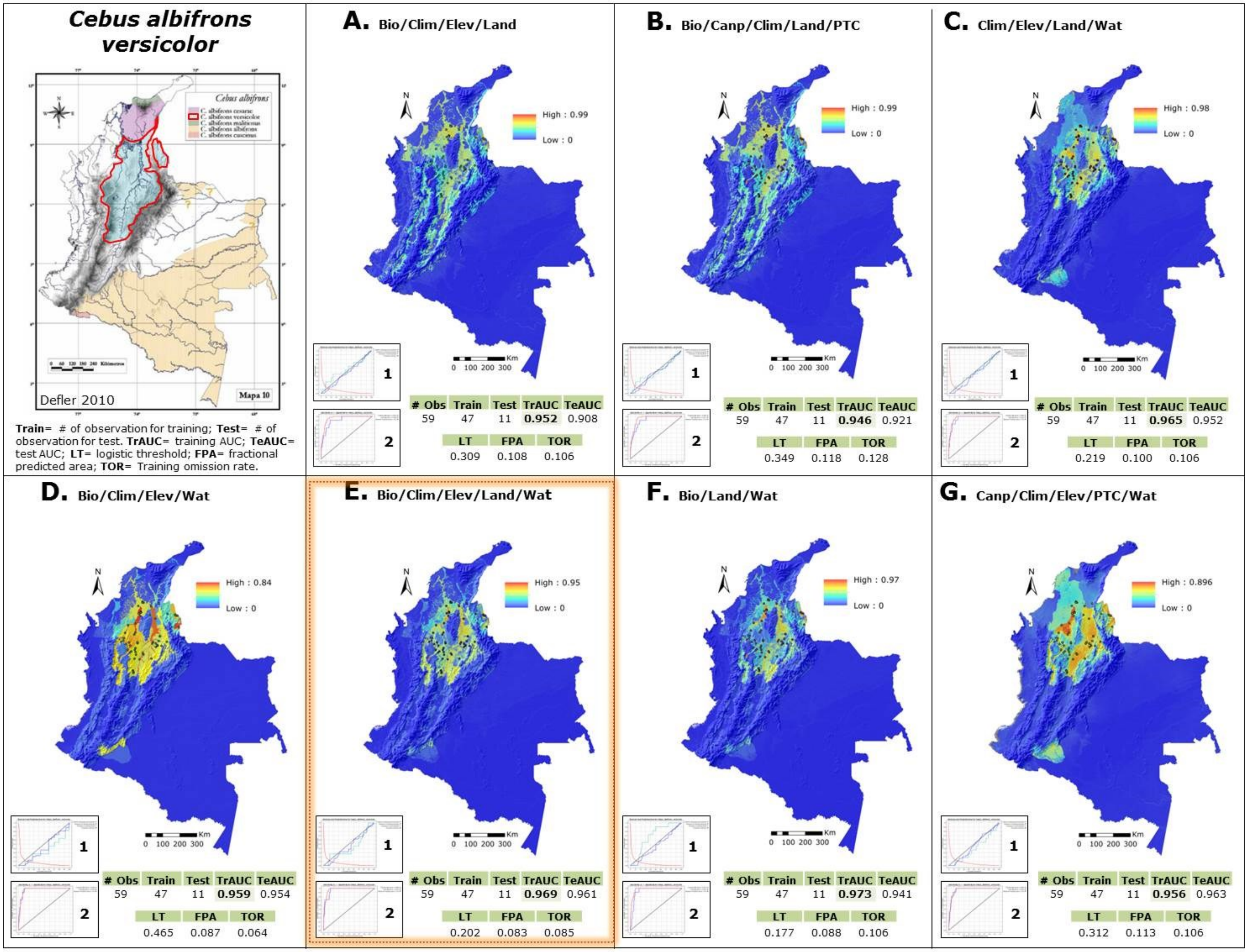

Plecturocebus ornatus
Callicebus
C. discolor
C. ornatus
C. caquetensis
Defler 2010
Mapa 14
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.952 0.954
LT FPA TOR
0.182 0.137 0.120
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.965 0.938
LT FPA TOR
0.171 0.120 0.120
C. Clim/Elev/Land/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.987 0.980
LT FPA TOR
0.303 0.037 0.040
D. Bio/Clim/Elev/Wat
High : 0.794
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.988 0.989
LT FPA TOR
0.281 0.040 0.040
E. Bio/Clim/Elev/Land/Wat
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.987 0.974
LT FPA TOR
0.325 0.043 0.040
F. Bio/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.988 0.972
LT FPA TOR
0.210 0.041 0.040
G. Canp/Clim/Elev/PTC/Wat
High : 0.82
Low : 0
Obs Train Test TrAUC TeAUC
32 25 6 0.984 0.978
LT FPA TOR
0.369 0.040 0.040
Km
0 100 200 300

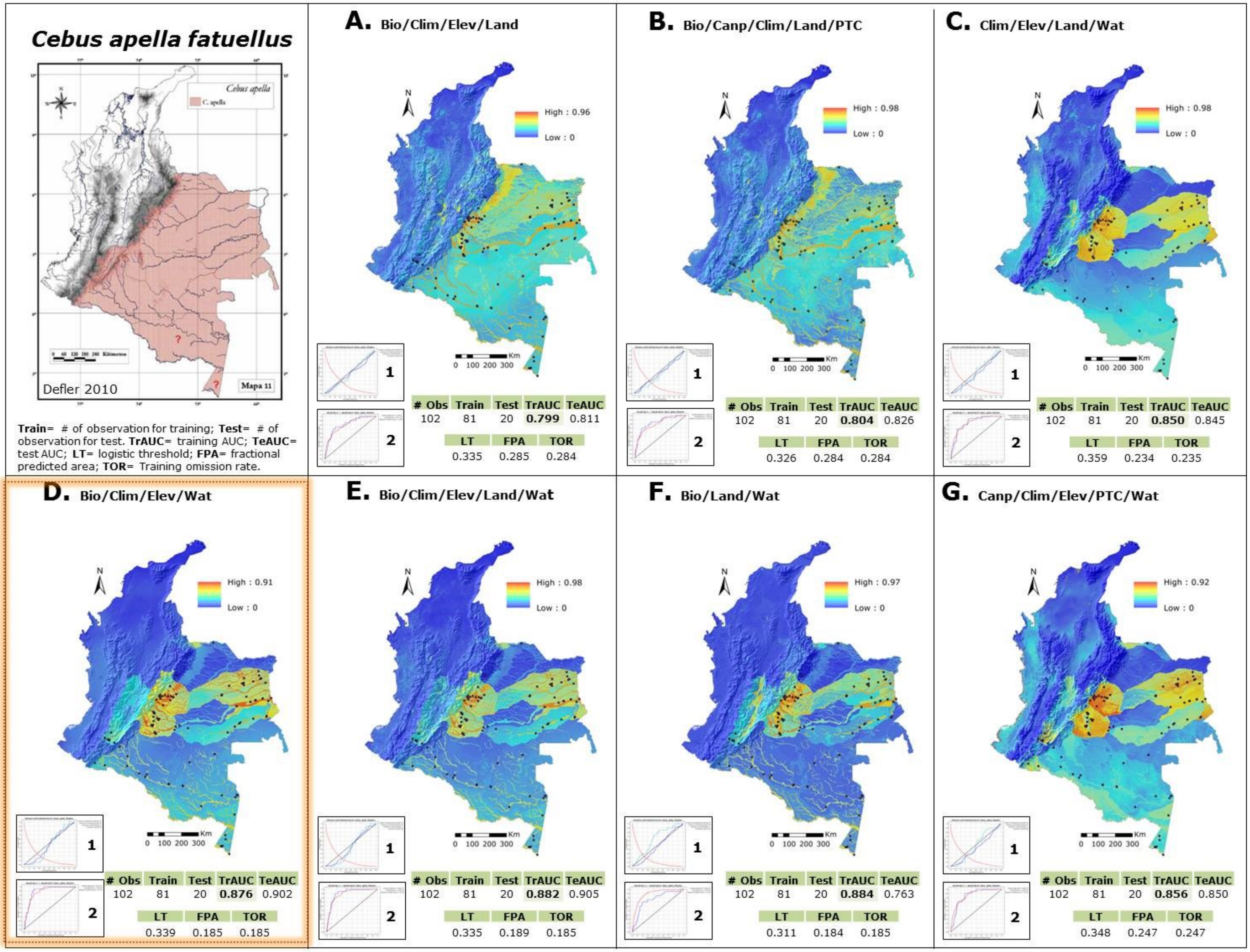

Cebuella pygmaea pygmaea
Cebuella pygmaea
C. pygmaea
Defler 2010
Mapa 2
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.958 N/A
LT FPA TOR
0.114 0.091 0.091
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.954 N/A
LT FPA TOR
0.117 0.092 0.091
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.963 N/A
LT FPA TOR
0.173 0.126 0.091
D. Bio/Clim/Elev/Wat
High : 0.88
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.959 N/A
LT FPA TOR
0.109 0.117 0.091
E. Bio/Clim/Elev/Land/Wat
High : 0.998
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.976 N/A
LT FPA TOR
0.104 0.091 0.091
F. Bio/Land/Wat
High : 0.994
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.968 N/A
LT FPA TOR
0.136 0.090 0.091
G. Canp/Clim/Elev/PTC/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
12 11 0 0.962 N/A
LT FPA TOR
0.288 0.099 0.091
0 100 200 300 Km
1
2

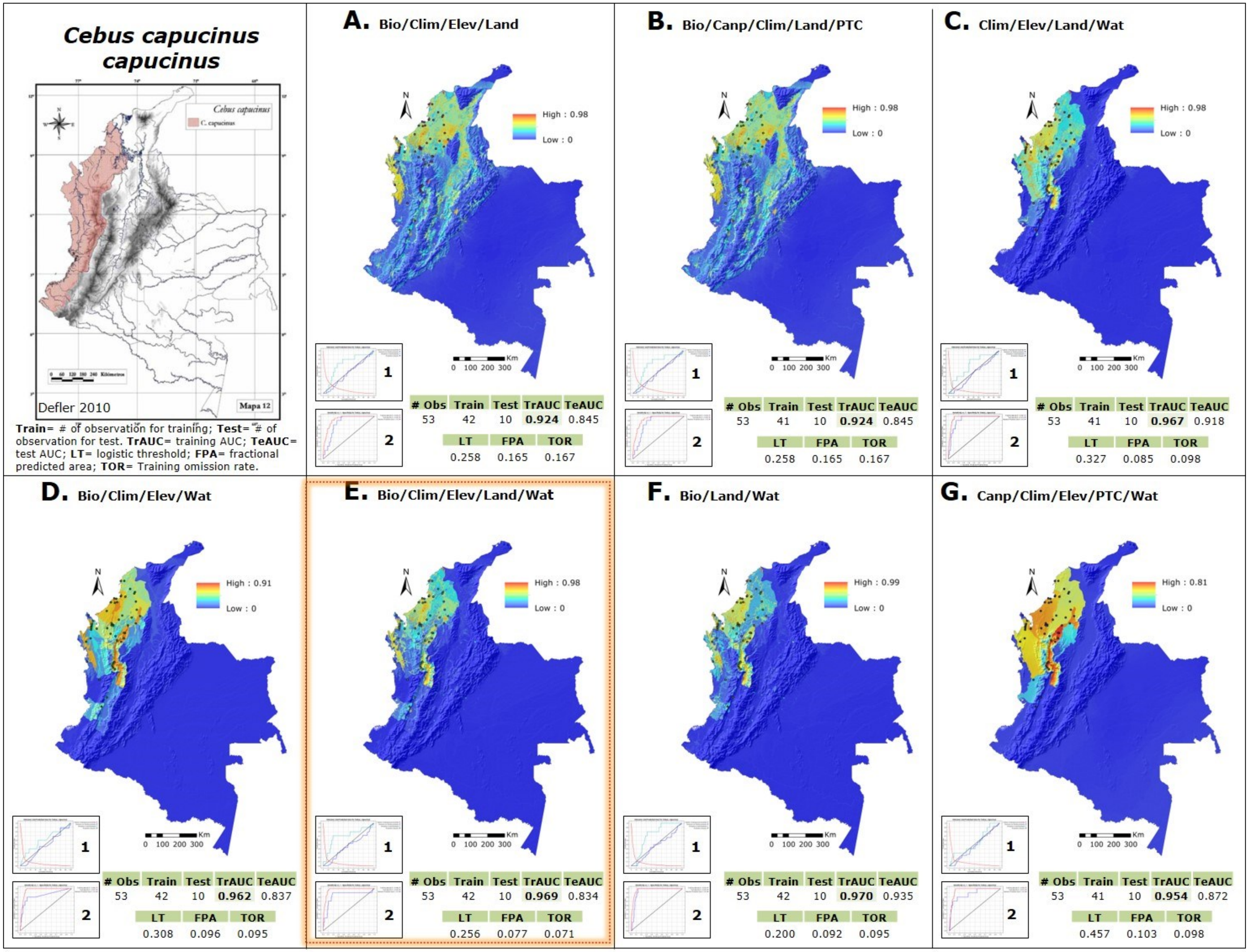

Cebus albifrons albifrons
Defler 2010
Mapa 10
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.94
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.910 0.798
LT FPA TOR
0.330 0.158 0.172
B. Bio/Canp/Clim/Land/PTC
High : 0.88
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.877 0.724
LT FPA TOR
0.280 0.426 0.310
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.910 0.943
LT FPA TOR
0.382 0.172 0.172
D. Bio/Clim/Elev/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.921 0.868
LT FPA TOR
0.304 0.158 0.172
E. Bio/Clim/Elev/Land/Wat
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.930 0.857
LT FPA TOR
0.271 0.135 0.138
F. Bio/Land/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.912 0.752
LT FPA TOR
0.227 0.169 0.172
G. Canp/Clim/Elev/PTC/Wat
High : 0.88
Low : 0
Obs Train Test TrAUC TeAUC
37 29 7 0.8890 0.910
LT FPA TOR
0.471 0.207 0.207
0 100 200 300 Km



Train= # of observation for training; **Test**= # of observation for test. **TrAUC**= training AUC; **TeAUC**= test AUC; **LT**= logistic threshold; **FPA**= fractional predicted area; **TOR**= Training omission rate.


Cebus albifrons versicolor
Cebus albifrons
Defler 2010
Mapa 10
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.952 0.908
LT FPA TOR
0.309 0.108 0.106
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.946 0.921
LT FPA TOR
0.349 0.118 0.128
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.965 0.952
LT FPA TOR
0.219 0.100 0.106
D. Bio/Clim/Elev/Wat
High : 0.84
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.959 0.954
LT FPA TOR
0.465 0.087 0.064
E. Bio/Clim/Elev/Land/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.969 0.961
LT FPA TOR
0.202 0.083 0.085
F. Bio/Land/Wat
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.973 0.941
LT FPA TOR
0.177 0.088 0.106
G. Canp/Clim/Elev/PTC/Wat
High : 0.896
Low : 0
Obs Train Test TrAUC TeAUC
59 47 11 0.956 0.963
LT FPA TOR
0.312 0.113 0.106
Km
0 100 200 300

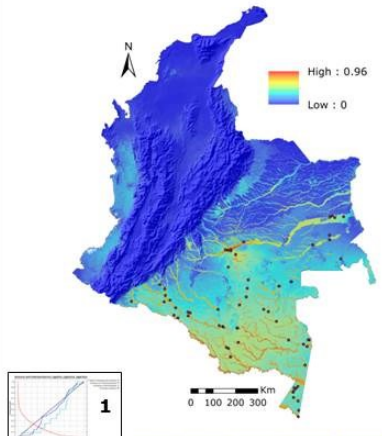

Cebus apella fatuellus
Cebus apella
C. apella
Defler 2010
Mapa 11
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.799 0.811
LT FPA TOR
0.335 0.285 0.284
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.804 0.826
LT FPA TOR
0.326 0.284 0.284
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.850 0.845
LT FPA TOR
0.359 0.234 0.235
D. Bio/Clim/Elev/Wat
High : 0.91
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.876 0.902
LT FPA TOR
0.339 0.185 0.185
E. Bio/Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.882 0.905
LT FPA TOR
0.335 0.189 0.185
F. Bio/Land/Wat
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.884 0.763
LT FPA TOR
0.311 0.184 0.185
G. Canp/Clim/Elev/PTC/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
102 81 20 0.856 0.850
LT FPA TOR
0.348 0.247 0.247
0 100 200 300 Km


Cebus capucinus capucinus
Cebus capucinus
C. capucinus
Mapa 12
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
53 42 10 0.924 0.845
LT FPA TOR
0.258 0.165 0.167
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
53 41 10 0.924 0.845
LT FPA TOR
0.258 0.165 0.167
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
53 41 10 0.967 0.918
LT FPA TOR
0.327 0.085 0.098
D. Bio/Clim/Elev/Wat
High : 0.91
Low : 0
Obs Train Test TrAUC TeAUC
53 42 10 0.962 0.837
LT FPA TOR
0.308 0.096 0.095
E. Bio/Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
53 42 10 0.969 0.834
LT FPA TOR
0.256 0.077 0.071
F. Bio/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
53 42 10 0.970 0.935
LT FPA TOR
0.200 0.092 0.095
G. Canp/Clim/Elev/PTC/Wat
High : 0.81
Low : 0
Obs Train Test TrAUC TeAUC
53 41 10 0.954 0.872
LT FPA TOR
0.457 0.103 0.098
Km
0 100 200 300
1
2

Lagothrix lagothricha lagothricha

Train= # of observation for training; **Test**= # of observation for test. **TrAUC**= training AUC; **TeAUC**= test AUC; **LT**= logistic threshold; **FPA**= fractional predicted area; **TOR**= Training omission rate.

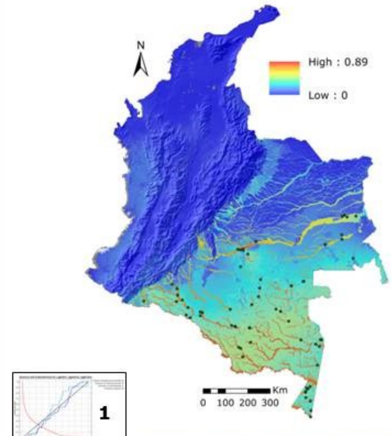
A. Bio/Clim/Elev/Land



# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.893**	0.913

LT	FPA	TOR
0.374	0.182	0.176

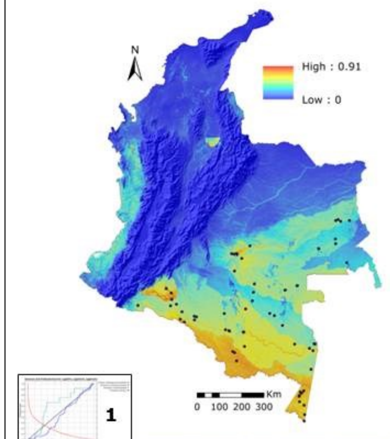
B. Bio/Canp/Clim/Land/PTC



# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.893**	0.880

LT	FPA	TOR
0.336	0.196	0.196

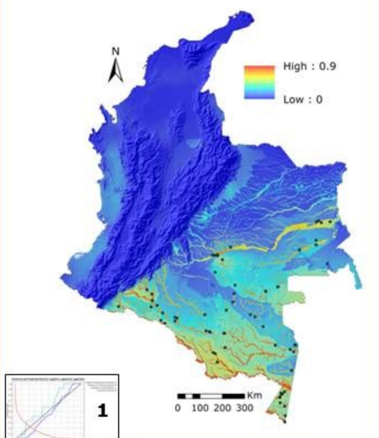
C. Clim/Elev/Land/Wat



# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.881**	0.795

LT	FPA	TOR
0.438	0.197	0.196

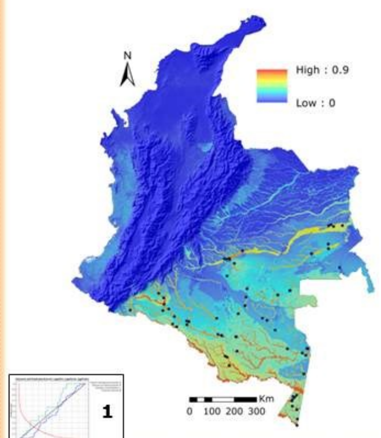
D. Bio/Clim/Elev/Wat



# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.910**	0.851

LT	FPA	TOR
0.327	0.171	0.176

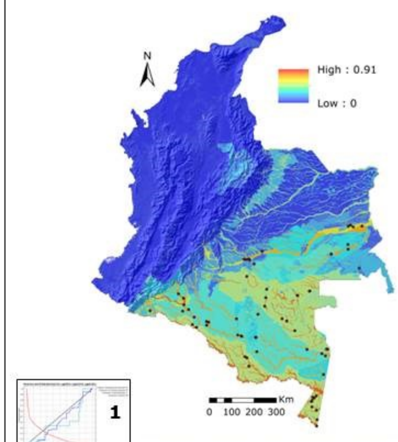
E. Bio/Clim/Elev/Land/Wat



# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.910**	0.846

LT	FPA	TOR
0.316	0.176	0.176

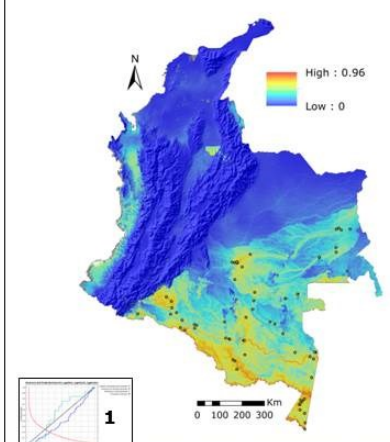
F. Bio/Land/Wat



# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.888**	0.893

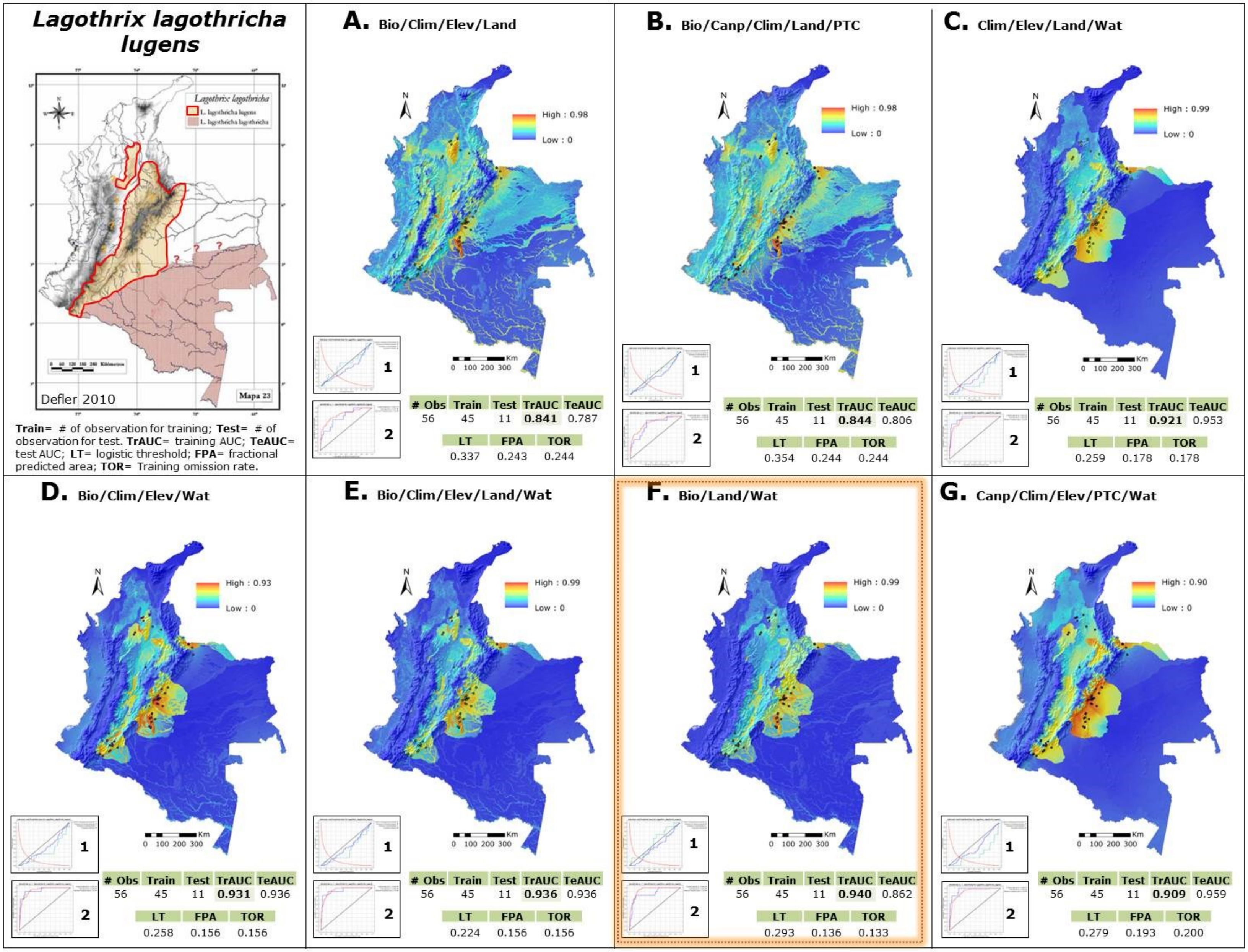
LT	FPA	TOR
0.341	0.196	0.196

G. Canp/Clim/Elev/PTC/Wat

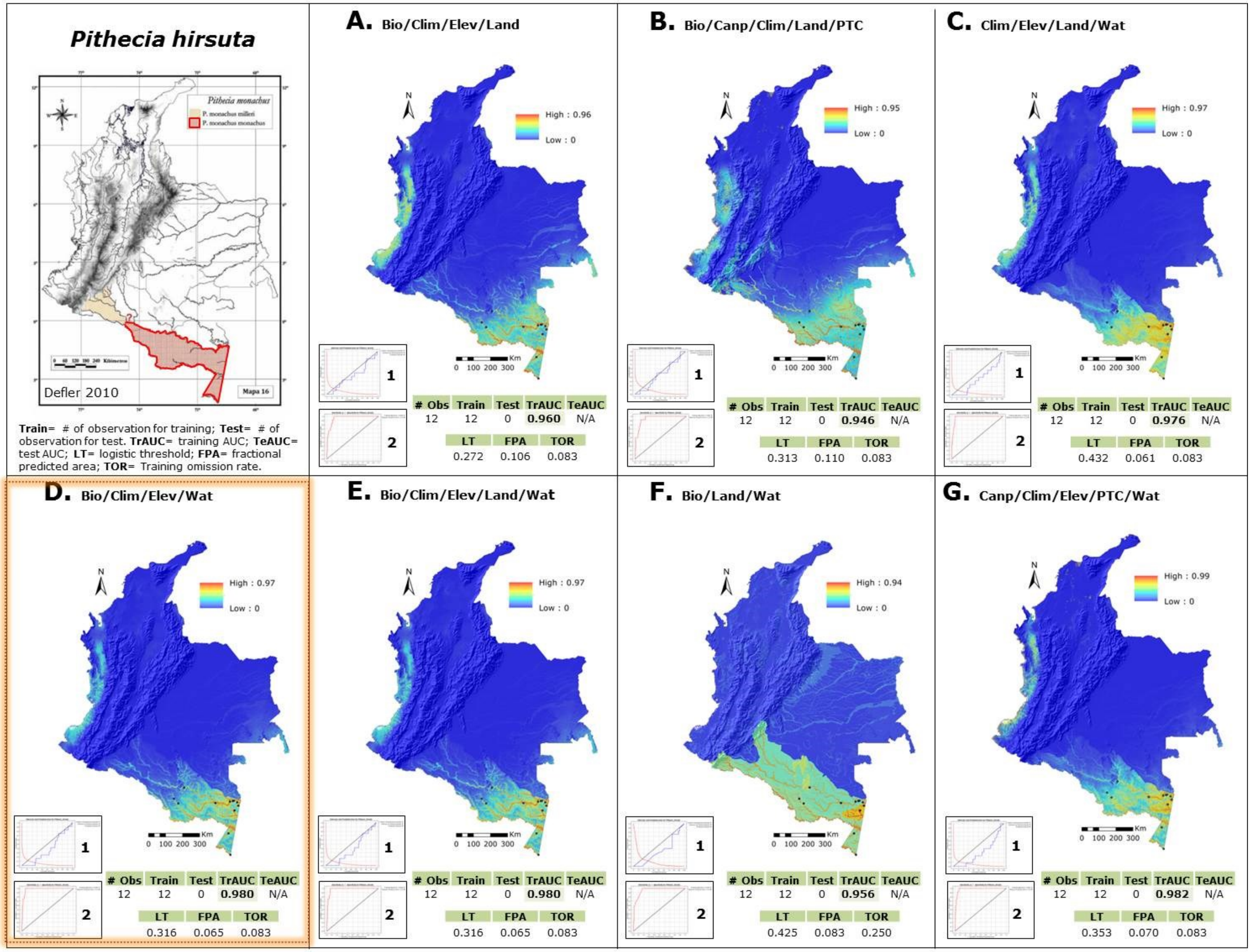


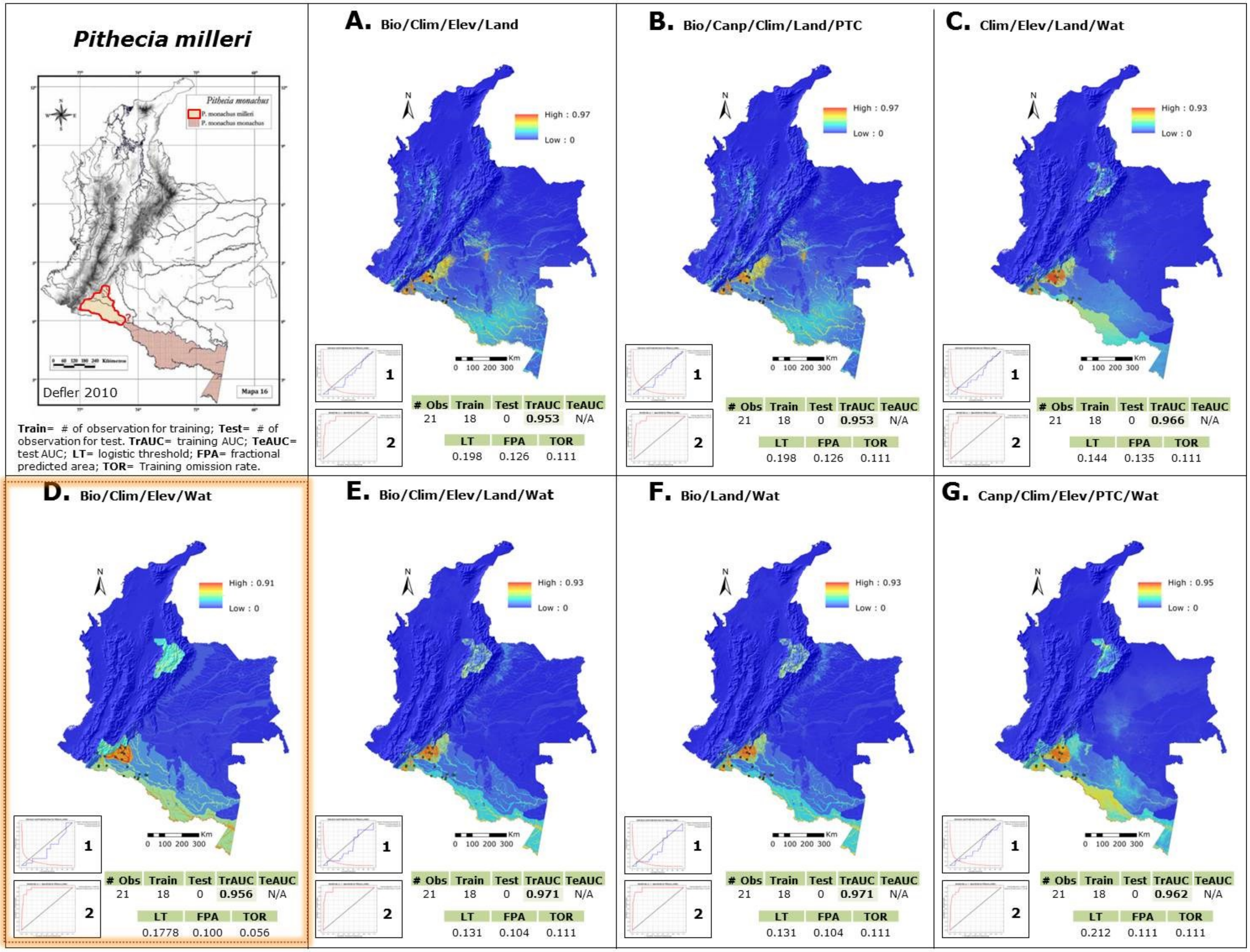
# Obs	Train	Test	TrAUC	TeAUC
64	51	12	**0.896**	0.847

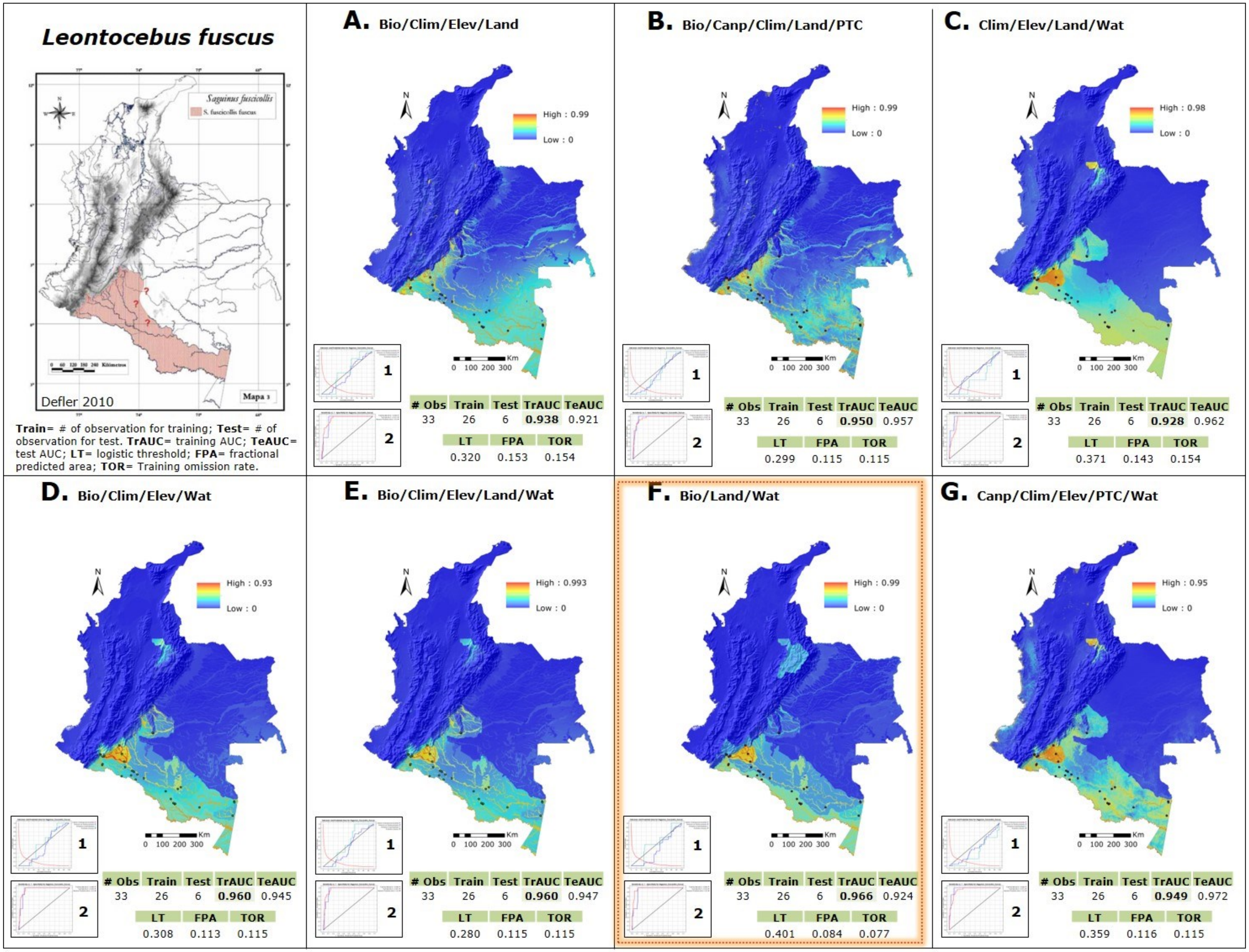
LT	FPA	TOR
0.410	0.196	0.196

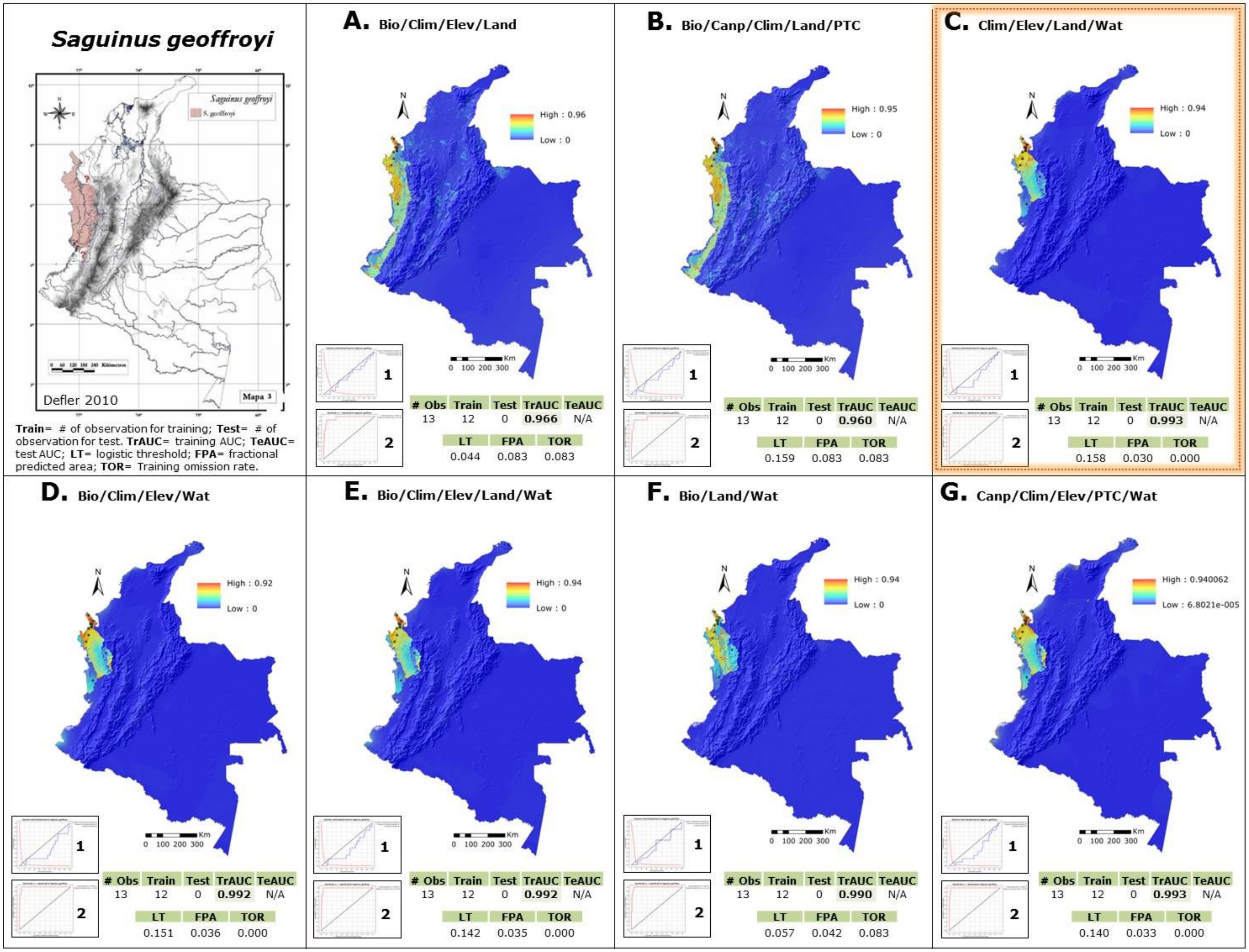


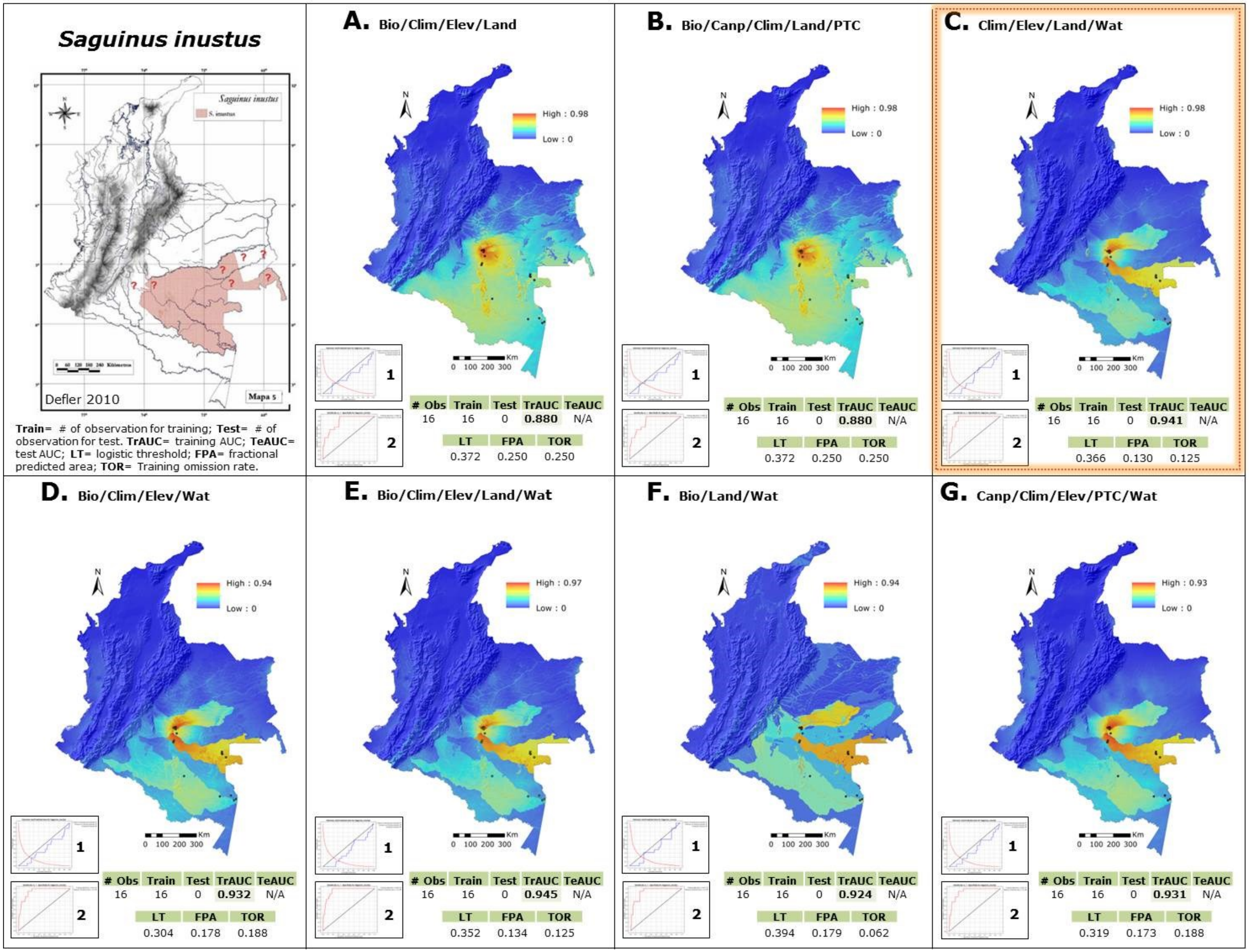
Lagothrix lagothricha lugens
Lagothrix lagothricha
L. lagothricha lugens
L. lagothricha lagothricha
Kilómetros
Mapa 23
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.98
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.841 | 0.787
LT | FPA | TOR
0.337 | 0.243 | 0.244
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.844 | 0.806
LT | FPA | TOR
0.354 | 0.244 | 0.244
C. Clim/Elev/Land/Wat
High : 0.99
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.921 | 0.953
LT | FPA | TOR
0.259 | 0.178 | 0.178
D. Bio/Clim/Elev/Wat
High : 0.93
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.931 | 0.936
LT | FPA | TOR
0.258 | 0.156 | 0.156
E. Bio/Clim/Elev/Land/Wat
High : 0.99
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.936 | 0.936
LT | FPA | TOR
0.224 | 0.156 | 0.156
F. Bio/Land/Wat
High : 0.99
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.940 | 0.862
LT | FPA | TOR
0.293 | 0.136 | 0.133
G. Canp/Clim/Elev/PTC/Wat
High : 0.90
Low : 0
Km
0 100 200 300
1
2
Obs | Train | Test | TrAUC | TeAUC
56 | 45 | 11 | 0.909 | 0.959
LT | FPA | TOR
0.279 | 0.193 | 0.200

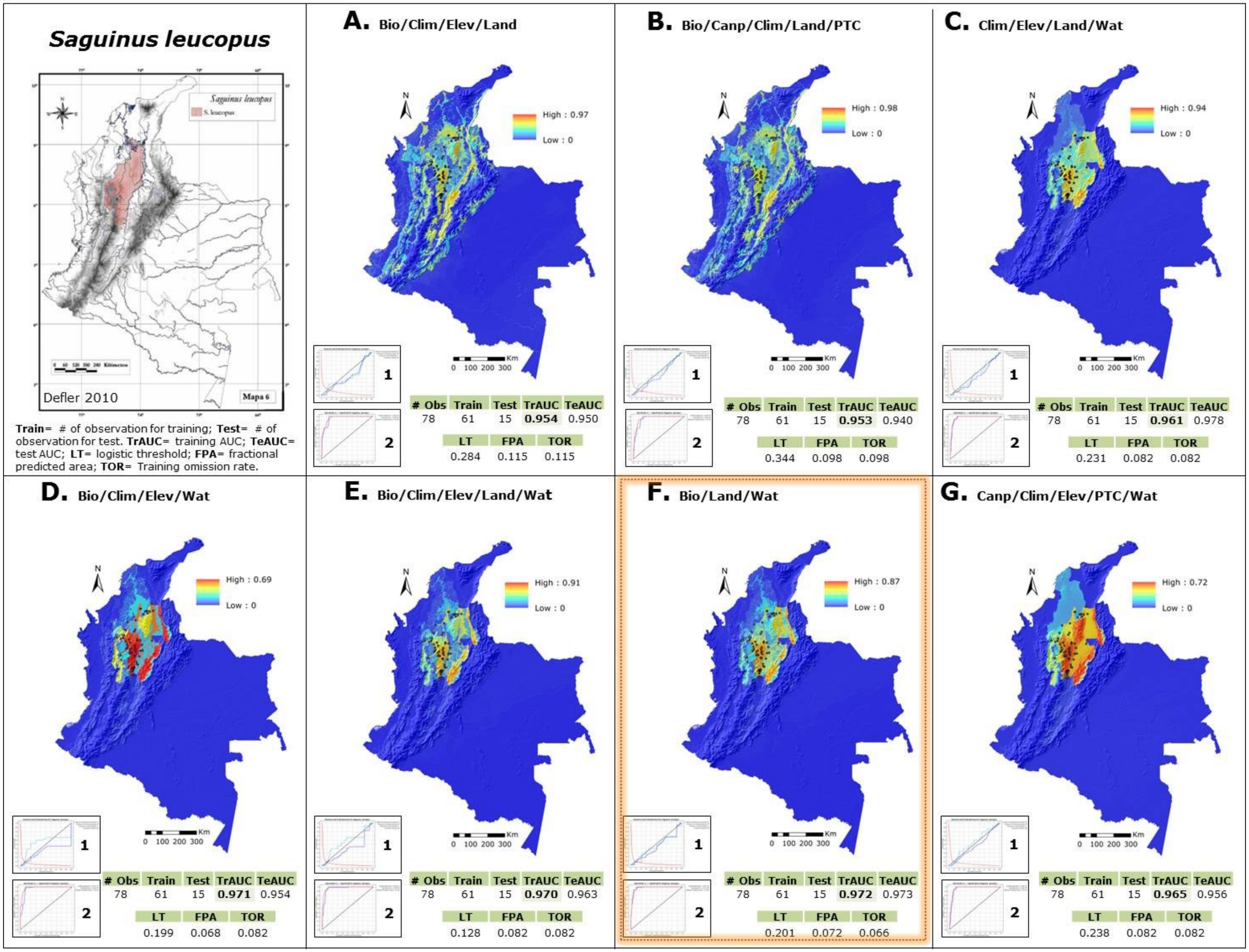

Pithecia hirsuta
Pithecia monachus
P. monachus milleri
P. monachus monachus
Defler 2010
Mapa 16
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.96
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.960 TeAUC N/A
LT 0.272 FPA 0.106 TOR 0.083
B. Bio/Canp/Clim/Land/PTC
High : 0.95
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.946 TeAUC N/A
LT 0.313 FPA 0.110 TOR 0.083
C. Clim/Elev/Land/Wat
High : 0.97
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.976 TeAUC N/A
LT 0.432 FPA 0.061 TOR 0.083
D. Bio/Clim/Elev/Wat
High : 0.97
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.980 TeAUC N/A
LT 0.316 FPA 0.065 TOR 0.083
E. Bio/Clim/Elev/Land/Wat
High : 0.97
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.980 TeAUC N/A
LT 0.316 FPA 0.065 TOR 0.083
F. Bio/Land/Wat
High : 0.94
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.956 TeAUC N/A
LT 0.425 FPA 0.083 TOR 0.250
G. Canp/Clim/Elev/PTC/Wat
High : 0.99
Low : 0
Obs 12 Train 12 Test 0 TrAUC 0.982 TeAUC N/A
LT 0.353 FPA 0.070 TOR 0.083
0 100 200 300 Km
N
1
2

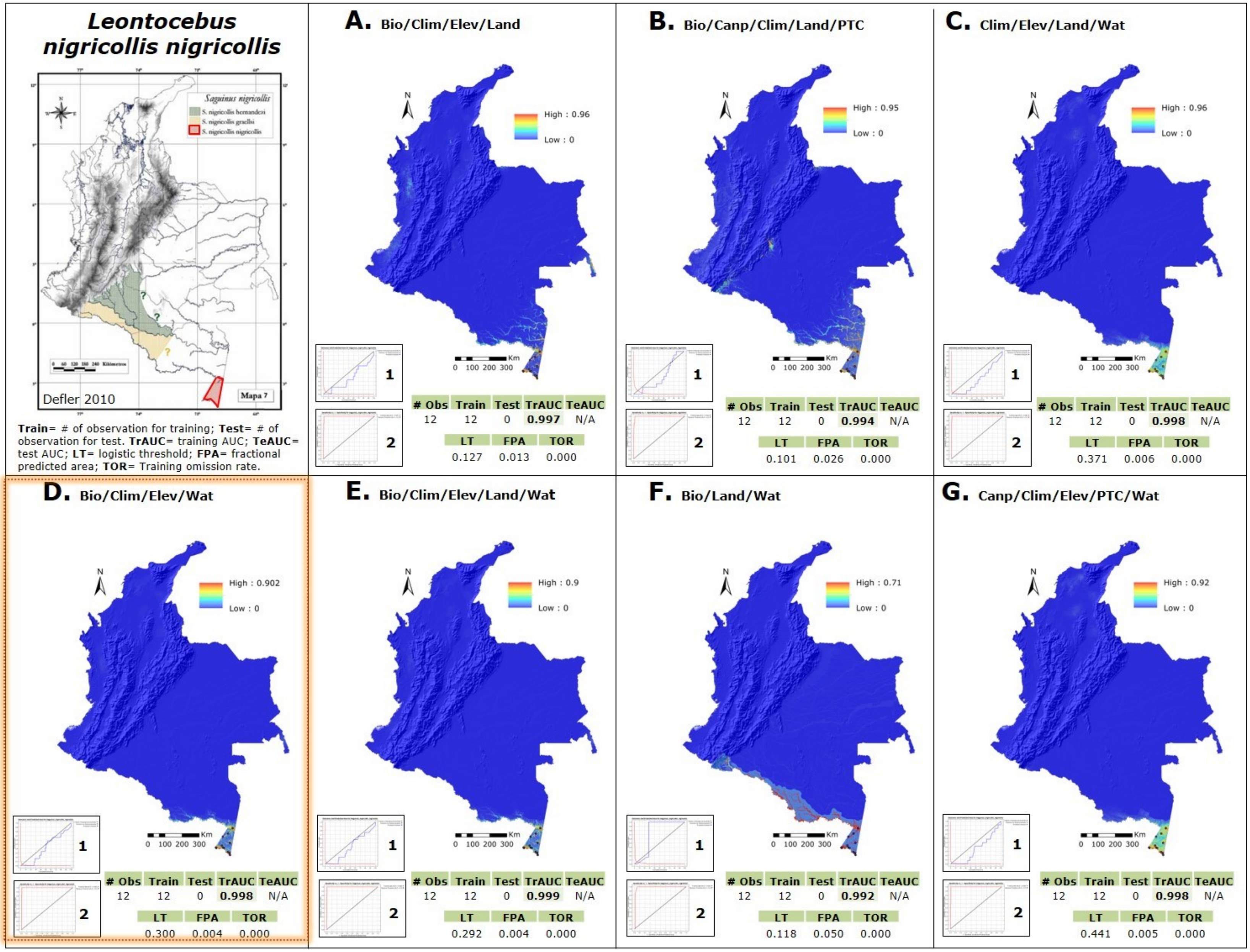

Pithecia milleri
Pithecia monachus
P. monachus milleri
P. monachus monachus
Mapa 16
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.97
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.953 TeAUC N/A
LT 0.198 FPA 0.126 TOR 0.111
B. Bio/Canp/Clim/Land/PTC
High : 0.97
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.953 TeAUC N/A
LT 0.198 FPA 0.126 TOR 0.111
C. Clim/Elev/Land/Wat
High : 0.93
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.966 TeAUC N/A
LT 0.144 FPA 0.135 TOR 0.111
D. Bio/Clim/Elev/Wat
High : 0.91
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.956 TeAUC N/A
LT 0.1778 FPA 0.100 TOR 0.056
E. Bio/Clim/Elev/Land/Wat
High : 0.93
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.971 TeAUC N/A
LT 0.131 FPA 0.104 TOR 0.111
F. Bio/Land/Wat
High : 0.93
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.971 TeAUC N/A
LT 0.131 FPA 0.104 TOR 0.111
G. Canp/Clim/Elev/PTC/Wat
High : 0.95
Low : 0
Obs 21 Train 18 Test 0 TrAUC 0.962 TeAUC N/A
LT 0.212 FPA 0.111 TOR 0.111
Km
0 100 200 300
1
2

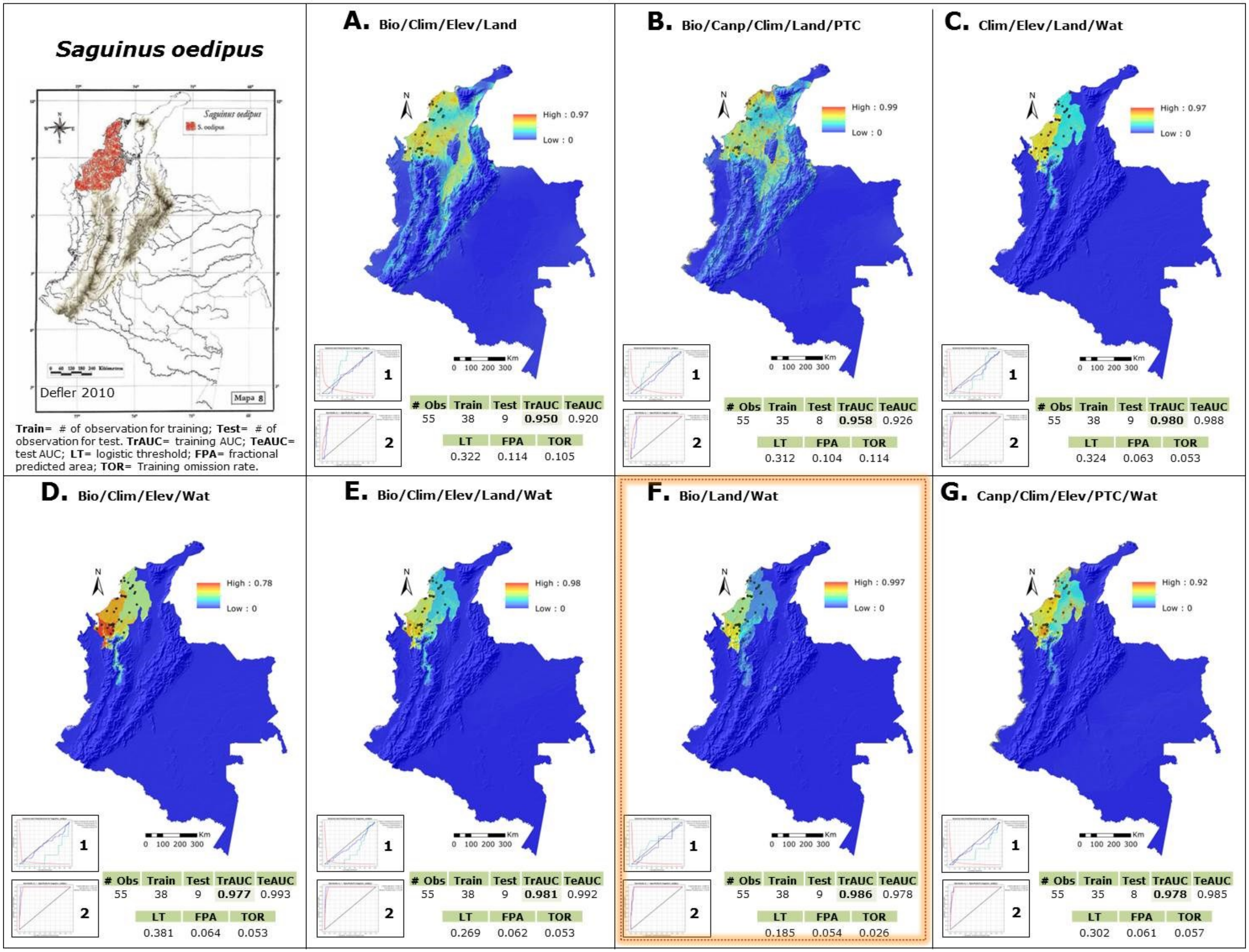

Leontocebus fuscus
Saguinus fuscicollis
S. fuscicollis fuscus
Mapa 3
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.938 0.921
LT FPA TOR
0.320 0.153 0.154
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.950 0.957
LT FPA TOR
0.299 0.115 0.115
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.928 0.962
LT FPA TOR
0.371 0.143 0.154
D. Bio/Clim/Elev/Wat
High : 0.93
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.960 0.945
LT FPA TOR
0.308 0.113 0.115
E. Bio/Clim/Elev/Land/Wat
High : 0.993
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.960 0.947
LT FPA TOR
0.280 0.115 0.115
F. Bio/Land/Wat
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.966 0.924
LT FPA TOR
0.401 0.084 0.077
G. Canp/Clim/Elev/PTC/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
33 26 6 0.949 0.972
LT FPA TOR
0.359 0.116 0.115
Km
0 100 200 300


Saguinus geoffroyi
Saguinus geoffroyi
S. geoffroyi
Mapa 3
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.96
Low : 0
Km
0 100 200 300
1
2
Obs 13 Train 12 Test 0 TrAUC 0.966 TeAUC N/A
LT 0.044 FPA 0.083 TOR 0.083
B. Bio/Canp/Clim/Land/PTC
High : 0.95
Low : 0
1
2
Obs 13 Train 12 Test 0 TrAUC 0.960 TeAUC N/A
LT 0.159 FPA 0.083 TOR 0.083
C. Clim/Elev/Land/Wat
High : 0.94
Low : 0
1
2
Obs 13 Train 12 Test 0 TrAUC 0.993 TeAUC N/A
LT 0.158 FPA 0.030 TOR 0.000
D. Bio/Clim/Elev/Wat
High : 0.92
Low : 0
1
2
Obs 13 Train 12 Test 0 TrAUC 0.992 TeAUC N/A
LT 0.151 FPA 0.036 TOR 0.000
E. Bio/Clim/Elev/Land/Wat
High : 0.94
Low : 0
1
2
Obs 13 Train 12 Test 0 TrAUC 0.992 TeAUC N/A
LT 0.142 FPA 0.035 TOR 0.000
F. Bio/Land/Wat
High : 0.94
Low : 0
1
2
Obs 13 Train 12 Test 0 TrAUC 0.990 TeAUC N/A
LT 0.057 FPA 0.042 TOR 0.083
G. Canp/Clim/Elev/PTC/Wat
High : 0.940062
Low : 6.8021e-005
1
2
Obs 13 Train 12 Test 0 TrAUC 0.993 TeAUC N/A
LT 0.140 FPA 0.033 TOR 0.000

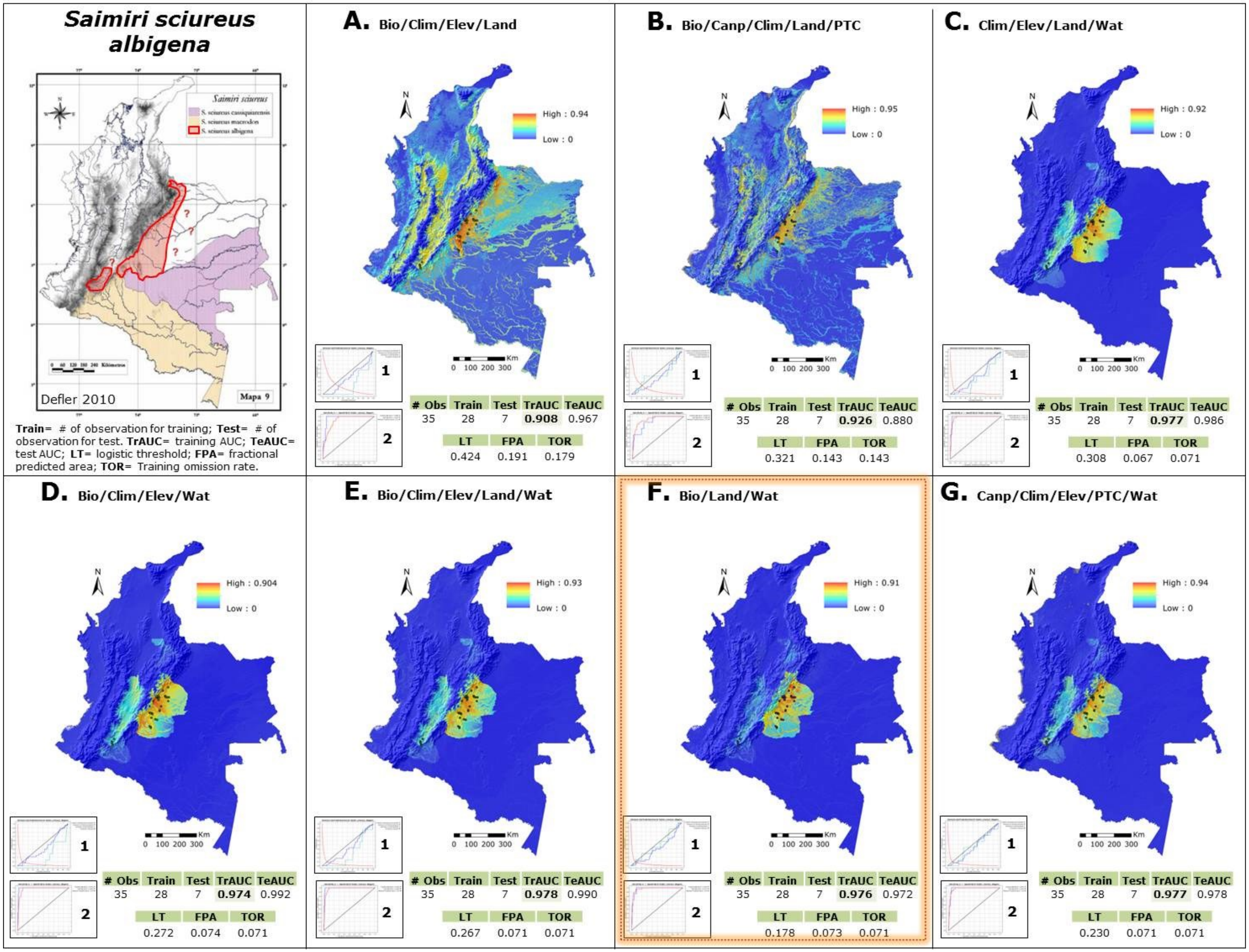

Saguinus inustus
Saguinus inustus
S. inustus
Defler 2010
Mapa 5
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.98
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.880 TeAUC N/A
LT 0.372 FPA 0.250 TOR 0.250
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.880 TeAUC N/A
LT 0.372 FPA 0.250 TOR 0.250
C. Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.941 TeAUC N/A
LT 0.366 FPA 0.130 TOR 0.125
D. Bio/Clim/Elev/Wat
High : 0.94
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.932 TeAUC N/A
LT 0.304 FPA 0.178 TOR 0.188
E. Bio/Clim/Elev/Land/Wat
High : 0.97
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.945 TeAUC N/A
LT 0.352 FPA 0.134 TOR 0.125
F. Bio/Land/Wat
High : 0.94
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.924 TeAUC N/A
LT 0.394 FPA 0.179 TOR 0.062
G. Canp/Clim/Elev/PTC/Wat
High : 0.93
Low : 0
Obs 16 Train 16 Test 0 TrAUC 0.931 TeAUC N/A
LT 0.319 FPA 0.173 TOR 0.188
Km
0 100 200 300
N
1
2


Saguinus leucopus
Saguinus leucopus
S. leucopus
Defler 2010
Mapa 6
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.954 0.950
LT FPA TOR
0.284 0.115 0.115
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.953 0.940
LT FPA TOR
0.344 0.098 0.098
C. Clim/Elev/Land/Wat
High : 0.94
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.961 0.978
LT FPA TOR
0.231 0.082 0.082
D. Bio/Clim/Elev/Wat
High : 0.69
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.971 0.954
LT FPA TOR
0.199 0.068 0.082
E. Bio/Clim/Elev/Land/Wat
High : 0.91
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.970 0.963
LT FPA TOR
0.128 0.082 0.082
F. Bio/Land/Wat
High : 0.87
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.972 0.973
LT FPA TOR
0.201 0.072 0.066
G. Canp/Clim/Elev/PTC/Wat
High : 0.72
Low : 0
Obs Train Test TrAUC TeAUC
78 61 15 0.965 0.956
LT FPA TOR
0.238 0.082 0.082
N
Km
0 100 200 300
1
2

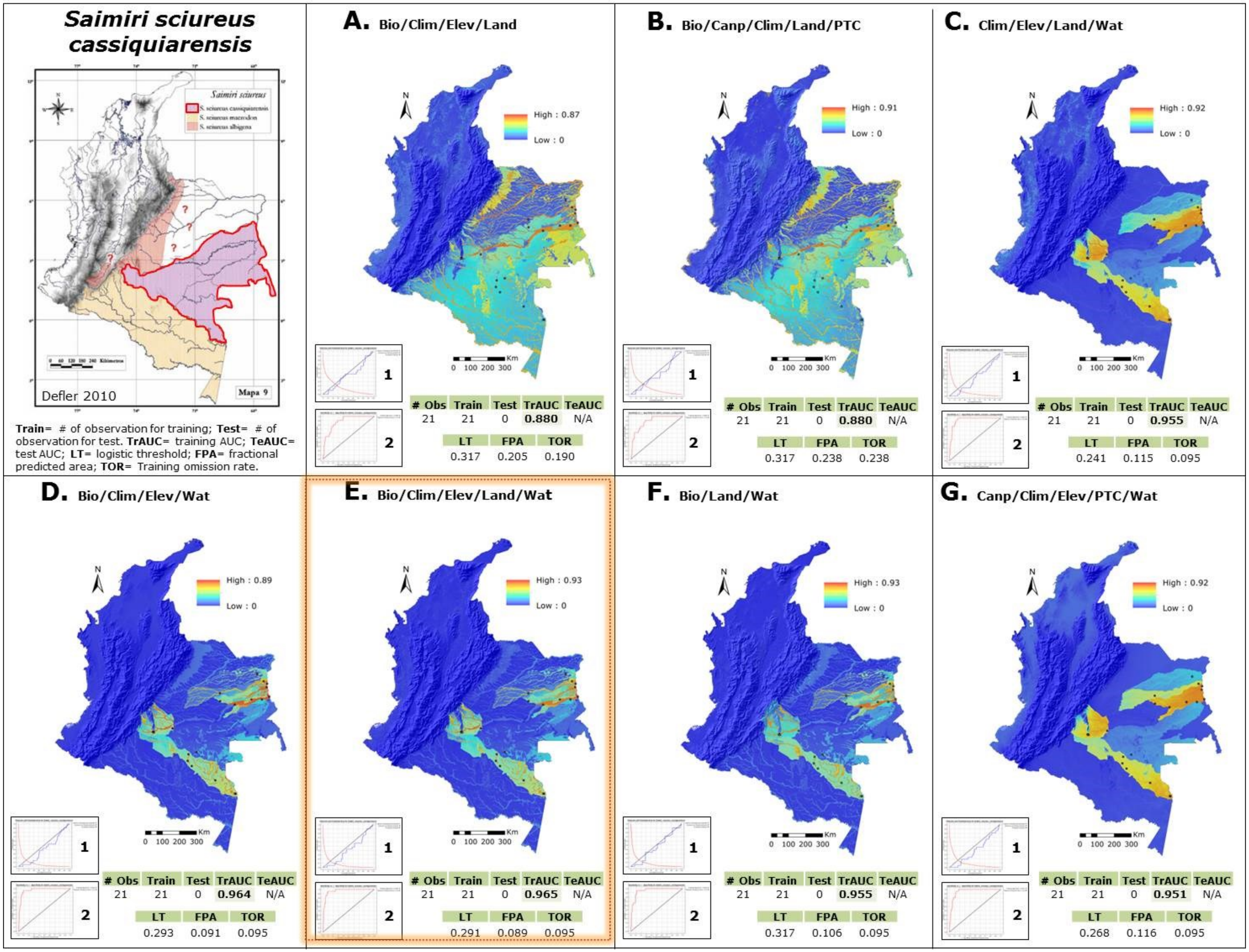

Leontocebus nigricollis nigricollis
Saguinus nigricollis
S. nigricollis hernandezi
S. nigricollis graciliis
S. nigricollis nigricollis
Mapa 7
Defler 2010
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.997 N/A
LT FPA TOR
0.127 0.013 0.000
B. Bio/Canp/Clim/Land/PTC
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.994 N/A
LT FPA TOR
0.101 0.026 0.000
C. Clim/Elev/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.998 N/A
LT FPA TOR
0.371 0.006 0.000
D. Bio/Clim/Elev/Wat
High : 0.902
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.998 N/A
LT FPA TOR
0.300 0.004 0.000
E. Bio/Clim/Elev/Land/Wat
High : 0.9
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.999 N/A
LT FPA TOR
0.292 0.004 0.000
F. Bio/Land/Wat
High : 0.71
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.992 N/A
LT FPA TOR
0.118 0.050 0.000
G. Canp/Clim/Elev/PTC/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
12 12 0 0.998 N/A
LT FPA TOR
0.441 0.005 0.000
Km
0 100 200 300
N
1
2

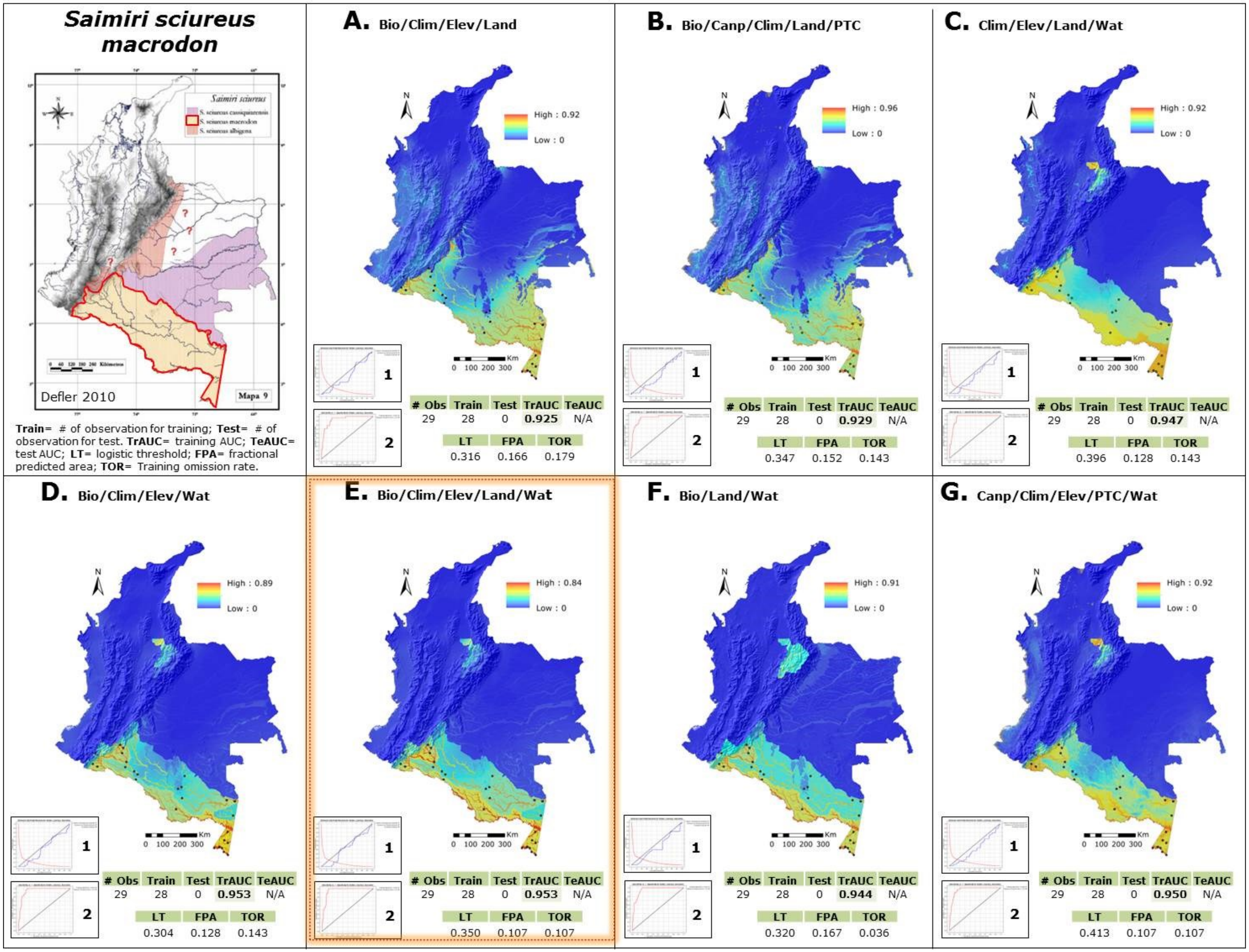


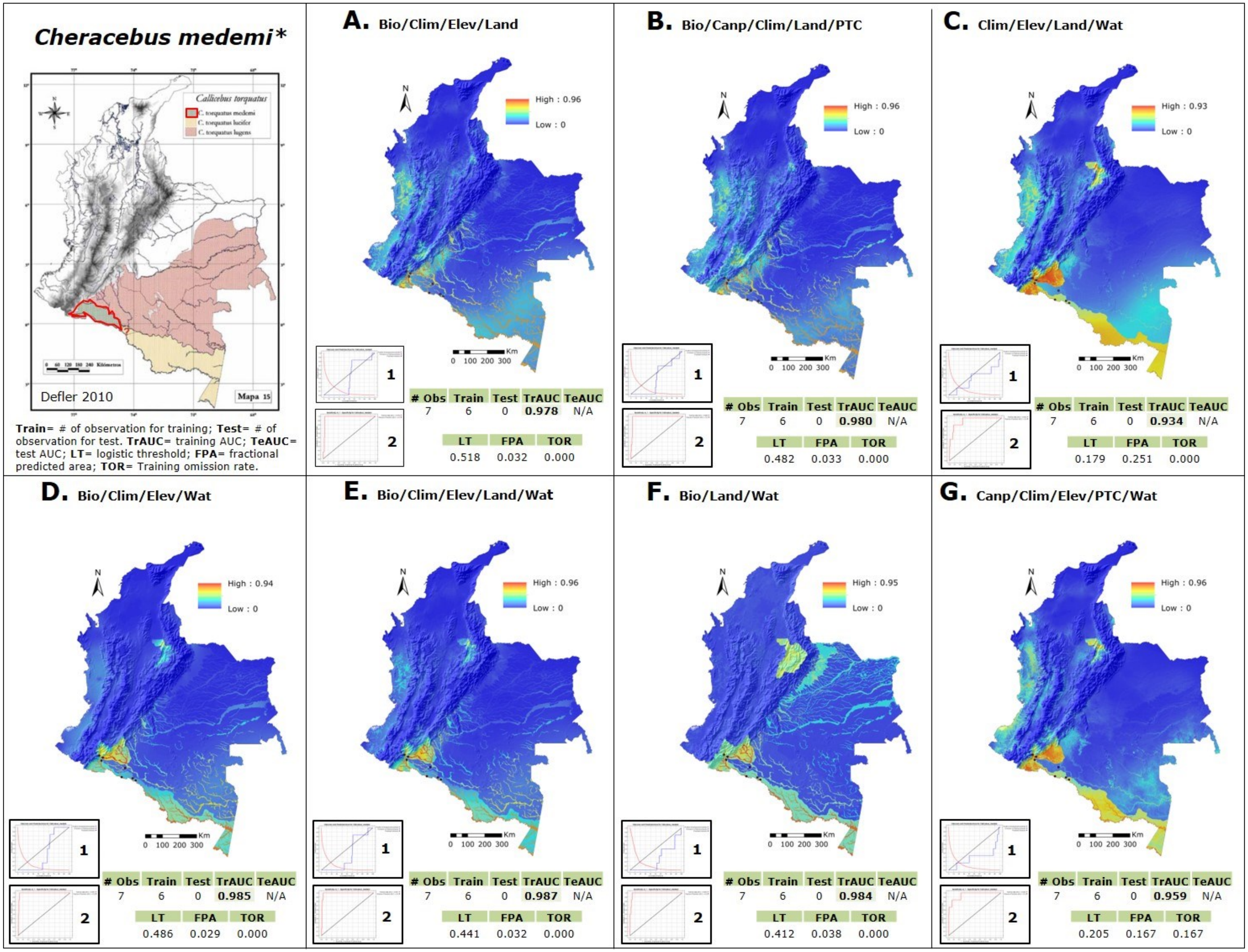
Saguinus oedipus
Defler 2010
Mapa 8
Saguinus oedipus
S. oedipus
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
55 38 9 0.950 0.920
LT FPA TOR
0.322 0.114 0.105
B. Bio/Canp/Clim/Land/PTC
High : 0.99
Low : 0
Obs Train Test TrAUC TeAUC
55 35 8 0.958 0.926
LT FPA TOR
0.312 0.104 0.114
C. Clim/Elev/Land/Wat
High : 0.97
Low : 0
Obs Train Test TrAUC TeAUC
55 38 9 0.980 0.988
LT FPA TOR
0.324 0.063 0.053
D. Bio/Clim/Elev/Wat
High : 0.78
Low : 0
Obs Train Test TrAUC TeAUC
55 38 9 0.977 0.993
LT FPA TOR
0.381 0.064 0.053
E. Bio/Clim/Elev/Land/Wat
High : 0.98
Low : 0
Obs Train Test TrAUC TeAUC
55 38 9 0.981 0.992
LT FPA TOR
0.269 0.062 0.053
F. Bio/Land/Wat
High : 0.997
Low : 0
Obs Train Test TrAUC TeAUC
55 38 9 0.986 0.978
LT FPA TOR
0.185 0.054 0.026
G. Canp/Clim/Elev/PTC/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
55 35 8 0.978 0.985
LT FPA TOR
0.302 0.061 0.057
N
Km
0 100 200 300
1
2



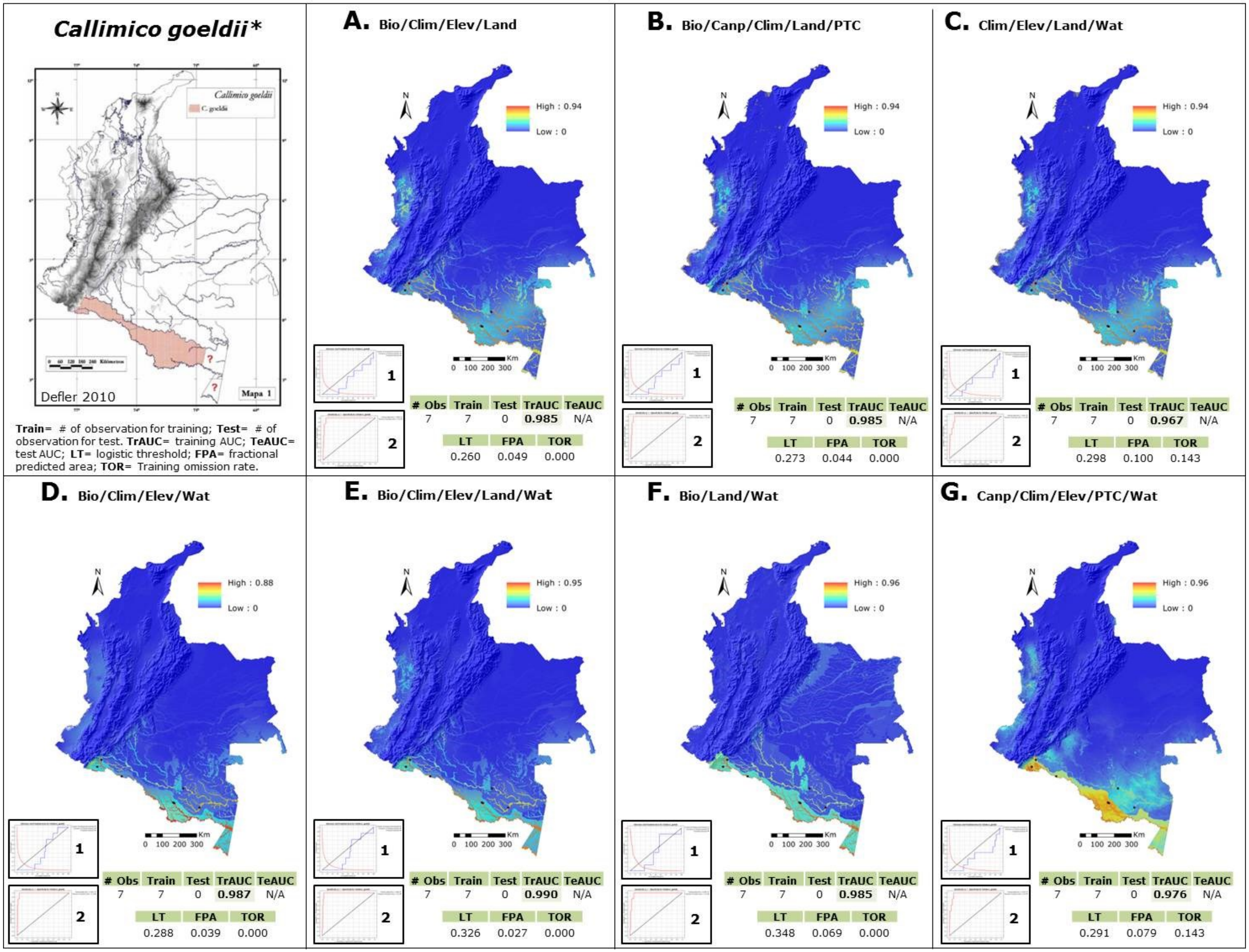
Saimiri sciureus albigena
Saimiri sciureus
S. sciureus cassiquiarensis
S. sciureus macrodon
S. sciureus albigena
Defler 2010
Mapa 9
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.94
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.908 0.967
LT FPA TOR
0.424 0.191 0.179
B. Bio/Canp/Clim/Land/PTC
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.926 0.880
LT FPA TOR
0.321 0.143 0.143
C. Clim/Elev/Land/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.977 0.986
LT FPA TOR
0.308 0.067 0.071
D. Bio/Clim/Elev/Wat
High : 0.904
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.974 0.992
LT FPA TOR
0.272 0.074 0.071
E. Bio/Clim/Elev/Land/Wat
High : 0.93
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.978 0.990
LT FPA TOR
0.267 0.071 0.071
F. Bio/Land/Wat
High : 0.91
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.976 0.972
LT FPA TOR
0.178 0.073 0.071
G. Canp/Clim/Elev/PTC/Wat
High : 0.94
Low : 0
Obs Train Test TrAUC TeAUC
35 28 7 0.977 0.978
LT FPA TOR
0.230 0.071 0.071

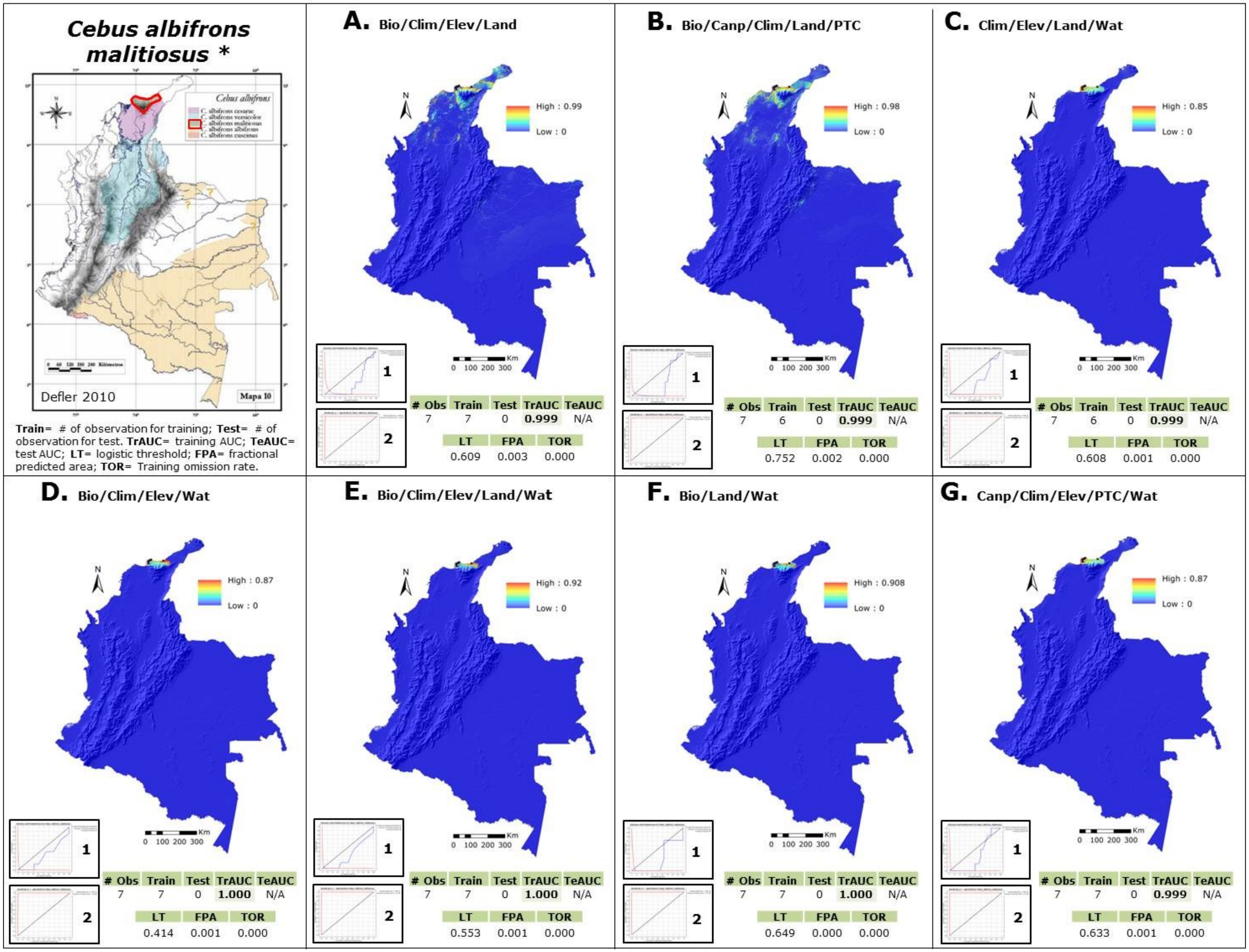

Saimiri sciureus cassiquiarensis
Saimiri sciureus
S. sciureus cassiquiarensis
S. sciureus macrodon
S. sciureus albigena
Defler 2010
Mapa 9
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.87
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.880 TeAUC N/A
LT 0.317 FPA 0.205 TOR 0.190
B. Bio/Canp/Clim/Land/PTC
High : 0.91
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.880 TeAUC N/A
LT 0.317 FPA 0.238 TOR 0.238
C. Clim/Elev/Land/Wat
High : 0.92
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.955 TeAUC N/A
LT 0.241 FPA 0.115 TOR 0.095
D. Bio/Clim/Elev/Wat
High : 0.89
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.964 TeAUC N/A
LT 0.293 FPA 0.091 TOR 0.095
E. Bio/Clim/Elev/Land/Wat
High : 0.93
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.965 TeAUC N/A
LT 0.291 FPA 0.089 TOR 0.095
F. Bio/Land/Wat
High : 0.93
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.955 TeAUC N/A
LT 0.317 FPA 0.106 TOR 0.095
G. Canp/Clim/Elev/PTC/Wat
High : 0.92
Low : 0
Obs 21 Train 21 Test 0 TrAUC 0.951 TeAUC N/A
LT 0.268 FPA 0.116 TOR 0.095
0 100 200 300 Km

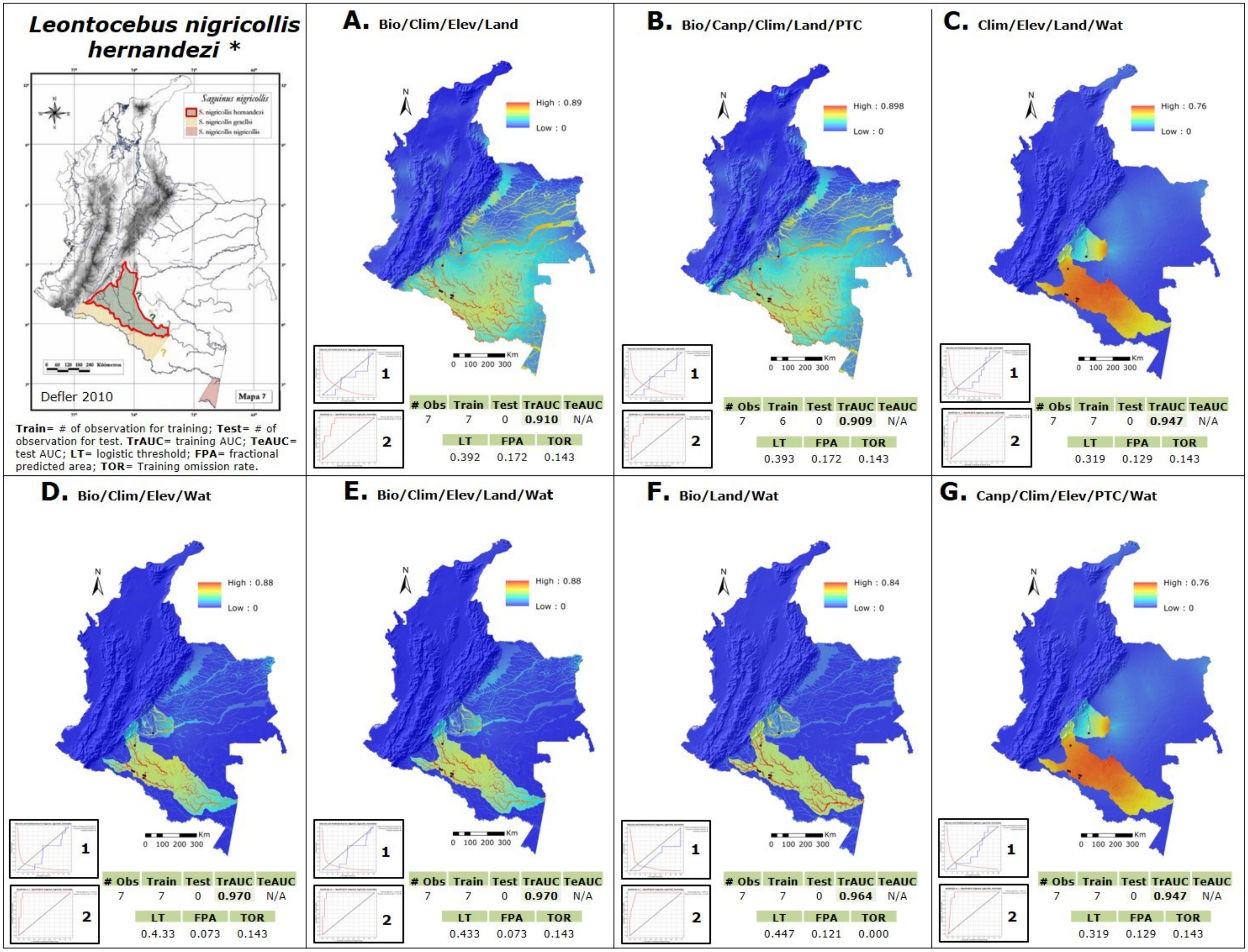

Saimiri sciureus macrodon
Saimiri sciureus
S. sciureus cassiquiarensis
S. sciureus macrodon
S. sciureus albigena
Defler 2010
Mapa 9
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.925 N/A
LT FPA TOR
0.316 0.166 0.179
B. Bio/Canp/Clim/Land/PTC
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.929 N/A
LT FPA TOR
0.347 0.152 0.143
C. Clim/Elev/Land/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.947 N/A
LT FPA TOR
0.396 0.128 0.143
D. Bio/Clim/Elev/Wat
High : 0.89
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.953 N/A
LT FPA TOR
0.304 0.128 0.143
E. Bio/Clim/Elev/Land/Wat
High : 0.84
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.953 N/A
LT FPA TOR
0.350 0.107 0.107
F. Bio/Land/Wat
High : 0.91
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.944 N/A
LT FPA TOR
0.320 0.167 0.036
G. Canp/Clim/Elev/PTC/Wat
High : 0.92
Low : 0
Obs Train Test TrAUC TeAUC
29 28 0 0.950 N/A
LT FPA TOR
0.413 0.107 0.107
Km
0 100 200 300
1
2



Cheracebus medemi*
Callicebus torquatus
C. torquatus medemi
C. torquatus lucifer
C. torquatus lugens
Defler 2010
Mapa 15
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.978 N/A
LT FPA TOR
0.518 0.032 0.000
B. Bio/Canp/Clim/Land/PTC
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.980 N/A
LT FPA TOR
0.482 0.033 0.000
C. Clim/Elev/Land/Wat
High : 0.93
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.934 N/A
LT FPA TOR
0.179 0.251 0.000
D. Bio/Clim/Elev/Wat
High : 0.94
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.985 N/A
LT FPA TOR
0.486 0.029 0.000
E. Bio/Clim/Elev/Land/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.987 N/A
LT FPA TOR
0.441 0.032 0.000
F. Bio/Land/Wat
High : 0.95
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.984 N/A
LT FPA TOR
0.412 0.038 0.000
G. Canp/Clim/Elev/PTC/Wat
High : 0.96
Low : 0
Obs Train Test TrAUC TeAUC
7 6 0 0.959 N/A
LT FPA TOR
0.205 0.167 0.167
0 100 200 300 Km


Callimico goeldii*
Callimico goeldii
C. goeldii
Defler 2010
Mapa 1
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.94
Low : 0
0 100 200 300 Km
Obs 7 Train 7 Test 0 TrAUC 0.985 TeAUC N/A
LT 0.260 FPA 0.049 TOR 0.000
B. Bio/Canp/Clim/Land/PTC
High : 0.94
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.985 TeAUC N/A
LT 0.273 FPA 0.044 TOR 0.000
C. Clim/Elev/Land/Wat
High : 0.94
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.967 TeAUC N/A
LT 0.298 FPA 0.100 TOR 0.143
D. Bio/Clim/Elev/Wat
High : 0.88
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.987 TeAUC N/A
LT 0.288 FPA 0.039 TOR 0.000
E. Bio/Clim/Elev/Land/Wat
High : 0.95
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.990 TeAUC N/A
LT 0.326 FPA 0.027 TOR 0.000
F. Bio/Land/Wat
High : 0.96
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.985 TeAUC N/A
LT 0.348 FPA 0.069 TOR 0.000
G. Canp/Clim/Elev/PTC/Wat
High : 0.96
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.976 TeAUC N/A
LT 0.291 FPA 0.079 TOR 0.143


Cebus albifrons malitiosus *
Cebus albifrons
C. albifrons cesarae
C. albifrons versicolor
C. albifrons malitiosus
C. albifrons albifrons
C. albifrons cuscinus
Defler 2010
Mapa 10
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.99
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.999 TeAUC N/A
LT 0.609 FPA 0.003 TOR 0.000
B. Bio/Canp/Clim/Land/PTC
High : 0.98
Low : 0
Obs 7 Train 6 Test 0 TrAUC 0.999 TeAUC N/A
LT 0.752 FPA 0.002 TOR 0.000
C. Clim/Elev/Land/Wat
High : 0.85
Low : 0
Obs 7 Train 6 Test 0 TrAUC 0.999 TeAUC N/A
LT 0.608 FPA 0.001 TOR 0.000
D. Bio/Clim/Elev/Wat
High : 0.87
Low : 0
Obs 7 Train 7 Test 0 TrAUC 1.000 TeAUC N/A
LT 0.414 FPA 0.001 TOR 0.000
E. Bio/Clim/Elev/Land/Wat
High : 0.92
Low : 0
Obs 7 Train 7 Test 0 TrAUC 1.000 TeAUC N/A
LT 0.553 FPA 0.001 TOR 0.000
F. Bio/Land/Wat
High : 0.908
Low : 0
Obs 7 Train 7 Test 0 TrAUC 1.000 TeAUC N/A
LT 0.649 FPA 0.000 TOR 0.000
G. Canp/Clim/Elev/PTC/Wat
High : 0.87
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.999 TeAUC N/A
LT 0.633 FPA 0.001 TOR 0.000
N
Km
0 100 200 300
1
2



Leontocebus nigricollis hernandezi *
Saguinus nigricollis
S. nigricollis hernandezi
S. nigricollis graellsi
S. nigricollis nigricollis
Defler 2010
Mapa 7
Train= # of observation for training; Test= # of observation for test. TrAUC= training AUC; TeAUC= test AUC; LT= logistic threshold; FPA= fractional predicted area; TOR= Training omission rate.
A. Bio/Clim/Elev/Land
High : 0.89
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.910 TeAUC N/A
LT 0.392 FPA 0.172 TOR 0.143
B. Bio/Canp/Clim/Land/PTC
High : 0.898
Low : 0
Obs 7 Train 6 Test 0 TrAUC 0.909 TeAUC N/A
LT 0.393 FPA 0.172 TOR 0.143
C. Clim/Elev/Land/Wat
High : 0.76
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.947 TeAUC N/A
LT 0.319 FPA 0.129 TOR 0.143
D. Bio/Clim/Elev/Wat
High : 0.88
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.970 TeAUC N/A
LT 0.4.33 FPA 0.073 TOR 0.143
E. Bio/Clim/Elev/Land/Wat
High : 0.88
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.970 TeAUC N/A
LT 0.433 FPA 0.073 TOR 0.143
F. Bio/Land/Wat
High : 0.84
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.964 TeAUC N/A
LT 0.447 FPA 0.121 TOR 0.000
G. Canp/Clim/Elev/PTC/Wat
High : 0.76
Low : 0
Obs 7 Train 7 Test 0 TrAUC 0.947 TeAUC N/A
LT 0.319 FPA 0.129 TOR 0.143
Km
0 100 200 300
N
1
2

Appendix K. List of 37 new conservation sites identified under the 17% conservation goal. Additional annotations about species distributions and prioritized conservation areas under 22 and 27% conservation goals can be found below the table.

Site	Natural Region	Geographic Sub-area	Dept.	Municipality	Description	CRR
1	Caribbean	Savannas of the valleys of Sinu and Upper San Jorge Rivers (5)	Cordoba	Lorica, Purisima	North east side of the department	ABF
2	Caribbean	Gulf of Uraba (7)	Antioquia	Turbo	Across plains in e mouth of the Atrato River	ABF
3	Caribbean	Gulf of Uraba (7)	Cordoba	Necocli, SanJuan de Uraba	Vicinity to the Marimonda marsh, low Mulatos River basin	ABF
4	Pacific	Baudo-Darien mountain range (11)	Choco	Unguia	Foothills of the Sierra del Darien mountain range near PNN Katios	ABF
5	Pacific	Alluvial valleys of Atrato and San Juan rivers (12)	Choco	Riosucio	Valley of the Salaqui River	ABF
6	Andean	Antioquian mountains (24)	Antioquia	Abejorral, Sonson	Valley of the Rivers Buey and lower Armas	ABF
7	Andean		Antioquia	La Pintada	Cauca canyon between the Palmira hill and De La Pintada cliffs (south-east region of the municipality)	ABF
8	Andean	Valley of Cauca river (20), Antioquian mountains (24)	Antioquia	Urrao, Abriarqui, Caicedo, Anza, Betulia, Concordia and Salgar	South-western region along the Cauca River canyon	ABF
9	Andean	Valley of Cauca river (20)	Antioquia	Taraza, Caceres	Northern areas along the lower Cauca River valley	ABF
10	Andean	Antioquian mountains (24)	Antioquia	Amalfi, Anori	Central areas in the Nechi River basin	ABF
11	Andean	Middle Magdalena (26)	Santander	El Playon, Rio Negro	Foothills west side Serranía de los Yariguies mountain range, close by PNN "Serranía de los Yariguies", ending at the north side of the Department in the middle Magdalena watershed.	ABF
12	Andean	Valley of Cauca river (20)	Caldas	Anserma, Neira, Filadelfia, Riosucio	Hills of Conchari, Cocorondo and Curi, in the mouth of the Tapia River and La Honda ravine	ABF
13	Andean	Western cordillera (17)	Risaralda	Marsella	Small areas_in the valleys of lower Otun River	ABF
14	Andean	Western cordillera (17)	Risaralda	Pereira	Small areas_in the valleys of the Cauca River	ABF
15	Pacific	Coastal plains of the Pacific region (13)	Cauca	Lopez de Micay	Middle and lower basin of the Micay river	CAZ

16	Pacific	Norther n sector western side of the western cordillera (9)	Choco	Riosucio	Along the valley of the Salaqui River	CAZ
17	Amazon	Amazon plain (42)	Putumayo, Caqueta	Puerto Guzman/ La Solita	Area between the upper Caqueta River and the lower Orteguaza River	CAZ
18	Amazon	Amazon plain (42)	Amazonas	Tarapaca	Mouth of the Cotuhé River into the Putumayo River, close to the border with Brazil	CAZ
19	Amazon	Amazon plain (42)	Amazonas	Leticia	Along the Purite River between the eastern side PNN Amacayacu and the Brazilian border	CAZ
20	Amazon	Amazon plain (42)	Amazonas	Leticia/Puerto Nariño	Along the Amazon River basin at the most southern side of the department and adjacent to the south side of the PNN Amacayacu	CAZ
21	Caribbean	Penisula of La Guajira (1)	Guajira	Uribia	Upper-middle Rancheria River before reaching the Caribbean Sea	CAZ
22	Caribbean	Sierra Nevada de Santa Marta mountain range (2)	Guajira	San Juan del Cesar	Northwest hillside of Sierra Nevada de Santa Marta mountain range (hills of the El Chorro, Cerro La Sierra, Bañadero, Los Mojones, Los Salados; Tomarrazon Mountains)	CAZ
23	Andean	Serrania de Los Motilones mountain range (33)	Guajira	La Jagua del Pilar, Urumita, Villanueva	By the Serranía de Perija Mountain range within the limits of the national park Sierra de Perija in Venezuela	CAZ
24	Andean	Antioquian mountains (24)	Bolivar	Santa Rosa del Sur, San pablo	Serrania San Lucas mountain range	CAZ
25	Caribbean	Savannas of the valleys of Sinu and Upper San Jorge Rivers (5)	Cordoba	Los Cordobas, Puerto Escondido, Moñitos	Across Upper Sinu River basin	CAZ
26	Caribbean	Caribbean savannas (4)	Cesar	El Copey	Area between the Garupal and the Paila Rivers	CAZ
27	Andean	Antioquian mountains (24)	Antioquia	Nechi, Caucasia	Nechi River valley, northern area of the department	CAZ
28	Andean	Antioquian mountains (24)	Antioquia	Anori, Amalfi	East side of the Ponce River basin	CAZ
29	Andean	Antioquian mountains (24)	Antioquia	San Carlos, San Luis	Between Nare and Caldera Rivers	CAZ
30	Andean	Antioquian mountains (24), Middle Magdalena (26)	Antioquia, Bolivar, Boyaca, Santander	Several	Large area adjacent to west side of the Central Cordillera, Serranía Las Iglesias and Serranía San Lucas, all along the valley of the Magdalena River in its course by the Departments of Bolivar, Santander and Antioquia, reaching the northwestern side of the department of Boyaca	OVERL

31	Andean	Middle Magdalena (26)	Santander	Cimitarra	Along the Carare River (a tributary of the Magdalena River)	OVERL
32	Andean	Antioquian mountains (24)	Antioquia	Ituango, Taraza	Upper Nechi River basin	OVERL
33	Caribbean	Savannas of the valleys of Sinu and Upper San Jorge Rivers (5)	Cordoba	San Bernardo del Viento	Close by the coastline.	OVERL
34	Pacific	Serranias Baudo - Darien mountain ranges (11)	Choco	Riosucio	Valley of the Salaqui river, northwest portion of the Department.	OVERL
35	Amazon	Amazon plain (42)	Putumayo	Puerto Guzman	Upper Caqueta River	OVERL
36	Amazon	Amazon plain (42)	Caqueta	La Solita	Lower Orteguaza River	OVERL
37	Amazon	Amazon plain (42)	Amazonas	Tarapaca, Leticia	Area adjacent to Putumayo, Purite and Amazon rivers.	OVERL

Numbers in parentheses beside geographic sub-area names correspond to their ID numbers in Appendix A. **Dept.**: Department (administrative division similar to Provinces in Canada) **CRR**: Cell Removal Rule; **ABF**: Additive Benefit Function; **CAZ**: Core-Area Zonation; **OVERL**: Overlapping areas.

Additional prioritized sites for conservation

When expending conservation targets to 22% and 27% protection (Figures 2.4 and 2.5, main chapter), overlapping areas were identified in: 1) Serranía de Abibe mountain range (Bolivar Department), the Mulatos River basin and Serranía de Urama mountain range (Antioquia Department); 2) municipalities of Otanche and Pauna in Boyaca; 3) forested areas in the Cundinamarca Department (Negro River basin, municipalities of Puerto Salgar, Caparrapi, Yacopi and La Palma); 4) forested areas in the Gulf of Uraba and Valley of the Sinu and upper San Jorge rivers, the coastal Pacific region (Choco Department) in zones along the middle Atrato and middle San Juan basin rivers, and a large area that include the PNN Los Katios, covering parts of the Serranía del Darien mountain range and Salaqui riverbed (Unguia, Riosucio and Jurado municipalities); 5) areas between the Putumayo River and Amazonas River (southern side of the Amazonas Department), especially forests associated to the lower Putumayo River in the corregimiento de Tarapacá and the area connecting with PNN Amacayacu to areas along the Cotuhé River.

In addition, priority areas increased in size 1) along the east side of the Serranía San Lucas mountain range (Bolivar and Cesar Departments) within the valley of the Magdalena River and extending north into the valley of the Cesar River (municipalities of La Loma, Chimichagua and Guiamaral); 2) from north by the Serranía de Perija mountain range heading south along the Serranía Los Motilones mountain range until reaching the north side of the department of Santander (municipalities El Playon and Rio Negro); 3) along the Amazon River (including the area of the Boia Uassu River) and the catchment area of the Calderon River from the border with Brazil to the southeast side of the PNN Amacayacu.

Individual priority areas were also identified for each cell removal rule in the 22% conservation target (Figure 2.4). In the case of the ABF rule: 1) central areas in the Serranía San Lucas mountain range (department of Bolivar), 2) habitats across the east side of the Magdalena River basin (Santander Department), and scattered throughout the Serranía de las Quinchas mountain range in the Departments of Boyaca (municipalities of Puerto Boyaca and Ochante) and Santander (municipalities of Bolivar and Jesus Maria), 3) wooded areas between the Mulatos and

San Juan rivers (Arboletes and San Pedro de uraba municipalities, western side of Antioquia Department), 4) in central zones in the Serranía de Urama mountain range and west foothills of Occidental Cordillera, 4) in the northern area of the Cordoba Department and in the Serranía de Las Palomas mountain range (Antioquia Department), 5) northeast areas (municipality of Riosucio) and the Serranía de los Saltos mountain range (Choco Department), 6) plains and Amazon slopes in the Eastern Cordillera, specifically along the Mesa del Guavio plateau (municipality of San Luis de Gaceno, south of Boyaca Department), 7) additional areas in the Orinoco region in the Cusiana River basin (municipalities of Mani and Tauramena, department of Casanare), parts of the Meta Department adjacent to the north side of PNN La Macarena, and across catchment areas of the rivers Metica, Ariari and Guejar. Finally, areas in the Amazon region are located in 8) the south of the La Macarena mountain range where the rivers Duda and Guayabero converge (Meta Department), 9) gallery forests associated to tributaries of the low Guayabero River (municipality of San Jose del Guavire, Guaviare Department), and along the Putumayo River (Puerto Arica and El Encanto).

In regards CAZ areas: 1) in the Caribbean Savannas (department of Cesar, south PNN Sierra Nevada de Santa Marta, Cesar Department), 2) the Andean region, particularly in the Serranía de Los Motilones mountain range (Cesar Department), 3) in the Catatumbo area near the east side of the PNN Catatumbo Bari (Norte de Santander Department), 4) plains between the low Mulatos and low Sinu river in northwest of the region of the Gulf of Uraba (Departments of Antioquia and Cordoba), 5) wooded areas in the Pacific region along the Parmillo River (southwest side of PNN Paramillo, Antioquia Department), 6) in the upper Quito River basin, the coastal zone of the municipalities of Acandi and Unguia along the Atrato River (Choco Department), 7) gallery forests along the Micay River and reaching the west side of the PNN Munchique (Cauca Department), 8) in the upper Mira River basin (municipality of Tumaco) and in west foothills of the western Cordillera in the municipality of Barbacoas (southern of the Nariño Department). Finally, 9) in the Amazon plateau, prioritized areas were selected adjacent to the south side of the national parks of Tinigua and Picachos (Meta Department) and in a small area in the upper Caqueta River (municipality of Puerto Guzman, Putumayo Department).

Under a 27% conservation scenario (Figure 2.5), major changes included increases in the number and size of overlapping areas: 1) forest in the north part of the Andean region, 2) in the

Caribbean region (Gulf of the Uraba in the Antioquia Department and forested areas in Savannas of the Cesar Department), and the El Corchal Mono Hernadez Sanctuary for flora and fauna (Sucre Department), 3) in the Pacific region in a continuous strip of land from Serranía del Darien mountain range to alluvial plains of the Atrato and San Jorge rivers, 4) areas connecting the Munchique national park with the pacific coast (south of the Cauca Department), 5) in the Meta Department by the foothills of the east Cordillera towards plains in the Orinoco region (Upper Meta River and Duda River) and the north/south area of the national parks complex of Tinigua, Macarena and Picachos.

Similarly, increases in number priority ABF and CAZ areas were also observed. ABF areas expanded within gallery forests in the department of Amazonas (Amazon region) and within riparian forest in central zones of the department of Meta across Meta and Guayabero river basins (Orinoco region) where prioritized CAZ areas were also identified. Additional areas were also found in the department of Santander, adjacent to the Serranía of Yariguies mountain range (Andean region). Priority CAZ and ABF zones were also within the north part of Central Cordillera in the upper Nechi river watershed (Department of Antioquia).

Additional priority CAZ areas were also detected in the Andean region, in the Catatumbo River basin at the east side of the Eastern Cordillera (department of Norte de Santander), and the catchment area of the upper Magdalena River (south of the department of Huila) along its course in the north parts of the department. Selected areas were also located besides the Cienaga Grande de Santa Marta Sanctuary for flora and fauna at the north of the department of Magdalena.

Implications for primates in Colombia

Under the 17% conservation goal, prioritized sites identified in the Amazon piedmont correspond to fragments of forested areas used by the Caqueta titi monkey (*Plecturocebus caquetensis*), a recently discovered endemic taxon considered as at most risk in Colombia (García et al. 2010 and Porter et al. 2013) and that is not currently protected. García et al. (2010) has emphasized in the importance of reserves for the survival of this species, due to the ongoing detrimental effect of mining activities and land conversion associated with illicit crops and extensive ranching within the range of the Caqueta titi monkey.

Although national parks or civil natural reserves should be the best way to safeguard the Caquetá titi monkey, it would be important to consider a Fauna Sanctuary (Santuario de Fauna in Spanish) as a more appropriate tool for protection since explicitly preserves species or communities of wild animals, and genetic resources of the national fauna (MAVDT 2010). The fauna sanctuary relates to the protected area category of “Habitat / species management area” (category IV) suggested by the IUCN (Dudley 2008), where the priority of the site is protecting, maintaining, or restoring particular species and/or fragments of ecosystems or habitats in areas already enduring substantial modification, with the possibility of constant management intervention. This category is a valuable conservation tool to protect particular target species under high risk of endangerment or extinction, such as is the case of the critically endangered Caquetá titi monkey, but possibly other species such spider monkeys and the Santa Marta white-fronted capuchin.

Another species that would benefit from conservation sites in this portion of the Amazon plains is the long-haired spider monkey (*Ateles belzebuth belzebuth*) and the Miller’s saki (*Pithecia milleri*). Although some populations of Miller’s sakies are secure in La Paya NNP (Defler 2010), the species’s conservation status is still considered vulnerable (Defler et al. 2006), with an unknown ecology and status of populations (Defler 2010, Porter et al. 2013 and Marsh & Veiga 2015).

Priority conservation sites identified in the north part of the Andean region (e.g., Serranía de San Lucas mountain range, the Nechí river basin and the upper Cauca basin, all part of the Nechí Forest Refuge), would protect the endemic Brown spider monkey (*Ateles hybridus brunneus*). However, assessments of its population status are still needed given the identification of areas of high vulnerability within its range (Figure 2.8), and additional refinement of remnant habitat would strengthen decision making. *A. hybridus* has been recently included in the list of the “world’s 25 most endangered primates”, with little known about number of individuals in the wild (Link et al. 2015a). Recently, the Serranía de San Lucas was declared as one of the six new protected areas to be included in the national park system in Colombia (MADS 2015). Several authors agreed to the importance of protecting this area as it is a potential refuge for not only for the brown spider monkey, but also other threatened species including the Santa Marta white-fronted capuchin, the white-footed tamarin, the grey-handed night monkey, and the Colombian woolly monkey (Defler et al. 2003, Morales-Jimenez 2004, Urbani et al. 2008, Defler 2010, Defler et al. 2010, Stevenson et al. 2010, Link et al. 2013, Rodríguez-Bolaños et al. 2013 and Roncancio et al. 2013).

In addition, the inclusion of new conservation areas benefit species with low level of protection as the national endangered Colombian black spider monkey (*Ateles fusciceps rufiventris*), the species occurs in two national parks (Los Katios and Las Orquideas) but have seen decreases in population size due to habitat loss and hunting (Cuarón et al. 2008a and Defler 2010). Moreover, mining rights appeared to exist around Las Orquideas National Park, near high vulnerability areas (Figure 2.7). Thus, new conservation sites in the Pacific region (Sierra del Darien mountain range and valley of the Salaqui River) could also protect primate habitats of low threat (Figure 2.7), although population and hunting pressure should be assessed and monitored. Defler (2010) suggests that the Colombian black spider monkey may become national extirpated if hunting activities not better controlled. This is especially relevant to this species given that life history traits such late maturation and long inter-birth intervals limit its capacity to recover from threats (Cuarón et al. 2008a). Hunting activities in this region have been also linked to decreases in population size of the South Pacific blackish howler monkeys (*Alouatta palliata aequatorialis*) to the point of considering it as rare within the Utria National Park (Cuarón et al. 2008b).

Sites prioritized for conservation in forested areas within the middle and lower basin of the River Micay would offer a valuable alternative to protecting Colombian black spider monkeys given the suitability habitat modelled for this area and low mining pressure. However, assessments of populations and local threats are needed given the incidence of illicit crops that can increase habitat fragmentation. Lastly, areas of higher habitat suitability of black spider monkeys are also predicted along the Cauca river valley in the region between the Antioquia Mountains and the west side of Western cordillera, where sites of high vulnerability and high conservation value were identified so observation in that areas would benefit this species. It is worth to mention that the conservation plan presented here is the first attempt to meet management measures suggested by Defler (2010) about increasing reserved sites for this taxon.

Adding protection in the Pacific would also benefit the Colombian white-throated capuchin (*Cebus c. capucinus*), the Geoffroy's tamarin (*Saguinus geoffroyi*), and the Panamanian night monkey (*Aotus zonalis*), a vulnerable species presumably being protected in seven national natural parks in the country but knowledge on population status is null (Cuarón et al. 2008c). Whereas that modeled conservation sites in the valley of the Cauca River (Antioquia Department) would also safeguard the near threatened varied white-fronted capuchin monkey (*Cebus a. versicolor*) and other vulnerable species such as the Colombian night monkey (*Aotus lemurinus*) and the white-footed tamarin (*Saguinus leucopus*).

Core-Area Zonation priority sites in central parts of the Andean region are strategic sites to protect key habitat for the white-footed tamarin. Additional reserves proposed by Roncancio et al. (2013) within the municipalities of Anori and Amalfi (Antioquia Department), Serranía San Lucas mountain range and the Bolivar Department are consistent with conservation sites prioritized in Zonation and within the probable range predicted for the white-footed tamarin. The same authors reported a 60% decrease on the habitat suitability for this endemic species, along with indications of local extinctions and total habitat loss. The vulnerability analysis also suggested the presence of illicit crops and mining rights within much of the modeled distribution for this endangered tamarin.

In addition, the grey-handed night monkey (*Aotus griseimembra*) and the Río Cesar white-fronted capuchin (*Cebus albifrons cesarae*) would benefit from prioritized Core-Area Zonation areas (that include a recently declared protected area by the Serrania de Perija (MADS 2015)) in the Guajira region, although examination of remaining habitats still needs to be addressed (Morales-Jiménez & Link 2008 and de la Torre et al. 2015b).

New conservation areas in the Caribbean region (Mouth of Atrato River, Urabá Gulf, Sinú River and Upper San Jorge River valleys) could be secured for endemic species such as the cotton-top tamarin (*Saguinus oedipus*). Despite the existence of strong conservation programs and having presence within three national parks, substantial percentage of suitable forest for this taxon is still disappearing (Miller et al. 2004 and Savage & Causado 2014). New reserves have been recognized as an important condition to further safeguard this emblematic taxon (Defler et al. 2003 and Defler & Rodríguez-Mahecha et al. 2013), as well as increasing protection of sympatric species as the South Pacific blackish howler monkey, the Colombian white-throated capuchin and the Colombian black spider monkey.

Changes in the distribution of some species of primates in Colombia

In regards increases on species distributions compared with known range maps, historical occurrence records for Saimiri sciureus cassiquiarensis in La Macarena (Orinoco region) probably may better represent that of Saimiri sciureus albigena given the existing description of the distribution for the subspecies (Boubli et al. 2008 and Defler 2010). Another possible misidentification is the Miller's saki (*Pithecia milleri*) with the modeled distribution encompassing habitats where the other species of saki (*Pithecia hirsuta*) occurs. Defler (2010) and Marsh (2014) further describe the controversy on distribution patterns of saki monkeys in Colombia. Misidentification may also explain increases in the distribution (ranges) of the collared titi monkey, with locations on the south side of the Caquetá River (Amazon region) when it should correspond instead to the distribution of the yellow-handed titi Monkey (*Cheracebus lucifer*) (Veiga & Palacios 2008 and Veiga et al. 2008 respectively).

On the other hand, wider ranges for the white-fronted capuchin (*C. a. albifrons*) and the endemic white-footed tamarin (*Saguinus leucopus*), may be tied to a similarity of environmental conditions between new and known areas and not to probabilities of actual occurrence (Roncancio et al. 2013). Suggested losses in the distribution for S. leucopus (Defler 2010) are consistent with the smaller range predicted for this species in this study.

Habitat loss due to forest harvesting and land conversion could be closely related with decreases in the distribution for the imperilled and sympatric species *A. palliata aequatorialis*, *Aotus zonalis*, *Ateles fusciceps rufiventris* and *Cebus capucinus capucinus*. In fact, current “deforestation hotspots” and predicted areas of clear-cuts (Etter et al. 2006) in the Pacific region occur within known distributions of these species (Defler 2010) and concur with locations modeled as unsuitable in this study. Highly restricted distribution of suitable habitats for the vulnerable grey-handed night monkey (*Aotus griseimembra*) in the Catatumbo area, are also associated to forest loss (Morales-Jimenez & Link 2008).

Finally, restricted ranges of suitable habitat for the Brumback's night monkey (*Aotus brumbacki*), and the Colombian squirrel monkey (*Saimiri sciureus albigena*) correlate with aggregated observations for a few localities within the same region. Information gaps for the Colombian black-handed titi monkey limit conservation efforts and the identification of habitat preferences, a quality displayed by other species within the genus (Veiga & Palacios 2008 and Defler 2010). This is also the case for the rare and habitat specialist Goeldi's marmoset monkey (Ferrari et al. 1999), where available data date back to 1976 (Cornejo 2008 and Defler 2010), and for the Hernández-Camacho's black mantle tamarin, with little information on its ecology and geographic distribution (Izawa 1978, Hershkovitz 1982 and Vargas 1994).

Appendix L. Distribution of new conservation sites from the Additive Benefit Function (ABF) and Core-Area Zonation (CAZ) rules at 17% conservation target, and their concurrence with the elevational and latitudinal diversity gradient suggested for Colombia (modified from Defler 2010, original: Hernández-Camacho & Defler 1989). Higher number of species is found in lowland areas in the Amazon region, south side of the country.