ECOLOGICAL CONNECTIVITY MODEL OF 5 ENDANGERED TREE SPECIES IN THE COLOMBIAN AMAZON

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[3] The article is derived from the conservation project " *SHORT-, MEDIUM- AND LONG-TERM PROJECT OF REFORESTATION OF THE COLOMBIAN AMAZON.''* whose coordination was in charge of Marta Ramos Escudero, manager and head of projects of the Corporación Colombian Forest, and that was developed from March 15, 2021 until August 31, 2021.

RESUME

In this study, the design of 1,200ha as ecological corridors and buffer zones is proposed as a measure for the expansion and restoration of the connectivity of the habitat of the 5 trees species: Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma); in the Ticuna indigenous territory, Amazonas of Colombia. The methodology used, the result of modifications of the Bentrup (2008) proposal, was based on the analysis of geographic parameters that define areas with the best territorial suitability for the habitat of the species. Likewise, the study is based on a cost analysis that, through a Geographic Information System, allows defining the potential location of the functional connectors. In this way, the model provides reliable information that allows us to accurately propose the layout of 1,200ha corridors and buffer zones. As will be seen in due course, the methodology used can be adjusted for other species.

Keywords: ecological corridors; buffer zones; Amazon basin; tree, Colombia.

Citation / Cite this article as: RAMOS, M. 2021. Ecological Connectivity Model Of 5 Endangered Tree Species In The Colombian Amazon. COLOMBIA WILD CORPORATION. 15 pages.

INTRODUCTION

The fragmentation of ecosystems and the loss of ecological connectivity, two of the main factors that have a profound impact on biodiversity, are largely caused by the increase and homogenization of agricultural and urban activities (Rodríguez-Soto et al., 2013; De León Mata et al., 2014; Johnstone et al., 2014; Gao Q, 2014; García-Marmolejo et al., 2015; Loro et al., 2015; Van Langevelde, 2015; Villemey et al., 2015; Burkart et al., 2016; Peled, 2016). Ecological connectivity is defined according to the degree to which the territory facilitates or hinders ecological processes significant as species movements through existing habitat resources in the landscape (San Vicente, 2014). Therefore, the preservation of ecological connectivity contributes to minimizing the negative effects of habitat fragmentation (Johnstone et al., 2014).

One way to contribute to reducing the loss of ecological connectivity is to design ecological corridors that function as buffer zones for the negative effects of fragmentation. In this sense, it is vital to consider the theoretical insights of Bentrup (2008), who defines ecological corridors as “strips of vegetation incorporated into the landscape [that serve] to influence ecological processes and provide a variety of goods and services. They are known for various names, such as wildlife corridors, greenways, windbreaks and filter strips” (p.1).

Although Colombia is characterized by having a high biodiversity, according to the red list of endangered animals it is one of the countries with the highest number of threatened species in the world (International Union for the Conservation of Nature, 2014). Among the factors that accentuate this situation, it is worth highlighting the intense deforestation of forests and the overexploitation of natural resources due to hunting and illegal animal trafficking (Sierra, 2013; Rodríguez and Ortega, 2012; De Osma Vargas-Machuca et al., 2014).

These circumstances contribute in various measures to the reduction and fragmentation of the habitat of game species such as the Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma), known locally as the trees species.

The trees species has a wide geographic distribution in the neotropical region of the Amazon territory of Colombia: it equally inhabits the humid, dry, tropical and subtropical forests of the Atlantic Coast, as well as some Andean foothills below 700 meters above sea level (Albuja et al., 1993; Tirira, 2007). According to the Convention on International Trade in Endangered Species of Fauna and Wild Flora (2009), the species is in danger of extinction

As the study by De Osma Vargas-Machuca et al. (2014) affirms, despite their decline and fragmentation, forests continue to be the habitat of Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma).

These species are found in the remnants of native forests located in the Ticuna indigenous territory.

Accordingly, the objective of this research is to propose the design of 1,200ha ecological corridors and buffer zones in the sectors with the best territorial aptitude for the glove; surfaces defined according to socio-economic, biophysical and social factors. Thus, the purpose of the project is to provide adequate measures to restore ecological connectivity between the remnants of native forest and thus favor an increase in the habitat of the species. In particular, it seeks to facilitate the mobility of seeds of Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma); in a sector that covers 1500 km2 in the north-central Ticuna indigenous territory: a space for agricultural, silvopastoral and agroforestry activities.

Although it is not under a specific political-administrative delimitation, the study area includes part of Jaramillo and Palomino. The surface is located between the following coordinates: 10 ° 38 '48.94994 "N and 74 ° 1' 26.20795" W (Vereda Cerro Azul) as a northwestern point; 10 ° 34 '2.396974 "N and 73 ° 36' 0.1186537" W (Vereda San Sebastian de Rabago) as a northeastern point; 10 ° 2 '13.88315 "N and 73 ° 53' 26.81301" W as a southwestern point (Durania), and 10 ° 31 '50.47746 "N and 73 ° 26' 33.37663" ’’ W as a southeast point, Vereda las Estrellas. (Figure 1).

PROJECT MAPS

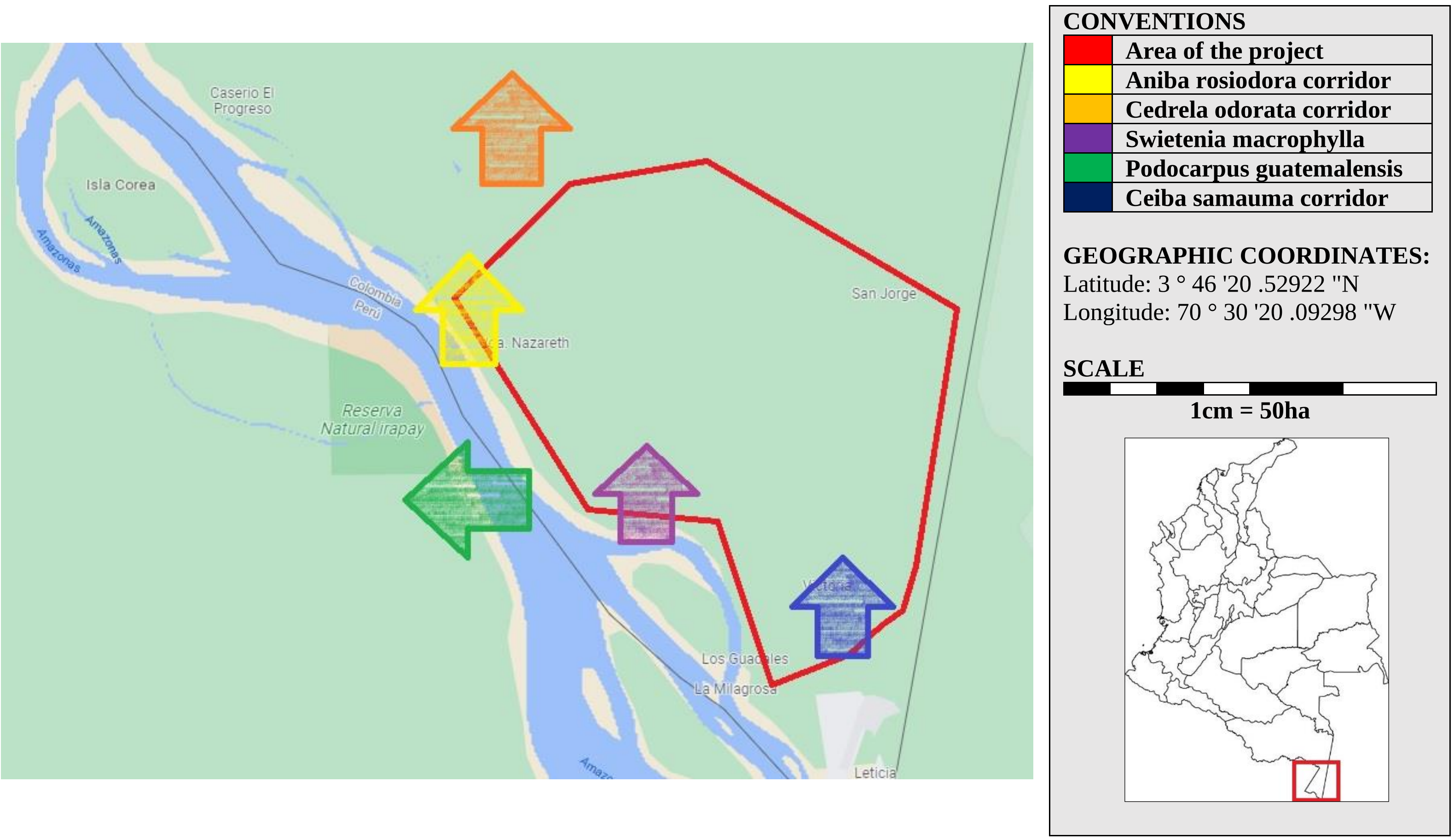


Figure 1. Location of the study area. Cartographic source: base map of the Agustín Codazzi Geographic Institute (2020) and thematic maps of the Ministry of the Environment of Colombia (2020)

METHODOLOGY

For the formulation of a proposal for ecological connectors in the study area, it was necessary:

a) identify native forest cover;

b) identify the territorial suitability for the presence of the Bois de rose (Aniba rosiodora),

Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma);
c) propose the creation of connectors —ecological corridors and buffer zones—, and
d) process geoinformation (figure 2).

1. Identification of native forest cover

Through the visual analysis provided by the ArcGIS Geographic Information Systems package (version 10.8), the forest cover was interpreted and delimited. The procedure was developed on a set of orthophotomaps at 1: 5000 scale generated by the Ministry of Agriculture by the Program of the National System of Information and Management of Rural Lands and Technological Infrastructure (Sigtierras), under the supervision of the Military Geographical Institute (IGM) . The orthophotomaps correspond to a UTM coordinate system, datum WGS-84, Zone 17. Likewise, these coordinates were acquired in 2020.

Identification of variables and elaboration of the maps of optimal areas by criterion, in order to develop the research, first of all factors, variables and criteria were defined in a matrix that represented the cartographic model. Subsequently, we proceeded with the compilation of cartographic information and other suitable remote sensing products for the formulation of a territorial suitability map in which the presence of the Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma); could be observed. Then, with this information, the ecological corridors and buffer zones suitable for the particular case were proposed.

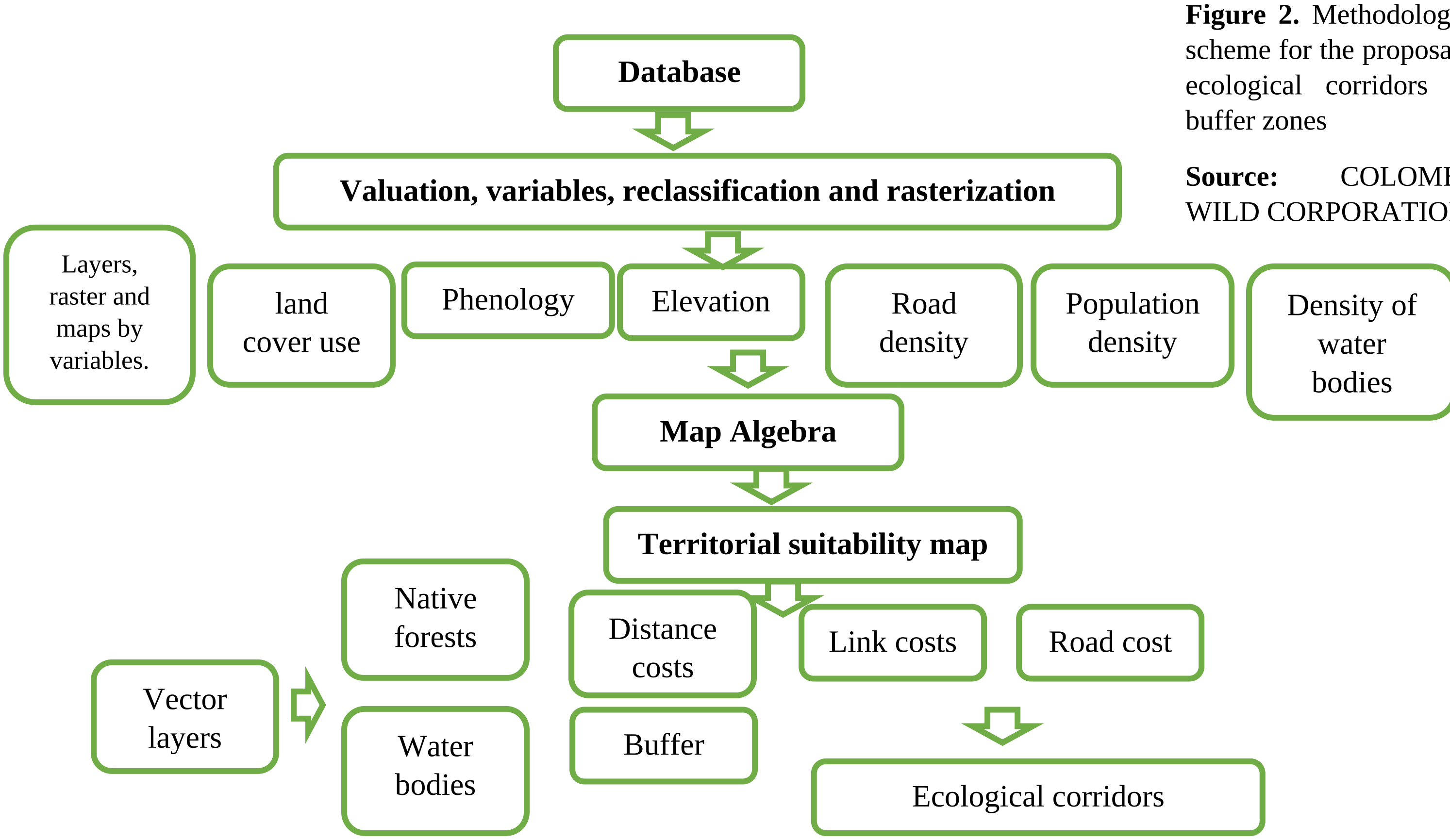


Figure 2. Methodological scheme for the proposal of ecological corridors and buffer zones

Source: COLOMBIA WILD CORPORATION

With this information, the ecological corridors and buffer zones suitable for the particular case were proposed.

Each of the variables was valued according to its importance for the presence of the species in the study area. The evaluation was carried out by experts who made up a multidisciplinary team related to the ecological and biological contingencies of the species. In sum, the research group raised values or scores higher than the circumstances in which certain variables were more favorable conditions for the presence of glove. Despite the particular evaluations of the aforementioned factors, it was decided not to formulate differentiated percentage weights for any of them. In other words, in the final stage of map algebra, no particular weight was given to any of the variables, since the level of adaptability of the species to the conditions offered by the environment was unknown. Consequently, differences of a greater or lesser incidence of social, biophysical and economic factors (table 1).

For the assessment and cartographic representation of the study, the ArcGIS 10.8 program was implemented. As a result, a map was obtained for each of the variables considered, thereby constituted a total of six layers in raster format. Subsequently, each one of them was zoned based on its level of importance —high, medium, low—, which was determined according to the environmental conditions for the existence of the species.

In some cases, we worked at the vector level and through the selection of attributes. The variables of the shapefile layers were chosen and later values were assigned as shown in table 1. Thus, in the case of the land use and cover layer, values of 3 were given to the forests; 2 to agroforestry areas, and 1 to pastures. On the other hand, in the aspect of the phenology of the vegetation, a value of 3 was given to the surfaces characterized by the presence of evergreen forests; from 2 to seasonal evergreen forests and, finally, from 1 to forests with semi-deciduous characteristics.

Factor	Criterion	Variable	Value	Source of information
Socio-economic	Coverage from the earth	Forests	3	MAE-Magap 2021, 1: 100,000
		Agroforestry	2	
		Pastures	1	
Bio-physical	Water density	High		IGM 2020, 1: 50,000
		Medium		
		Short		
	Vegetation phenology	Evergreen forests	3	MAE 2013, 1: 100,000 seasonal
		Evergreen forests	2	
		Semi-deciduous	1	
	Elevation	487-680 m	3	Curvas de nivel IGM 2019, 1:50.000
		294-486 m	2	
		100-293 m	1	
Social	Density	High	3	IGM 2020,

	population	Medium	2	1: 50,000
		Short	1	
	Road density	High	3	IGM 2020, 1: 50,000
		Medium	2	
		Short	1	

Table 1. Factors, criteria, variables and evaluation weighed to obtain the map of territorial aptitude
Source: COLOMBIA WILD CORPORATION

For the study of the topography of the place, the anticipated creation of an irregular network of triangles (TIN) was necessary: a digital data structure used in a geographic information system (GIS) for the representation of a surface. In this particular case, a layer of official contour lines performed every 40 meters was taken as a starting point.

Subsequently, the measurements were adapted to the raster format and the appraisals were reclassified into three equal ranges according to the elevation level. Thus, values of 3 were given to the elevations that oscillated between 680 and 487 meters; from 2 to those ranging between 486 and 294 meters, and 1 to those ranging between 293 and 100 meters.

In the cases of water, population and road densities, the density tool was used. Its use was fundamental both for the study of shapefile factors in the format of lines —bodies of water and roads— and for elements that correspond to points —populated centers—. From a vector layer, this tool calculated the density of the features in a radius corresponding to each output cell. Subsequently, a new layer was generated that estimated the required densities so that they were, in turn, reclassified into three categories.

Regarding population and road densities, values of 3 were given to the areas with the lowest concentration; from 2 to those that had a medium density, and from 1 to those that showed a significant presence of said variables.

It is worth noting that values based on the concentration of water bodies corresponded to the water density in contexts in which a higher water density - or a greater presence of water bodies per unit of land - made the areas more suitable for species survival. Consequently, a value of 3 was given to areas with a high density of bodies of water; one of 2 to those of medium density, and one of 1 to those of low density.

After obtaining the layers of each criterion, a map crossing known as map algebra was performed in the program's raster calculator. As a result, around 11 classes were generated.

Subsequently, the calibration of the model was carried out through reclassification processes. Three classes were obtained in total, which coincided with the following cataloging standard: the area with value 3 corresponded to the one with the greatest territorial aptitude; the value 2 with a medium territorial aptitude, and the value 1 with a low territorial aptitude. It is worth noting that the format transformation raster to vector was necessary so that the metric statistics of the surface of each of these values were obtained.

Proposal of connectors: ecological corridors and buffer zones.

Based on strategic modifications of the Bentrup (2008) guidelines, a proposal was developed that allows identifying vital landscape elements for the optimal design of corridors ecological and buffer zones. Identification in the matrix landscape, as well as core areas or nodes, was taken as a starting point. The core areas are biological units of great importance for the rescue of biodiversity and are represented by the remnants of native forest. For its part, the matrix corresponds to the areas that have been occupied by agroforestry, pastoral and urban activities.

The ecological corridors and buffer zones were designed according to the location and size of the nodes. It is worth noting that an ecological corridor is defined as an elongated connector that fulfills the functions of restoring the territorial junctions that link the nodes and increasing access to resources. Ecological corridors can be of several types: linear, landscape corridors or step corridors —stepping stones—.

For their part, the buffer zones, areas transitional areas represented by strips of vegetation that are incorporated into the landscape around the core areas or forest nodes, they fulfill various functions such as increasing the habitat; influence ecological processes; provide populations with varied goods and services, and protect the edges of forest remnants from possible threats (Bentrup, 2008).

In this sense, we proceed to work on the layers of native forest cover and identification of territorial aptitude. Given that the latter meets the necessary conditions for the presence of the glove to flourish in the study area, the proposal for the creation of ecological connectors was developed in accordance with the guidelines described below.

A selection of data by attributes was made from which the remnants of native forest cover were chosen most significant in terms of surface. The choice of these extensions as nodal segments had as selection criteria the dimensions of the remnants and the size of the species that inhabited them. In this case, a small reptile such as the trees species carranchina requires a minimum area of 2.5 acres, an area that is equivalent to 10,117.14 m2 (Bentrup, 2008). Consequently, the measure obtained as a reference value for the remnants of vegetation corresponds to ≥1 ha.

The forest core areas were then divided into blocks, according to their concentration levels per unit of land. This allowed a proposal to be developed directed towards the need for connectivity of the remnants. Likewise, a buffer area of 30 meters was applied to all bodies of water with permanent flow, with which they came to be considered areas of reforestation. However, many of them had riparian vegetation in their surroundings, so it was concluded that reforestation along the entire canal was unnecessary. These bodies of water thus became natural connectors for selected native forest patches.

In order to generate matrix images for the corridors' proposal, the Spatial Analyst Tools extension of the ArcGIS 10.11 program was implemented. The use of this systematized tool allowed the planning of corridors for areas lacking natural connectors. In this context, it is essential to consider the importance of a matrix image, which consists of the representation of one or several combined factors that have an impact on the route or journey through a given area (De Oliveira Lozada, 2010).

For the start node of the corridor layout, the process called Cost Distance was carried out.

In this phase, it was essential to bias the parameter, which led to the definition of the best or least cost route. This analysis has a considerable scope since its effects vary according to the factor being analyzed: in other words, the effects change depending on whether they are based, for example, on the slope or on bodies of water. Given that in this particular case the study was based on territorial aptitude, the route traced involved the calculation of the areas - or cells - that met the best territorial conditions for the survival of the species.

The Cost Back Link tool was applied for the remnant of the beginning of the corridors' layout. The study allowed the optimal cells to be defined to organize a route that would go to the nearest sources or remnants. Next, the process called Cost Path was carried out, in order to obtain the path from the source node to the destination node. A buffer of 100 meters was generated for these routes on each side, which corresponded to the areas of the corridors that had to be restored. On the other hand, the nearby forest remnants that had more than one hectare and that shared similarities in the appearance of the vegetation, were grouped with a buffer of 100 meters that allowed them to stay connected. As a final result, a graphic representation of the ecological corridors of the areas with the best territorial characteristics was obtained.

RESULTS AND DISCUSSION

In figure 3 the optimal areas for the development of the habitat of the Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma); species are shown and classified according to defined criteria. It is observed that for coverage and use the largest area is covered by pastures with an area of 926.31 km2 (61%). Meanwhile, the agroforestry land corresponds to an area of 334.69 km2 (22%) and the forests comprise only 253.38 km2 (17%), which is They are distributed in a dispersed way, mainly to the southeast and center of the study area.

The most homogeneous phenology and with the greatest territorial distribution occurs in the seasonal evergreen forest, given its 1102.98 km2 (73%). In contrast, the evergreen forest covers 39.54 km2 (2%) restricted to a strip to the east, which constitutes it as the area with the most appropriate phenology. This territorial extension extends to the west with the semi-deciduous forest, which has 373.56 km2 (25%). It is observed that the optimal altitude range is between 487 and 680 meters above sea level (36.92 km2 and 3%). This area is characterized by its difficult access, which removes it from human disturbances. The other elevation bands are located between 292 and 486 meters above sea level and occupy 1,447.92 km2 (97%).

It is important to bear in mind that the water density is an essential criterion for the study, since the guanta usually inhabits areas close to river tributaries and / or with high concentrations moisture. As can be seen in the maps, the sectors that have the optimal water conditions for the survival of the species are scarce: they only correspond to 196.21 km2 (13%) of the 1500 km2 of the study area.

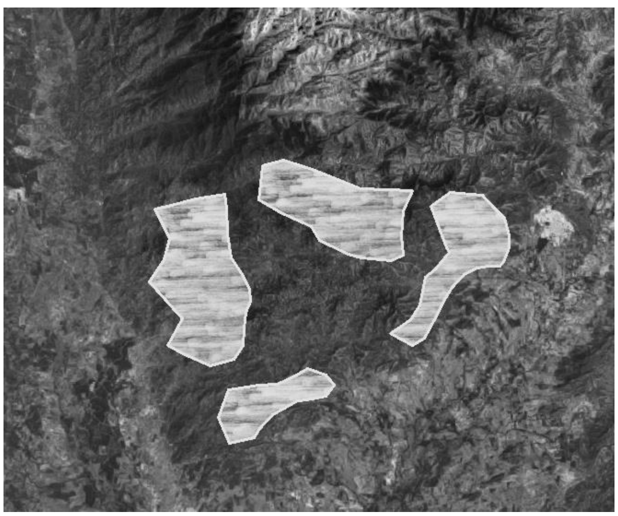
On the other hand, the area with the lowest road density, which represents the optimal space for the survival of the species, consists of 204.52 km2 (13%). The area is located in the southeast of the territory, which coincides with the area with the lowest population density; surface area that occupies a little more territory: 242.85 km2.

The study of the exposed cartographic representation can lead to conclusive results for the purpose of the writing. The territorial suitability map shows that 51% (761 km2) of the area has an average territorial aptitude for the development of the species, while 27% (408 km2) of the territory presents low conditions, and 21% (331 km2) of the study area has the

best characteristics for the conservation of the guanta .

The area whose characteristics are most desirable is distributed in a scattered manner in the south and east of the study sector, and

coincides with 66.51 km2 of the native forest remnants (figures 4 and 5).



Land use

Phenology

Population density

Elevation

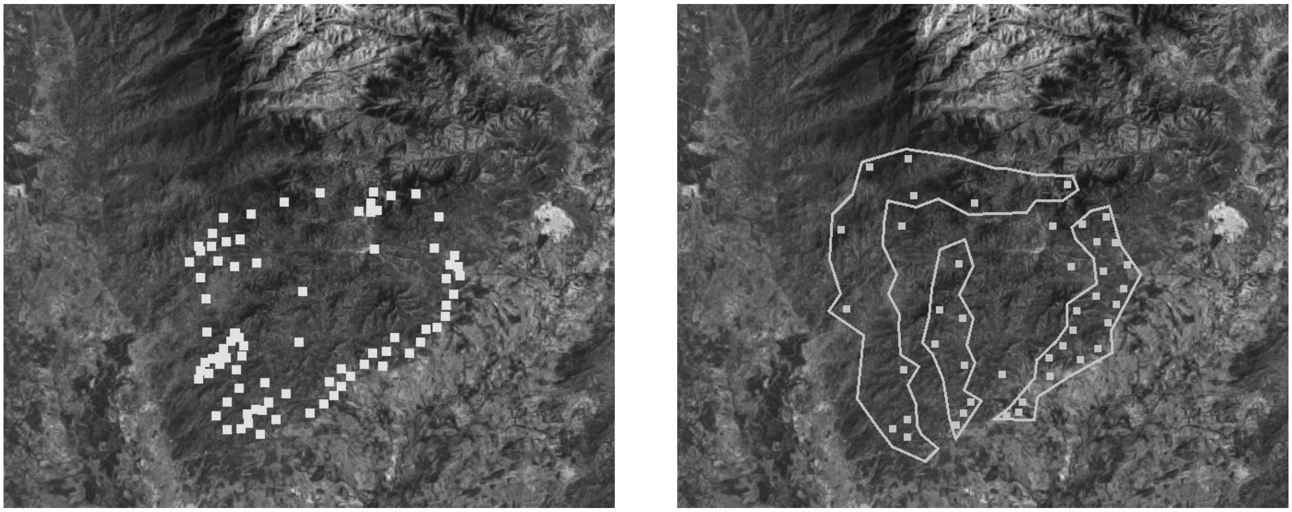


Figure 3. Maps of optimal territories divided by criteria **Source:** this research.

The territorial suitability map provided guidelines that led to determining which areas could be reforested through the buffering method and / or through the design of ecological corridors (figure 6). Consequently, the area was subdivided into seven subsets or blocks depending on the territorial location and the

Water density

proximity between the remnants of native forest (figure 7 and table 2). In block 1, it is proposed to create 11 short ecological corridors that would join the main nucleus with smaller patches around it: 2.27 km2 would be reforested and 3.90 km2 of forest would be preserved, since this is one of the sectors in which the agricultural matrix is more homogeneous. Something similar would happen with block 2, which is located south of the largest populated center in the Flavio Alfaro area. In this case, a corridor that requires reforestation of 0.43 km2 is recommended.

Block 3 is located in a sector with low anthropic intervention. However, the roadway separates it from the subsets of forest remnants in the south and east that correspond, respectively, to blocks 4 and 5. Consequently, it is proposed to create a buffer zone that allows grouping more than 10 patches. of forest and two corridors, which

Road density

would allow to connect two pieces that, despite being the most isolated, make up the current habitat of the guanta. In the process, 9.64 km2 of forest would be reforested.

In the case of block 4, a buffer zone is proposed that allows the connection of more than 25 remnants of forests with surfaces greater than one ha, in addition to two ecological corridors. For him process, which would involve the preservation of the 19.39 km2 of current forest, the reforestation of 43.74 km2 is required.

Although it is characterized by the isolation caused by the presence of the road from the previous block, block 5 is for its part one of the most important in the area, since it is located in an associated area with the Oro river basin and which suffers little disturbance. In this sector, a complex of ecological corridors and buffer zones is proposed, which would imply a greater investment in terms of reforestation, since it would be necessary to provide attention to 84.86 km2. The additional benefits of the articulation of the proposed initiatives would be proportional to the effort since 61.70 km2 of natural forest would be conserved.

To the north is block 6, which groups 7.65 km2 of natural forest. The largest remnant was designed with seven connectors that integrate six small patches around it and an elongated patch that corresponds, in turn, to a riparian forest. In the process described, less than 1 km2 would be reforested. Finally, block 7, located to the east of the study area, has 2.87 km2 of natural forest. In his case, it is proposed that six connectors join seven pieces to the nucleus, thereby reforesting 1.48 km2.

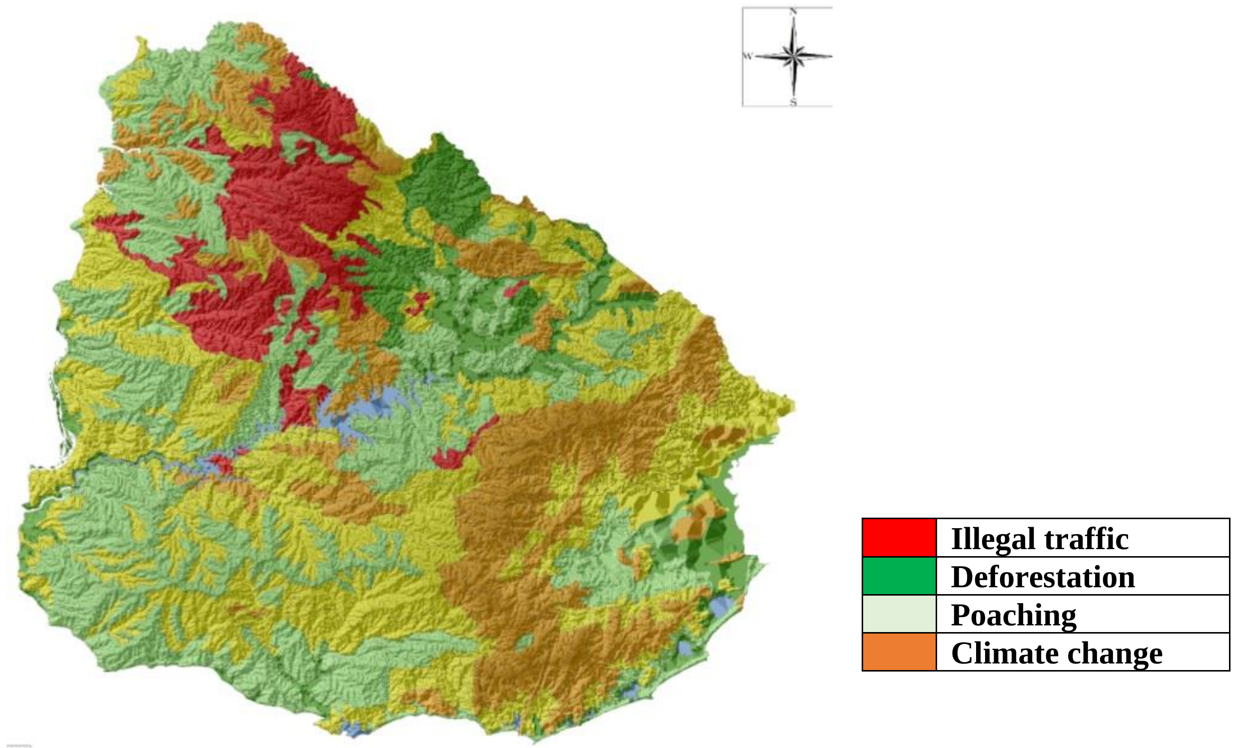


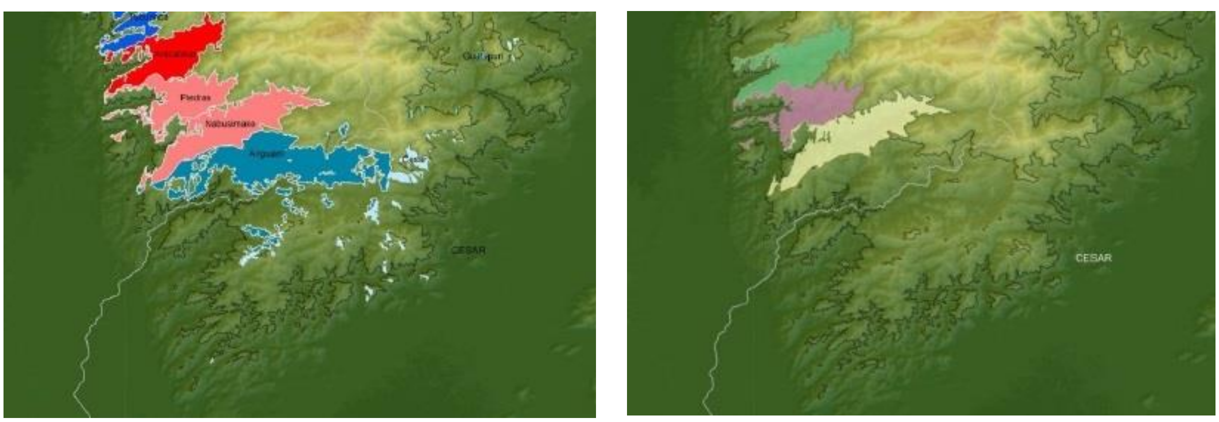
Figure 5. Threats

This proposal seeks to increase the size of the habitat of the Cuniculus paca and other associated wildlife, in addition to contributing to the preservation of current native forests and the restoration of the connectivity between patches of natural forest. Therefore, the design of vegetation zones that help to protect the forest remnants is suggested: an increasingly necessary conservation and regeneration measure in tropical landscapes. It is imperative to recognize that connectors play an essential role in the potential conservation and recovery of biodiversity because they reverse the loss of forests that has caused profound changes in the composition of the community, as well as the loss and isolation of wild species (Durães et al., 2013; Rodríguez-Soto et al., 2013; Peles et al., 2016).

It is worth remembering that ecological corridors are the elements of the landscape that avoid the negative effects of fragmentation and improve the prospects for biodiversity in green and urban spaces (Vergnes et al., 2012; Guneroglu et al., 2013; Loro et al. al., 2015). For this reason it is important to keep them in It counts within comprehensive territorial planning, since its administration is essential to optimize the effectiveness of nature conservation policies (San Vicente and Valencia, 2012).

	Areas with trees species population
	Indigenous settlements

	Population density
	Forest density
	Road density



	Connectivity population 1
	Buffer 1
	Connectivity population 2
	Buffer 2

	Isolated population 1
	Isolated population 2
	Isolated population 3

Figure 6. Proposal for ecological corridors and buffer zones

At this point it is worth evaluating the strategies that allowed the development of the project. The key to restoring a landscape made up of remnant forest mosaics was in providing reforestation configurations based on multi-criteria spatial analysis. Namely, the integration of social and physical-natural factors provided a basis for spatial analysis, while biological and ecological components allowed refining the selection of sectors with the best territorial aptitude for Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma). This procedure was necessary to achieve ecologically consistent results and to avoid excluding valuable reforestation options a priori.

Likewise, the use of multiple criteria based on distance made it possible to capture the variations of the pixels: fundamental aspects for the construction of the territorial aptitude map. For its part, the distance represents a significant element for the evaluation of the proximity with specific types of biodiversity hotspots and with sources of disturbance such as towns and roads. In this sense, the availability of geographic data played an important role in grouping the criteria.

The adopted valuation enhances the suitability of nearby forests and minimizes the effects of nearby sources of disturbance. In the latter case, viability was very low in all easily accessible areas, leaving them exposed to exploitation. In this sense, for future research it is considered ideal to improve the effectiveness of the methodology, selecting another set of data that is related to the level of adaptability of the species to the conditions offered by the environment.

CONCLUSIONS

The study area consists of an area of 1500 km2 divided into fragmented native forests (253.38 km2) and a homogeneous agricultural-urban matrix of considerable territorial breadth (1246.62 km2). Through the proposal of ecological connectors, the recovery of a total of 143.76 km2 is proposed, with which it is proposed to contribute to the restoration of connectivity; the improvement of terrestrial habitat of the Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma); reducing the negative effects of fragmentation, and conserving biodiversity.

The methodology used for the definition of ecological corridors and buffer zones is one of the few that is based on geographical and biological criteria directed towards the identification of the ideal spaces for the development of the project. Such a methodology is very useful at the level of planning and land use planning.

Although this proposal corresponds to the Bois de rose (Aniba rosiodora), Spanish cedar (Cedrela odorata), Big Leaf Mahogany (Swietenia macrophylla), Ocotillo de Llano (Podocarpus guatemalensis) and Huimbo (Ceiba samauma); species, the methodology used can be adapted to other types of habitats and specimens. Thus, for species or functional groups of species associated with forest ecosystems, it is only necessary to adjust the width of the ecological corridors and the buffer zones to the areas that the species require to develop their habitats.

BIBLIOGRAPHY

- USDA, ARS, National Genetic Resources Program. GRIN National Germplasm Resources Laboratory, Beltsville, Maryland. http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?401553 (Jan 31, 2008)
- Steel Duarte, Luis Enrique. 2000. Trees, People and Customs. Plaza & Janés editors. Colombia S.A. University Francisco Jose de Calda. Bogota
- Varty, N. 1998. Aniba rosaeodora. 2006 IUCN Red List of Threatened Species; downloaded August 20, 2007
- Calderón, E. (compiler) 1997. List of Colombian plants in danger. July 1997 version. Alexander von Humboldt Biological Resources Research Institute. (unpublished).
- Coppen, JJW 1995. Flavors and fragrances of plant origin. FAO, Rome.
- Erfurth, T. and Rusche, H. 1976. The commercialization of tropical wood. FAO, Rome.
- FAO Forestry Department. 1986. Data book on endangered tree and shrub species and their provenance. FAO, Rome.
- IBAMA 1992. Official list of species of flora Brasileira ameaçadas de extinçao (unpublished).
- Kubitzki, K. and Renner, S. 1982. Flora Neotropica: Lauraceae I (Aniba and Aiouea). New York Botanical Gardens, New York.
- Oldfield, S., Lusty, C. and MacKinven, A. (compilers). 1998. The World List of Threatened Trees. World Conservation Press, Cambridge, United Kingdom.
- Pires O'Brien, J. 1997. Additional information on Brazilian tree species.
- Van der Werff, H. 1994. Notes: list of threatened plants in South America.
- Varty, N. 1996. Data collection forms for the Brazilian Atlantic forest species.
- WCMC (comp.) 1996. Report of the Second Regional Workshop, held at CATIE, Turrialba, Costa Rica, November 18-20, 1996. Project for the Conservation and Sustainable Management of Trees (not published).

Thanks to the Ticuna indigenous administrative council for allowing studies in ancient indigenous territories.