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## MULTIVARIATE CHARACTERIZATION OF THE ENTITIES THAT MAKE UP THE PATRIMONY OF NATURAL AREAS OF THE ECUADORIAN STATE: PHASE I

CARACTERIZACIÓN MULTIVARIADA DE LAS ENTIDADES QUE CONFORMAN EL  
PATRIMONIO DE ÁREAS NATURALES DEL ESTADO ECUATORIANO: FASE I

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### Abstract

This study has considered a careful compilation of biotic, abiotic and anthropogenic management data of the Natural Protected Areas of Ecuador (PANE). It aims to create a new space to analyze and discuss the relationship between the most interesting variables in protected areas using multivariate analysis tools, a novel techniques to simultaneously analyze complex and abundant data groups. This paper shows the results of this analysis, discussing both the natural richness and the problems of the different protected areas of Ecuador.

**Keywords:** PANE (Patrimony of Natural Areas of the Ecuadorian State), Cluster Analysis, Management Techniques.

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### Resumen

El presente trabajo ha considerado la compilación cuidadosa de datos bióticos, abióticos, antrópicos y de gestión de las diferentes Áreas naturales Protegidas que conforman lo que actualmente se denomina el Patrimonio de Áreas Naturales del Ecuador. Se pretende, a través del presente documento generar un espacio donde se analicen y discutan las relaciones entre las variables de interés registradas en las Áreas Protegidas, aplicando herramientas de análisis multivariado: una manera idónea con la cual se puede analizar de manera simultánea juegos de datos complejos y/o abundantes. El presente documento muestra los resultados de este análisis, así se discute la riqueza natural y la problemática de las diferentes áreas protegidas. Va dirigido a la sociedad ecuatoriana en general.

**Palabras claves:** PANE (Patrimonio de Áreas Naturales del Estado ecuatoriano), Análisis de Clasificación, Análisis de Ordenamiento.

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# 1. Introduction

The protected areas are areas determined by a state, subject to a legal and institutional label, defined to guarantee the conservation of their particular environmental and cultural riches ([es.wikipedia.org](http://es.wikipedia.org)). They are basically divided into five groups: Areas of Protection of Flora and Fauna, National Parks, Protected Areas of Natural Resources, Biosphere Reserves and Areas of Urban Recreation.

A protected area is commonly defined as: A surface of the earth or sea dedicated especially to the protection and maintenance of the biodiversity and the associated natural and cultural resources, managed through legal means or other effective means ([es.wikipedia.org](http://es.wikipedia.org)), (IUCN, 1994). Therefore, the protected areas are special maintenance territories aimed at the administration, management, and protection of the environment and the renewable natural resources: flora, fauna, and others that reside there.

In this way, the protected areas constitute spaces created by society as a whole, coordinating efforts that guarantee human life and that of other species in conditions of well-being; in other words, the conservation of biodiversity as well as maintaining necessary ecological processes for their conservation.

The natural protected areas have various functions ([www.manejodeareasprotegidas.org](http://www.manejodeareasprotegidas.org); [conservation.org.ec](http://conservation.org.ec)):

- They constitute a strategy to conserve biodiversity and other natural resources.
- They provide alternatives to raise the quality of life in the communities inside and outside their borders.
- They possess a large variety of monetary and non-monetary values which are of importance to the different groups of users and other groups interested in the same.
- They provide goods and services to neighboring communities as well as to other population centers in their zones of influence, sometimes even on a global scale.
- They contribute to humans' well-being since they help to conserve natural resources and

maintain environmental services which sustain the lives of millions of people.

In order for these functions to be attained with spontaneity and harmony, the protected areas have to fulfill a variety of objectives that guide their management, like protection of the environment, contribution to sustainable development, and the provision of recreational and educational services for the visitors. The activities related to these objectives can affect each other and create conflict. Therefore, those in charge of the areas have to exercise effective management, aiming to balance the ecological, social, and economic preoccupations associated with the achievements of said objectives (<http://www.manejodeareasprotegidas.org>).

Ecuador, much like other neotropical countries, is a mega-biodiverse country, due to the variety and variability of its landscapes, ecosystems, and species of flora and fauna. Through an important official effort, neotropical biodiversity, in particular that of Latin America, has, for many decades, intended to be protected through national systems of protected areas, with varying luck and success in each of the countries.

Within this context, the development of different investigations about the structure and functional dynamics of the individual protected areas or as members of a greater management system, results in an important theme for the society that manages it. The new models of management of protected areas should be seen as entities that maintain, to a greater or lesser degree, similarities among themselves, of biological, geographic, or landscaped types, with certain levels of success (and sometimes even failure) of their management activities and management of their ecosystems and resources, the incidence of human activities in them, etc. Therefore, they shouldn't be observed as individual entities, but rather entities related to each other due to particular affinities, which can only be differentiated analyzing their particular characteristics as a whole.

Therefore, the multifactorial analysis of the physical and ecological richness of the protected areas, its situation, its management attributes, and its current problems, is frequently considered a tool, which, if used well, could contribute to the good

management and operation of such areas and of the systems in which they are immersed (Hockings *et al.*, 2000; Honey and Rome, 2001; Quinn, 2002; Worboys *et al.*, 2001).

In Latin America and Ecuador this form of characterization and approaching reality and problems of the national systems of the protected areas is relatively recent. Far from some efforts relatively isolated to characterize such systems as multifactorial, executed in Mexico, Brazil and Chile (<http://www.manejodeareasprotegidas.org>), one could say that very little of this investigation has been executed in the region, so that the present study would constitute a novel way to approach such problems for Ecuador.

It should be mentioned that, in recent years, a lot of very valuable information has been generated, which characterizes the different elements of biotic, abiotic, and anthropic nature, in different protected areas of the Ecuadorian State (PANE) (Ministerio de Ambiente de Ecuador-MAE, 2007b; ECOLAP and MAE, 2007).

Nonetheless, in spite of this grand investigative effort, the documents generated generally concentrate on or work only with protected areas in an individual way, and do not carry out an integrated analysis of the information, in which one can simultaneously observe ecological characteristics, as well as the most relevant management characteristics of the protected area of the PANE, through a methodology that allows observation not only of the situation of the particular protected area, but also what happens with that entity (or a particular group of entities) within a context made up of a total of the heritage protected areas.

In the present project of investigation, this complete panorama was sought after to observe, through the application of multivariate techniques of analysis of information, which permitted the carrying out of the most complete preliminary characterization of the present state of the protected areas which make up the PANE as an integrated and interactive group of fundamental entities, members of National System of Protected Areas of Ecuador (SNAP).

This integral analysis, which included ecological characteristics, management, and contemporary problems of the protected areas, entails a broad value for the Ecuadorian society in general, and for different governmental and non-governmental or-

ganizations, interested in the structural, functional, and managerial dynamic of the entities of PANE in their group.

## 1.1 General Objectives

1. Examine the structural and functional relationships between the different entities which make up the patrimony of natural areas of the Ecuadorian state, in function of the physical, geographical, and ecological characteristics and of the current managerial activities.
2. Distinguish groups of Protected Areas similar in their reality and problems.

## 1.2 Specific Objectives

1. Compile pertinent information of all the current Protected Areas, including physical, geographical, ecological, and management of the area.
2. Systematically apply two multivariate analysis techniques (the other Cluster Analysis and one being Organizational Analysis) to the information of the protected areas of the PANE.
3. Observe, examine, and analyze the tendencies (of the protected areas and of the variables studied) in the results of the two techniques of the PANE.

## 2. Materials and Methods

In its first phase, the project was developed between April 2012 and April 2013 in three stages:

**Stage 1:** Compilation of pertinent information of all the current protected areas within the PANE, of their physical, geographic, ecological nature, and management. For this, the physical and virtual libraries of the Ministry of the Environment (MAE) were visited, as well as the Ministry of Coordination of Natural and Cultural Heritage, the Eco-Ciencias Foundation, and other higher learning centers (see Bibliography). In the case of some of the protected areas, it was necessary to obtain information over the phone or personally at the regional offices of the Ministry of the Environment.

**Stage 2:** The data from the Areas of the PANE were registered and ordered in large matrixes of information (Appendices 1, 2 and 3), to which two techniques of Multivariate Analysis (Cluster Analysis and Organizational Analysis) were systematically applied.

The Cluster Analysis was done using an Agglomerative Method in function of the average union, and having as a measure of reference the Bray-Curtis Dissimilarity between elements (protected areas); the Principal Component Analysis was done based on the Matrices of Correlation or of Co-variance. Both types of methods are thoroughly explained in texts like those by Greig-Smith (1964); Whittaker (1973); Matteucci and Colma (1982); Pielou (1984); McCune (1987); Ter Braak (1987); Digby and Kempton (1991); Fariñas (1996) and Yáñez (1997).

**Stage 3:** This included the observation and/or discrimination of the tendencies found in both types of analyses carried out, as well as the structuring of the conclusions and the respective recommendations, in function of the findings carried out.

### 3. Results and Discussion

#### 3.1 The Protected Areas of Ecuador

The National System of Protected Areas of Ecuador (SNAP) was created in 1976, for the preliminary strategy of conservation of outstanding wild areas of Ecuador, with the purpose being the conservation of the biodiversity and historical cultural heritage, in addition to archeological remains, sites, and settlements of the country (ECOLAP and MAE, 2007).

Currently, SNAP is made up of 46 protected areas that cover more than 5,143,700 hectares of the earth's surface and 13,100,000 hectares of sea surface. The surface of the protected areas on land is equivalent to approximately 19% of the national land territory. The system covers the 24 provinces of the country and it includes a major part of the ecosystems with 42 plant formations, of the 46 existing in Ecuador, with differences in altitude that range from sea level to 6,300 meters (<http://ecuadortouristique.wordpress.com>).

In addition to having a unique biodiversity, the areas of SNAP are a source of key environmental services, particularly those related to sources of

fresh water, which is consumed in different cities of the country, used in hydroelectric plants and in agriculture (ECOLAP and MAE, 2007).

#### 3.2 Management categories of the Protected Areas of Ecuador

Depending on their particular characteristics, the areas of SNAP possess distinct management categories (Gobierno de la República del Ecuador, 1981):

**National Park:** An area with one or various ecosystems, spanning a minimum of 10,000 hectares. Contains an important diversity of species of flora and fauna, geological features, and habitats that are important to science, education, and recreation. The management of the area should be in its natural condition, for the preservation of the ecological, aesthetic, and cultural remains, any exploitation or occupation of it is prohibited.

**Ecological Reserve:** An area of at least 10,000 hectares, with one or more ecosystems with species of wild flora and fauna that are important or threatened with extinction. To avoid this, any type of exploitation or occupation is prohibited. It usually contains singular geological formations in natural or partially altered sites.

**Biological Reserve:** Land or water areas of variable size. The objectives for such areas are oriented primarily to the conservation of the wildlife, as well as natural processes, making the implementation of scientific investigation and educational environmental activities possible.

**National Recreation Area:** An area with a surface of 1,000 hectares or more, where scenic beauty exists, with touristic or recreational resources in a natural environment, and easily accessible from population centers.

**Wildlife Refuge:** An area essential in guaranteeing the existence of wildlife (resident or migratory), it can be used for scientific, educational, or recreational purposes.

**Fauna Production Reserve:** A natural or partially altered area, of variable size, but enough for the development and economic use of the wild fauna.

**Marine Reserve:** A marine area that includes a column of water, sea bed and subsoil that contains predominately natural systems, that is an object to management activities to guarantee the protection and maintenance of its biodiversity, at the same time providing a sustainable flow of natural products, services, and use for the benefit of the community.

**Geobotanic Reserves:** A land area with natural or partially modified ecosystems, but includes singular scenic, geological, and geomorphological beauty.

### 3.3 List and map of the Protected Areas of Ecuador

The following lists the Protected Areas of the PANE in a classified way, by management and organizational category, in function of the time transpired from their official creation, from the oldest to the most recent. Additionally, in Figure 1, one can observe the geographical placement of the majority of them.

#### National Parks

1. Galápagos, 77 years since its creation
2. Cayambe - Coca, 43 (first reserve, currently park).
3. Cotopaxi, 38.
4. Sangay, 38.
5. Cajas, 36.
6. Machalilla, 34.
7. Yasuní, 34
8. Podocarpus, 31.
9. Sumaco Napo - Galeras, 19.
10. Llanganates, 17.
11. Yacuri, 4.

#### Biological Reserves

1. Limoncocha, 28 years.
2. El Quimi, 7.
3. Cerro Plateado, 3.

#### Ecological Reserves

1. Cotacachi - Cayapas, 45 years.
2. El Ángel, 21.
3. Antisana, 20.
4. Manglares Cayapas - Mataje, 18.
5. Los Ilinizas, 17.
6. Mache - Chindul, 17.
7. Manglares - Churute, 17.
8. Arenillas, 12.
9. Cofán - Bermejo, 11.

#### GeoBotanic Reserve

1. Pululahua, 47 years.

#### Fauna Production Reserves

1. Cuyabeno, 34 years.
2. Chimborazo, 26.
3. Manglares del Salado, 11.
4. Reserva PF Marino Costera Puntilla Santa Elena, 5.

#### Wildlife Reserves

1. Paschocha, 17 years.
2. Isla Santa Clara, 14.
3. Isla Corazón y Fragatas, 11.
4. La Chiquita, 11.
5. Manglares Estuario del Río Muisne, 10.
6. El Zarza, 7.
7. Manglares El Morro, 6.
8. Manglares Estuario Río Esmeraldas, 5.
9. Refugio Marino-Costero Pacoche, 5.
10. El Pambilar, 3.

### Natural Recreation Areas

1. El Boliche, 34 years.
2. Parque Lago, 11.
3. Samanes, 3.
4. Isla Santay, 3.
5. Playas de Villamil, 2.

### Binational Park

1. Parque Binacional El Cóndor, 14 years.

### Marine Reserve

1. Galápagos, 17 years.
2. Galera San Francisco, 5.

## 3.4 Variables considered in the current investigation

### 3.4.1 General data of the Protected Areas

Data like the complete name of the area, the initials they are normally known by, the regions of the country they are founding, the time passed since their official creation, the surface area in hectares, their annual minimum and maximum temperatures, the minimum and maximum altitude, the minimum, maximum, and average precipitation, the number of park rangers at the beginning of 2012, and the number of hectares per existing park ranger to the same date was obtained (Appendix 1).

### 3.4.2 Data about the ecosystems in the Protected Areas

In a second matrix, data was registered about the main types of existing ecosystems in each area, using 15 general categories of ecosystems (adapted from that which was proposed by ECOLAP y MAE, 2007): Coastal and Marine Ecosystems (among which include mangrove, coast, intertidal areas, coral reefs, open ocean water); Humid and Tropical Forests and Jungles; Montane and Premon-tane Cloud and Semi-Cloudy Forests; High Andean or Altimontane Forests; Dry Forests and Dry

Bushes; Lagoons, Wetlands and Grasslands, Perpetual Snow, Paramo (Andean Moor); Bushy Paramo; Herbaceous Paramo (with scrublands and moss); Frailejones Paramo; Semidesert Coast; Thickets of Miconia; Pampa and Fern Zones; Scalesia Forests (Appendix 2).

### 3.4.3 Data about the problems and/or realities of management of the Protected Areas

The Protected Areas constitute a notable part of the conservation strategies of a country. Nonetheless, by themselves they are insufficient to guarantee the conservation of species of native and endemic flora and fauna, as well as the necessary ecosystem services.

Due to this, in a third matrix, data was registered about the large problems or realities of management of each Area, considering 16 general categories of problems (obtained after a profound revision of the technical documentation, see Bibliography and occasional interviews): Development of crops within the area and/or progress in the agricultural border; loss of native vegetable coverage, deforestation and extraction of wood; livestock and shepherding activity; erosion; fires and burning of native vegetation; human infrastructure present within the area; invasive/dangerous vegetable species introduced; hunting, fishing and illegal and/or excessive collection of native fauna; shrimp production; petroleum activity and/or extraction of gas; mining activity; solid residues; residual water from populations and industries; demographic growth within the area and/or conflicts for land possession; natural threats-volcanism; management measures considered relative to global climate change.

## 3.5 Multivariate characterization of the Protected Areas

### 3.5.1 In relation to the general aspects of the Protected Areas

After having completed the respective Classification Analysis (utilizing an Agglomerative Method in function of the Average Union, having the Dissimilarity of Bray-Curtis among the protected areas as a reference of measurement [Appendix 1]), the position of the areas is shown in Figure 2.

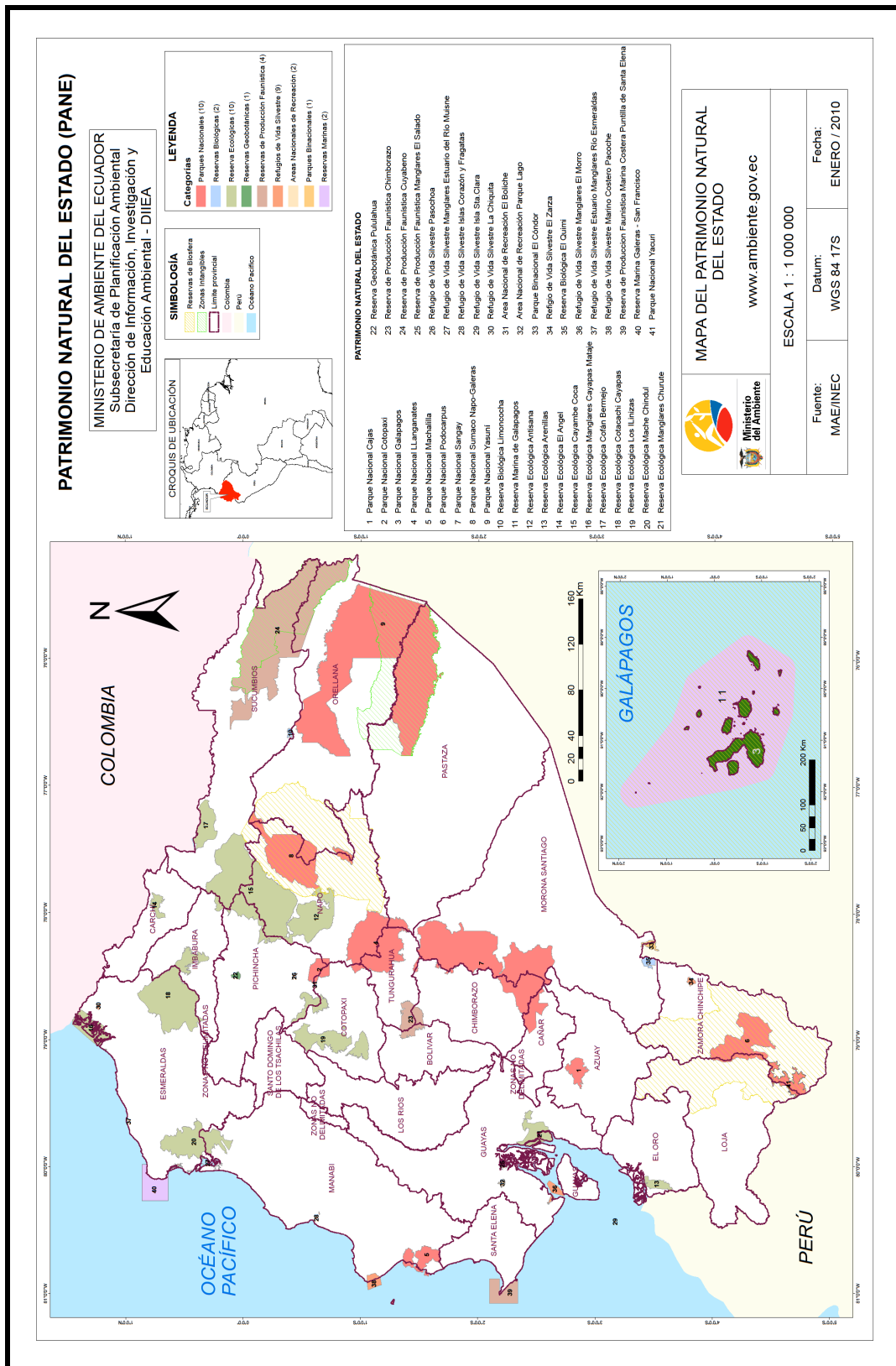
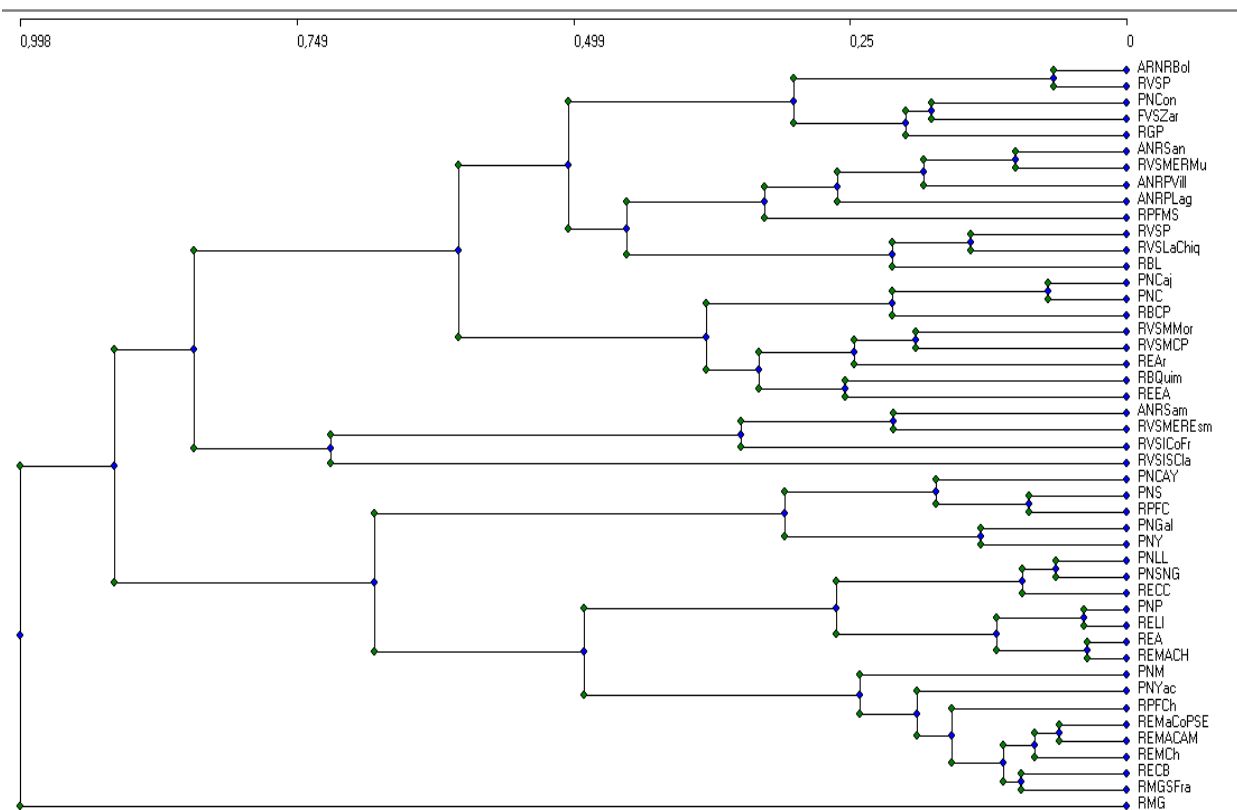


Figure 1. Map of the Protected Areas of Ecuador. Source: Ministry of the Environment of Ecuador. Sub-Secretary of Environmental Planning. Office of information, investigation, and environmental education – DIIEA, 2010.





**Figure 2.** Cladogram of the protected areas of the natural patrimony areas of the Ecuadorian state in function of their ecological, creation, and current management characteristics (Appendix 1).

Note how the conglomerates or clusters were obtained: the first encompasses the protected areas from ANRBol (El Boliche National Recreation Area) to REEA (El Ángel Ecological Reserve); the second includes from ANRSam (Samanes National Recreation Area) to RVSiScla (Santa Clara Island Wildlife Refuge); the third from PNCAY (Cayambe Coca National Park) to RMGSFia (Galera San Francisco Marine Reserve); and the fourth formed only by RMG (Galapagos Marine Reserve).

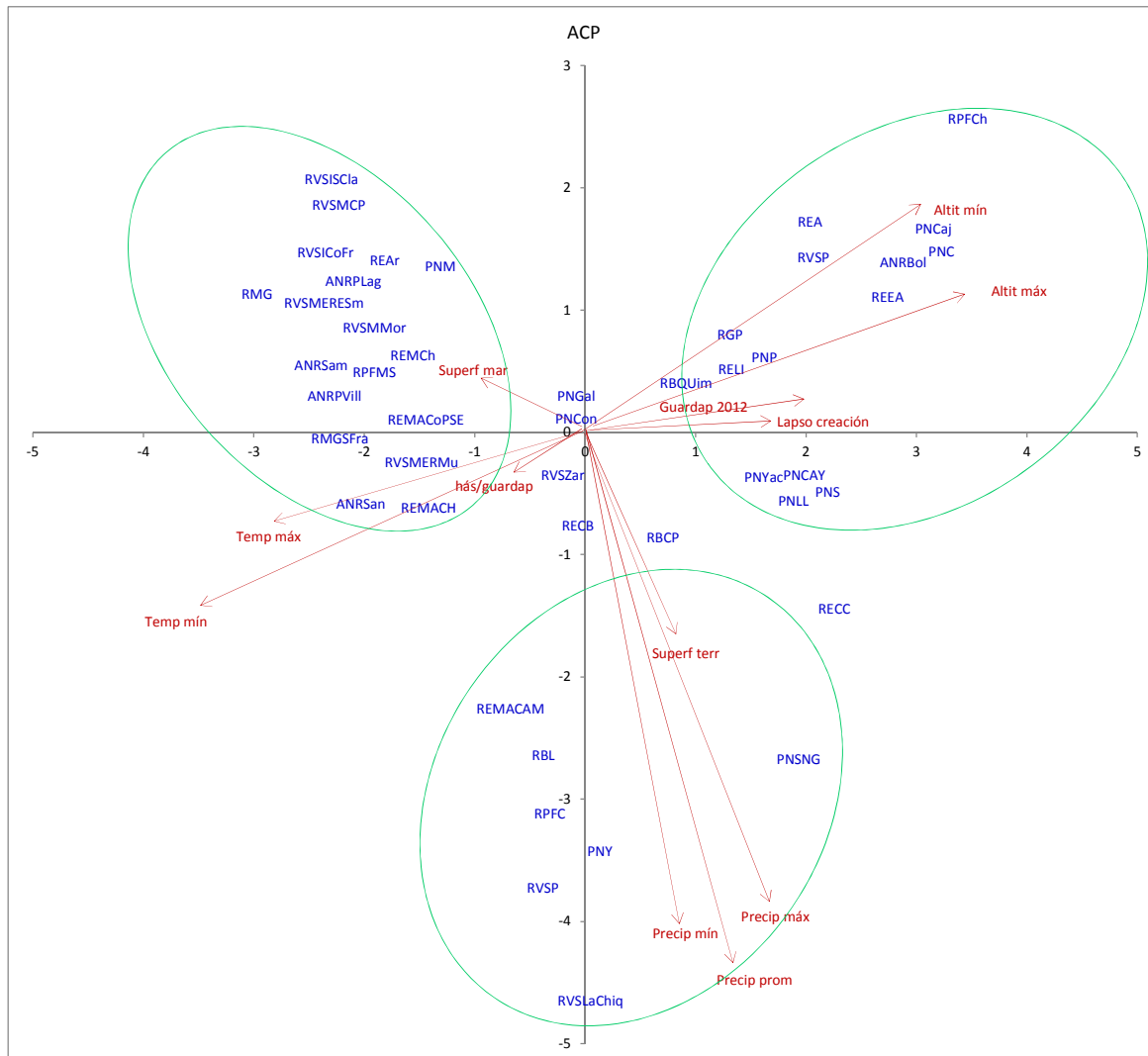
This formation of conglomerates of the protected areas supports their values in relation to their ecological, creation, and current management variables; whose relationships are better appreciated in the organizational graph generated by the Analysis of Principal Components (ACP), based on a Correlation Matrix (Figure 3).

Observe how the more important (longest) vectors chart the position of the protected areas in rela-

tion to them: the Altitude (minimum and maximum of the Area), the age of the protected area (lapse in creation), and the total number of park rangers (2012) are more in the Andean and Altoandina areas (ex.: RPFCh, Chimborazo Fauna Production Reserve; PNCaj, Cajas National Park; REEA, El Ángel Ecological Reserve; among others).

On the other hand, in the lower altitudes, but with higher levels of precipitation and in general with more surface area, were the PNSNG (Sumaco Napo Galeras National Park), PNY (Yasuní National Park), RPFCh (Cuyabeno Fauna Production Reserve) among others.

Finally, with lower altitudes but with lower levels of precipitation, and correlated with higher maximum and minimum temperatures, one can appreciate the protected areas like Machalilla National Park (PNM), Churute Manglar Reserve (RMG) and Samanes National Recreation Area, among others.



**Figure 3.** Organizational graph (based on an ACP) of the different Protected Areas of the Patrimony of Natural Areas of the Ecuadorian state in function of their general ecological, creation, and management characteristics (Appendix 1). Note: F1 (horizontal axis) = absorbed 35% of the variation; F2 (vertical), 30%. (Guardap. is referred to park rangers).

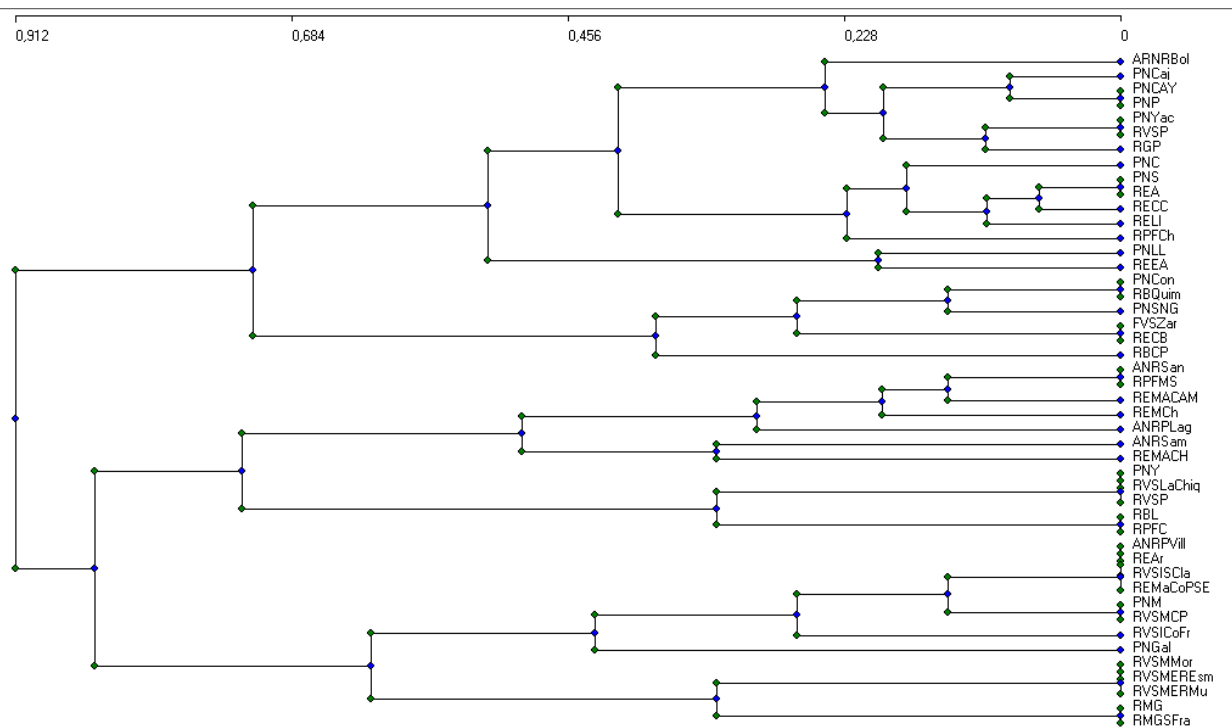
### 3.5.2 In relation to the ecosystems of the Protected Areas

After having completed the respective Classification Analysis (using an Agglomerative Method in function of the Average Union, and having as a measure of reference the Bray-Curtis Dissimilarity between Protected Areas, Appendix 2), the position of the Areas is shown in Figure 4.

Note how four conglomerates or clusters were obtained: the first encompasses the protected areas from ANRBol (El Boliche National Recreation Area) to REEA (El Ángel Ecological Reserve); the second includes from PNCon (El Condor National Park) to

RBCP (Cerro Plateado Biological Reserve); the third from ANRSan (Santay National Recreation Area) to RPFC (Cuyabeno Fauna Production Reserve); and the fourth formed by ANRPVill (Villamil Beaches National Recreation Area) to RMGSFra (Galera San Francisco Marine Reserve).

This formation of conglomerates of the protected areas deals with the values of these elements in relation to the types of ecosystems present or absent in them; whose relationships are appreciated best in the Organization Drawing generated by the Analysis of Principal Components, based on the Covariance Matrix (Figure 5).



**Figure 4.** Cladogram of the Protected Areas of the Natural Patrimony Areas of the Ecuadorian state in function of the presence or absence of different ecosystems in them (Appendix 2).

Observe how the longest vectors (corresponding to the most relevant ecosystems, by their frequency and surface) draw the position of the protected areas in relationship to them: for example, the tropical rainforest is represented by Amazon protected areas like PNY (Yasuní National Park), RPFCh (Cuyabeno Fauna Production Reserve), RBL (Limoncocha Biological Reserve) and also by some coastal areas like REMACH (Mache-Chindul Ecological Reserve) and RVSLaChiq (La Chiquita Wildlife Refuge).

Other protected areas (center right of the organizational graph) represent those in which Andean systems predominate like cloud forests, different types of paramos and permanent snow: RPFCh (Chimborazo Fauna Production Reserve), PNCaj (Cajas National Park), REEA (El Ángel Ecological Reserve), PNS (Sangay National Park), among others.

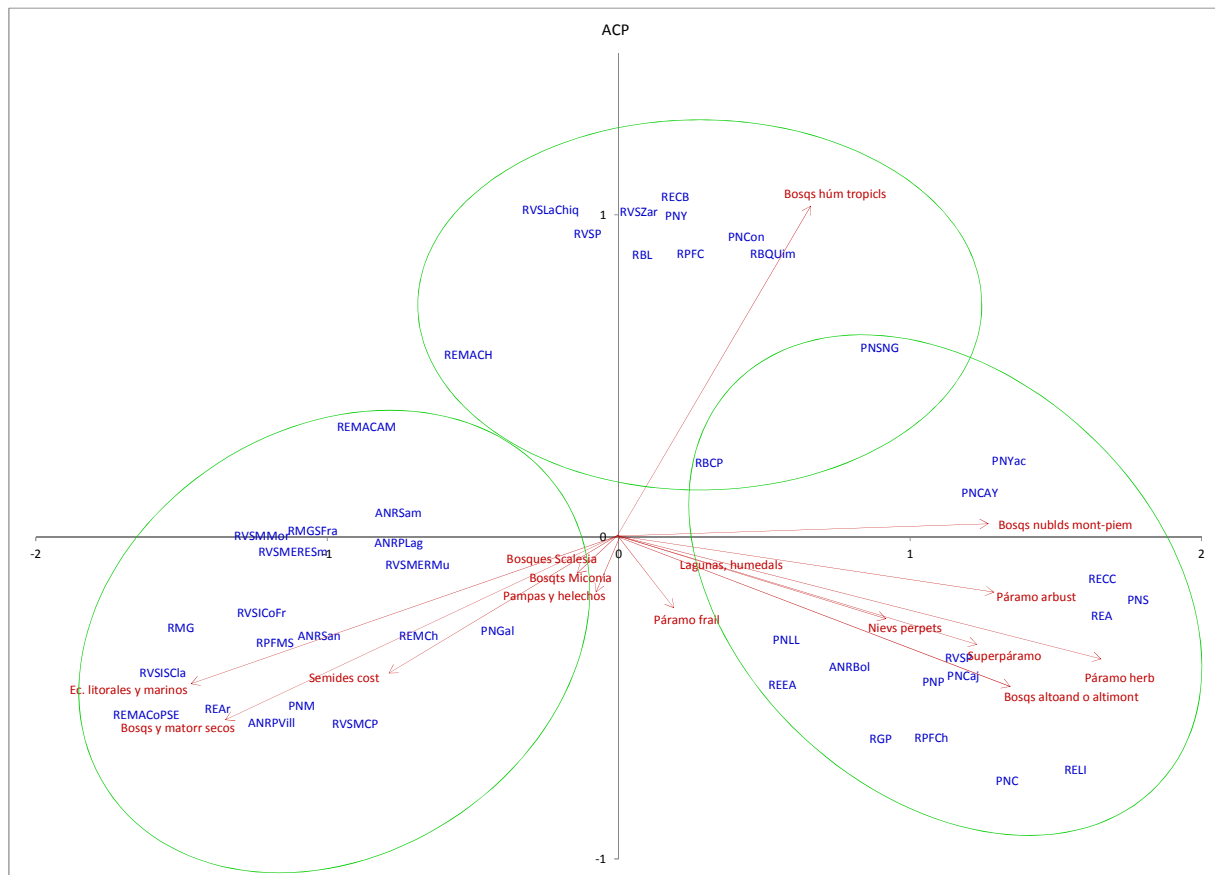
On the other hand, toward the center left of the drawing one can observe those areas that are found strongly associated with ecosystems of dry coastal forests and shrubs, coastline and beaches, coastal semi-deserts, such as: PNM (Machalilla National Park), REAr (Arenillas Ecological Reserve), REMCh

(Manglares-Churute Ecological Reserve), and PNG (Galapagos National Park).

### 3.5.3 In relation to the problems and/or realities of the management of the Protected Areas

After having completed the respective Classification Analysis, (based on a Bray-Curtis Dissimilarity Matrix); considering the problems and/or management realities that occur or not in the protected areas (Appendix 3), and applying an Agglomerative Method in function of the Average Union of the elements or areas, the position of the same is shown in Figure 6.

Note how the three conglomerates or clusters were obtained: the first of them encompasses the Protected Areas from ANRBol (El Boliche National Recreation Area) to RVSP (Pasochoa Wildlife Refuge); the second includes from PNCAY (Cayambe-Coca National Park) to RVSLaChiq (Chiquita Wildlife Refuge); the third from the PNCon (Condor National Park) to RBL (Limoncocha Biological Reserve).



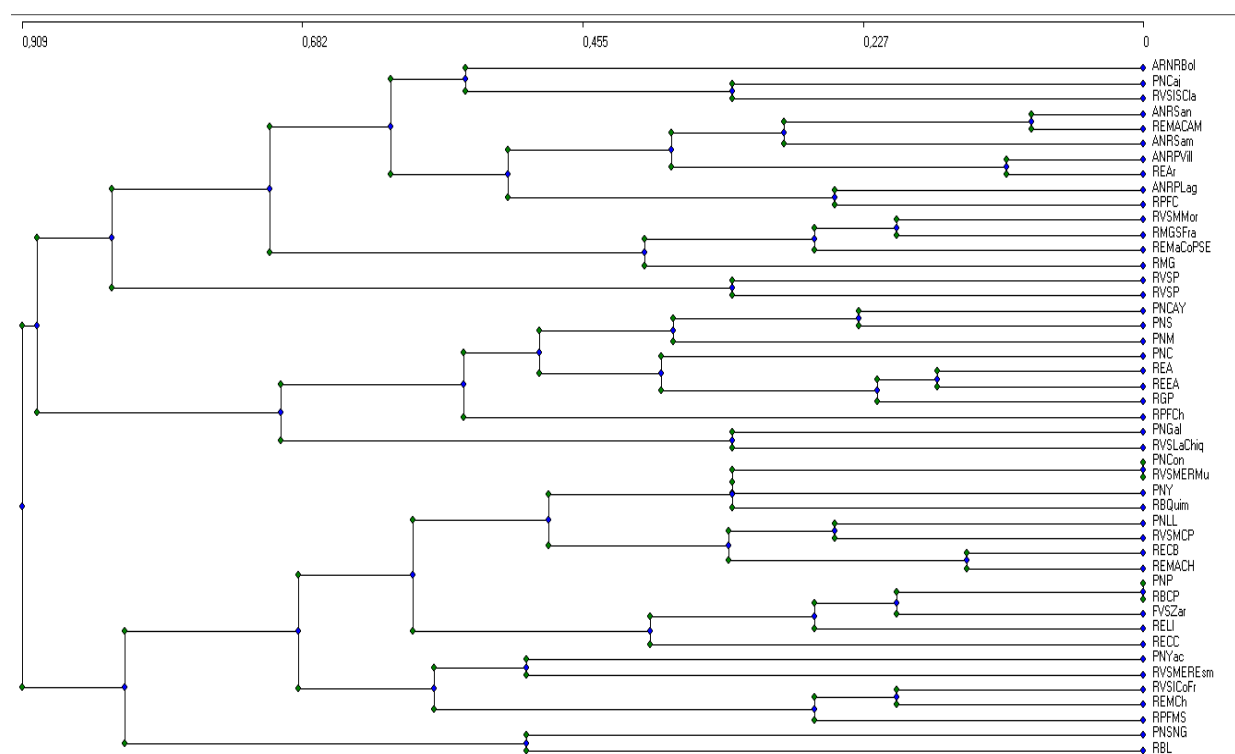
**Figure 5.** Organizational graph (based on an ACP) of the different Protected Areas of the Natural Patrimony Areas of the Ecuadorian state in function of the large types of ecosystems present or absent in them (Appendix 2). **Note:** F1 (horizontal axis) = absorbed 45% of the variation; F2 (vertical), 16%. Bosqs. húm. tropics. refers to tropical rainforest, Bosqs. nublds. refers to cloud forest, lagunas to lagoons, helechos to ferns, matorr. secos to dry shrubs and Ec. litorales y marinos to coastal and marine.

This formation of conglomerates of the Protected Areas deals with the values of these elements in relation to the types of problems and/or management realities in them; whose relationships are appreciated best in the organizational graph generated by the Analysis of Principal Components, based on the Covariance Matrix (Figure 7).

Note how the longest vectors correspond to the most relevant and recurring management issues in the protected areas. For instance, areas like RGP (Pululahua Geobotanical Reserve), REEA (El Angel Ecological Reserve), PNC (Cotopaxi National Park), PNCAY (Cayambe-Coca National Park), PNS (Sangay National Park), RPFCh (Chimborazo Faunistic Production Reserve), and the PNLL (Llanganates National Park), are inherently associated

to fires occurrence, demographic growth inside or at the perimeter of the protected zone, land litigation, stockbreeding and herding, erosion, volcanism, agricultural expansion and introduction of invasive plant species, mainly.

Other protected areas (upper right area of the organizational graph: ANRSam –Samanes National Recreation Area, REMACAM –Cayapas-Mataje Mangrove Ecological Reserve, ANRSan –Santay National Recreation Area, RPFMS –Salado Mangrove Fauna Production Reserve, RVSiCoFr –Corazon and Fragatas Island Wildlife Refuge) actually show another type of problem, related to the contamination from waste water, solid waste, shrimp production, and the loss of native vegetation coverage, mainly.



**Figure 6.** Cladogram of the protected areas of the Patrimony of Natural Areas of the Ecuadorian state in function of the occurrence or not of problems and/or realities of their management (Appendix 3).

Finally, toward the bottom right area, one observes some protected areas like: REMCh (Churute Mangrove Ecological Reserve), PNY (Yasuni National Park), RBL (Limoncocha Biological Reserve), RECC (Cotacachi Cayapas Ecological Reserve), REMACH (Mache Chindul Ecological Reserve), PNP (Podocarpus National Park), PNSNG (Sumaco Napo-Galeras National Park), among others, where the biggest issue revolves around the loss of native vegetation coverage, timber extraction, the development of mining or oil activities, hunting, fishing, and harvesting of wild fauna clandestinely.

## 4. Conclusions and Recommendations

The efforts implemented in Ecuador, in order to preserve the protected areas, like guidelines and policies, community work, declaration of new protected zones, among others, have been weakened due to the impact of environmental and social issues of diverse nature, which prevent the proper manage-

ment of such areas and their constituting ecosystems. Therefore, it is imperative to research more about this topic and bring out the results widely, as to expedite the generation of activities for optimizing the administration of the protected areas in Ecuador.

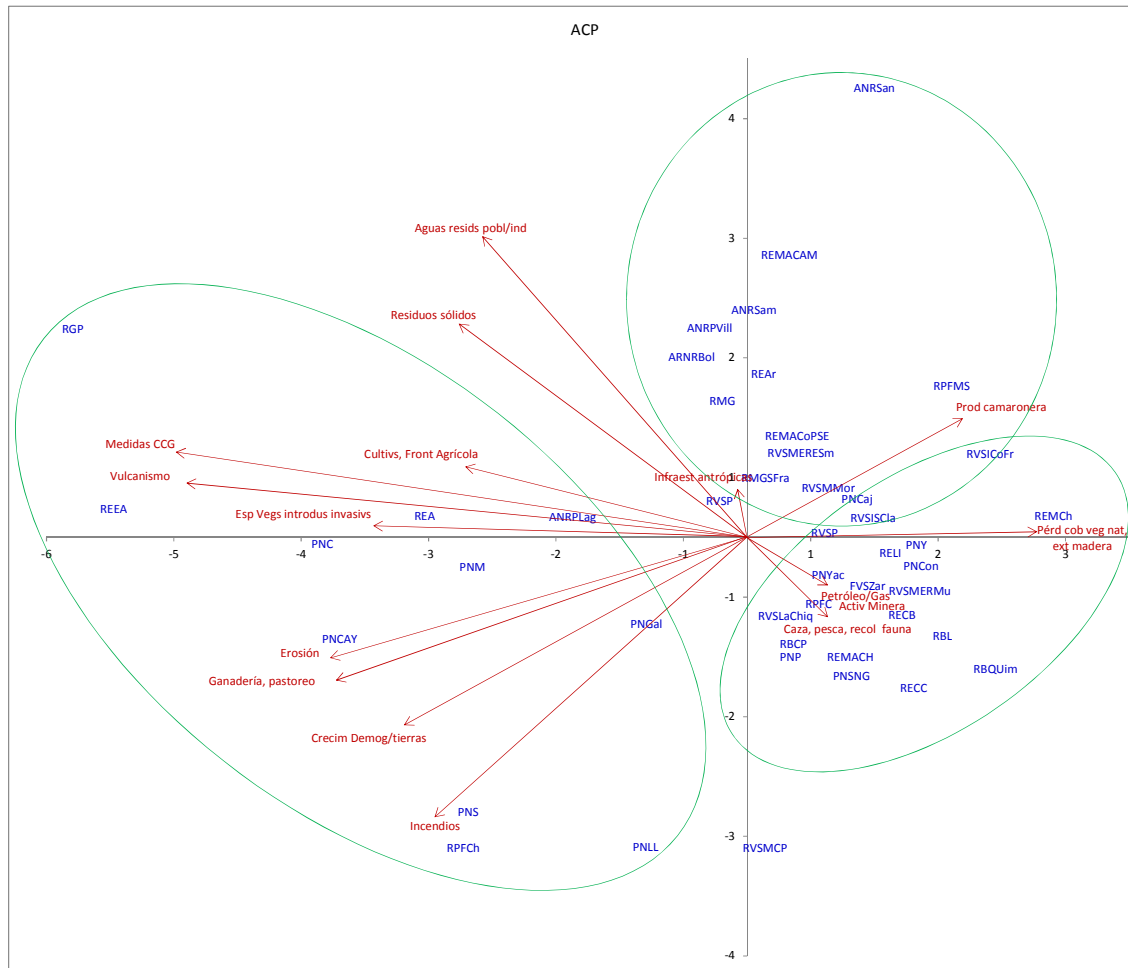
Moreover, in the tropical Andes (the area which encompass the highest index of biodiversity and variety of species with a high population density), there exist serious conflicts between the preservation of native species and human development activities, despite the fact that it is the place where we can find some of the most important biodiversity conservation areas in the planet.

Within this context, the current research constitutes one of the first efforts for characterizing the large system of entities which conforms the Ecuadorian patrimony of natural areas as a whole.

The performed diagnostic should make us think deeply about the necessity to foment and continue with complementary and parallel research to the current one, in order to emphasize the design of contingency measures and the reduction of negative en-

Equally important is to reach a higher level of technical and cooperative integration between the

pertinent governmental and non-governmental instances, in order to start a joint effort that safeguard the integrity of the *National System of Protected Areas (SNAP)* of the country as a whole and the *Patrimony of State Natural Areas (PANE)* of Ecuador in particular.



**Figure 7.** Organizational graph (based on an ACP) of the different protected areas of the Natural Patrimony Areas of the Ecuadorian state in function of the large problems and/or management realities detected in them (Appendix 3). **Note:** F1 (horizontal axis) = absorbed 30% of the variation; F2 (vertical), 24%. Prod. camaronera refers to shrimp production; Pérd. cob. veg. nat ext. maderera to Loss of vegetation cover by logging; Petróleo/Gas Activ. Minera to Oil / Gas Mining Activity; Caza, pesca, recol. fauna to Hunting, fishing, wildlife collection; Incendios to fires; Crecim. Demog/tierras to Demographic growth/lands; Ganadería, pastoreo to stockbreeding and herding; erosión to erosion; Esp. Vegs. introdus invasivs. to introduction of invasive plant species; Vulcanismo to volcanism; Cultivs, Front. Agrícola to agricultural expansion; Residuos Sólidos to solid waste; Aguas resid. to waste water.

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## Appendix

### Appendix 1

Data of creation, location and ecology of the protected areas of the Patrimony of Natural Areas of the State of Ecuador.

No.	Full Name	Typical Acronym	Predominant Region	Timeframe (since 2013)	Land area (ha)	Marine area (ha)	Minimum annual temperature (°C)	Maximum annual temperature (°C)	Minimum altitude (msnm)	Maximum altitude (msnm)	Minimum precipitation (mm/year)	Maximum precipitation (mm/year)	Avg. Pre-cipitation (mm/year)	Park rangers (beginning of 2012)	Hectares/p. ranger (beginning of 2012)
1	Área Nacional de Recreación El Boliche	ANRBol	Central sierra	34	392	0	0	16	3000	3704	1400	1800	1600	10	39,2
2	Área Nacional de Recreación Isla Santay	ANRSan	South coast	3	2214	0	19	37	0	10	500	3400	1900	3	738,0
3	Área Nacional de Recreación Parque Lago	ANRPLag	South coast	11	2283	0	23	27	0	300	600	700	650	3	761,0
4	Área Nacional de Recreación Playas de Villamil	ANRPVill	South coast	2	2478,12	0	20	34	0	100	600	1800	1200	2	1239,1
5	Área Nacional de Recreación Samanes	ANRSam	South coast	3	379,79	0	20	35	10	50	950	1250	1150	6	63,3
6	Parque Nacional Cajas	PNCaj	South sierra	36	28804	0	-2	18	3150	4445	1000	2000	1500	18	1600,2
7	Parque Nacional Cayambe-Coca	PNCAY	North Amazon region / North sierra	43	403103	0	5	25	600	5790	1400	2700	1800	31	13003,3
8	Parque Nacional Cotopaxi	PNC	Central sierra	38	33393	0	0	22	3400	5897	1000	2000	1500	19	1757,5
9	Parque Nacional El Cóndor	PNCon	South Amazon region	14	2440	0	13	23	200	2920	1500	2000	1800	3	813,3
10	Parque Nacional Galápagos	PNGal	Insular region	77	799540	0	19	33	0	1707	200	1700	950	231	3461,2
11	Parque Nacional Llanganates	PNLL	Central sierra	17	219707	0	3	24	1200	4638	1000	4000	2500	8	27463,4
12	Parque Nacional Machalilla	PNM	Central coast	34	56184	14430	22	26	0	840	161	1120	650	22	2553,8

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No.	Full Name	Typical Acronym	Predominant Region	Timeframe (since 2013) since its creation	Land area (ha)	Marine area (ha)	Minimum annual temperature (°C)	Maximum annual temperature (°C)	Minimum altitude (msnm)	Maximum altitude (msnm)	Minimum precipitation (mm/year)	Maximum precipitation (mm/year)	Avg. Pre- cipitation (mm/year)	Park rangers (beginning of 2012)	Hectares/p. ranger (beginning of 2012)
13	Parque Nacional Podocarpus	PNP	South sierra	31	146280	0	6	22	900	3600	1500	3000	2250	17	8604,7
14	Parque Nacional Sangay	PNS	Central sierra/Central Amazon region	38	517765	0	6	24	1000	5230	500	4000	2250	23	22511,5
15	Parque Nacional Sumaco Napo-Galeras	PNSNG	North Amazon region	19	205249	0	6	24	500	3732	2000	5500	3750	13	15788,4
16	Parque Nacional Yacuri	PNYac	South Amazon region	4	73300	0	8	18	2000	3791	750	3000	1900	6	12216,7
17	Parque Nacional Yasuní	PNY	North Amazon region	34	982000	0	24	26	300	600	2800	3200	3000	17	57764,7
18	Refugio de Vida Silvestre El Pambilar	RVSP	North Coast	3	3123,2	0	24	27	140	455	3000	5000	4000	8	390,4
19	Refugio de Vida Silvestre Isla Corazón y Fragatas	RVSICoFr	Central coast	11	750	0	24	29	0	10	400	500	450	5	150,0
20	Refugio de Vida Silvestre Isla Santa Clara	RVSISCIa	South coast	14	5	2	17	32	0	100	110	130	124	2	2,5
21	Refugio de Vida Silvestre La Chiquita	RVSLaChiq	North Coast	11	809	0	22	26	20	120	4000	5000	4600	2	404,5
22	Refugio de Vida Silvestre Manglares el Morro.	RVSMMor	South coast	6	10130,16	0	23	26	0	100	800	1000	900	6	1688,4
23	Refugio de Vida Silvestre Manglares Estuario del Río Muisne	RVSMERMu	North Coast	10	3173	0	23	27	0	10	500	3000	1750	3	1057,7
24	Refugio de Vida Silvestre Manglares Estuario Río Esmeraldas	RVSMEResm	North Coast	5	242,58	0	24	27	0	50	700	740	723	3	80,9
25	Refugio de Vida Silvestre Marino Costero Pacoche	RVSMCP	North Coast	5	13545	0	16	32	0	363	100	500	300	6	2257,5

Continued on next page.

No.	Full Name	Typical Acronym	Predominant Region	Timeframe (since 2013)	Land area (ha)	Marine area (ha)	Minimum annual temperature (°C)	Maximum annual temperature (°C)	Minimum altitude (msnm)	Maximum altitude (msnm)	Minimum precipitation (mm/year)	Maximum precipitation (mm/year)	Avg. Precipitation (mm/year)	Park rangers (beginning of 2012)	Hectares/p. ranger (beginning of 2012)
26	Refugio de Vida Silvestre Paschoa	RVSP	Central sierra	17	500	0	3	21	2800	4210	1000	2000	1500	6	83,3
27	Refugio de Vida Silvestre El Zarza	FVSZar	South Amazon region	7	3643	0	20	25	1400	1680	1900	2100	2000	5	728,6
28	Reserva Biológica Cerro Plateado	RBCP	South Amazon region	3	26114,5	0	10	24	840	3120	2000	3000	2500	3	8704,8
29	Reserva Biológica el Quimi	RBQuim	South Amazon region	7	9071	0	18	14	1700	2480	1500	2000	1800	3	3023,7
30	Reserva Biológica Limoncacha	RBL	North Amazon region	28	4613	0	23	27	200	230	3000	3400	3200	6	768,8
31	Reserva de Producción de Fauna Chimborazo	RPFCCh	Central sierra	26	58560	0	-3	14	3200	6310	900	1100	1000	16	3660,0
32	Reserva de Producción de Fauna Cuyabeno	RPFC	North Amazon region	34	603380	0	23	27	200	300	2800	3200	3000	18	33521,1
33	Reserva de Producción de Fauna Manglares del Salado	RPFMS	South coast	11	5407	0	24	28	0	200	1000	1200	1110	3	1802,3
34	Reserva de Producción Faunística Marino Costera Puntilla Santa Elena	REMaCoPSE	Central coast	5	47447	0	20	26	0	100	600	2400	1500	5	9489,4
35	Reserva Ecológica Antisana	REA	North Amazon region / North sierra	20	120000	0	3	17	1200	5758	300	2000	1200	12	10000,0
36	Reserva Ecológica Arenillas	REAr	South coast	12	17083	0	22	26	0	300	300	1000	650	3	5694,3
37	Reserva Ecológica Cofán Bermejo	RECB	North Amazon region	11	55451	0	17	25	400	2275	1500	3000	2250	10	5545,1
38	Reserva Ecológica Cotacachi-Cayapas	RECC	North Coast / North sierra	45	243638	0	4	24	50	4933	1000	5000	3000	31	7859,3
39	Reserva Ecológica El Ángel	REEA	North sierra	21	15715	0	7	18	3644	4768	1000	2500	1800	10	1571,5
40	Reserva Ecológica Los Iltizas	RELI	Central sierra	17	149900	0	9	22	800	5265	500	3000	1750	10	14990,0

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No.	Full Name	Typical Acronym	Predominant Region	Timeframe (since 2013) since its creation	Land area (ha)	Marine area (ha)	Minimum annual temperature (°C)	Maximum annual temperature (°C)	Minimum altitude (msnm)	Maximum altitude (msnm)	Minimum precipitation (mm/year)	Maximum precipitation (mm/year)	Avg. Pre- cipitation (mm/year)	Park rangers (beginning of 2012)	Hectares/p. ranger (beginning of 2012)
41	Reserva Ecológica Mache - Chindul	REMACH	North Coast	17	119172	0	18	36	150	800	3000	3000	1900	13	9167,1
42	Reserva Ecológica Manglares Cayapas-Mataje	REMACAM	North Coast	18	49350	0	22	27	0	35	2000	4000	3000	6	8225,0
43	Reserva Ecológica Manglares Churute	REMCh	South coast	34	49389	0	26	29	5	600	900	1000	960	11	4489,9
44	Reserva Geobotánica Pululahua	RGP	North sierra	47	3383	0	5	29	1600	3356	500	3000	1750	11	307,5
45	Reserva Marina de Galápagos	RMG	Insular region	17	0	13000000	18	29	0	0	200	1700	950	77	168831,2
46	Reserva Marina Galera San Francisco	RMGSFra	North Coast	5	54604	0	18	36	0	300	500	2500	1500	4	13651,0

## Appendix 2

Data of presence (1) - absence (0) of different type of the principal ecosystems in the protected areas of the Patrimony of Natural Areas of the State of Ecuador.

No.	Full Name	Coastal and marine ecosystems (mangrove, coastal, intertidal zone, coral, open ocean waters)	Tropical humid forest and jungle	Cloud and semi-cloud mountain and foothill forest (premountain)	High-Andean or altimontane forests	Dry forests and brush woods	Lagoons, wetlands, marshlands	Perpetual snow	Superparamo (Large Andean Moor) (Gelidophila)	Bushy paramo (Bushy Andean Moor)	Herbaceous paramo (grassland + musk)	Fraillejon paramo (Andean moor (Fraillejon)	Coastal semi desert	Miconia bosquet	Zone of pampas and ferns	Scalesia forests
1	Área Nacional de Recreación El Boliche	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
2	Área Nacional de Recreación Isla Santay	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
3	Área Nacional de Recreación Parque Lago	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
4	Área Nacional de Recreación Playas de Villamil	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
5	Área Nacional de Recreación Samanes	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6	Parque Nacional Cajas	0	0	1	1	0	1	0	0	1	1	0	0	0	0	0
7	Parque Nacional Cayambe-Coca	0	1	1	1	0	1	0	0	1	1	0	0	0	0	0
8	Parque Nacional Cotopaxi	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0
9	Parque Nacional El Cóndor	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
10	Parque Nacional Galápagos	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1
11	Parque Nacional Llanganates	0	0	1	0	0	1	0	1	0	1	1	0	0	0	0
12	Parque Nacional Machalilla	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0
13	Parque Nacional Podocarpus	0	1	1	1	0	1	0	0	1	1	0	0	0	0	0
14	Parque Nacional Sangay	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0

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No.	Full Name	Coastal and marine ecosystems (mangrove, coastal zone, open ocean waters)	Tropical humid forest and jungle	Cloud and semi-cloud mountain and foothill forest (premountain)	High-Andean or altimontane forests	Dry forests and brush woods	Lagoons, wetlands, marshlands	Perpetual snow	Superparamo (Large Andean Moor) (Geliidofitia)	Bushy Andean Moor)	Herbaceous paramo (grassland + musk)	Traillejon paramo (Andean moor Traillejon)	Coastal semi desert	Miconia bosquet	Zone of pampas and ferns	Scalestia forests
15	Parque Nacional Sumaco Napo-Galeras	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0
16	Parque Nacional Yacuri	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0
17	Parque Nacional Yasuní	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Refugio de Vida Silvestre El Pambilar	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Refugio de Vida Silvestre Isla Corazón y Fragatas	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20	Refugio de Vida Silvestre Isla Santa Clara	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
21	Refugio de Vida Silvestre La Chiquita	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Refugio de Vida Silvestre Manglares el Morro	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
23	Refugio de Vida Silvestre Manglares Estuario del Río Muisne	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
24	Refugio de Vida Silvestre Manglares Estuario Río Esmeraldas	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
25	Refugio de Vida Silvestre Marino Costero Pacoche	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0
26	Refugio de Vida Silvestre Pasochoa	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0
27	Refugio de Vida Silvestre El Zarza	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
28	Reserva Biológica Cerro Plateado	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
29	Reserva Biológica el Quimi	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0

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No.	Full Name	Coastal and marine ecosystems (mangrove, coastal, intertidal zone, coral, open ocean waters)	Tropical humid forest and jungle	Cloud and semi-cloud mountain and foothill forest (premountain)	High-Andean or altimontane forests	Dry forests and brush woods	Lagoons, wetlands, marshlands	Perpetual snow	Superparamo (Large Andean Moor) (Gelidoflora)	Bushy paramo (Bushy Andean Moor)	Herbaceous paramo (grassland + musk)	Frailejon paramo (Andean moor)	Coastal semi desert	Miconia bosque	Zone of pampas and ferns	Scaleia forests
30	Reserva Biológica Limoncacha	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
31	Reserva de Producción de Fauna Chimborazo	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0
32	Reserva de Producción de Fauna Cuyabeno	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
33	Reserva de Producción de Fauna Manglares del Salado	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
34	Reserva de Producción Faunística Marino Costera Puntilla Santa Elena	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
35	Reserva Ecológica Antisana	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0
36	Reserva Ecológica Arenillas	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0
37	Reserva Ecológica Cofán Bermejo	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
38	Reserva Ecológica Cotacachi-Cayapas	0	1	1	1	0	0	1	1	1	1	0	0	0	0	0
39	Reserva Ecológica El Ángel	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0
40	Reserva Ecológica Los Ilinizas	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0
41	Reserva Ecológica Maché - Chindul	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
42	Reserva Ecológica Manglares Cayapas-Mataje	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
43	Reserva Ecológica Manglares Churute	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0
44	Reserva Geobotánica Fululahuá	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0

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No.	Full Name	Coastal and ma- rine ecosystems (mangrove, coast, intertidal zone, corals, open ocean waters)	Tropical humid forest and jungle	Cloud and semi-cloud mountain and foothill forest (premountain)	High-Andean or altimontane forests	Dry forests and brush woods	Lagoons, wetlands, marshlands	Perpetual snow	Superparamo (Large Andean Moor) (Gelidoflita)	Bushy paramo (Bushy Andean Moor)	Herbaceous paramo (grassland + musk)	Frailejon paramo (Andean moor frailejon)	Coastal semi desert	Miconia bosquet	Zone of pampas and ferns	Scalasia forests
45	Reserva Marina de Galápagos	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	Reserva Marina Galera San Francisco	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

### Appendix 3

Data of presence (1) - absence (0) of problems and/or status of management of the protected areas which are part of the *Patrimony of Natural Areas of the State of Ecuador*.

Area No.	Acronym	Crops inside the area and/or advance of the agricultural frontier	Lost of native vegetal coverage, deforestation, wood extraction	Livestock activity and pasturing	Erosion	Fires and burn- ing of native vegetation	Anthropic infrastructures	Invasive or dangerous in- troduced plant species	Hunting, fish- ing and illegal collection of wildlife	Shrimp farming	Oil activity and/or gas extraction	Mining activities	Solid waste	Residual waters of towns and industries	Demographic growth inside the area and/or land litigation	Natural threats; conflicts	Measures around the CCG
1	ARNRBoI	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
2	ANRSan	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0
3	ANRPLag	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0
4	ANRPVill	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
5	ANRSam	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
6	PNCaj	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7	PNCAY	1	0	1	0	0	0	1	1	0	0	0	0	0	1	1	0
8	PNC	1	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0
9	PNCcon	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
10	PNGal	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0
11	PNLL	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0
12	PNM	1	1	1	1	0	1	0	1	0	0	0	1	0	1	0	0
13	PNP	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
14	PNS	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	0
15	PNSNG	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
16	PNYac	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
17	PNY	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
18	RVSP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	RVSiCoFr	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
20	RVSiSCla	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
21	RVSLaChiq	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
22	RVSMMor	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
23	RVSMERMu	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
24	RVSMEResm	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
25	RVSMCP	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0

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Area No.	Acronym	Crops inside the area and/or advance of the agricultural frontier	Loss of native vegetal coverage, deforestation, wood extraction	Livestock activity and pasturing	Erosion	Fires and burn- ing of native vegetation	Anthropic infrastructures	Invasive or dangerous in- troduced plant species	Hunting, fish- ing and illegal collection of wildlife	Shrimp farming	Oil activity and/or gas extraction	Mining activities	Solid waste	Residual waters of towns and industries	Demographic growth inside the area and/or land litigation	Natural threats; volcanicism	Measures around the CCC
26	RVSP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
27	FVSZar	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
28	RBCP	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
29	RBQuim	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
30	RBL	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
31	RPFCh	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0
32	RPFC	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0
33	RPFMS	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0
34	REMaCoPSE	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0
35	REA	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0
36	REAr	0	1	0	0	0	1	0	0	0	0	0	1	1	1	0	0
37	RECB	0	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0
38	RECC	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0
39	REA	1	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1
40	RELI	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
41	REMACH	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0
42	REMACAM	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0
43	REMCh	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
44	RGP	1	0	1	0	0	0	1	0	0	0	0	1	1	1	1	1
45	RMG	0	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0
46	RMGSFra	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0