CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE
Faculty of environmental sciences
Department of Ecology

BIRDS IN THE CANARY ISLANDS, SPAIN: THEIR COLONIZATION, HABITATS AND CONSERVATION

BACHELOR THESIS

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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BACHELOR THESIS ASSIGNMENT

Vela Vela Verónica

Thesis title

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Objectives of thesis

This work has as main purpose to show the changes that have happened in the Canary Islands in recent times as their habitat and biodiversity concerns. More specifically, we will discuss how these changes have affected the Avifauna in the Islands, ie nesting and non-nesting species as well as endemic and invasive species, in order to determinate it's respective protection procedures.

Methodology

Will be prepared a literature review from especially scientific papers and books which will contain:

1. Analyse of how the vegetation in the Canary Island has been changing since the islands were inhabited 2500 yeras ago.
2. Evaluation of the changes in the Avifauna of the islands according to changes in vegetation.
3. Review of the special protection procedures for some endemic birds.

Schedule for processing

Deadline for final text for last revision: April 5th 2014

The proposed extent of the thesis

The thesis will have an extention of approximately 30 pages of text and the rest in the appendix

Keywords

Macaronesia, Oceanic Islands, Canary Islands, Avifauna, Biogeography, Bird colonization

Recommended information sources

DELGADO J.D., ARROYO N.L., ARÉVALO J.R., FERNÁNDEZ-PALACIOS J.M.,2007. Edge effects of roads on temperature, light, canopy cover, and canopy height in laurel and pine forests (Tenerife, Canary Islands). Landscape and Urban Planning 81, 2007: 328–340.

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Electronic apporoval: March 11. 2014

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Dean

Declaration

I declare that this bachelor thesis was written by me and me alone, merely using the cited sources. I agree with the loan of my work and its publication.

In Prague, 16.4.2014 Verónica Vela Vela

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It is my pleasant privilege to acknowledge my sincere gratitude towards my respected teachers for their encouragement, valuable suggestions and constructive criticism. Particularly, I would like to thank my thesis supervisor Dr. Petr Zasadil for his constant advice and supervision during the last months. Also, for his patience I would like to thank my cousin Dr. Felipe Martínez who reviewed earlier drafts of this paper. Last but not least, I would like to express my heartfelt thanks to my family and friends who always have been there during rough times, I'm really thankful for having you in my life.

Abstract

The Canary Islands are a Spanish archipelago strategically situated between Africa, Europe and America. This archipelago consists of 7 principal islands: Tenerife, El Hierro, La Gomera, La Palma, Fuerteventura, Gran Canaria and Lanzarote. The islands origin is volcanic and occurred ~20,5 million years ago during the tertiary. Due to the rugged geomorphology of the islands, the vegetation has a great diversity. The concentric vegetation pattern of the islands consists of six principal levels: Peak vegetation on the top, subalpine scrub, Pine forest at leeward, evergreen forest at windward (Laurel forest and Fayal-Brezal vegetation), Thermophile forest and at coastal level is found the Tabaibal-Cardonal vegetation. With the arrival of the first settlers, the most affected vegetation was the Laurel Forest and the arid and subarid vegetation of Tabaibal – Cardonal. But currently the most degraded are the semi-arid and humid areas of the Thermophile forests. The Canary Islands is characterized by an allopatric speciation. The principal factor that explains the biological richness of the islands according to the short statistic analysis in this work is the total area of each island against the distance from the continent. The distribution of trees and shrubs within the islands was a result of the influence of deterministic factors, but the distribution of birds was caused by random events. Currently the avifauna of the archipelago is less diverse than before the arrival of the first settlers 2.500 years ago. The endemic avian species are 5 and the endemic subspecies are 30. Nature protection in the Canary Islands is given at both national and international level, but still within the protection plans for the Canary Islands, have been found some inconsistencies, because the current Catalog of endangered species in the Canary Islands reduced drastically the number of endangered species and just 2 of the 8 action plans determined for the protection of birds have been approved. The end of this documents deals with the principal recommendations to improve avifauna protection in the Canary Islands.

Keywords: Macaronesia, Oceanic Islands, Canary Islands, Avifauna, Biogeography, Bird colonization.

Abstrakt

Kanárské ostrovy jsou Španělské souostroví strategicky umístěné mezi Afrikou, Evropou a Amerikou. Toto souostroví se skládá ze 7 hlavních ostrovů: Tenerife, El Hierro, La Gomera, La Palma, Fuerteventura, Gran Canaria a Lanzarote. Původ ostrovů je vulkanický, k jejich vzniku došlo přiblížně před 20,5 miliony let v průběhu třetihor. Vzhledem k členité geomorfologii je na ostrovech velmi různorodá vegetace, kterou můžeme členit na šest hlavních výškových stupňů: subalpínská vegetace, subalpínské křoviny, lesy borovice kanárské, stálezelené vavřínové a vřesovcové lesy, teplomilné křovinaté lesy, sukulentový buš a pobřežní vegetace. S příchodem prvních osadníků nejvíce degradované byly vavřínové lesy, sukulentový buš a pobřežní vegetace. Ale v současné době nejvíce degradované jsou teplomilné křovinaté lesy. Kanárské ostrovy se vyznačují alopatrickou speciací. Na základě statistické analýzy uvedené v této práci, je hlavním faktorem, který vysvětluje biologické bohatství ostrovů, celková plocha každého ostrova proti vzdálenosti od kontinentu. Zastoupení stromů a keřů v rámci ostrovů bylo výsledkem vlivu deterministických faktorů, ale výskyt ptáků je výsledkem působení náhodných událostí. V současné době ptactvo souostroví je méně rozmanité než před příchodem prvních osadníků před 2500 lety. Je zde 5 endemických druhů ptáků a 30 endemických poddruhů. Ochrana přírody na Kanárských ostrovech je organizována na národní i mezinárodní úrovni. V rámci plánů ochrany pro Kanárské ostrovy, byly nalezeny některé nesrovnalosti ohledně aktuálního počtu ohrožených druhů ptáků, a jen 2 z 8 akčních plánů určených pro ochranu ptáků byly schváleny. Závěr práce je zaměřen na základní doporučení ke zlepšení ochrany ptactva na Kanárských ostrovech.

Klíčová slova: Makaronézie, Oceánské ostrovy, Kanárské ostrovy, Ptáci, Biogeografie, Kolonizace ptáků.

Contents

Table of Figures

1 Introduction

The Canary Islands has been classified as "fortunate" since historical times. With the greatest biodiversity of the Macaronesian region, is an important study center for many scientist around the world (FERNÁNDEZ-PALACIOS J.M. 2004). The principal studies have focused on the endemic plants, invertebrates and reptiles, but after a relevant discovery in the avifauna of the islands, the interest started to grow (ILLERA J.C et al. 2012; JUAN C. et al. 2000). After the arrival of primitive settlers called "Guanches" about 2.500 years ago and the Spanish colonization in the XV century, the biodiversity of the Canary Islands started to have a complete different appearance. In the beginning, the most affected vegetation was the Laurel forest where the settlers found great living conditions, especially good water sources for cultivation. Nowadays, the most degraded vegetation is the Thermophile forest where is situated most part of the population. As James Lovelock once says: "Evolution of living organisms is so closely coupled with the evolution of their environment, that together they constitute a single evolutionary process" (MARRERO A. 2004). Different cited authors in this work as Sánchez Marco et al. (2010) or De la Rosa et al. (2010) suggest that the avifauna in the Canary Islands before the arrival of humans was quite high but due to different human activities the number of taxa decreased. In order to explore all the possible factors that have influenced the Canarian avifauna, this document explores geography, geology, climate and the different vegetation types of the Canarian archipelago as well as knowledge about the theories of Island Biogeography. Furthermore, gives a look at the different colonization patterns that the bird species used to reach this archipelago and their respective speciation within the islands. The combination of this information allows the author to create a better perspective about the situation of the avifauna in the archipelago. The principal factors that have affected the Canarian avifauna were: The scarcity of fresh water due to the destruction of the laurel forest, hunting, introduction of predators, habitat changes, increasing of contamination and tourism. Nature protection in the Canary Islands is given at both national and international level. The most relevant areas for the protection of birds in the archipelago are: National Parks, the European network of special conservation zones (Natura 2000) which consist of Special Areas of Conservation (ZEC) and Special Protected Areas for Birds (ZEPA) (RODRÍGUEZ ZARAGOZA P. 2006) as well as some worldwide protections programs like the Important Bird Areas (IBA) and the Endemic Bird Areas (EBA) or the Biosphere reserves designed by UNESCO (FERNÁNDEZ-PALACIOS J.M et al. 2008a).

1.1 Aim of thesis

The bachelor thesis researches the habitat and avifauna diversity changes in the Canary Islands since the arrival of the first settlers. Specifically, the document discusses the relation between these changes at the Islands' Avifauna. The research aims to make a contribution with possible new approaches to improve avifauna protection in the Canary Islands.

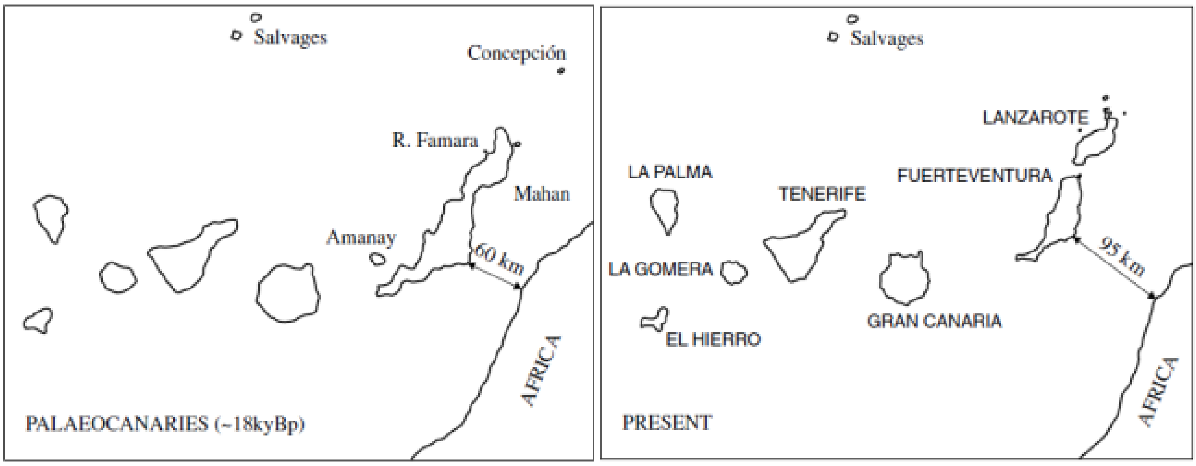
2 Canary Islands

2.1 Geography

The Canary Islands are a Spanish archipelago situated in the Atlantic Ocean between 27°37´ and 29°25´N, and 13°20´ and 18°10´W, northwest of Africa. This archipelago is a roughly linear chain of 500 km long (GEYER A. et al. 2010). It belongs to the Macaronesian biogeographical region along with 4 other archipelagos (Azores, Madeira, Selvagens and Cape Verde). It is strategically situated between three big continents: Africa, Europe and America. This location make the Canary Islands an important study center for many scientist around the world (FERNÁNDEZ-PALACIOS J.M. 2004). At the beginning of times, during the glacial period of the Pleistocene, the level of the sea was much lower than it is now due to the condensation of big portions of water. The African continent and the Canarian archipelago were closer and the islands of Lanzarote, Fuerteventura and their surrounding islets were connected and formed one big island called "Mahan", thus facilitated the colonization of the archipelago (Fig. 2.1) (FERNÁNDEZ-PALACIOS J.M. et al. 2008a).

The archipelago has a total area of 7.447 km^2, consists of 7 principal islands: Tenerife, El Hierro, La Gomera, La Palma, Fuerteventura, Gran Canaria and Lanzarote. There are other 5 islands less inhabited (La Graciosa) or uninhabited (Montaña Clara, Alegranza, Roque del Este, Roque del Oeste). These islands create the Chinijo Archipelago located in the northeastern section of the Canary Islands. Fuerteventura is the closest island to the African coast. It is located about 95 km (Cape Juby). The island La Palma is the farthest. It is situated 416 km from the African coast.

Fig. 2.1 The Canary Islands during the last glacial of the Pleistocene (left) and at present times (right) (FERNÁNDEZ-PALACIOS J.M. et al. 2008a).



Tenerife is the biggest island with an area of 2.034 km^2. It has a pyramidal shape and it has the highest peak of the archipelago named El Teide. This is also the highest elevation in whole Spain with 3.718 m (PALAZUELOS E.R et al. 1981).

Table 1 Geographical features of the Canary Islands (MORALES MATOS G., 2001 ex. FERNÁNDEZ-PALACIOS & MARTÍN ESQUIVEL, 2001).

Island	Area (Km^2)	Altitude (m)	Coastal Perimeter (Km)	Distance to the continent (Km)	Age (Mill. years)
Tenerife	2.034	3.718	269	284	7,5
Fuerteventura	1.655	807	255	95	20,5
Gran Canaria	1.560	1.948	197	196	14,5
Lanzarote	807	670	203	125	15,5
La Palma	708	2.426	126	416	1,5
La Gomera	370	1.487	87	333	12
El Hierro	269	1.501	95	383	0,8
La Graciosa	27,5	266	28	151	0,04
Alegranza	10,2	289	14	168	0,04
Lobos	4,4	122	9	123	0,05
Montaña Clara	1,3	256	4	159	0,03
Canarias	7.447	3.718	1.291	95	20,5

The islands of the Macaronesian region have a volcanic origin from the tertiary in the repercussion of the mobilist geologic revolution. They are relatively young ~20,5 million years. They went through different cathastrophes which create rugged landscapes, greatest biodiversity and the highest number of endemic species of the macaronesian region

(ANGUITA F. et al. 2000). Xerophytic shrublands, pine and laurel forests, lagoons and alpine habitats characterize the Macaronesia region (ILLERA J.C et al. 2012 ex. Gillespie and Clague 2000). The climatological situation and configuration have a deep Atlantic character and their flora and fauna are related with the African and European continents (JUAN C. et al. 2000; PALAZUELOS E.R et al. 1981). The islands stands out of the tropical precipitation zone, they are in a subtropical zone where the water is a scarce resource and a big problem for all the islands, specially the island of Fuerteventura and Lanzarote which have the most arid and dry land. The islands present different microclimates. The combination of the humid trade winds, rugged landscapes and additional dry northwest winds blowing at higher elevation create inversion zones and marked vegetation zones. Some islands, like Tenerife and La Palma, exhibit this phenomenon. (JUAN C. et al. 2000).

The overall population of the islands is 2,117,519 inhabitants (2011). Tenerife is the most populated followed by Gran Canaria. The principal anthropogenic factor influencing the biodiversity is the road fragmentation which has an important ecological impact (DELGADO J.D. et al. 2004). The Canary Islands is one of the 17 autonomous communities of Spain. It is divided into two provinces: The province of Santa Cruz de Tenerife (La Palma, La Gomera, El Hierro and Tenerife) with the capital in Santa Cruz de Tenerife and the province of Las Palmas (Gran Canaria, Fuerteventura y Lanzarote) whose capital is Las Palmas de Gran Canaria, each of the seven principal islands is ruled by an island council named “Cabildo Insular”.

2.2 Geology

2.2.1 Origin

It is important to talk about geology in the Canary Islands, since the diversity of vegetation is directly related with the type of surface where is situated. The possible causes of the origin of a sea island are volcanism, erosion, coral formations or different sediments accumulation over the years. In the case of the Canarian Archipelago, volcanism is the reason of its origin which means that has developed from point zero and every organism that inhabits there arrived by itself despite the distance from the continent (FALINSKI J.B. 1993; HAEUPLER H. 1993). Moreover, the theory of a continental origin of the the islands of Lanzarote and Fuerteventura has been recently rejected (1. FERNÁNDEZ-PALACIOS J.M. 1999).

Since the 19th century, many local geology inconsistencies in the Canary Islands are the central focus for many studies of volcanologist. The most important are: prolonged volcanic activity, geographic and geotectonic situation and morphological and petrological variety. These studies confirm the cause of geodiversity in the island. Wilson (1963) and Morgan (1971) are the first scientists interested in this phenomenon. They improve the hotspot model to explain the creation of a new island. Morgan (1971) includes the Canary Islands in this model (BRITO CASTRO M.C. et al. 2008). Throughout history, discovered evidence develops several models to explain this phenomenon. Each model explains the origin of this archipelago from different approach. Moreover, any of them consolidates a fully proved model. There are still unresolved questions. The most popular theories are: Hotspots and the Propagating fracture.

The classic hotspot or mantle plume model

This model proposes the existence of a thermal plume in the lower mantle, better known as hotspot. The cause of its formation is a columnar elevation of mantle warmer and less dense than the surrounded mantle. It rises from the base of the lower mantle until the lithosphere. The lower prevailing pressure triggers the formation of magma. This results on the rise of the mantle to the surface. The movement of the plate over the thermal plume anchored in the mantle forms the series of volcanic islands; these islands are older as they move away from the thermal focus. The Canaries case presents a plume supposedly located in the African plate and the youngest islands are located on the west part of the archipelago. The arguments to reject this theory relay on the age of the islands. From east to west, the age unapplied to its location (Table 1). There is recent volcanic activity at the island El Hierro, La Palma and Lanzarote. These islands are located completely in the opposite side. However, La Gomera, which is near to El Hierro, is inactive for the last ~ 3 mill.years (BRITO CASTRO M.C. et al. 2008).

The propagating fracture

This model proposed by Anguita and Hernán in 1975 talks about a relation between the Canaries and the Atlas Mountains, postulating that a leaky megashear is connecting both areas. The creation of this model was inspired on the decreasing ages of the islands from east to west and it explains the situation as follows: "The orogenic movement of the Atlas Mountains experiencing a tensional phase would explain the magmatism of the Canaries through decompression melting; when subject to compression, important quiescent periods would ensue" (ANGUITA F. et al. 2000). However, this model lacks to argue the reasons of the undetected submarine fracture between the Canaries and the continent during the seismic exploration (BRITO CASTRO M.C. et al. 2008).

The uplift of tectonic blocks

The uplift of tectonic blocks was based on the different height of each island. Propose that the islands were formed over blocks originated from a compressive tectonics of the African plate due to its low velocity (2 cm/year, compared to the Pacific plate with 10 cm/year) during the tertiary. The volcanic cycles would have coincided with sporadic relaxation of the tectonic stresses allowing the magma to escape (ARAÑA V. et al. 1986).

The intermittent inclined plume or blob model

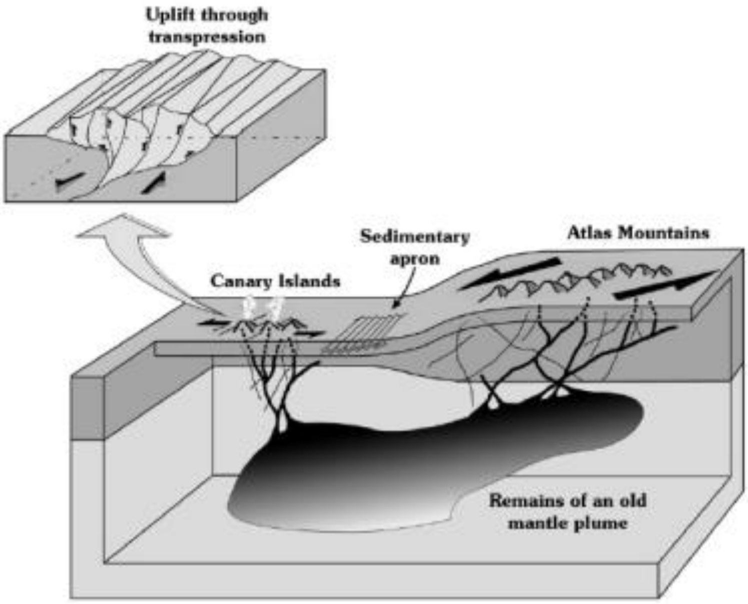
The explanation of the chronological gaps in the Canary Islands rocks was the goal of this theory. The different magmatic cycles and the gaps are the result of geochemical diversity caused by the heterogeneity of the blobs, each blob will reach the surface leading to a volcanic activity and once the blob has run out the volcanism stops and will last until the arrival of the next blob (HOERNLE K. et al. 1993). The mystery of the Canary Islands rocks is that for example the gaps in Gran Canaria last five million years (from 10 to 5 Million years ago); and seven million years (from 12 to 5 Million years ago) in Fuerteventura, while the gaps in Hawaii lasted for just 1 million years (ANGUITA F. et al. 2000 ex. WOODHEAD 1992) .

The unifying model

Anguita and Hernán in 2000 proposed a model unifying the three most important models for the origin of the Canary Islands which are the hotspot, the propagating fracture and the uplift blocks. This theory rejects the idea of a hotspot, because during studies of the lithosphere was demonstrate: first, that there is no dome or bathymetric and gravimetric elevation which is typical for other hotspots and second, that there were no evidences of a reheated lithosphere due to a hotspot.

The explanation of the origin with this theory is that the thermal anomaly is the result of a fossil plume which arrived in the upper mantle near the end of the Triassic (~200 Million years ago); this thermal anomaly has a desk shape very large that includes the Atlas Mountains and reaches the North of Europe. These seismic topographic studios proved that the Atlas Mountains and the Canaries have the same types of structures and that the periods of magmatism in the islands agree with the compression in the Atlas Mountains.

Fig. 2.2 Illustration of the origin of the Canary Island explained by the Unifying model (ANGUITA F. et al. 2000, Fig. 8).



2.2.2 Evolution

The oceanic islands during its evolution suffer two different processes that help on the construction of a perfect environment for the primary succession. The construction processes are those which with the upwelling of new magmatic material help to soften and rejuvenate the landscape and soil, covering cliffs or other extreme landscapes. The destruction processes are the product of continuous erosion caused by water in the soil, wind or the sea creating abrupt terrains. The difference of the Canaries from other volcanic island is that these processes are given simultaneously not consecutively (except on La Gomera where there is no volcanism activity), stimulating the diversity of ecosystems and the conservation of a heterogeneous habitat (1. FERNÁNDEZ-PALACIOS J.M. 1999).

The creation of the Canary Islands happened during four stages about 20,5 million years ago. The first islands reaching the surface were Lanzarote and Fuerteventura (15.5 – 20.5 mill. years) which are the closest to the African continent and Europe and have a shape mainly flat. On the second stage of evolution, the islands of Gran Canaria, Tenerife and La Gomera were born. Gran Canaria "The round island" is the third highest island with 1.948 m.a.s.l and also very old (14.5 mill. years). La Gomera is the wettest island with 12 million years. Tenerife, the most popular island of the Macaronesia with 7,5 million years is the only one that completely has all the biotopes that identify the Canaries and therefore contains the highest biodiversity and number of endemic species also at Macaronesian level. La Palma was born on the third stage of evolution (1.5 mill. years), is the most north-westerly and the second highest island with and elevation of 2.426 m. The last one, El Hierro, is the youngest with 0.8 million years, the smallest one with 269 km^2 and the furthest island from Africa; the whole island is like a crater of a huge volcano (MORALES MATOS G. 2001; PALAZUELOS E.R et al. 1981).

Another important factor that helps to maintain the good state of preservation of the island is the presence of rift zones. "Rift zones are volcano tectonic features that control the development of some insular structures, possibly changing their location rate of activity and configuration as the different islands evolved". This special zones also help to study the special dispersion of volcanism and determinate the statistical probability of an eruption. Only relative young islands with an historic activity have rift zones; a good example is the island of Lanzarote where the rift zones are possibly rejuvenated (CARRACEDO J.C 1994).

In the case of Tenerife, the rift zones appear probably when the island was born and have been improving his shape and structure since then. The principal rift zone of Tenerife is Santiago del Teide Rift (NW - SE); the name of the caldera is Las Cañadas and has 1700 m and the second is called Dorsal Rifts (ENE - WSW). In the southern part of Tenerife is situated a there is a zone that some scientist have classified as third rift zone (N - S) (GEYER A. et al. 2010).

2.3 Climate

The Canarian archipelago has always been classified as "fortunate" since historical times. Is situated on the tropic of cancer and has a subtropical maritime climate, a factor that constantly influence on the diversity of the islands, even among them, in addition to other factors like humidity, pressure, altitude, exposition and temperature as well as precipitation, ocean currents and winds. The Canaries are surrounded by a cold oceanic current coming from the Gulf current, called the Canary current which flows from Northeast to Southwest until African shores. Once the current make contact with the Canary archipelago, its velocity starts to increase until 60 cm per second forming swirls. This current, helps to attenuate the temperatures on the islands; without its effect, the temperatures would be much higher (MORALES MATOS G. et al. 2000; PALAZUELOS E.R. et al. 1981). The climate of the Canary Islands, like the rest of the oceanic islands which form the Macaronesia, is totally conditioned by the climate of the Central Atlantic and by a practically nonexistent continental shelf. The Ocean permanently influence the temperature gradients, making shorter the amplitude variation between day and night, and so, summer and winter (DE LUQUE SÖLLHEIM A.L. et al. 2011). In winter the Islands are frequently under the influence of monsoon streams produced between the north of Africa and the ocean, in summer the winds are always warm but in autumn and spring are warm just when these winds have its origin in Sudan or the center of Sahara, sometimes winds from the Sahara blow to the islands accompanied with sand and dust forming clouds everywhere with an altitude sometimes of 4000 m. In autumn these winds are stronger and can cause big disasters in the agriculture, but are no very common (ORTUÑO MEDINA F. 1980; SUCHODOLETZ H.V. et al. 2013).

The winds that mainly influence the atmosphere of the archipelago are the trade winds which occur 50% of the time in winter and almost the 90% in summer. The influence of trade winds on the Canaries is relevant over all the characteristics of the islands, special its vegetation. These winds coming from the northeast with a cool and wet stream an altitude between 1000 – 1500 m.a.s.l and over this stream, another against it from the northwest with a warmer and drier character at an altitude of 2500 – 300 m.a.s.l. This situation cause a thermal inversion with a temperature variation of at least 10°C where the humidity cannot reach enough elevation to condense and become precipitation, so the result of this phenomenon is a cloud-sea or in Spanish "Mar de nubes“ characteristic of all the islands higher than 1500 m. It‘s curious to know that the altitude changes its effects on the temperate when it approximates to

500 m.a.s.l. Normally the temperature will decrease 1°C when the altitude increase 100 m but in this case the process is interrupted at the beginning of the cloud-sea and continue like that until 1500 m.a.s.l. When the polar winds reach the islands in any of its forms, break the compact barrier of the cloud sea producing big precipitations (MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980). The combination of relief and trade winds gives to each island a unique vegetation character. The relative humidity of each island is determinate by its position against the trade winds; the places situated at windward are less dry than the places at leeward where the conditions change radically during summer (FERNÁNDEZ-PALACIOS J.M. et al. 2008b).

Fig. 2.3 The cloud sea "Mar de nubes" caused by thermal inversion (Tenerife).

Thanks to the relief not all the islands are as dry as Lanzarote and Fuerteventura; the altitude plays an important role on the concentration of humidity which is bigger at higher altitudes (FERNÁNDEZ-PALACIOS J.M. 1993a). But the location of the Island in this situation is also important, otherwise the islands in Cabo Verde (which are drier), will have the same appearance of the Canaries, that's why the Canary archipelago is called "fortunate". The high altitude of the islands and its relief makes possible the existence of four different climatic zones. The first one is the lower zone, reaching altitudes of 500 m when is situated at windward, and altitudes of 1000 m at leeward; is the drier one similar to a tropical zone where the evaporation is 10 times higher than the precipitation and the vegetation is mainly xerophytic. The second zone is the cloudy zone situated between 500 – 1500 m only where the trade winds have a direct effect, so the precipitations increase and the evaporations decrease creating a moderate temperature conditions facilitating the existence of mesophile vegetation. The temperature rapidly increase as it begins the entrance to the third zone with a continental character, situated right in the end of the cloud-sea at 1500 m when the altitude starts influencing the temperature normally again; there the precipitations decrease under 500 mm. The last zone is the subalpine zone over the 2200 m, the characteristics of this zone are: dry air, relative humidity below 50%, precipitation rate of 300 mm which most often occur as snow and high evaporation. Only the islands of Tenerife, La Palma and Gran Canaria have developed all of these climatic zones while La Gomera and El Hierro just until the cloudy zone and Fuerteventura and Lanzarote just the first climatic zone (ORTUÑO MEDINA F. 1980).

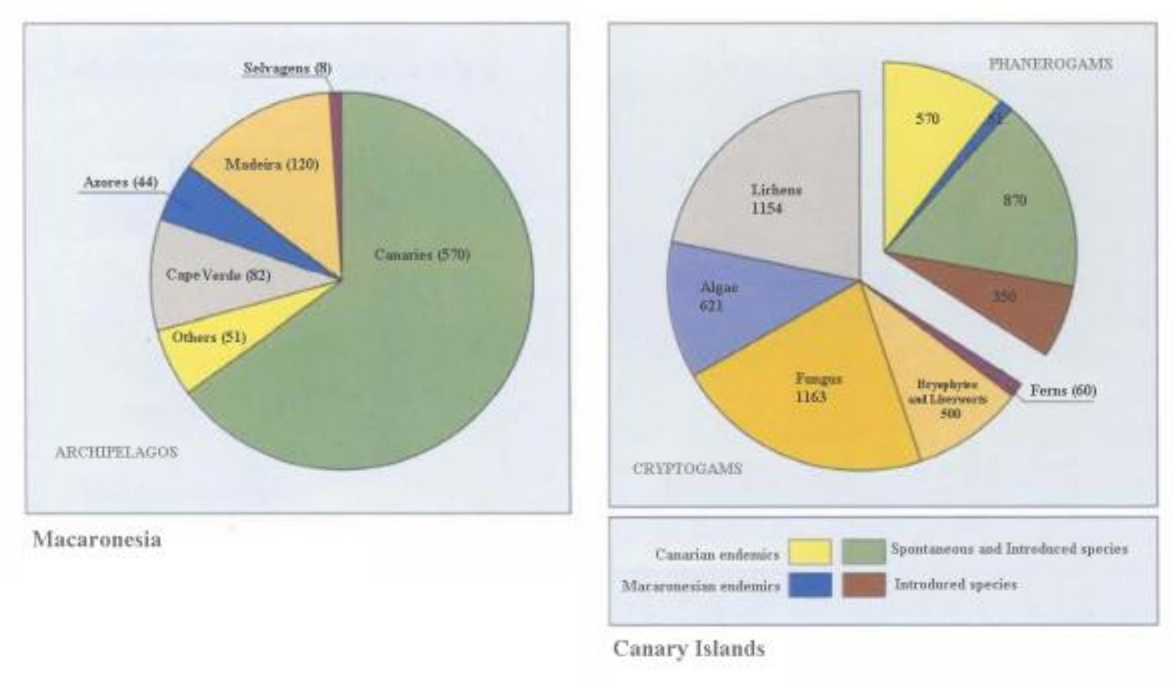
3 Vegetation and its changes over time

The vegetation of the island has a key role in the avifauna population of the archipelago. This part of the document summarizes the biodiversity of vegetation in the islands. As it was mentioned before, water is a scarce source in the islands. The problem increased in the XV century when the Spanish colonizers arrived to the archipelago. The first settlements of population were near to the cloudy zone of the islands where the laurel forest was situated in big proportions. This zone was selected also for agriculture because of the great conditions of its soil where dryland farming was introduced and in addition to wood exploitation caused almost the destruction of the laurel forest (ORTUÑO MEDINA F. 1980).

The main source of water in the islands comes from the horizontal rain. The water is captured by the forest when the humidity condenses over its leaves. In a year, this process can produce almost 2.763 liters of water that produce a constant stream of water for all the zones in the island. All the islands have a basin character, but El Hierro is specially characterized because has two deposits of water which are used as a source for all the islands (ORTUÑO MEDINA F. 1980).

The flora in this archipelago is divided into cryptogams; plants that reproduce by spores without flower or seeds (lichens, fungi, algae and bryophytes) and phanerogams or spermatophytes which produce seeds (ferns and higher plants). The flora consists of about 2000 species divided among native, introduced and plants with an undefined status. During the last 2500 years, the islands have been occupied and influenced with introduced species, but the people before the colonization barely left a trail of destruction in the habitat, it began with the arrival of Europeans. 350 species from the total, are introduced with a known origin, a number of 300-400 species are not fully classify into native or introduced due to little information about them, the native species which may have arrived spontaneously have a total number of 1300 and 40% of it are exclusive from the archipelago. The Canarian archipelago is so, the richest archipelago with the biggest number of exclusive species from the Macaronesia, almost 70% (MORALES MATOS G. et al. 2000). The Canary Islands have a concentric vegetation pattern (FALINSKI J.B. 1993) with six principal levels. On the top is found the peak vegetation and lower the subalpine scrub, then the pine forest (mainly situated at leeward), at windward the evergreen forest, in the middle the thermophile forest and at coastal level is found the arid and sub arid scrub called Tabaibal-Cardonal (MORALES MATOS G. et al. 2000).

Fig. 3.1 This diagram shows the composition of the flora in the Macaronesian region (left) and in the Canary Islands (right). The flora in the Canary archipelago is divided into cryptogams and phanerogams (spermatophytes) and represents almost 70% of the endemic species in the Macaronesian region. Modified from the original diagram in MORALES MATOS G. et al. 2000.



3.1 Tabaibal-Cardonal Vegetation (Arid and sub-arid scrub)

This vegetation is found in the lower and coastal areas of the islands, reaching 700 m above sea level. Is one of the most representative vegetation types of the Canary Islands due to the extremely xerophytic character and its sensibility, with low scarce precipitations and high evaporation, together with the laurel forest, are the most destroyed flora of the Canaries. Its flora is related to the flora in some places of northern Africa like Morocco (MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980; RÜDIGER O. et al. 2007). Long time ago before the colonization, islands like Lanzarote and Fuerteventura, had a vegetation climax in this zone, but with the establishment of populations in the XV century, this vegetation was affected with increasing of contamination, nitrification, as well as maritime commercial activities, tourism and different water harvesting techniques for banana and tomato plantations (ORTUÑO MEDINA F. 1980; RÜDIGER O. et al. 2007). Currently, this area is so degraded that from the extensive belts of Tabaibal and Cardonal that covered the coastal areas, just remains a bunch of stains and traces of this vegetation, making almost impossible to establish a relevant space for its protection.

The flora in this zone is quite high and mainly characterized by the genus *Euphorbia*, some of the plants are: *Euphorbia balsamifera*, *E. atropurpurea*, *E. regis-jubae*, *E. canariensis, E. aphylla* and *E lamarckii* (colonized most of the places affected by degradation) as well as other genus of plants like: *Opuntia*, *Agave*, *Aeonium* and also plants like *Astydamia latifolia, Frankenia ericifolia,* among others (FERNÁNDEZ-LUGO S. et al. 2009; MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980; RÜDIGER O. et al. 2007). The avifauna in this zone is also high, characterized mainly by xerophile, halophile and coastal species. Some typical species are: The Trumpeter Finch (amantum) - *Bucanetes githaginea amantum*, the Lesser Short-toed Lark and the subspecies - *Calandrella rufescens rufescens* (Tenerife I.) or *Calandrella rufescens polatzeki* (Gran Canaria, Fuerteventura and Lanzarote), the Hoopoe – *Upupa epops,* the Eurasian Thick-knee (Western Canarian) - *Burhinus oedicnemus distinctus,* the Canary Islands Chat (Fuerteventura) - *Saxicola dacotiae dacotiae* (Fuerteventura). Other species live on the edge with other vegetation and therefore form part of both, for example: The Berthelot's Pipit (nominate) - *Anthus berthelotii berthelotii*, the Grey Wagtail (Canarian) - *Motacilla cinerea canariensis*, the Eurasian Linnet - *Carduelis cannabina meadewaldoi* (Tenerife) and the Eurasian Linnet (harterti) - *Carduelis cannabina harterti* (Lanzarote). Some species here are endangered like the Houbara Bustard - *Chlamydotis undulata fuertaventurae* (Fuerteventura and Lanzarote), the Black-bellied Sandgrouse - *Pterocles orientalis orientalis* (Fuerteventura I., Iberian Peninsula and Morocco to w Iran) and the Cream-colored Courser (bannermani) - *Cursorius cursor cursor* (Canary Islands, North Africa, Arabian Pen. and Socotra I.) (ALAMO TAVIO M. et al. 1991; (Avibase 2013; GÓMEZ P.M. et al. 1987).

Fig. 3.2 Distribution of vegetation in an idealized Canary Island (JUAN C. et al. 2000).

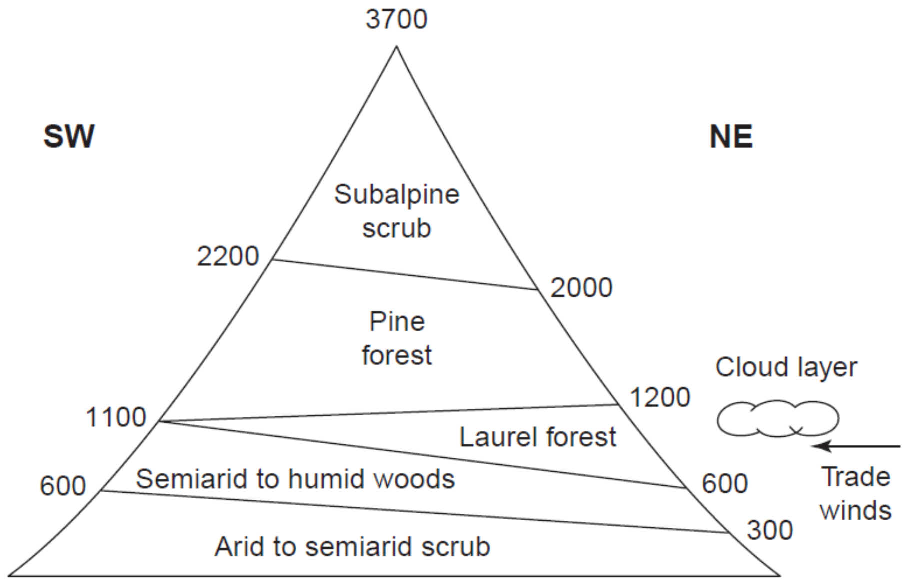
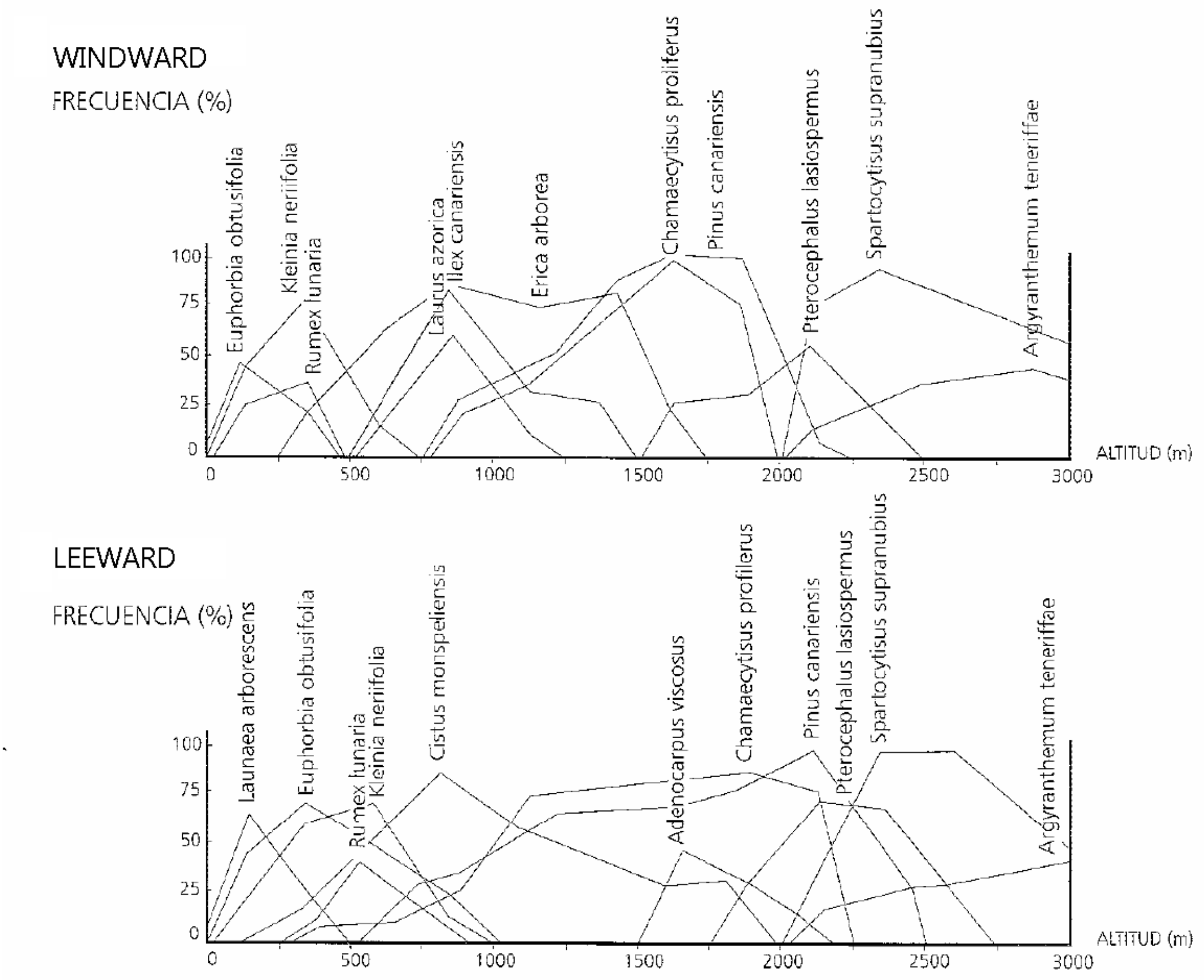


Fig.3.3 Altitudinal distribution of the most frequent species of plants in Tenerife (FERNÁNDEZ-PALACIOS J.M. 1999).



3.2 Thermophile forest (Semiarid to humid woods)

The distribution of this forest depends on its location within the island. At leeward where the conditions are drier due to the absence of trade winds, the forest can reach altitudes from 700 to 900 m under the dry pine forest, but the zones at windward with high levels of humidity just reach altitudes of 200-500 m under the evergreen forest and above the coastal vegetation. This vegetation zone is characterized for a dense understory (250-450 mm) and temperatures between 8°C and 15°C, the flora is composed by some tree species and scrubs. The more representative and better conserved plant communities during time are: Junipers (*Juniperus phoenica L.*) with big populations in El Hierro and La Gomera and less conserved in Tenerife, Palms *(Phoenix canariensis)* situated where the humidity is higher and is better conserved in the islands of La Gomera and Gran Canaria, Dragon trees *(Dracaena draco)* a damaged vegetation that cannot be seen in large numbers because is scattered throughout the island in small groups or single exemplars, also the Olive trees *(Olea europaea)* and the *Pistacia lentiscus* trees. In northern parts, these communities are usually found mixed, but in drier parts with rocky character in the north, can be found specific communities of junipers like *Juniperus turbinata spp. Canariensis* (FERNÁNDEZ-PALACIOS J.M. et al. 2008b).

Nowadays, because these are the most inhabited territories, the vegetation is very degraded, as can be seen in the islands of Fuerteventura and Lanzarote where in the past, their tops were covered by this vegetation with thermophilic subhumid character, but today is practically gone and the islands of La Gomera and El Hierro maintain the best conserved communities. The substitution vegetation is shaped by plants like: *Rhammus cremulata, Hypericum canariense, Cistus monspeliensis, Euphorbia lamarckii, E. regis-jubae, Artemisia thuscula* and *Rumex lunaria.* Despite the scarce character of the vegetation at present times due to the water stress of the mediterranean climate present in the zone, has a great diversity of species both flora and fauna (FERNÁNDEZ-PALACIOS J.M. et al. 2008b; MORALES MATOS G et al. 2000).

The bird diversity in thermophile forest is mainly supplemented by habitats around it, because thanks to the ecotone or transition character of the thermophile zone, the birds from the coastal zone and the evergreen forest are always connected. The uneven character in the distribution of this vegetation helps the mixture between the endemic bird species and the surrounded avifauna. This mixture starts to be an essential part of this zone and so is classified as part of it. The junipers vegetation is an important element that preserves the diversity of this zone, because the dense cover of the vegetation is used as bird refuge for endangered species like the White-tailed Laurel Pigeon - *Columba junoniae* or cliffs with junipers are nesting places for birds like: the Common Kestrel – *Falco tinnunculus*, the Barbary Falcon - *Falco pelegrinoides* or the Eurasian Buzzard - *Buteo buteo*, etc. Other generalist species also prefer this zone for its density, like the Sardinian Warbler - *Sylvia melanocephala*, the Blackcap - *Sylvia atricapilla*, the Plain Swift - *Apus unicolor* or the Common Raven - *Corvus corax.* Dominant bird species in this zone are: The Canary Islands Chiffchaff - *Phylloscopus canariensis*, the Island Canary - *Serinus Canaria*, the Tenerife Blue Tit or African Blue Tit which has two other subspecies found in the Canary islands: *Cyanistes teneriffae teneriffae* (La Gomera and Tenerife) and *Cyanistes teneriffae hedwigii* (Gran Canaria), the European Goldfinch - *Carduelis carduelis* and the European or Tenerife Robin - *Erithacus rubecula*, among others (FERNÁNDEZ-PALACIOS J.M. et al. 2008b).

3.3 Evergreen forest “Monteverde” (Laurel forest and Fayal-Brezal)

The evergreen forest is situated in the highest islands within the cloudy zone at windward and has two principal types of vegetation, the laurel forest (trees with 10-15 m of altitude) and another type of vegetation with poorer cover called Fayal-brezal. The Laurel forest located between 600 to 1200 m above sea level, is characterized by high humidity (80%) and less xerophytic character than the Fayal-brezal vegetation, is a forest of Mediterranean tertiary ancestors who occupied southern Europe and north Africa about 20 million years ago (MARRERO A. 2004 ex. Depape 1922; SANTOS GUERRA A. 1990).

The laurel forest contains the greatest diversity of trees and scrubs of all the Canary Islands (MORALES MATOS G. et al. 2000), although the understory zone is much poorer than in the thermophile forest, being dominated by cryptogam plants like ferns, lichens and mosses due to its dense cover (80%) (DELGADO J.D. et al. 2007; MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980). The most important density was reach on the central and western islands of the archipelago, but has been reduced due to the degradation with dryland farming. Currently, the best conserved areas are situated in Tenerife, La Palma, La Gomera and El Hierro.

The typical vegetation in this zone is formed by: *Laurus azorica, L. novocanariensis, Erica scoparia, E. arborea, Ilex canariensis, Prunus lusitanica, Persea indica, Apollonias barbujana* and *Ocotea phoetens,* etc (ABOAL J.R. et al. 1999; ARÉVALO J.R. et al. 2008; FERNÁNDEZ-LUGO S. et al. 2009; MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980).

The Avifauna that inhabit this forest is characterized by having two main preferences: First, those birds mainly generalists that haven't been deeply affected by the edge effects of roads but instead have found nice environments for setting and have adapted to them, and second, those specialist birds that prefer the forest interior where the anthropological effects do not have such impact over them. However, the species along road edges are also further affected by nest depredators like the endemic lizards *(Gallotia galloti)* or by loss of breeding habitats, but even under these conditions, this zone shows higher diversity than in the forest interior; here the predominant birds are passerines: the Blue Tit - *Parus caeruleus*, the Eurasian Blackbird - *Turdus merula*, the European Robin - *Erithacus rubecula*, the Island Canary - *Serinus canaria* or the Chaffinch - *Fringilla coelebs.* On the other side, species like the Goldcrest - *Regulus regulus* or the Dark-tailed Laurel Pigeon - *Columba bollii* are more specific about their habitat and are attached to the forest interior (DELGADO J.D. et al. 2004; DELGADO J.D. et al. 2007). As this distribution of birds show us; the hypothesis postulated by De Graaf in 1992 saying that the ecotone zones with major disturbance shows higher levels of diversity and density of species is confirmed. Thanks to the diversity of bird species and their constant dispersion, the laurel forest has been renovating its vegetation mainly by the slow but effective process of re-seeding at least in the island of Tenerife (ARÉVALO J.R. et al. 2008 ex. CARVALHO 2002).

The vegetation Fayal-brezal situated above the cloudy zone as a transition bridge to the continental zone has spread in recent years as it has colonized degraded areas of laurel forest. This vegetation has been better preserved by people since the first settlements, because is a source of many useful materials for agriculture like cuttings or rods. Characteristic of this zone are plants like *Myrica faya* (present also in the laurel forest), *Erica arborea* (with xerophytic characteristics) and *Ilex canariensis*. In the islands of Fuerteventura and Lanzarote had a minimal presence and nowadays remain just some communities of *Erica arborea* extremely degraded (FERNÁNDEZ-LUGO S. et al. 2009; MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980).

3.4 Pine forest

This type of vegetation is found both at windward slope over the evergreen forest between 1200 and 2000 m and at leeward slopes above the coastal and thermophile forest between 500 and 2300 m with drier characteristics (DELGADO J.D. et al. 2004). Unlike the laurel forest, the pine forest has a canopy cover of 60% favoring the abundance of the understory. Some of the dominating plants that characterize the understory are also characteristic from the Fayal-Brezal vegetation like *Myrica faya* and *Erica arborea*, also some others like *Adenocarpus foliolosus*, *Daphne gnidium* and *Chamaecytisus proliferus.* An endemic and abundant specie as is *Cistus symphytifolius* (DELGADO J.D. et al. 2007) and others from the genus *Lotus spp*. which reactive the germination of their seeds with the presence of fire, colonize those places where the pine forest have been recently affected by fires and so, in this places can form a vegetation climax (MORALES MATOS G. et al. 2000). But the major part is just modifications made by men (ORTUÑO MEDINA F. 1980).

The extreme conditions where these forests are located, greatly affects the vegetation. Fires occur frequently, but also suffer frost in the higher parts with some periods of snow and strong winds. These factors constantly influence the vegetation which unlike the laurel forest has a more homogeneous and open character where the Canary island pine – *Pinus canariensis* predominates (DELGADO J.D. et al. 2004; MORALES MATOS G. et al. 2000). The large presence that this forest have today is mostly thanks to reforestation with *Pinus canariensis,* but also has been frequently the reforestation with *Pinus pinea* and *Pinus radiata.* The places reforested with *Pinus radiata* reach large hectares, but have disadvantages because this pine is more sensitive to pests and has no fire resistance compared to the Canary island pine (DELGADO J.D. et al. 2004; MORALES MATOS G. et al. 2000; ORTUÑO MEDINA F. 1980).

Another difference from the laurel forest, is that the road edge effects don't affect the avifauna from the pine forest in the same way; the diversity of birds along road edges are similar with the diversity of birds in the forest interior (DELGADO J.D. et al. 2004). The typical birds dominating this habitat are for example the Great Spotted Woodpecker - *Dendrocopos major*, the Blue Chaffinch - *Fringilla teydea* and the Canary Islands Kinglet - *Regulus teneriffae* as well as other more generalistic species as the Chaffinch - *Fringilla coelebs*, the European Serin - *Serinus serinus*, the Eurasian Sparrow hawk - *Accipiter nisus*, the Blackcap - *Sylvia atricapilla* and the Canary Islands Chiffchaff - *Phylloscopus canariensis* (FERNÁNDEZ-PALACIOS J.M. et al. 2008b).

3.5 Subalpine scrub and Peak vegetation

This vegetation occurs in the highest peaks just in the islands of La Palma and Tenerife which exceed 1900-2000 m of altitude. Despite factors such as annual snowfall, low precipitations, strong winds and drought limiting the development of tree formations; this area is characterized by being a concentration point for endemic species because it has not been as disturbed as other vegetation zones by agricultural activities, so this vegetation has been well preserved and it can be said that is in good condition.

The vegetation is found irregularly dispersed forming clusters taking advantage of the best soils (MORALES MATOS G. et al. 2000). In the beginning, before the European colonization, the lower parts were occupied by *Juniperus cedrus*, but degradation by fire regeneration techniques or livestock, got rid of most of these specimens leaving only some of them very isolated from each other. In La Palma, the zones occupied by this tree, were reforested with *Adenocarpus viscosus* and in Tenerife with *Spartocytisus supranubius*, which nowadays characterize the vegetation of the zone. Much more higher above 3000 m, the peak vegetation lies on volcanic soils and just plants like *Viola cheiranthifolia* (endemic from the Teide peak), *Argyrantheum teneriffae*, *Nepeta teydea* and *Erysium scoparium* as well as *Polycarpaea aristata*, *Cerastium arvense* or *Tolpis webii* survive in this hostile environment (ORTUÑO MEDINA F. 1980).

The avifauna that inhabits this hostile place, do not nest here because of its extreme conditions, so they either abandon it in winter, or look for food somewhere else. Some of the birds that characterize this zone are: The Common Chiffchaff - *Phylloscopus collybita*, the Berthelot's Pipit - *Anthus berthelotii*, the Blue Chaffinch - *Fringilla teydea*, the Plain Swift - *Apus unicolor*, the Rock Dove - *Columba livia canariensis*, the Common Raven - *Corvus corax canariensis*, the Common Kestrel - *Falco tinnunculus canariensis*, the Island Canary - *Serinus Canaria*, the Blue Tit - *Parus caeruleus teneriffae* and the Red Kite - *Milvus milvus.* This example of birds is just a little part of the list that conform all the avifauna and shows that avifauna in the Canary Islands is mainly characterized by endemic subspecies (ORTUÑO MEDINA F. 1980).

4 Avifauna in the Canary Islands

This chapter combines the geographical, geological, climate and vegetation factors in a specific avifauna information output that consolidates a tool for their conservation.

4.1 Biogeography

The study about the distribution of species of fauna and flora within an island since their origins as a result of different factors (i.e. altitude, elevation, area, distance to the closer continent, etc) that continuously affect the island environment has been useful to better understand the colonization and diversification processes suffered by these species when first arrived to the island and to determinate their importance and individual conservation (FERNÁNDEZ-PALACIOS J.M. 2004).

The islands are 6% of the total Earth's land surface and are characterized by their isolation. That is why, the set of communities living here, are much simpler compared with continental species. First of all, less ecological phenomena have been involved in their evolution process in the island scenario, and second of all, the genetic material of many species has been reduced due to the inability of reproduction with species from the community of origin. The population of an island depends on the individual characteristics of the island and of the species that are about to colonize. The island will have higher probabilities of colonization if is closer to the continent because much more species will have the ability to arrive, also if the island area is bigger, the species will have more space for distribution and less competition between them will occur, although this will depends on the quality of the ecosystems where they have settled. The altitude of the island and the variety of wind and sea currents surrounding the zone will allow little organisms as diasporas to reach the island at different elevations and cardinal points. Furthermore, all the species must have the energy and strength needed not only to effectively colonize an island, but also to establish stable communities within the specific environment of a single island. The birth rate of these communities should be the adequate to overcome the degradation or extinction of the species caused by inbreeding. Given the case, that only one individual arrives to the island, this individual should have a wide ecological valence and the ability to asexual reproduction (i.e. vegetative reproduction in plants or parthenogenesis in animals) until the arrival of another individual. The neo-endemic species are not the only ones that inhabit an island scenario. There exists also species that have older origins than the island, those are called paleo-endemic species, and they probably arrived to the island looking for refuge (FERNÁNDEZ-PALACIOS J.M. 2004).

In the Canary Islands an important example of paleo-endemism is the Laurel forest which was distributed across southern central Europe and North Africa 20 million years ago (MARRERO A. 2004 ex. Depape 1922) but then colonized the Canarian archipelago, Azores and Madeira where now the Laurel forest has most important distribution. These facts show that the islands offer better conditions when it comes to deal with ecologic phenomena that affect their populations. For example the surrounding sea attenuates the temperature variations between winter and summer and also in the case of birds, is easier for them to solve thermal problems or shortage of food and water just moving a few meters above the altitudinal gradient (FERNÁNDEZ-PALACIOS J.M. 2004).

The model of insular biography proposed by Robert MacArthur and Edward O. Wilson (1967) in the book "The Theory of Island Biogeography", explains that the biological richness of an island, is determinate by two principal factors: Distance to the continent and the Area. The immigration rate will decrease with an increasing distance, while the extinction rate will increase with decreasing area of the island (CARRASCAL L.M. et al. 2002).

With help of the data provided by the Spanish Ornithological Society (Sociedad Española de Ornitología, SEO/BirdLife) and the Canarian Ornithological Society (Sociedad Ornitologica Canaria, SOC), a list of the birds that inhabit the archipelago was made, subsequently where classified to each island (further information in Appendix 1) and then it was calculated the total number of birds in each island (Table 2).

Were tested two different models with the language for statistical computing and graphics "R" (R Development Core 2011): the first one was taking both explanatory variables (*Species ~ Distance * Area*) and the second one just talking distance from the continent as the only explanatory variable (*Species ~ Distance)*. Multiple regression was chosen to make the analysis, and to obtain the significance of each explanatory variable on the species number was used the Poisson distribution with Chi-squared test; then the regression equation for each model was completed and the models were compared.

Table 2 Canary Islands with its respective number of bird species and data of its area and distance from the African continent. (SEO/BirdLife).

Island	Number of Species	Area (km)	Distance (km)
La Palma (LP)	129	708	416
El Hierro (EH)	128	269	383
La Gomera (LG)	135	370	333
Tenerife (TF)	155	2034	284
Gran Canaria (GC)	145	1560	196
Lanzarote (LZ)	129	807	125
Fuerteventura (FV)	137	1655	95

Results

A total of 175 species where classified according to their location on the Canary Island and their status (Appendix 1) (Anonymous n.d.). The results from the first model on R showed that the variable Distance is not significant controlling for the variable Area (Pr (>Chi) = 0.553), although the variable Area is marginally significant (P<0.1) controlling for the variable Distance (Pr (>Chi) = 0.068 •). Also indicates that the fitted value *"species"* is given by

$$\hat{y} = 4.753 - 0.000193x_1 + 0.000107x_2$$

The second model shows as well that the variable distance is not significant even when is not collectively used in the model (p=0.677) because the value is not closer to cero. Using AIC, the R program showed that both models have almost the same relevance. However while testing the two different models, the Pr (>Chi) value of the intercept showed always a bigger significance than the explanatory variables. "When the intercept is significant in regression analysis it could mean that there is also a constant in the model, in addition to all other explanatory variables. Forcing an intercept to zero, usually increases prediction error and therefore should be avoided if possible" (CONJEPURAM S., LinkedIn n.d.). As it was already said, a lot of factors have influence on the distribution of a specie, so maybe if these models were completed by classifying all the birds according to all of these factors, then the perfect model may be found to explain this situation.

Clearly in this theory are missing important factors that influence the number of the species living in an island, because the processes of speciation that the species suffer after its colonization are not taken into consideration. That is why Mark Lomolino (2000) proposes a new model where the speciation plays an important role. Thus, when the variables distance and area increase, the speciation rate will decrease and as a result, the immigration and extinction rates will increase as well (FERNÁNDEZ-PALACIOS J.M. 2004). José María Fernández P. and Anderson C. (1993b) used the same basis to conclude in a different analysis, that in the Canary Islands, random events were responsible for the distribution of land birds, but the distribution of trees and shrubs was a result of the influence of deterministic factors.

The Canary Islands like others oceanic islands, are characterize by an allopatric speciation caused by geographical isolation followed by a founder event, which means that the colonizers are just a minimal part of the population of origin. The consequence of this phenomenon is a big lost or variation of the population alleles followed by the events of adaptive radiation. The adaptive radiation will conclude in the creation of new species. Some of the evolutionary trends that the species may adopt to create new species are: Increase or decrease in size (the Tenerife Lizard – *Gallotia galloti*), woodiness of plants, loss of dispersal ability as well as the abilities of defense and competition, diet change or changes in breeding frequency leading the species to extinction (FERNÁNDEZ-PALACIOS J.M. 2004).

4.2 Colonization and diversification

Researches about the origin of the Macaronesian avifauna (as well as reptiles and mammals) have showed according to phylogenetic analyses, that the extant species are close related with the Paleartic taxa and that the way of colonization may be explained by factors such as wind. Different colonization patterns mediated by winds have been proposed. One can be related with winds coming from the Sahara desert that could explain colonization patterns from east to west, as the stepping-stone model propose, from older to younger island (JUAN C. et al. 2000). The Sahara winds can also explain the colonization pattern from southern islands to northern islands. The opposite colonization pattern from north to south, may be explained by the trade winds prevailing at northeastern or northwestern parts (ILLERA J.C. et al. 2007).

The migration of birds to the macaronesian region coincides with the cruel conditions during the paleartic, but thanks to the ability of birds when altering their migratory behaviour, they were able to survive these difficult times (FINLAYSON C. et al. 2012). The principal phylogenetic studies in the Macaronesia have focused on invertebrates, plants and reptiles because show high diversification (JUAN C. et al. 2000). The interest on the phylogenetic diversification of birds started when eggshells with an estimated age of 5-15 million years (Miocene/Pliocene) were found in the island of Lanzarote. The surprise was that the eggshells appear to be from the genus *Strutio* or *Aepyornis* (extinct) , but all the extant ratite (*Strutio*) birds are flyghtless, so the explanation of how these eggshells arrive to the island is still unknown (ILLERA J.C et al. 2012 ex. GARCÍA-TALAVERA 1990; SAUER E.G.F. et al. 1972). The primitive settlers, called "Guanches", and their different agricultural and hunting activities had an effect on the extinction of different organisms, about 22% went extinct (DE LA ROSA M.A. et al. 2010). But comparing with other archipelagos like Hawaii (50%), the presence of humans did not leave big dissasters (ILLERA J.C et al. 2012; SÁNCHEZ MARCO A. 2010). Although, the fact is that the avian diversity before their arrival was much higher. This can be explained with the taxon cycle theory, which says that when a specie have been competing a long time with native species or new colonizers, their extinction becomes more possible (MAC ARTHUR R.H. et al. 1967). Bird fossils found in the Canary Islands, show that their colonization is relatively recent (0,01-2,6 million years ago). This explains, that despite of the diversity of habitats found in the archipelago, the isolation, age and distance to the African continent, the Canarian avifauna does not show a large diversification (ILLERA J.C et al. 2012), just the endemic pigeons have an older origin within the islands during the Miocene (GONZALES J. et al. 2009). The absence of birds 3,8 million years ago may be explained by mass extinction by unknown factors or recent volcanic eruptions of some islands, but this also would cause the extinction of other organisms as mammals or plants, although their fossils do not show such absence (ILLERA J.C et al. 2012; JUAN C. et al. 2000).

4.2.1 Endemic bird species

The Canary Islands have 5 endemic extant bird species and other 30 endemic subspecies (CARRASCAL L.M. et al. 2005; KVIST L. et al. 2005; SÁNCHEZ MARCO A. 2010). The extinct endemic species mostly belong to families as *Turnidae, Fringillidae, Procellariidae, Phasianidae, Rallidae, Strigidae and Haematopodidae*, some of them are: 1. The Trias greenfinch - *Carduelis triasi* (ALCOVER J.A. et al. 1987) found in La Palma, went extinct during the late pleistocene, 2. The Olson's shearwater – *Puffinus Olsoni* (McMINN M. et al. 1990) which may have gone extinct due to lack of adequate environments to survive after the arrival of the Europeans, 3. The Hole's shearwater – *Puffinus holeae* (WALKER C.A. et al. 1990) went extinct after the first settlers, 4. The Canary quail – *Coturnix Gomerae* (JAUME D. et al. 1993) widely spread in the Canarian archipelago was part of the diet of the Guanches, 5. The long-legged bunting – *Emberiza Alcoveri* (RANDO J.C. et al. 1999) which was flightless and an easy prey for the now extinct endemic rats and the later introduced cats (SÁNCHEZ MARCO A. 2010), 6. The Canary Islands Oystercatcher - *Haematopus meadewaldoi* went extinct during historical epoch maybe because of human activities (BANNERMAN D.A. 1913).

The 5 endemic extant species of the Canarian Archipelago are: Phylloscopus canariensis, Columba Junoniae, Columba bollii, Fringilla teydea and Saxicola dacotiae. But they are not the most diverged bird species in the islands. The Blue tit and the Common chaffinch show a larger lineage with a total of 6 subspecies evolved from them. The Blue Tit – *Parus caeruleus* may have colonized the archipelago according to Grant (1979) from the central islands Tenerife or Gran Canaria going though Lanzarote and Fuerteventura. Consequently, El Hierro was colonized from La Gomera and the island of La Palma independently. Populations at Lanzarote and Fuerteventura first went extinct and later recolonized.The speciation of the blue tit in the Canary Islands left 4 different subspecies: 1. *P.c. ombriosus* from El Hierro, characterized by occupy the higher zones of the Pine forest, 2. *P.c degener* from Lanzarote and Fuerteventura occupies dense shrubs, 3. *P.c. teneriffae* from La Gomera, Tenerife and Gran Canaria inhabits gardens and Pine forest, 4. *P.c. palmensis* from La Palma which prefers the same vegetation as the *P.c. ombriosus* (KVIST L. et al. 2005).

The Common Chaffinch – *Fringilla coelebs* inhabits just 5 islands of the archipelago: Tenerife, La Gomera, Gran Canaria, La Palma and El Hierro. May have arrived to the archipelago 1.09 million years ago (RANDO J.C. et al. 2010) starting its colonization in the island of La Palma, then moved to Tenerife, La Gomera and El Hierro and finally Gran Canaria (MARSHALL H.D. et al. 1999). This bird followed the north-south colonization pattern before mentioned. Currently has a wide ecological valence than the endemic Chaffinch – *Fringilla teydea*. Within the Canary Islands the speciation of the Common Chaffinch left 3 subspecies: 1. *F.c.canariensis* found in La Gomera, Tenerife and Gran Canaria, 2. *F.c.ombriosa* found in El Hierro, 3. *F.c.palmae* from La Palma (FERNÁNDEZ-PALACIOS J.M. 2004; SUÁREZ N.M. et al. 2009). A closely related specie is the endemic Blue Chaffinch – *Fringilla teydea* which colonization dates 1.99 million years ago, before the islands of El Hierro and La Palma were emerged. It inhabits just forest of Canary pine *(Pinus canariensis)* (RANDO J.C. et al. 2010) in the islands of Gran Canaria and Tenerife were has developed into two subspecies: 1. F.t. teydea found in Tenerife, 2. F.t.polatzeki in Gran Canaria (SUÁREZ N.M. et al. 2009).

The Canary endemic bird species are exclusively distributed within the autochthonous vegetation of the islands. The Canary Island Stonechat – *Saxicola dacotiae* form part of the species diverged from *Saxicola torquata* 1.6 million years ago. The phylogenetic relationships between the species and subspecies from the genus *Saxicola* are not fully studied yet, and the place of origin among the three continents were the *Saxicola* group id distributed (Africa, Asia and Europe) is still unknown (ILLERA J.C. et al. 2008). The Canary Island Stonechat is restricted to Fuerteventura and its surrounding islets, and its distribution within them is limited by human activities, prevailing on slopes with high shrub cover, ravines and stony field (ILLERA J.C. et al. 2001; 2010). In Fuerteventura is endemic the subspecie *S.d.dacotiae* and in the islets of Montaña Clara and Alegranza was distributed the *S.d.murieae*, now extinct (ILLERA J.C. 2001).

The Canary Island Chiffchaff – *Phylloscopus canariensis* currently inhabits the islands of Tenerife, La Gomera, La Palma, El Hierro and Gran Canaria where is distributed through ecosystems with forest and shrub character. The study about its phylogenetic information comes from the study realized by Heilbig et al. in 1996 about the Common Chiffchaff – *Phylloscopus collybita,* but nowadays is recognized as a single endemic specie. Apparently, all the exemplars of *Phylloscopus canariensis* are unique specie, but different studies about its morphology, behavior and specially the call, shows that the species in the island of Gran Canaria have a distinct lineage (RODRÍGUEZ ACOSTA L. 2011), even microgeographically among different sites of the Tenerife island the specie does not share the same call (NAGUIB M. et al. 2001).

The endemic Canarian Pigeons are probably the oldest avian colonizers of the archipelago, following an east-to-west colonization pattern as the islands were emerging, and later went extinct on the eastern part of the archipelago. The Laurel Pigeon - *Columba junoniae* colonized the islands 25.3-16.8 million years ago during the Miocene whilst the Bolle's Pigeon – *Columba bollii* did it during the upper Miocene probably 5 million years ago (GONZALES J. et al. 2009) when changes on vegetation and fauna were happening in many continents (GONZALES J. et al. 2009 ex. CERLING T.E. et al. 1997). The pigeons just inhabit the western islands with Evergreen "Monteverde" forest cover (Tenerife, La Palma, La Gomera and El Hierro) (EMMERSON K.W. et al. 1986). These two pigeons belong to two different clusters, although their phylogenetic position within the genus *Columba* is still unknown (GONZALES J. et al. 2009).

5 Conservation

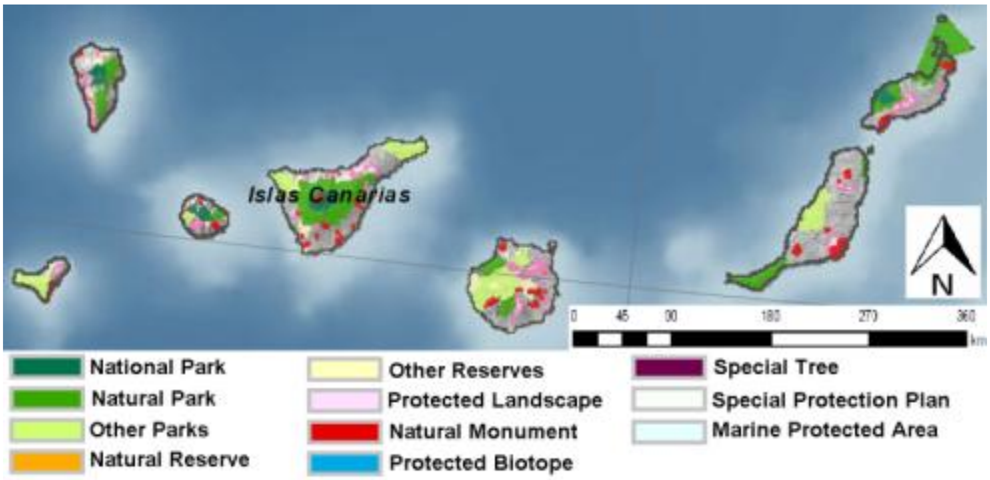
5.1 Protected Areas

The Spanish landscape has negatively changed in the last three millennia, but especially in last centuries. The protection of nature in Spain mainly started when the scarcity of characteristic species began to be very noticeable, for example the tree cover of the mediterranean ecosystems, which is characterize by its slow regeneration. This scarcity was caused principally by increasing of agriculture, deforestation, overgrazing or overhunting, industrial pollution and tourism. In 1918, the first two National Parks were created and in 1980 increased the number to nine. Thanks to the Spanish constitution of 1978, the conservation of nature was improved when most of that responsibility was transferred to the autonomous communities, and now they continue with the creation of protected areas. The Canary Islands rapidly began the formation of protected areas within their territory. Currently four National Parks form this network. These are found in the Islands of Tenerife, La Palma, La Gomera and Lanzarote (MORILLO C. et al. 2000).

- **Teide National Park (Tenerife)**

This National park is characterize by two types of zones, the lower and warmer zone with the greatest community of the typical *Spartocytisus supranubius* and at higher altitudes the subalpine zone where the Teide violet *(Viola cheirathifolia)* is present. The I.B.L value (Free bioclimatic intensity, "Intensidad Bioclimática Libre") in this park is able to reach 1, 23, what explains the great diversity of its flora. The park is also represented by a big caldera called "Las Cañadas" which is one of the most important caldera in the world where the peak "El Teide" is found. Just 8 of the 12 present bird species nest in the park, all of them have to leave the park when the winter comes or at least have to find the food somewhere else, and two species went extinct in recent years. The nesting birds of the park are: *Corvus corax tingitanus, Anthus.b.bertheloti, Lanius Excubitor, Phylloscopus canariensis, Apus.u.unicolor, Columbia livia canariensis, Alectoris barbara koenigi, Falco tinnunculus canariensis*. The extinct birds are: *Neophron p.percnopterus, Milvus.m.milvus* (ORTUÑO MEDINA F. 1980).

Fig. 5.1 Protected Areas of the Canary Islands. Modified from the map "Espacios Naturales protegidos" of Spain **(MAGRAMA. 2013)**.



- **Caldera de Taburiente National Park (La Palma)**

It is characterized by the best preserved community of Canary Pine *(Pinus canariensis)* where the Avifauna is the most important population of vertebrates. In the park, the most common species are: *Fringilla coelebs palmae, Turdus merula agnetae, Sylvia a. atricapilla, Parus caeruleus palmensis, Motacilla melanope, Turdus auritus, Phyrrhocorax p.barbarus* (Not typical from the Canary Islands, just inhabit this island), *Corvus corax tingitanus, Falco tinnunculus canariensis, Columbia livia canariensis, Columba trocaz bollii* (ORTUÑO MEDINA F. 1980).

- **Garajonay National Park (La Gomera)**

Currently preserves the best exemplar of Laurel forest with an authentic look and a completely natural environment. Together with the National Park in La Palma, are the only natural water sources that remain in the archipelago. The Avifauna is mainly related with the Laurel forest, formed with about 42 species. The most representative birds are the nesting Pigeons: *Columba trocaz bollii*, *Columba junoniae* and *Columbia livia canariensis.* Some other nesting birds are also representative: *Turdus merula cabrerae*, *Fringilla coelebs tintillion, Phylloscopus canariensis, Parus caeruleus teneriffae, Erithacus rubecula microrhychus, Serinus canaria, Anthus bertheloti, Scolopax rusticola,* among others. Probably two species went extinct, or at least, there is no record of presence in the last years: *Neophron percnopterus* and *Milvus milvus* (ORTUÑO MEDINA F. 1980).

- **Timanfaya National Park (Lanzarote)**

This park in the island of Lanzarote has a geological importance preserving the greatest volcanic eruptions from the XVII century. The landscape has a poor vegetation cover, so the absence of big animals is evident. The presence of the Avifauna within the park is rare or accidental, distributed in the islets and habitats with slopes, some of them are: *Corvus corax tingitanus, Motacilla cinerea cinerea, Anthus bertheloti, Calandrella rufescens polatzeki, Passer hispaniolensis, Acanthis cannabina harterti, Parus caeruleus degener, Pkylloscopus canariensis, Upupa epops, Columbia livia, Haematopus ostralegus meadewaldoi* (extinct), *Falco tinnunculus dacotiae,* among others (ORTUÑO MEDINA F. 1980).

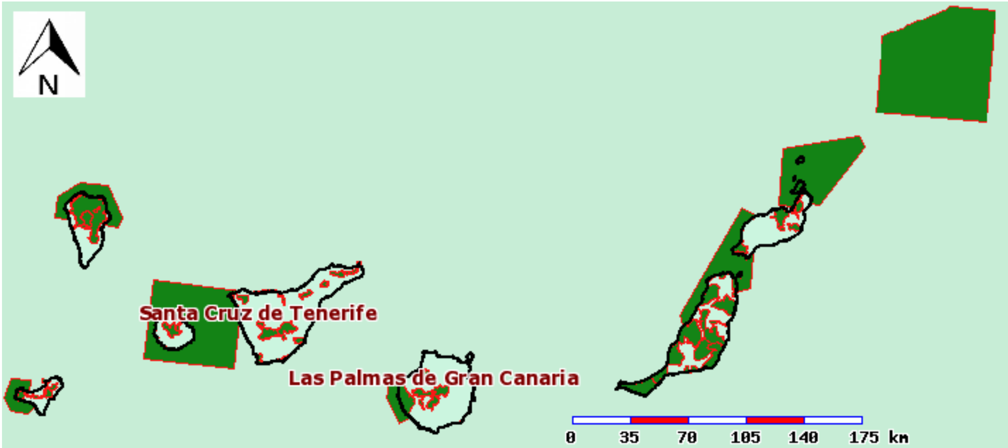
The protection of nature at the level of the European Union in the Canary Islands began in 1990 when the “Habitat Directive” was approved formerly limited to birds (MORILLO C. et al. 2000). The evolution of this policy was the creation of the European network of special conservation zones named Natura 2000 which today means the 28,7% of the Spanish territory and consists of Special Areas of Conservation (ZEC) earlier consider as Sites of Community Importance (LIC) and Special Protected Areas for Birds (ZEPA) (GARAY ZABALA J. n.d.). In 2006 the Canary government approved 15 new areas within ZEPA network and increased the area of 12 of them (RODRÍGUEZ ZARAGOZA P. 2006). Today, 36,5% of the land area of the Canarian archipelago is covered by ZEPA (INFANTE O. et al. 2011).

Fig. 5.2 Natura 2000 network in the Canary Islands. Modified from the map "Red Natura 2000" of Spain **(MAGRAMA. 2013)**.

Some worldwide protection programs have also been involved in the conservation of the Canary Islands biodiversity. One of them is the program of Important Bird Areas (IBA) which is considered as the minimum network to ensure the survival and management of bird species. The Canary Islands have a total of 67 IBA covering the 30,9% of the land area of the archipelago. Seabirds are the most benefited, because these zones are mainly frequented by their breeding populations. Some of these birds are: The Bulwer's Petrel - Bulweria bulwerii, The Cory's Shearwater - *Calonectris diomedea,* The Common Tern - *Sterna hirundo,* The Roseate Tern - *Sterna dougallii,* The Manx Shearwater - *Puffinus puffinus*, The Little Shearwater - *Puffinus assimilis,* The European Storm Petrel - *Hydrobates pelagicus*, The Madeiran Storm Petrel - *Oceanodroma castro*, The White-faced Storm Petrel - *Pelagodroma marina*, The Lesser Black-backed Gull - *Larus fuscus* and Caspian Gull - *Larus (argentatus) cachinnans*, among others (INFANTE O. et al. 2011).

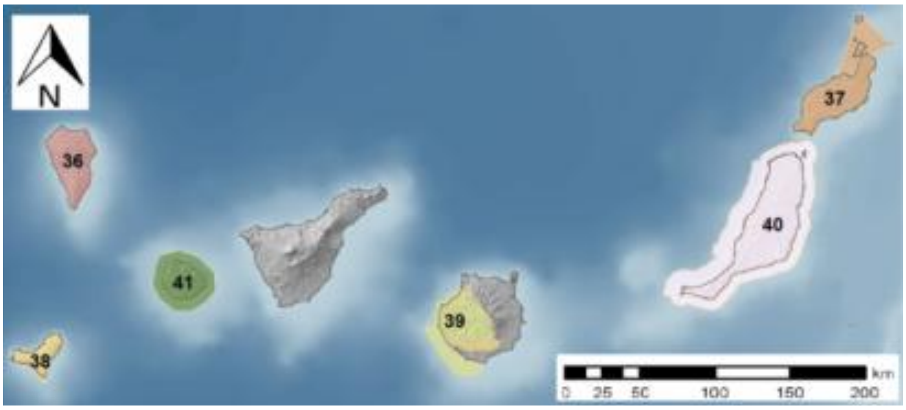
The most important areas for the conservation of birds are the Endemic Bird Areas (EBA). Recently, this worldwide program identified the Canary Islands due to its great number of endemic bird species as the only Endemic Bird Area (EBA) of Spain (BirdLife International. n.d.).

Fig. 5.3 Map of the Important Bird Areas in the Canary Islands. http://www.seo.org/cartografia-iba/



The Biosphere reserves are another protected area network within the Canaries designated by UNESCO (Decree 103/2010, 29th of July) (FERNÁNDEZ-PALACIOS J.M et al. 2008a). Respectively, 6 Biosphere reserves have been declared in the archipelago: La Palma (1983), Lanzarote (1993), El Hierro (2000), Gran Canaria (2005), Fuerteventura (2009). The last one in 2012 was the biosphere reserve of La Gomera which was declared by The Man and the Biosphere Programme (MAB) of UNESCO (GOBCAN. n.d.).

Fig. 5.4 Map of the Biosphere Reserves of the Canary Islands. Modified from the map "Reservas de la Biosfera" of Spain **(MAGRAMA. 2013)**.



The Biosphere reserve in La Palma is declared world biosphere reserve. It includes two Special Areas of Conservation (ZEC) in the sea. One of them is a marine reserve of fishing interest. The biosphere reserve in Lanzarote has the 41,6% covered by some Canarian network of Protected areas, for example, the extensive lava fields from the Timanfaya National Park. In El Hierro, the biosphere reserve is characterized by the biodiversity richness of its coasts; recently in the island, was signed a commitment proposing that the island will be 100% ecologic and self-sufficient in agriculture, fishing, livestock, and food in eight years. The biosphere reserve in Gran Canaria occupies 46% of the South-western part of the island

and is formed by two National Reserves, one Rural Park and two Natural Parks. The one in Fuerteventura is meant to protect the especial populations of two endemic subspecies, the Canarian Houbara - *Chlamydotis undulata fuertaventurae* and the endemic Egyptian Vulture - *Neophron percnopterus majorensis,* this reserve is also an important migratory pass for birds and its autochthonous farm landscape is based on soil conservation. The Reserve of "Jarde" situated in the center of Fuerteventura, was created to protect steppe birds mainly the Canarian Houbara - *Chlamydotis undulata fuertaventurae* which is the animal symbol of the island but also other steppe bird species as: The Black-bellied Sandgrouse **-** *Pterocles orientalis*, the Eurasian Stone-curlew - *Burhinus oedicnemus,* the Spectacled Warbler - *Sylvia conspicillata*, the Lesser Short-toed Lark - *Calandrella rufescens,* the Cream-coloured Courser - *Cursorius cursor*, the Berthelot's Pipit - *Anthus berthelotii*, the Northern Shrike - *Lanius excubitor,* the Trumpeter Finch **-** *Bucanetes githagineus,* the Canary Islands Stonechat **-** *Saxicola dacotiae*, the Egyptian Vulture - *Neophron percnopterus,* the Common Buzzard - *Buteo buteo*, the Barbary Falco - Falco pelegrinoides, the Common Kestrel - *Falco tinnunculus* , and the Barbary Partridge **-** *Alectoris Barbara* (1.SEO/BirdLife n.d.). The biosphere reserve in Fuerteventura is the only member of the UNWTO (The United Nations World Tourism Organization). The last biosphere reserve in La Gomera is characterized by the perfect conserved laurel forest in the National Park Garajonay which was recognized by UNESCO as a World Heritage Site for its wonderful natural values and by the presence of the endemic giant lizard of La Gomera *(Gallotia bravoana),* one of the most endangered reptiles in the world (GOBCAN. n.d.).

5.2 Action Plans

The Canarian archipelago despite of been an important tourist destination, has a better preserved biodiversity than other regions in Spain. In 2001 with the approval of the decree 151, 23rd of July, the catalog of endangered species in the Canary Islands was created, which classified the species into the following categories: I. Endangered (E), II. Species susceptible to habitat disturbance (S), III. Vulnerable (V), IV. Species of Special Interest (IE). Since then, has been changing according to the respective evolution of the threatened species in this catalog with the help of the School of Biologists (COB) of Canary Islands. The last actualization of the catalog was in 2010 with the publication of the Law 4/2010, 4th of June. The autonomous community of Canary Islands as all the Spanish autonomous communities, since 1989 creates Recovery Plans for the species considered endangered and Conservations

Plans for the species considered vulnerable within the catalog of endangered species in the Canary Island (GOBCAN. 2009).

According to the evaluation and actualization in 2009 of the current evolution of the threatened species in this catalog, three bird species are endangered: *Corvus corax canariensis, Fringilla teydea polatzeki* and *Neophron percnopterus* (both subspecies *Neophron percnopterus majorensis* and *Neophron percnopterus percnopterus*). According to the last data update in 2012 on the website of SEO birdlife, the Canary Government has approved the Recovery Plan just for two of them: *Fringilla teydea polatzeki* (RP-2005), *Neophron percnopterus majorensis* (RP-2006). Another 6 Action Plans are waiting for approval (SAP: Community species action plan prepared), these correspond to the following species: *Chlamydotis undulata fuerteventurae (IE)* SAP-1995, *Columba bollii (S)* SAP-1995, *Columba junoniae (S)* SAP-1995, *Dendrocopos major canariensis (IE)* SAP-1999, *Fringilla teydea teydea (V)* SAP-1995, *Neophron percnopterus percnopterus (E)* SAP-2008. These data are only a small sample of many of the endangered species within the Spanish territory that are only protected by a paper (2.SEO/BirdLife n.d.).
Nevertheless, some of the action plans that are waiting for the approval of the Canary Government and some others are co-financed by the European Union through the LIFE-Nature fund and its successor Life + "Nature and Biodiversity". The Life+ Program aims to contribute to the political development and the implementation of law into the projects of nature conservation, generally contributes to sustainable development. Some of the Life+ projects approved by EU in the Canary Islands are:

1996	Actions for the Conservation of the laurel pigeons *(Columba bollii and Columba junoniae)*
	Actions for the conservation of the Tenerife Great Spotted Woodpecker - *Dendrocopos major canariensis* (IE).
1998	Conservation of Gran Canaria blue chaffinch - *Fringilla teydea polatzeki*
2002	Control of Invasive Vertebrates in the Islands of Spain and Portugal (LIFE2002NAT/CP/E/000014)

6 Discussion

The Canary Islands despite of been a young archipelago, within the Macaronesian region and the Spanish territory have the richest biodiversity (MORALES MATOS G. et al. 2000) and the highest number of endemic species (ANGUITA F. et al. 2000). This is the reason why the Canary Islands are considered an important study center for many scientist around the world (FERNÁNDEZ-PALACIOS J.M. 2004).

The biodiversity in the Canary Islands have suffered many changes since the arrival of primitive settlers and the Spanish colonization. As the vegetation concerns, its distribution and climax condition suffered an important damage. The principal anthropogenic factor influencing the biodiversity is the road fragmentation which has an important ecological impact, approximately 2,8% (5,692 hectares) of the total area is occupy by roads. Exist approximately 12,441 km of roads and the road density in protected areas is 2,15 km/km^2 (DELGADO J.D. et al. 2004).

Regarding the avifauna in the islands; during the quaternary probably consisted of about 173 taxa. Moreover, the extant avifauna including species and subspecies as well decreased its number to 165 of which 92 represent the breeding bird population (SÁNCHEZ MARCO A. 2010). About 22% went extinct (DE LA ROSA M.A. et al. 2010).

In Appendix 1, a list of the extant birds in the Canary Islands is presented. The data was collected from the information published by the Spanish Ornithological Society (Sociedad Española de Ornitología, SEO/BirdLife). Most of the information about the habitats of these birds was not fully specified and classified within the categories presented in this table, so the classification of the species within the category of ecosystems is an estimation of this information. In order to facilitate future statistical calculations needed for further studies about the biodiversity, the presence or absence of each species within a category was labeled by numbers. The number 1 means the presence of the species within a category, and blank means its absence (Blanks can be easily replaced by zeros). By summing the values for each column within the category of ecosystems, the following data were obtained: Tabaibal-Cardonal: 73, Thermophile forest: 60, Laurel forest: 7, Pine forest: 29, Peak forest: 7, Aquatic ecosystems/Cliffs: 81, Fields: 13, near Human Activities (Synanthropic): 16.

Comparing these results with the information given in earlier chapters in the present work, was possible to conclude the following: The Tabaibal-Cardonal vegetation and the Aquatic ecosystems of cliffs, according to the results presented in the table have the highest number of species (73 and 81 respectively), followed by the Thermophile forest. These results are consistent with the theory of De Graaf 1992 which postulates that the ecotone zones with major disturbance shows higher levels of diversity and density of species. The areas with Tabaibal-Cardonal vegetation, being coastal areas, are the most affected by tourism which is a factor of important influence on biodiversity. The thermophile forest located within the most inhabited parts of the islands has a diversity of birds mostly supplemented by species from surrounding vegetation, that's why the Avifauna is huge. And finally the avifauna of aquatic ecosystems and cliffs, as all the islands, has an important presence, as the ocean is the main source of food.

It is necessary as well, to mention the studies made by Luis M. Carrascal et al. in 2005 about the Avifauna in Tenerife. The results show that the highest densities of bird species occur within the most degraded habitats by human activities and lower densities occur in areas with autochthonous forests. This is also consistent with data from our table: Laurel forest: 7, peak vegetation (7). An exception was the number of species in the Pine forest which was higher than in field areas of areas near to humans (Synanthropic species).

The Canary Islands have economic and politic support for nature conservation at regional, national, international (EU) and global (UNESCO) level (FERNÁNDEZ-PALACIOS J.M. et al. 2008a). But still, within the protection plans for the Canary Islands, have been found some inconsistencies that have caused the warning of environmental organizations. With the resolution of the Law 4/2010, 4th of june, the catalog of endangered species in the Canary Islands was updated changing the cataloging criteria. The main problem is that this catalog does not follow the recommendations of cataloging made in the previous evaluation in 2009. This catalog eliminates the category II. Species susceptible to habitat disturbance (S) and add the species of this category to the category I. Endangered (E) or III. Vulnerable (V). The category IV. Species of Special Interest (IE) is also eliminated and the species of this category lose their classification as threatened staying just as part of the Canary database of biodiversity with any special protection.

The new classification is as follows: I. Endangered, II. Vulnerable, III. Species of special interest to the ecosystems of Canary Islands and IV. Species of special protection. The species classified within the new category III will be protected inside the natural protected areas, but outside then can be treated as any other. The problem is that many threatened species have wide amplitude of distribution and breed in different places that are not legally protected. For example some steppe birds like the Eurasian Stone-curlew – *Burhinus oedicnemus* (both subspecies the *B. o. insularum* on the eastern islands and the *B. o. distinctus* on the western and central islands) and the Trumpeter Finch – *Bucanetes githaginea*, but the affected species are more (BARONE TOSCO R. 2014). That's the reason why the Law 4/2010 was denounced by the environmental community of the Canary Islands and the European Commission ordered Spain to modify the catalog (WWF 2013). The new catalog of 2010 reduced drastically the number of endangered species compared to both previous catalogs 2001 and 2009 and a great number of species were classified into the category III where are just partially protected. The last document created to improve this problem, was the decree 139/2011, 4th of February, for the development of the list of wildlife species of special protection regime and the Spanish catalog of threatened species. Currently, the catalog is still under review and no date of publication of the new catalog was announced yet.

An advantage for the endemic avifauna of the Canary Islands is that are mostly distributed among the native vegetation of the island; areas that are well protected by law. The Canary Islands Chiffchaff - *Phylloscopus canariensis* characterized by its wide ecological valence that according to Luis M. Carrascal (2005) in Tenerife formed part of the most observed birds during the study. The Laurel Pigeon - *Columba junoniae* and the Bolle's Pigeon – *Columba bollii* limit their distribution to the Evergreen forest which constitutes a protected area. The Blue Chaffinch - *Fringilla teydea* reaches its highest population densities on the island of Tenerife among the forest of Canary pine *(Pinus canariensis).* The Canary Island Stonechat – *Saxicola dacotiae* restricted to Fuerteventura. According to this information of distribution, the endemic species that require greater protection are: Both pigeons, the Laurel Pigeon and the Bolle's Pigeon, the Canary Island Stonechat and the Blue Chaffinch. It has to be recognized, that with the current protection programs, endemic species and subspecies with narrow ecological valence like the *Columba junoniae, Columba bollii, Fringilla teydea teydea* and *Dendrocopos major canariensis* that in the past were considered scarce, nowadays their number increased simultaneously with the recovery of their habitats. (CARRASCAL L.M. et al. 2005).

It is crucial the approval of all the action plans that are still in the waiting list, but also is very important to add some of these action plans that consist only on paper like the action plan for the Canary Island Stonechat – *Saxicola dacotiae* presented in 2002 by Juan C. Illera. This author also in 2010 made a study about the nest site selection of the Canary Island Stonechat and the results showed than “less than 1% of the examined area would be suitable for nesting habitats”. Another action plan that should be developed is the one for the subspecie of The Canary Islands Chiffchaff - *Phylloscopus canariensis.* As it was mentioned before, the study made by Laura Rodriguez A. in 2011 and Naguib M. et al. in 2001 about this bird, shows that the species in the islands of Gran Canaria and Tenerife have different morphological and genetic characteristics and should be treated like separated species. That’s why is really important to continue the study about these species to improve future action plans exclusive for them.

7 Summary

- ✓ The principal factor that explains the biological richness of the islands according to the short statistic analysis in this work is the total area of each island against the distance from the continent.
- ✓ With the arrival of the first settlers, the most affected vegetation was the Laurel Forest and the arid and subarid vegetation of Tabaibal – Cardonal. But today, the settlements have moved to the semi-arid and humid areas of the Thermophile forests which are currently the most degraded.
- ✓ The principal factors that have affected the Canarian avifauna are: The scarcity of fresh water due to the destruction of the laurel forest, hunting, introduction of predators, habitat changes, increasing of contamination and tourism.
- ✓ The fact is that the avian diversity before the human activities was much higher.
- ✓ The Tabaibal-Cardonal vegetation and the Aquatic ecosystems of cliffs, according to the results presented in the table have the highest number of species (73 and 81 respectively), followed by the Thermophile forest.
- ✓ Lower densities of bird species occur in areas with autochthonous forests.
- ✓ The avifauna of the autochthonous forests of the Canary Islands is identified with the following characteristics:
    - The low number of species that are currently on the island compared to ancient times.

- High population density.
- The high rate of endemicity despite the high probability of extinction within an island, about 40 times higher than within any continent (FERNÁNDEZ-PALACIOS J.M. 2004).
- Great annual stability of the population abundance (DELGADO J.D. et al. 2004 ex. MARTÍN AND LORENZO 2001; SANCHEZ MARCO A., 2010)

✓ Within the protection plans for the Canary Islands, have been found some inconsistencies, because the current Catalog of endangered species in the Canary Islands reduced drastically the number of endangered species and just 2 of the 8 action plans determined for the protection of birds have been approved.

✓ Although, it has to be recognized, with the current protection programs, the species *Columba junoniae, Columba bollii, Fringilla teydea teydea* and *Dendrocopos major canariensis* have increased their number simultaneously with the recovery of their habitats.

✓ It is crucial the approval of all the action plans in addition with another two plans for the Canary Island Stonechat – *Saxicola dacotiae* and the Canary Islands Chiffchaff - *Phylloscopus canariensis* in the islands of Tenerife and Gran Canaria, because the protection of the endemic species should be of main concern.

✓ It is really important to continue with the study about all the extant bird species to improve future action plans.

✓ To enhance the study about the distribution of birds and their habitat preferences, I propose the realization of a table with the percentages of current vegetation types of each island. This table of vegetation percentages in addition with the values of the present table in Appendix 1 of this work will help for example, future calculations of the Index of vegetation diversity and the Index of bird diversity in the Canary Islands, in order to make much more suitable management plans with important impact on the conservation of the Canarian avifauna.

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9 Appendix

- Appendix 1

Abbreviations for the presence of the bird species in the Canary Islands: R-Resident, I-Introduced, W-Wintering, A-Aestival, M-Migratory, E-Endemic, r-rare. Species present in: 1 – Tabaibal-Cardonal vegetation, 2 – Thermophile forest, 3 – Laurel forest, 4 – Pine forest, 5 – Subalpine vegetation, 6 – Aquatic ecosystems/Cliffs, 7 – Fields, 8 – Near human activities (Synanthropic). 1 = Presence of the specie within a category, Blank = Absence.

Species	Presence in the Canary Islands	Islands							Ecosystem							
		TF	FV	GC	LZ	LP	LG	EH	1	2	3	4	5	6	7	8
Phasianidae																
Phasianidae																
Alectoris barbara	Rr	1	1		1	1	1	1	1							
Alectoris rufa	Rr			1					1							
Coturnix coturnix	R	1	1	1	1	1	1	1	1						1	
Meleagris gallopavo	R/I		1	1						1						
Turnicidae																
Numida meleagris	Rr/I	1							1							
Anseriformes																
Anatidae																
Anas acuta	Wr	1	1	1	1	1	1	1						1		
Anas clypeata	Wr	1	1	1	1	1	1	1						1		
Anas crecca	W	1	1	1	1	1	1	1						1		
Anas platyrhynchos	Wr	1	1	1	1	1	1	1						1		
Anas penelope	Wr	1	1	1	1	1	1	1						1		
Anas strepera	Wr	1	1	1	1	1	1	1						1		
Aythya ferina	Wr	1	1	1	1	1	1	1						1		
Aythya fuligula	Wr	1	1	1	1	1	1	1						1		
Marmaronetta angustirostris	R		1	1										1		
Tadorna ferruginea	Wr	1	1											1		
Podicipediformes																
Podicipedidae																

Species	Presence in the Canary Islands	TF	FV	GC	LZ	LP	LG	EH	1	2	3	4	5	6	7	8
Podiceps nigricollis	Wr	1	1	1	1	1	1	1						1		
Phoenicopteriformes																
Phoenicopteridae																
Phoenicopterus roseus	Wr	1	1	1	1	1	1	1						1		
Apodiformes																
Apodidae																
Apus apus	M/A			1					1	1		1			1	1
Apus pallidus	Ar	1	1	1	1	1	1	1	1	1	1	1		1	1	1
Apus unicolor	R	1	1	1	1	1	1	1	1					1		
Pterocliformes																
Pteroclidae																
Pterocles orientalis	R		1		1				1						1	
Columbiformes																
Phasianidae																
Columba bollii	R/E	1				1	1	1			1					
Columba guinea	R/I	1									1					
Columba junoniae	R/E	1				1	1				1					
Columba livia	R	1	1	1	1	1	1	1	1					1		1
Streptopelia decaocto	R	1	1													1
Streptopelia roseogrisea	R/I	1	1	1	1	1	1	1								1
Streptopelia senegalensis	R		1	1	1		1									1
Streptopelia turtur	R	1	1	1	1	1	1	1	1	1		1				1
Gruiformes																
Rallidae																
Fulica atra	Rr	1	1	1										1		
Gallinula chloropus	R	1	1	1			1							1		
Otidae																
Chlamydotis undulata	R		1		1				1							
Cuculiformes																
Cuculidae																
Clamator glandarius	Mr	1	1	1	1	1	1	1	1	1						
Cuculus canorus	A	1	1	1	1	1	1	1	1	1		1		1		
Procellariiformes																
Procellariidae																
Bulweria bulwerii	A	1	1		1	1	1	1						1		

Species	Presence in the Canary Islands	TF	FV	GC	LZ	LP	LG	EH	1	2	3	4	5	6	7	8
Calonectris diomedea	A	1	1	1	1	1	1	1						1		
Puffinus puffinus	A	1				1								1		
Puffinus assimilis	W	1	1				1	1						1		
Hydrobatidae																
Hydrobates pelagicus	R	1	1		1		1	1						1		
Oceanodroma castro	Rr	1			1			1						1		
Pelagodroma marina	Ar				1									1		
Pelecaniformes																
Sulidae																
Morus bassanus	W	1	1	1	1	1	1	1						1		
Sulidae																
Phalacrocorax carbo	Wr		1	1	1	1	1	1						1		
Ciconiiformes																
Ardeidae																
Ardea cinerea	W	1	1	1	1	1	1	1						1		
Ardea purpurea	Ar	1	1	1	1	1	1	1						1		
Ardeola ralloides	Ar	1	1	1	1	1	1	1						1		
Bubulcus ibis	W	1	1	1	1	1	1	1						1		
Egretta garzetta	W	1	1	1	1	1	1	1						1		
Ixobrychus minutus	Ar	1	1	1	1	1	1	1						1		
Nycticorax nycticorax	M	1	1	1	1	1	1	1						1		
Ciconiidae																
Ciconia ciconia	Mr	1	1	1	1	1	1	1	1					1		1
Threskiornithidae																
Platalea leucorodia	Wr	1	1	1	1	1	1	1						1		
Threskiornis aethiopicus	R/I	1	1	1	1	1	1	1						1		
Charadriiformes																
Haematopodidae																
Haematopus ostralegus	Wr	1	1	1	1	1	1	1	1					1		
Recurvirostridae																
Himantopus himantopus	M/A	1	1	1	1	1	1	1						1		
Recurvirostra avosetta	Ar	1	1	1	1	1	1	1						1		

Species	Presence in the Canary Islands	TF	FV	GC	LZ	LP	LG	EH	1	2	3	4	5	6	7	8
Burhinidae																
Burhinus oedicnemus	R		1		1				1	1						
Glareolidae																
Cursorius cursor	R		1		1				1							
Charadriidae																
Charadrius alexandrinus	R	1	1	1	1				1					1		
Charadrius dubius	R	1	1	1										1		
Charadrius hiaticula	W	1	1	1	1	1	1	1	1					1		
Pluvialis squatarola	W	1	1	1	1	1	1	1	1					1		
Vanellus vanellus	Wr	1	1	1	1	1	1	1	1						1	
Scolopacidae																
Actitis hypoleucos	W	1	1	1	1	1	1	1						1		
Arenaria interpres	W	1	1	1	1	1	1	1	1				1	1		
Calidris alba	W	1	1	1	1	1	1	1	1				1			
Calidris alpina	W	1	1	1	1	1	1	1						1		
Calidris canutus	W	1	1	1	1	1	1	1	1				1	1		
Calidris ferruginea	W	1	1	1	1	1	1	1	1				1	1		
Calidris minuta	W	1	1	1	1	1	1	1	1				1	1		
Gallinago gallinago	Wr	1	1	1	1	1	1	1						1		
Limosa lapponica	M/W	1	1	1	1	1	1	1	1				1	1		
Limosa limosa	W	1	1	1	1	1	1	1	1					1		
Numenius arquata	Wr	1	1	1	1	1	1	1	1							
Numenius phaeopus	W	1	1	1	1	1	1	1	1					1		
Philomachus pugnax	M/W	1	1	1	1	1	1	1	1							
Scolopax rusticola	R	1				1	1	1	1	1		1				
Tringa glareola	M/W	1	1	1	1	1	1	1						1		
Tringa nebularia	M/W	1	1	1	1	1	1	1						1		
Tringa ochropus	W	1	1	1	1				1	1	1					
Tringa totanus	W	1	1	1	1	1	1	1	1					1		
Stercorariidae																
Stercorarius parasiticus	W	1	1	1	1	1	1	1						1		

Species	**Presence in the Canary Islands**	**TF**	**FV**	**GC**	**LZ**	**LP**	**LG**	**EH**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Stercorarius pomarinus	Wr	1	1	1	1	1	1	1						1		
Stercorarius skua	W	1	1	1	1	1	1	1						1		
Sternidae																
Chlidonias hybridus	M	1	1	1	1	1	1	1						1		
Chlidonias niger	M/A	1	1	1	1	1	1	1						1		
Gelochelidon nilotica	Ar	1	1	1	1	1	1	1						1		
Sternula albifrons	Ar	1	1	1	1	1	1	1						1		
Sterna dougallii	Wr	1	1	1	1	1	1	1						1		
Sterna hirundo	Ar	1	1	1	1	1	1	1						1		
Sterna sandvicensis	W	1	1	1	1	1	1	1						1		
Alcidae																
Fratercula arctica	Wr	1	1	1	1	1	1	1						1		
Laridae																
Larus canus	Wr	1	1	1	1	1	1	1						1		
Larus fuscus	W	1	1	1	1	1	1	1						1		
Larus marinus	Wr	1	1	1	1	1	1	1						1		
Larus michahellis	R	1	1	1	1	1	1	1						1		
Larus ridibundus	W	1	1	1	1	1	1	1						1	1	1
Strigiformes																
Tytonidae																
Tyto alba	R	1	1	1	1			1	1	1					1	1
Strigidae																
Asio otus	R	1		1		1	1	1		1	1					
Falconidae																
Falco eleonorae	Ar				1				1					1		
Falco pelegrinoides	R	1	1		1											
Falco tinnunculus	R	1	1	1	1	1	1	1	1	1						
Accipitriformes																
Accipitridae																
Accipiter nisus	R	1		1		1	1	1		1		1				
Buteo buteo	R	1		1		1	1		1	1		1			1	
Milvus migrans	Ar			1					1	1				1	1	
Neophron percnopterus	R		1		1				1					1		

Species	**Presence in the Canary Islands**	**TF**	**FV**	**GC**	**LZ**	**LP**	**LG**	**EH**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Pandionidae																
Pandion haliaetus	Rr	1			1		1	1						1		
Psittaciformes																
Psittacidae																
Nymphicus hollandicus	R/I	1							1							
Psittacidae																
Agapornis fischeri	R/I			1						1		1				
Agapornis personata	R/I			1						1		1				
Amazona ochrocephala	R/I	1								1		1				1
Melopsittacus undulatus	R/I	1							1	1						
Myiopsitta monachus	R/I	1	1	1		1			1	1						
Nandayus nenday	R/I	1							1	1						
Poicephalus senegalus	R/I	1														1
Psittacula krameri	R/I	1		1					1	1		1				
Coraciiformes																
Meropidae																
Merops apiaster	Mr	1	1	1	1	1	1	1	1	1						
Coraciidae																
Coracias garrulus	Mr	1	1	1	1	1	1	1	1	1						
Upupidae																
Upupa epops	R	1	1	1	1	1	1	1	1	1						
Piciforme																
Picidae																
Dendrocopos major	R	1		1						1		1				
Passeriformes																
Laniidae																
Lanius meridionalis	R	1	1	1	1				1	1						
Lanius senator	M	1	1	1	1	1	1	1		1						
Corvidae																
Corvus corax	R	1	1	1	1	1	1	1	1	1		1				
Pyrrhocorax pyrrhocorax	R					1			1	1						
Sylviidae																
Hippolais polyglotta	Mr	1	1	1	1	1	1	1								

Species	Presence in the Canary Islands	TF	FV	GC	LZ	LP	LG	EH	1	2	3	4	5	6	7	8
Phylloscopus canariensis	R/E	1		1		1	1	1		1		1				
Phylloscopus bonelli	M	1	1	1	1	1	1	1				1				
Phylloscopus sibilatrix	Mr	1	1	1	1	1	1	1				1				
Phylloscopus trochilus	M	1	1	1	1	1	1	1		1		1				
Sylvia atricapilla	R	1		1		1	1	1		1		1				
Sylvia borin	M	1	1	1	1	1	1	1		1		1				
Sylvia cantillans	Mr	1	1	1	1	1	1	1		1		1				
Sylvia communis	M	1	1	1	1	1	1	1		1						
Sylvia conspicillata	R	1	1	1	1	1	1	1		1						
Sylvia melanocephala	R	1	1	1		1	1	1		1						
Paridae																
Cyanistes teneriffae	R	1	1	1	1	1	1	1		1		1				
Alaudidae																
Alauda arvensis	Wr	1	1	1	1	1	1	1	1							
Calandrella rufescens	R	1	1	1	1				1							
Hirundinidae																
Delichon urbicum	M	1	1	1	1	1	1	1	1	1	1		1	1	1	1
Hirundo rustica	M	1	1	1	1	1	1	1	1						1	1
Hirundo daurica	M	1	1	1	1	1	1	1	1	1						
Riparia riparia	M	1	1	1	1	1	1	1	1							
Regulidae																
Regulus teneriffae	R/E	1				1	1	1				1				
Muscicapidae																
Erithacus rubecula	R	1		1		1	1	1		1		1				
Ficedula hypoleuca	M	1	1	1	1	1	1	1		1		1				
Luscinia megarhynchos	Mr	1	1	1	1	1	1	1	1	1						
Muscicapa striata	M	1	1	1	1	1	1	1	1							
Oenanthe oenanthe	M	1	1	1	1	1	1	1	1					1		
Phoenicurus ochruros	Wr	1	1	1	1	1	1	1						1		1
Phoenicurus phoenicurus	M	1	1	1	1	1	1	1								

Species	**Presence in the Canary Islands**	**TF**	**FV**	**GC**	**LZ**	**LP**	**LG**	**EH**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Saxicola dacotiae	R/E		1						1	1						
Saxicola rubicola	Wr	1	1	1	1	1	1	1	1	1						
Accipitridae																
Turdus merula	R	1		1		1	1	1		1		1				
Turdus philomelos	Wr	1	1	1	1	1	1	1		1		1				
Sturnidae																
Sturnus vulgaris	W	1	1	1	1		1	1	1	1					1	
Motacillidae																
Anthus berthelotii	R	1	1	1	1	1	1	1		1						
Anthus campestris	Wr	1	1	1	1	1	1	1	1							
Anthus pratensis	Wr	1	1	1	1	1	1	1	1							
Anthus trivialis	M	1	1	1	1	1	1	1		1		1				
Motacilla alba	W	1	1	1	1	1	1	1	1							
Motacilla cinerea	R	1		1		1	1							1		
Motacilla flava	M	1	1	1	1	1	1	1	1							
Passeridae																
Passer hispaniolensis	R/I	1	1	1	1	1	1	1		1					1	1
Passer montanus	R/I			1						1						
Petronia petronia	R	1		1		1	1	1		1						
Estrildidae																
Estrilda melpoda	R/I	1	1	1	1	1	1	1	1	1						
Estrilda troglodytes	R/I	1	1	1	1	1	1	1	1							
Emberizidae																
Miliaria calandra	R	1	1	1	1	1	1	1	1							
Fringillidae																
Carduelis cannabina	R	1	1	1	1	1	1	1	1							
Carduelis carduelis	R	1		1			1			1						
Carduelis chloris	R	1	1	1			1			1						
Fringilla coelebs	R			1		1	1			1		1				
Fringilla teydea	R/E	1		1						1		1				

Species	Presence in the Canary Islands	TF	FV	GC	LZ	LP	LG	EH	1	2	3	4	5	6	7	8
Rhodopechys githaginea	R	1	1	1	1		1		1							
Serinus canaria	R	1		1		1	1	1	1	1						

- **Appendix 2**

Fig. 9.1 The "Thousand-year-old dragon" (Dracaena draco) in the north of Tenerife.

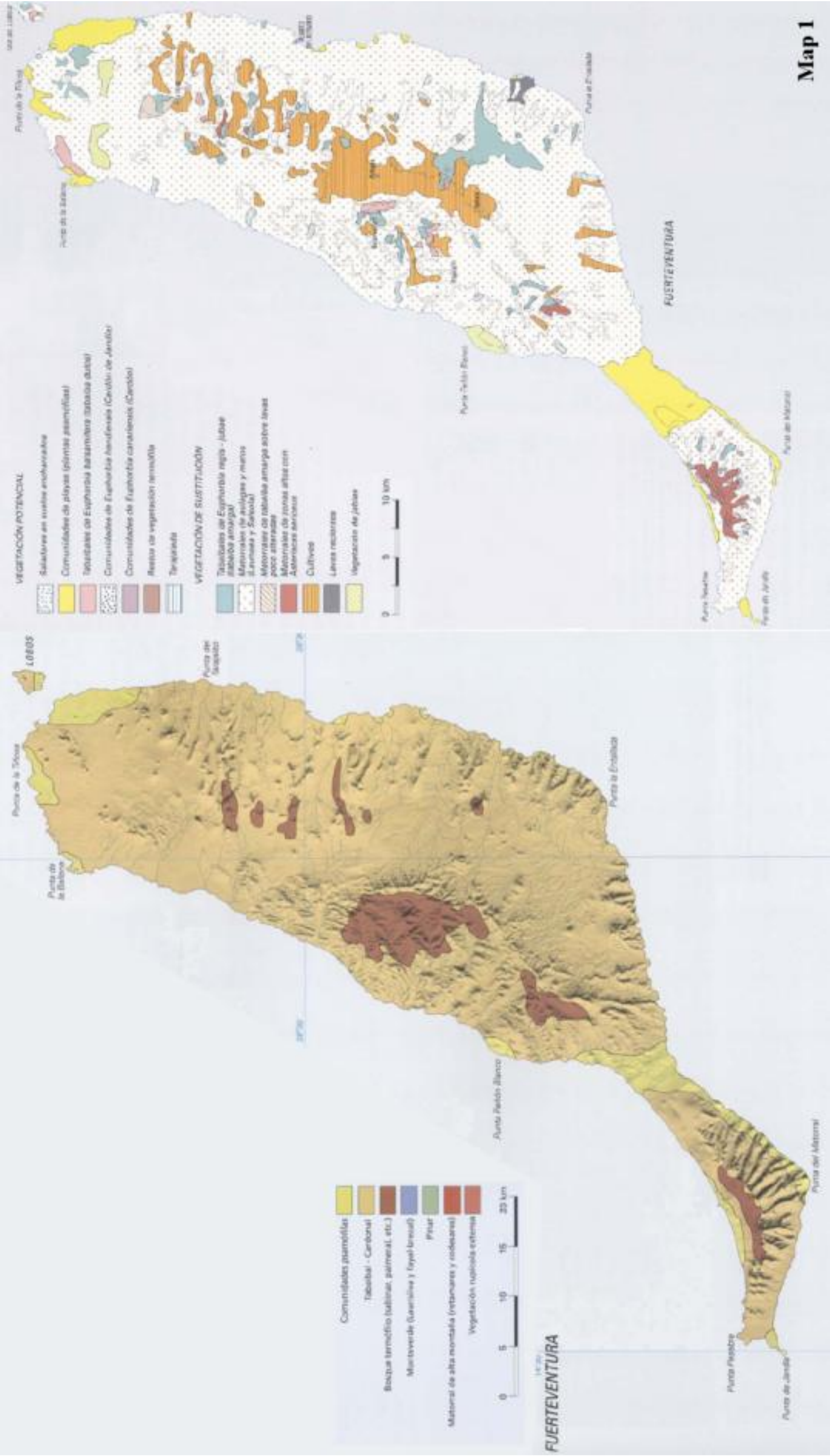
Fig. 9.2 Chronological gaps in the rocks created by different Magmatic cycles (Tenerife)

Fig. 9.3 Caldera of "Las Cañadas" and Teide volcano in Tenerife (ALEAN J. et al. 2005)

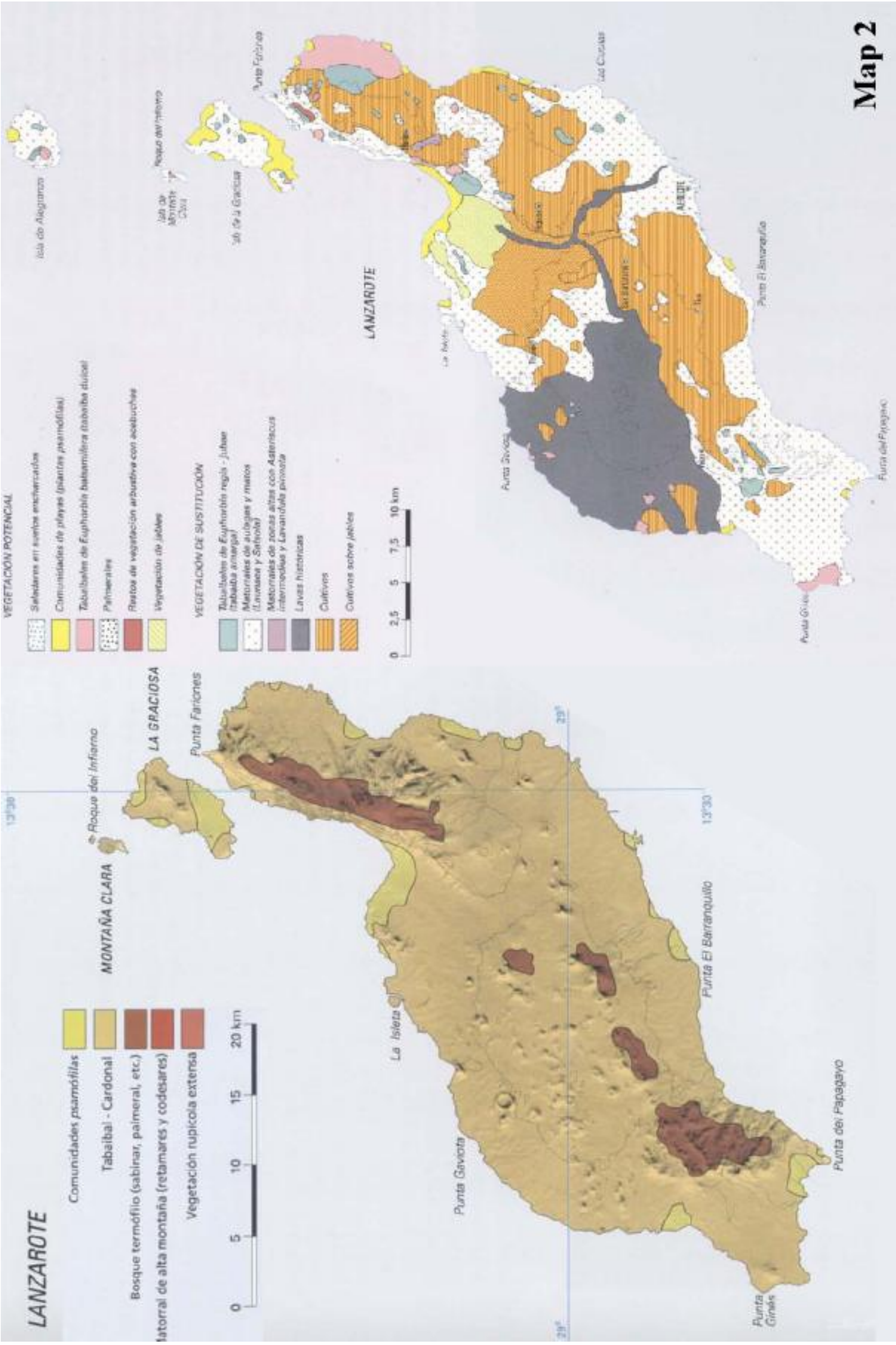
Fig. 9.4 The inhabited part of "Cliffs of the Gigants" situated in the western coast of Tenerife.

- **Appendix 3**

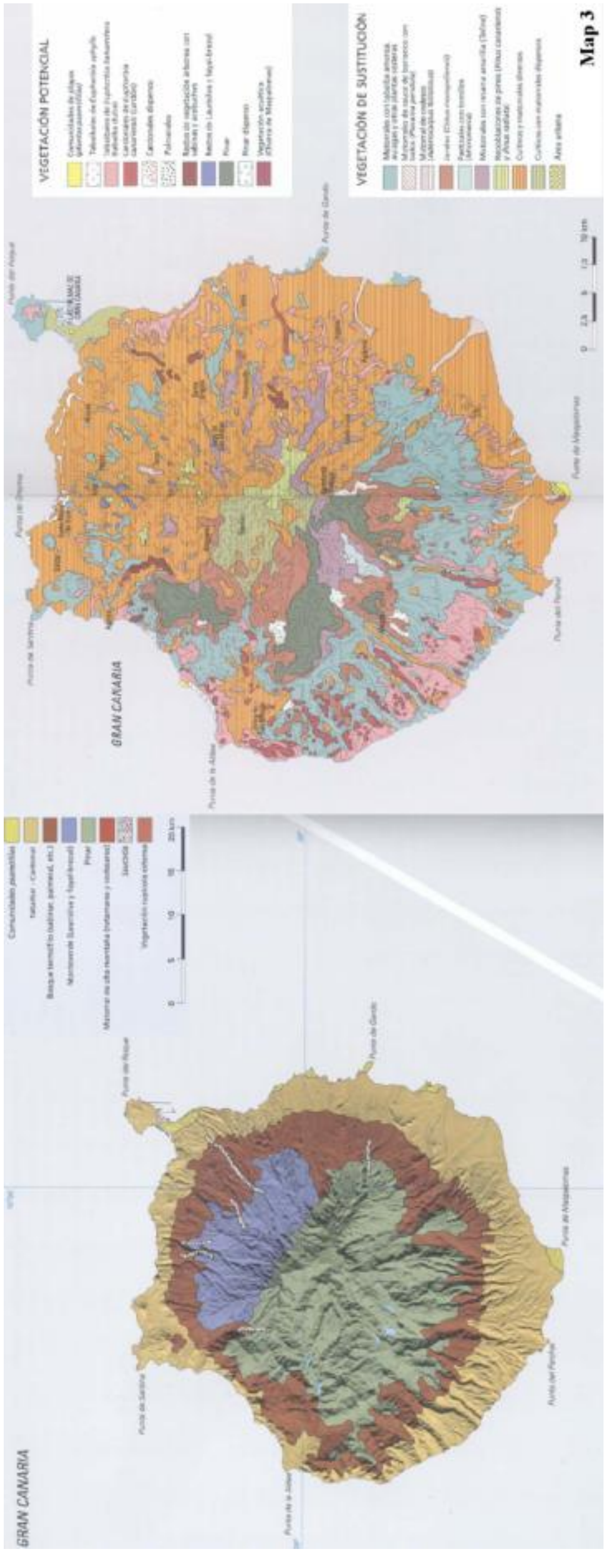
The following maps are modified from MORALES MATOS G. et al. 2000 and show the changes suffered by vegetation since the arrival of humans. The maps bellow (left) show the potential vegetation of the island in the beginning of times. The maps above (right) show the current vegetation of the islands.

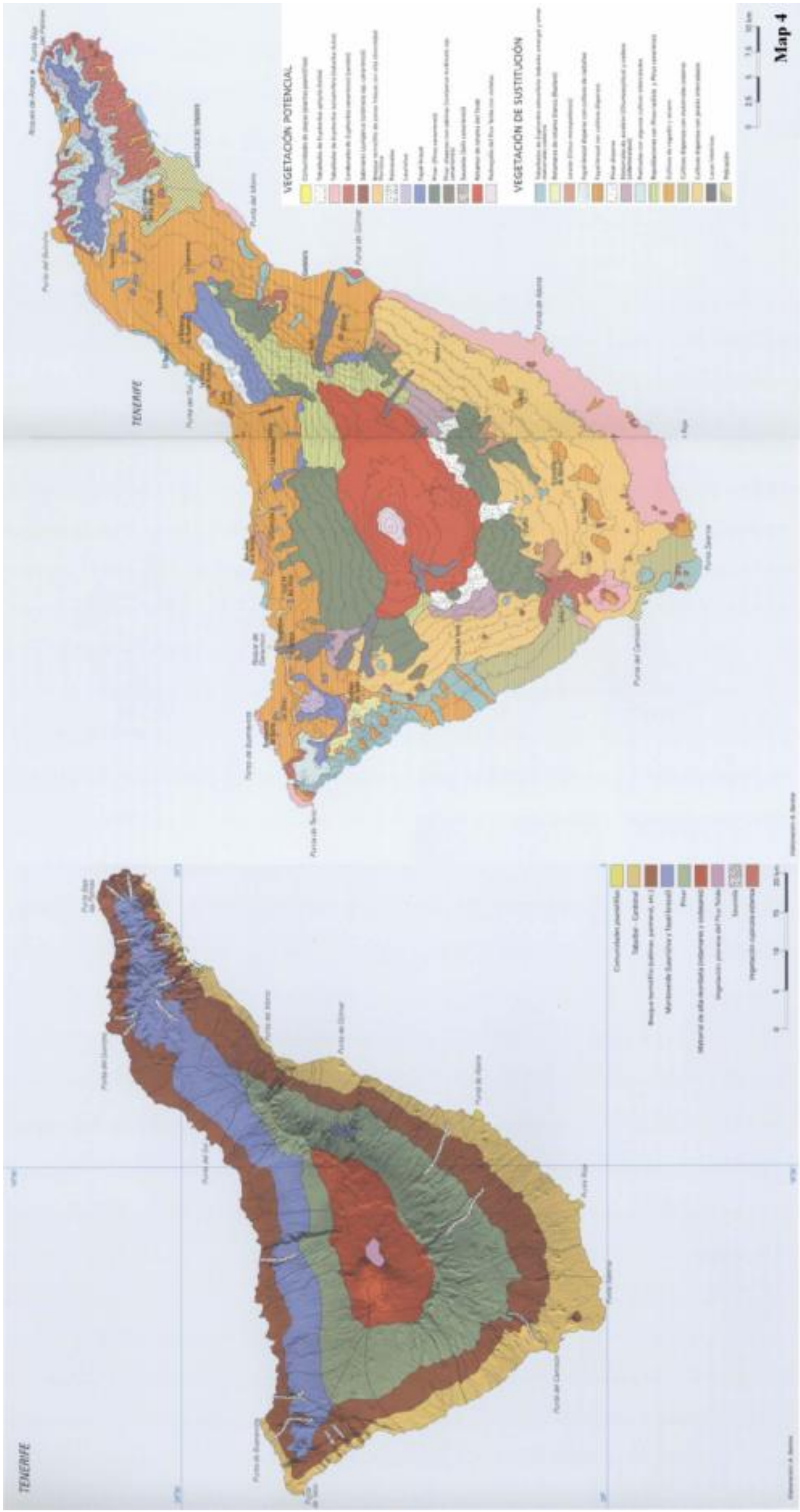


Map 1

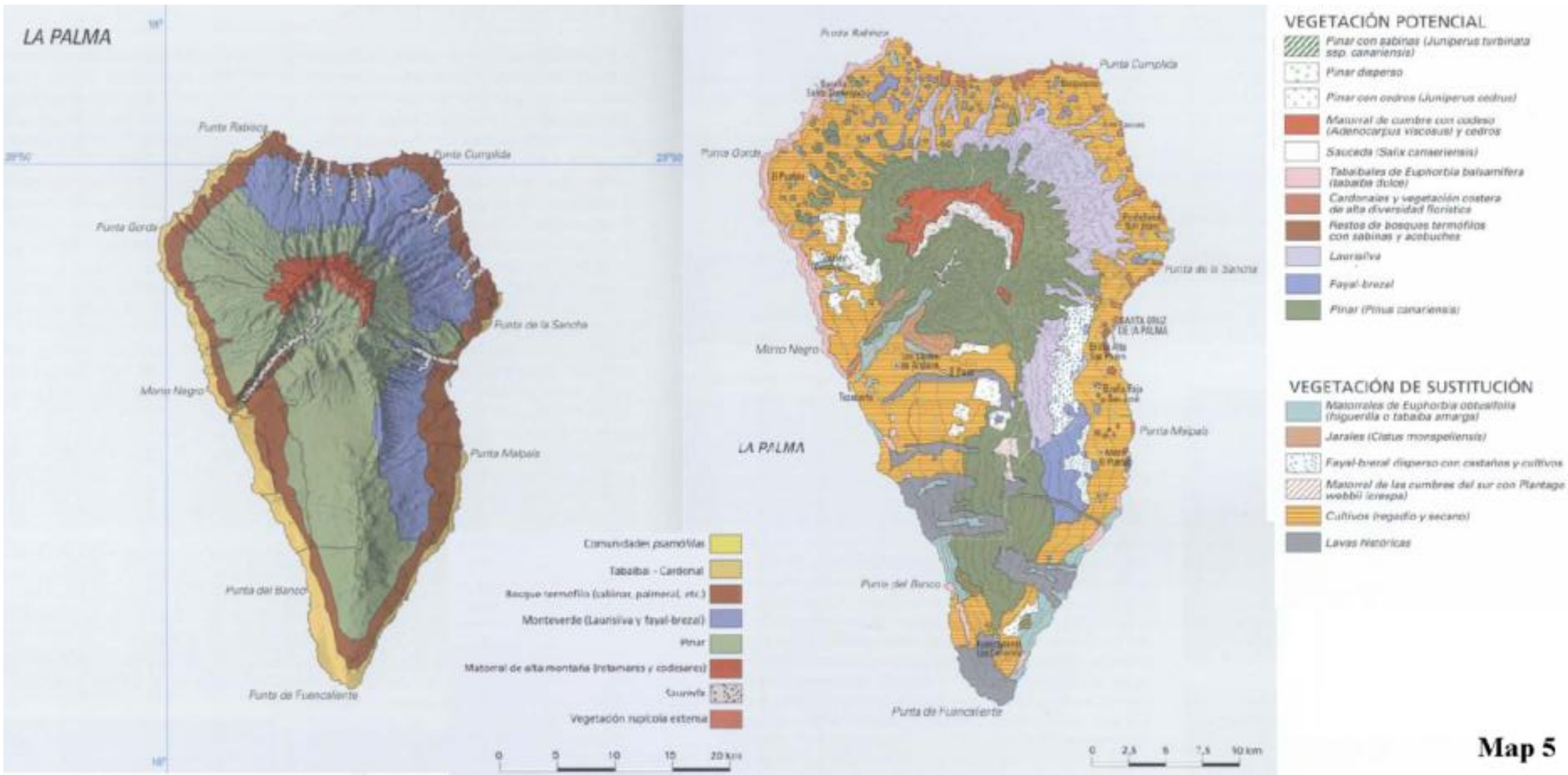

LANZAROTE
Comunidades psamófilas
Tabaibal - Cardonal
Bosque termófilo (sabinar, palmeral, etc.)
latorral de alta montaña (retamares y codesares)
Vegetación rupícola extensa
0 5 10 15 20 km
MONTAÑA CLARA
Roque del Infierno
LA GRACIOSA
Punta Fariones
La Isleta
Punta El Barranquillo
Punta Gaviota
Punta del Papagayo
Punta Ginés
VEGETACIÓN POTENCIAL
VEGETACIÓN DE SUSTITUCIÓN
Lavas históricas
Cultivos
Cultivos sobre jables
0 2,5 5 7,5 10 km
LANZAROTE

Map 2


GRAN CANARIA
GRAN CANARIA
VEGETACIÓN POTENCIAL
VEGETACIÓN DE SUSTITUCIÓN
Map 3

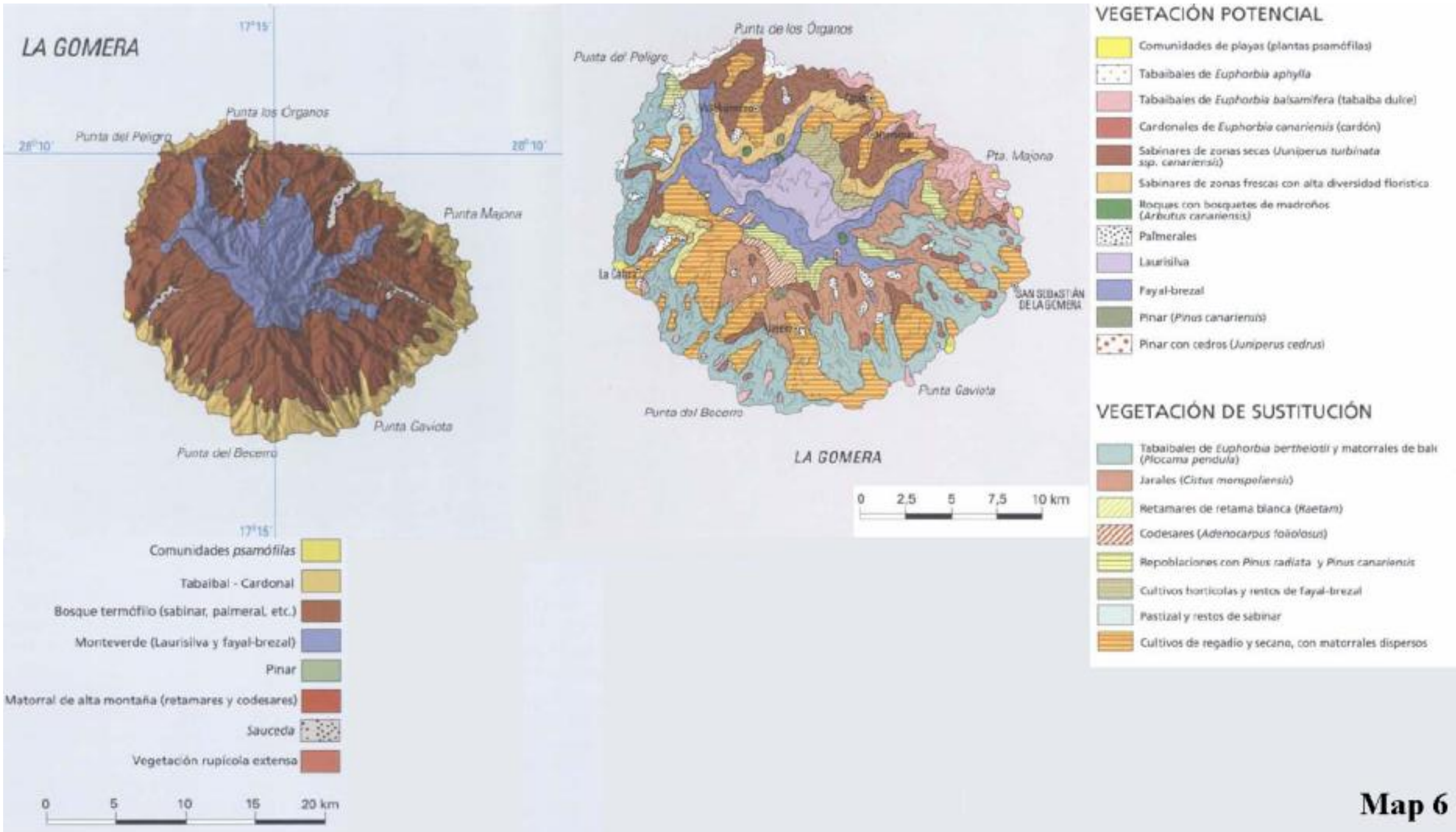

TENERIFE
VEGETACIÓN POTENCIAL
VEGETACIÓN DE SUSTITUCIÓN
TENERIFE

Map 4

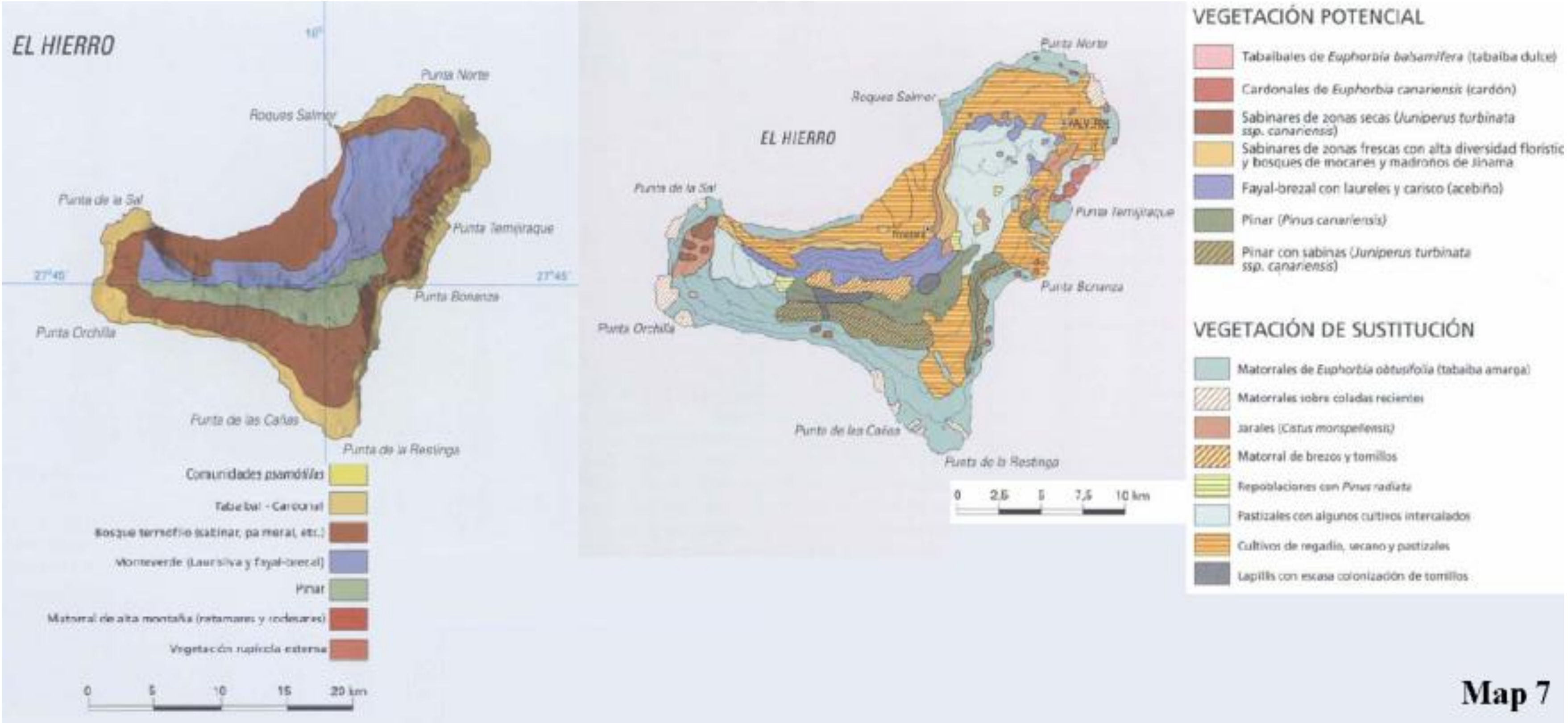


LA PALMA
Punta Rabiosa
Punta Cumplida
Punta Gorda
Punta de la Sancha
Morro Negro
Punta Malpaís
Punta del Banco
Punta de Fuencaliente
Comunidades psamófilas
Tabaibal - Cardonal
Bosque termófilo (sabinar, palmeral, etc.)
Monteverde (Laurisilva y fayal-brezal)
Pinar
Matorral de alta montaña (retamares y codesares)
Saucedà
Vegetación rupícola externa
0 5 10 15 20 km
LA PALMA
SANTA CRUZ DE LA PALMA
0 2,5 5 7,5 10 km
VEGETACIÓN POTENCIAL
Pinar con sabinas (Juniperus turbinata ssp. canariensis)
Pinar disperso
Pinar con cedros (Juniperus cedrus)
Matorral de cumbre con codeso (Adenocarpus viscosus) y cedros
Sauceda (Salix canariensis)
Tabaibales de Euphorbia balsamifera (tabaiba dulce)
Cardonales y vegetación costera de alta diversidad florística
Restos de bosques termófilos con sabinas y acebuches
Laurisilva
Fayal-brezal
Pinar (Pinus canariensis)
VEGETACIÓN DE SUSTITUCIÓN
Matorrales de Euphorbia obtusifolia (higuerilla o tabaiba amarga)
Jarales (Cistus monspeliensis)
Fayal-brezal disperso con castaños y cultivos
Matorral de las cumbres del sur con Plantago webbii (crespa)
Cultivos (regadío y secano)
Lavas históricas

Map 5


LA GOMERA
17°15'
28°10'
Punta los Órganos
Punta del Peligro
Punta Majona
Punta Gaviota
Punta del Becerro
Comunidades psamófilas
Tabaibal - Cardonal
Bosque termófilo (sabinar, palmeral, etc.)
Monteverde (Laurisilva y fayal-brezal)
Pinar
Matorral de alta montaña (retamares y codesares)
Sauceda
Vegetación rupícola extensa
0 5 10 15 20 km
Punta de los Órganos
Punta del Peligro
Pta. Majona
La Calera
SAN SEBASTIÁN DE LA GOMERA
Punta Gaviota
Punta del Becerro
LA GOMERA
0 2,5 5 7,5 10 km
VEGETACIÓN POTENCIAL
Comunidades de playas (plantas psamófilas)
Tabaibales de Euphorbia aphylla
Tabaibales de Euphorbia balsamifera (tabaiba dulce)
Cardonales de Euphorbia canariensis (cardón)
Sabinares de zonas secas (Juniperus turbinata ssp. canariensis)
Sabinares de zonas frescas con alta diversidad florística
Bosques con bosquetes de madroños (Arbutus canariensis)
Palmerales
Laurisilva
Fayal-brezal
Pinar (Pinus canariensis)
Pinar con cedros (Juniperus cedrus)
VEGETACIÓN DE SUSTITUCIÓN
Tabaibales de Euphorbia berthelotii y matorrales de bal (Plocama pendula)
Jarales (Cistus monspeliensis)
Retamares de retama blanca (Raetam)
Codesares (Adenocarpus foliolosus)
Repoblaciones con Pinus radiata y Pinus canariensis
Cultivos hortícolas y restos de fayal-brezal
Pastizal y restos de sabinar
Cultivos de regadío y secano, con matorrales dispersos

Map 6



EL HIERRO
10°
Punta Norte
Roques Salmor
Punta de la Sal
Punta Tamiraque
27°45'
27°45'
Punta Bonanza
Punta Orchilla
Punta de las Cañas
Punta de la Restinga
Comunidades psamófilas
Tabaibal - Cardonal
Bosque termófilo (sabinar, palmeral, etc.)
Monteverde (Laurisilva y Fayal-brezal)
Pinar
Matorral de alta montaña (retamares y codesares)
Vegetación rupícola externa
0
5
10
15
20 km
EL HIERRO
Punta Norte
Roques Salmor
Punta de la Sal
Punta Tamiraque
Punta Bonanza
Punta Orchilla
Punta de las Cañas
Punta de la Restinga
0
2,5
5
7,5
10 km
VEGETACIÓN POTENCIAL
Tabaibales de Euphorbia balsamifera (tabaiba dulce)
Cardonales de Euphorbia canariensis (cardón)
Sabinares de zonas secas (Juniperus turbinata ssp. canariensis)
Sabinares de zonas frescas con alta diversidad floristic y bosques de mocanes y madroños de Jinama
Fayal-brezal con laureles y carisco (acebiño)
Pinar (Pinus canariensis)
Pinar con sabinas (Juniperus turbinata ssp. canariensis)
VEGETACIÓN DE SUSTITUCIÓN
Matorrales de Euphorbia obtusifolia (tabaiba amarga)
Matorrales sobre coladas recientes
Jarales (Cistus monspeliensis)
Matorral de brezos y tomillos
Repoblaciones con Pinus radiata
Pastizales con algunos cultivos intercalados
Cultivos de regadío, secano y pastizales
Lapillis con escasa colonización de tomillos

Map 7