The Laurel Forest An Example for Biodiversity Hotspots threatened by Human Impact and Global Change

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The Laurel Forest
An Example for Biodiversity Hotspots threatened by Human Impact and Global Change

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Part I.

Summary

1. Abstract

The Canary Islands' laurel forest is a montane evergreen forest formation of an outstanding floristic and biogeographic value. It is endemic to several islands of the Macaronesian biogeographic region, confined to the humid areas limited by the influence of the trade wind clouds. In recent times this relict forest vegetation, which once covered large proportions of the Canary Islands, suffered from a massive range reduction and fragmentation due to human exploitation.

This thesis evaluates the phylogeography and population structure of the laurel forest on the basis of two characteristic plant taxa representative for the whole vegetation complex: The widespread and dominant canopy-building tree species *Laurus novocanariensis* and the more constrictive Canary Island endemic *Ixanthus viscosus.* Analyses exhibit low levels of differentiation on within- as well as between-island level. Especially for *Laurus* the exchange between populations from different islands, even over longer distances, is obvious. On island level the forest fragmentation has low impact on population divergence up to now.

Furthermore, we localised the genetic hotspots of both model species within the laurel forest distribution range on Tenerife. A small-scale grid square sampling strategy combined with approaches from population and landscape genetics enabled the development of detailed maps showing the centres of genetic diversity and thus revealing the connection between forest fragmentation and diversity loss.

Additionally, we analysed the ecological preferences of the two species, recognising not abiotic factors, but rather past forest degradation as having the most important impact on the current distribution range of the endemic *Ixanthus.*

Based on these findings we discuss the necessity and opportunities for conservation strategies of the Canary Islands' laurel forest in the future.

2. Zusammenfassung

Der kanarische Lorbeerwald ist eine montane, immergrüne Waldgesellschaft von außergewöhnlichem floristischen und biogeographischen Wert. Er ist endemisch auf einigen Inseln der biogeographischen Region Makaronesien, wo er in den humiden, unter Einfluss der Passatwolken stehenden Gebieten existiert. In jüngerer Zeit erlitt diese Reliktvegetation, die einst ausgedehnte Gebiete der Kanarischen Inseln bedeckte, bedingt durch menschliche Nutzung massive Gebietsverluste sowie -fragmentierung.

Die vorliegende Arbeit untersucht Phylogeographie und Populationsstrukturen des Lorbeerwaldes anhand zweier charakteristischer Pflanzenarten, die repräsentativ für den gesamten Vegetationskomplex stehen: der weitverbreiteten und vorherrschenden, kronendachbildenden Baumart *Laurus novocanariensis* (Kanaren-Lorbeer) und dem weniger weit verbreiteten Kanarenendemiten *Ixanthus viscosus* (Kanaren-Enzian). Die Analysen zeigen ein geringes Niveau der Populationsdifferenzierung sowohl innerhalb als auch zwischen den Inseln. Besonders für Lorbeer ist der Austausch zwischen den Inselpopulationen auch auf größeren Distanzen offenbar. Innerhalb der Inseln scheint die Fragmentierung des Waldes bisher einen geringen Einfluss auf die Populationsdifferenzierung zu haben.

Desweiteren lokalisierten wir die genetischen Hotspots beider Modellarten innerhalb des Lorbeerwaldgebietes auf Teneriffa. Eine kleinräumige, planquadratbasierte Sammelstrategie kombiniert mit populations- und landschaftsgenetischen Ansätzen ermöglichte die Entwicklung von detaillierten Karten, welche die Zentren der genetischen Vielfalt visualisieren. Diese verdeutlichen die Verbindung zwischen Waldfragmentierung und Diversitätsverlust.

Zusätzlich haben wir die ökologischen Präferenzen der Modellarten analysiert und herausgefunden, dass nicht abiotische Faktoren, sondern die zurückliegende Degradation des Waldes am bedeutendsten für das aktuelle Verbreitungsareal des Endemiten *Ixanthus* ist.

Basierend auf diesen Ergebnissen diskutieren wir abschließend die Notwendigkeit sowie die Möglichkeiten für den zukünftigen Schutz des kanarischen Lorbeerwaldes.

Part II.

Introduction

3. Canary Islands and the Laurel Forest

For many years the Canary Islands have been a Mecca-like destination for scientists of many disciplines, which was caused by the islands' uniqueness, remarkable richness in flora and fauna, easy accessibility and model-system likeness. Since Alexander von Humboldt visited Tenerife in 1799 and recorded first findings about geological and botanical geography, biologists, geologists and geographers discovered the islands for their studies.

Geologic History

The Canary Islands archipelago is composed of seven main islands, which are — from west to east — El Hierro, La Palma, La Gomera, Tenerife, Gran Canaria, Fuerteventura and Lanzarote. The archipelago is situated in the Atlantic ocean off the northwest African coast of Morocco.

Starting over 21 million years ago with the beginning of the oligocene, volcanic eruptions formed an archipelago of subaerial, oceanic islands. Generated most likely by a mantle plume or a hot spot (Coello, 1992), island ages and erosion states decline from east to west. Island ages are proposed from 20 (Fuerteventura) to one million (El Hierro) years (Holik, 1991). Tenerife itself was formed out of the three preliminary, older islands Teno (7.4 Mio), Anaga (5.8 Mio), and Roque del Conde (11.6 Mio) less than two million years ago (Ancochea, 1990), which is reflected in common phylogeographic patterns of different species (Juan et al., 2000).

Climate

The climate of the Canary Islands is mainly influenced by their oceanic location, the proximity to the African mainland, the trade winds and the ocean currents. While the eastern islands Lanzarote and Fuerteventura show a desert-like climate, the western islands are more influenced by a Mediterranean climate (Sperling et al. (2004), Wildpret de la Torre (1997)). But due to their partly high elevations, microclimate is varying significantly, because the islands are a topographic barrier for the trade winds. Therefore, a clearly apparent altitudinal and exposure depending zonation is present (Sperling et al., 2004), resulting in several characteristic bioclimatic belts (del Arco et al., 2006). They harbour different vegetation types: saline coastal vegetation communities, arid scrublands in the lowlands, semiarid thermophilous woodlands, laurel forests, pine forests, summit scrublands and alpine habitats in the highest parts (Seidel (1978), Juan et al. (2000)). Tenerife, with its peak of Teide being 3718 m high, is the highest island of the archipelago and all vegetation belts are present (Sperling et al. (2004), Wildpret de la Torre (1997)).

This large variation of ecological conditions is essential for the high biodiversity on the islands, but also the long stable geoclimatic characteristics and the changes of the insular landscape contribute to the unique and diverse flora (Whittaker et al., 2008). This makes the Canaries as an island ecosystem within the highly diverse Mediterranean region a "hotspot within a hotspot" (Médail, 1999).

The Laurel Forest History and Ecology of an Unique Ecosystem

The laurel forest is a vegetation complex on the Canary Islands archipelago. It is often referred to as *laurisilva*, or, subsumed with the heath scrubs, as *monteverde* (Pott et al., 2003).

The laurel forest is an endemic, humid subtropical forest that is unique to several islands of the Macaronesian biogeographic region (Aboal et al. (2002), Emerson (2003)) with an outstanding floristic and biogeographic value (del Arco Aguilar et al., 2010). Those broadleaved, evergreen forests, also addressed as the biome of temperate rain forests, are distributed on the humid coastlines worldwide (Pott, 2006). The laurel forests of Europe are growing on the Canary Islands, on Madeira and on the Azores. On the Canaries, the forests are located in the cloud area on the northern windward slopes of the western islands Tenerife, Gran Canaria, El Hierro, La Palma and La Gomera between the lower mostly disappeared vegetation belt of the thermophile forests (Fernández-Palacios et al., 2008) and the upper belt of pine forests.

For the existence of the laurel forest the trade winds are of essential prominence (Kämmer, 1974). These are moisture laden winds from NE direction, which are forming an orographic cloud belt on the slopes exposed to the North between approximately 500 and 1500 meters above sea level (Guimarães and Olmeda, 2008). This more or less constant impounding of clouds is named *mare de nubes*, a sea of clouds (Fernández-Palacios, 1992). Firstly, due to the cloud cover, mean annual temperatures are between 13 °C to 15 °C (19 °C), and evaporation and radiation are decreased (Guimarães and Olmeda (2008), Fernández-Palacios and Nicolás (1995)). Secondly, the clouds supply this area with rainfalls of about 1000 mm per year and a more or less constant amount of indirect or horizontal precipitation (fog drip) through fog (Fernández-Palacios and Nicolás, 1995), which adds a significant deal of water to the direct precipitation. Several studies concerning the amount of fog precipitation with partly contradicting results have been conducted (Prada et al. (2009), Regalado and Ritter (2010), Marzol Jaen (2002)), but it seems for sure that fog precipitation can exceed the vertical precipitation during the summer months (Still et al., 1999). Therefore, even in the dry summer season from June to August, the clouds sustain a semi-humid climate creating the necessary environmental conditions to conserve the supposed relict forest (Sperling et al., 2004) for which the dry summers of the Mediterranean climate are not suitable. More detailed bioclimatic belts were evaluated by del Arco et al. (2006).

Thus the trade wind clouds define the altitudinal range which represents a suitable habitat for the laurel forests.

The evergreen sclerophyllous vegetation of the laurel forests is supposed to be of a relict character, because in the late Eocene it was spread in the whole Tethyan region, which is today Southern Europe and Northern Africa (Axelrod, 1975). This ancient vegetation is addressed as the Madrean-Tethyan flora. *Laurus* fossils and other laurel forest taxa from the Pliocene-Oligocene period were found in Central Europe as well as on the Black Sea coast (Rodríguez-Sánchez and Arroyo, 2008). Other fossils found on Madeira suggest that laurel forests had grown 20 million years ago on the Macaronesian islands (Guimarães and Olmeda (2008), Sziemer (2000)). With the beginning of the latest ice age and the development of the seasonal Mediterranean climate, the subtropical vegetation disappeared from the mainlands due to changing climate conditions: southern Europe became too cold and North Africa too dry ((Pott et al., 2003), Pott (2006), Wildpret de la Torre (1997)), but paleoclimatic data shows that the climate conditions on the Canary Islands have been more or less stable during the Quaternary glacial and interglacial periods (Rodríguez-Sánchez and Arroyo, 2008). Therefore, a number of taxa from the Madrean-Tethyan flora were able to survive there and in some areas of the mainlands, which makes the laurel forests as we know it today a pauperised version of the former Tertiary vegetation. Consequently, despite the somewhat misleading name "relict", today's laurel forests should not be seen as a Tertiary museum (Pott et al., 2003), because species composition changed significantly over the time: they consist of relict taxa, which became extinct everywhere else, and modern taxa, which newly evolved in the Holocene (Bramwell (1976), Vargas (2007)). The vascular plant flora is more than 50 % endemic to the Canaries (680 taxa); also remarkable is the high proportion of endemic and endangered species native to the laurisilva (Reyes-Betancort et al. (2008), del Arco Aguilar et al. (2010)).

The species-rich tree layer in the laurel forest of Tenerife is made up by the four Lauraceae species *Laurus novocanariensis*, *Persea indica*, *Apollonias barbujana* and *Ocotea foetens* together with similar looking members of other families like *Prunus lusitanica*, *Picconia excelsa*, *Ilex platyphylla* and the more rare taxa *Pleiomeris canariensis* and *Heberdenia excelsa*. All those taxa have got similar laurel-shaped leaves which are characteristic for the temperate rain forests. Typical for the laurel forest are liana species and epiphytes (mosses, ferns) which grow on trunks and trees as well as a rich understory containing many endemic species (Wildpret de la Torre, 1997): It's the most diverse forest ecosystem on the Canary Islands (del Arco Aguilar et al., 2010).

On drier, colder and more exposed stands such as windswept crests and on poor soils, *Erica arborea* and *Myrica faya* are replacing the laurel forest species and form the species-poor formation of the Myrico fayae-Ericion arboreae, the heaths endemic to Macaronesia, which are also assigned to the monteverde. This community is also replacing the laurel forest on degraded stands as a succession formation (Pott et al. (2003), Guimarães and Olmeda (2008), Wildpret de la Torre (1997)).

Human Impact and Current State

The actual vegetation of the Canary Islands differs significantly from the potential natural vegetation (PNV) due to human intervention over thousands of years.

The transfiguration of the PNV started with the first inhabitants, the Guanches, a Berber ethnic that arrived on the Canary Islands approximately 2000–3000 years ago (de Nascimento et al. (2009), Parsons (1981)). Even as a pastoral society they started to change the vegetation not negligibly with their cattle and the need for firewood, as pollen analysis had shown (de Nascimento et al. (2009), Fernández-Palacios et al. (2011)). Another opinion is given by del Carmen Machado Yanes et al. (1997), accounting for limited overall impacts which could also be connected to climate changes. But undoubtedly the more important increase of the land use and rapid deforestation began with the conquest of the Castillians starting in 1402 and with the transition from a pastoral to an agriculture society (Wildpret de la Torre, 1997). The wood from the laurel forest tree species was used for construction, firewood, coal, furniture and for poles on plantations. Additionally, the deep soils and the climate of the laurel forest areas were the perfect location for agriculture (Pott et al., 2003). Only 50 years ago, the main focus in economy shifted again, from agriculture to mass tourism, so that the land use magnified on the coastal regions, while half of all agriculture land (50,000 ha) began to lie fallow since 1986 (Günthert et al. (2012), Fernández-Palacios and Whittaker (2008)).

Today, most of the Canary Islands' vegetation is shaped by human activities, as it was shown by del Arco Aguilar et al. (2010) in a recent study: Only 26.7 % of the Canary Islands are covered with remnants of the PNV, while most parts of the islands are dominated by substitution communities and more rural or urban areas without significant vegetation. Well preserved laurel forest communities currently cover 10,181 ha on the Canary Islands, which are only 11.8 % of their potential distribution range (86,624 ha). Together, the *monteverde* covers 35.6 % of its potential area, with a higher proportion of the *fayal-brezal* substitution community: On Tenerife, 8,462 ha of substitutional *fayal-brezal* are present. Compared to the other vegetation complexes on Tenerife, the laurel forest has lost most of its former area, coming right behind the thermo-sclerophyllous woodlands (del Arco Aguilar et al., 2010).

The massive impact on the natural vegetation has lead to the situation that approximately one third of all endemic plant species are currently listed on the Red List of the Canary Islands (Reyes-Betancort et al., 2008).

Due to the fact that more agricultural used sites lie fallow, natural succession to secondary laurel forest becomes an important topic. *Erica arborea* and *Myrica faya*, the characteristic species from *fayal-brezal*, are considered as pioneer taxa, while *Laurus novocanariensis* is a non-pioneer, shade-tolerant species, regenerating by seedlings and suckers (Fernández-Palacios and Arévalo, 1998). The only long-term study from a larger disturbed area by Arévalo et al. (2008) comes to the conclusion that regeneration is very slow (much more than 20 years). But the state of mature laurel forest can be achieved again, if neighboured forest is intact to provide dispersion by birds and vegetative regrowth, which is one of the characteristic regeneration strategies in laurel forest species to maintain the species richness (Fernández-Palacios and Arévalo (1998), Arévalo et al. (2008)).

Conservation

As early as 1974, Voggenreiter (1974) recognised the necessity of conservation of the remnants of the native flora of Tenerife and described the massive transformation of natural vegetation in degraded areas or species-poorer secondary forest communities. To conserve the laurel forests existence is not just a matter of species and diversity protection, but people are benefiting directly from its existence: the forests, especially in steep places, are a protection against soil erosion and land slides. Secondly, on the Canary Islands water shortage is common, also because of increasing consumption, while the forest belts retard the run-off of rain water and add additional water from fog precipitation (Wildpret de la Torre, 1997).

Especially oceanic island ecosystems are more vulnerable, therefore they harbour a big proportion of endangered endemics (Caujapé-Castells et al., 2010), what is a future challenge for conservation science and island preservation.

Currently approximately 40 % of the Canary Islands, are under different levels of protection (Gobienero de Canarias, Reyes-Betancort et al. (2008)), this of course includes parts of the remaining laurel forest formations. For example, the laurel forests of La Gomera were protected since 1981 within the Garajonay National Park, on La Palma, laurel forests are included in the Biosphere Reserve of Los Tiles; both of them are declared by the UNESCO (Wildpret de la Torre, 1997). On Tenerife, there are the Anaga Rural Park (since 1987) with the most diverse laurel forests on the islands (Wildpret de la Torre, 1997) and the Teno Rural Park, both including continuous remnants of Tenerifes laurel forests, although Park Rural underlies a low level of protection (Reyes-Betancort et al., 2008).

As the best conserved laurel forest formations on the Canaries are considered Garajonay National Park (La Gomera), El Pijaral Reserve (Tenerife, Anaga) and Tiles Reserve (La Palma) (Guimarães and Olmeda, 2008). In autumn 2013, Anaga Rural Park entered the approbation period for becoming an UNESCO biosphere reserve in 2014 (Unknown, 2013).

According to Fernández-Palacios and Whittaker (2008), the about 20 % of former laurel forests, that remain today, are in a stable and save extent, but in a regrettable state of conservation (Fernández-Palacios et al., 2011), as the existing conservation network has suffered from political decisions in the last years despite the warnings from the scientific community (Fernández-Palacios and de Nascimento, 2011).

Studies regarding the geographical distribution of the total flora diversity on the Canary Islands are lacking until now. Nevertheless, geographic and diversity patterns of endemic spermatophyte plant taxa were investigated exhaustively and area-wide (Reyes-Betancort et al. (2008), Caujapé-Castells et al. (2013)). Subject to studies concerning genetic diversity were mostly endemics (Silvertown (2004), Trusty et al. (2005), Fuertes-Aguilar et al. (2002)), but there are also analyses concerning phylogeographic patterns of wider-spread species, for example in *Picconia* (Ferreira et al., 2011) and *Erica* (Désamoré et al. (2011), Désamoré et al. (2012)). Overall, the genetic diversity of Canary Island species is higher than of mainland species due to great geological age and the gene flow from mainland areas Francisco-Ortega et al. (2000).

Studies concerning intra-island diversity in a small scale are missing, despite the fact that the protection of genetic diversity is today recognised as an important issue in conservation.

4. Aims of this Study

In the doctoral thesis at hand, a model-like characterisation of the laurel forest with a focus on Tenerife, using two model plants, is provided. We aimed to analyse the population structure of *Laurus novocanariensis* and *Ixanthus viscosus*, two characteristic species from the laurel forest of the Canary Islands, representing one canopy-building and dominant tree species, which can be seen as an indicator of former laurel forest vegetation communities, and an endemic perennial understory herb which seems to be restricted to the more intact respectively primary laurel forest stands.

The priority here is not only to analyse distinct, representative populations, but also to provide a fine-scale overall genetic landscape that covers the whole distribution area of those model plants, showing the connection between genetic diversity level and geography by using an area wide exhaustive sampling of the target species. Genetic hotspots and genetic pauperised areas were identified and could be set in context to regions, fragmentation intensity and existing areas under protection, as genetic diversity is considered important for conservation efforts as well as for succession of fallow lands.

Additionally, in search for environmental factors as another explanation for the distribution of present genetic diversity apart from population history and human influence, the ecological niches for both species were determined from their current distribution range using biologically meaningful climate parameters.

5. Model Species: *Laurus novocanariensis* and *Ixanthus viscosus*

Two model species from the laurel forest were chosen to analyse the diversity patterns in the laurel forest remnants of Tenerife: *Laurus novocanariensis* Rivas Mart., Lousâ, Fern.Prieto, E.Díaz, J.C.Costa & C.Aguiar and *Ixanthus viscosus* (Aiton) Griseb.

5.1. *Laurus*

Laurus novocanariensis is a broadleaved, evergreen tree from the family of the Lauraceae, and is distributed in the Mediterranean and in laurel forests of the Macaronesian biogeographic region. On the Canary islands, the laurel tree is known as "loro".

The Lauraceae are a large family of mainly woody species. Rohwer (1990) outlined it with approximately 50 genera and 2500 to 3000 species, which have their emphasis of distribution in the tropics and subtropics, with one exception of four species respectively genera of this family on the Canary Islands (*Laurus novocanariensis, Apollonias barbujana, Persea indica* and *Ocotea foetens*). Newer phylogeographic analysis are supporting an early split of a Gondwanean and Laurasian-South American group (Rohwer, 2000), but until now there is no overall-phylogenetic tree for the family due to the amount of species and the very low intrafamily genetic divergence (Rohwer (2000), Chanderbali et al. (2001)). Morphology and flower characters in the family are elusive and currently do not support the molecular identified lineages within the family (Rohwer (2000), Rohwer and Rudolph (2005), Chanderbali et al. (2001)), therefore, major rearrangements and a finer phylogeny are to be expected.

By today the taxonomic background of the genus *Laurus* is not clarified. Traditionally, two species of the genus had been distinguished: *Laurus nobilis* L. in south and western Europe and *Laurus azorica* (Seub.) Franco on the Azores, the Canary Islands and Morocco, but in 2001 Arroyo-García et al. (2001) asked for a taxonomic revision due to their findings in AFLP analysis, which showed closer relationships of samples from the Canaries and the Iberian Peninsular than from the Iberian Peninsular itself. Concurrent results were discussed by Rodríguez-Sánchez et al. (2009) who came with the call for only one species within the genus. Contrastingly, Rivas-Martínez et al. (2002) provide a newer concept of three species, which distinguishes *Laurus nobilis* in the Mediterranean, *Laurus azorica* on the Azores and *Laurus novocanariensis* Rivas Mart., Lousâ, Fern.Prieto, E.Díaz, J.C.Costa & C.Aguiar., which includes Madeiran, Canarian and Moroccanian populations. This study only deals with individuals from the Canary Islands (plus an subgroup from the Azores), therefore the taxonomic discordances are negligible for this and, in the following, the Canarian taxon is addressed as *Laurus novocanariensis*.

Overall genetic diversity is low within the genus (Rodríguez-Sánchez et al., 2009), but the diversification of extant *Laurus* took place in the eastern Mediterranean, followed by westward range expansion and subsequent diversification, combined with range contraction and break-ups during the Quaternary Ice Age. The colonisation of the Canary Islands could not be reconstructed until now due to the lacking of haplotype diversity (Rodríguez-Sánchez et al., 2009), but the climate on the Canary Islands as well as in some refugia in the Mediterranean is assumed to be suitable for *Laurus* all over the LGM (Rodríguez-Sánchez and Arroyo, 2008), which makes *Laurus* one of the Tertiary relict plant genera in Europe.

The species *Laurus novocanariensis* Rivas Mart., Lousâ, Fern.Prieto, E.Díaz, J.C.Costa & C.Aguiar is one of the most abundant and canopy-building tree species in the laurel forests (Rivas-Martínez et al. (1993)) of the Canary Islands. As a character species, its relatively broad ecological amplitude allows it to grow wherever the evergreen, broadleaved forests of the Canary islands are present, which is in elevations between about 500 and 1200 meters on areas influenced by the trade winds. Traditionally, the wood from laurel trees was used for poles for crops and firewood (Pott, 2006), the leaves were also used as spices and are still until today (Rivera and Obón, 1995), the fruit essential oil is used by the local population for several therapeutic treatments (Castilho et al., 2005).

Like many plant and animal species from the Canary Islands, *Laurus novocanariensis* is a well-studied taxon. For example, numerous studies deal with tree regeneration (Fernández-Palacios and Arévalo, 1998), sex ratio and pollination (Forfang and Olesen, 1998), seed bank analysis (Arévalo and Fernández-Palacios, 2000) and physiological traits (González-Rodríguez et al. (2001), Jimenez et al. (2000), Morales et al. (2002)). More recent studies are concerned with the laurel forest as an ecosystem and direct and indirect human impact (Nogué et al. (2013), Martín et al. (2012)). Former phylogeographic studies cover the whole Mediterranean area and show no resolution on Macaronesian level (Arroyo-García et al. (2001), Rodríguez-Sánchez et al. (2009)), therefore nothing is known about the population structure and distribution of genetic diversity within the

Canary Islands until now.

5.2. *Ixanthus*

Contrastingly, there are only few studies about the second model species, *Ixanthus viscosus* (Aiton) Griseb. (Kanarenenzian).

Ixanthus is a monotypic Canary Island endemic, which is distributed on all western islands (Kunkel, 1993).

According to Schönfelder and Schönfelder (1997), *Ixanthus*, from locals addressed as *Reina del monte*, is a perennial, basal woody herb, which grows up to two meters in height. During its flowering time March to July, yellow, typical Gentianaceae flowers appear. The leaves are opposite and show three to five conspicuous parallel nerves. *Ixanthus* is an understory plant of the primary laurel forest, distributed as a character species in the communities of Ixantho-Laurion azoricae Oberdorfer ex Santos respectively Ixantho viscosae-Laurion novocanariensis Oberdorfer ex Santos in Rivas Martínez, Amaiz, Barreno & A. Crespo, where it is frequently distributed (Rivas-Martínez et al., 1993). Its emphasis is in the moistest and shadiest stands of laurel forest, which are supposed as the most undisturbed forest areas. The existence of scattered presence of this species is considered as proof for the formerly wide spread laurel forests on the Canary Islands (Stierstorfer, 2005).

Altogether, little is known about this species.

Apart from studies concerning ethnobiology, phytopharmacology and phytochemistry (Darias et al. (1989), Bravo and Herrera (1995), Ortega et al. (1988)), relationships were clarified in a phylogenetic study of Thiv et al. (1999). Based on nuclear *ITS* and chloroplast *matK* sequence data, the Mediterranean genus *Blackstonia* is considered a sister taxon. Chromosome counts suggest that *Ixanthus* ($2n = 62$) is a polyploid and dysploid of *Blackstonia* ($2n = 20$), (Thiv et al. (1999), Zeltner (1970)). A newer analysis of chromosome numbers shows $2n = 70$ (Suda et al., 2005), which is of course not contrary to the former hypothesis.

Origin of the species is unclear by today, because an estimate from ITS divergence data suggests an age ranging from 6.6 to 47.1 million years, which was the time of the laurel forests in African Mainland and the Canary Islands after they emerged from the Atlantic ocean (Thiv et al., 1999). Newer estimates based on ITS and matK data (Kondraskov et al., in prep.) give an age for the crown group from 0.866 mya (0.298 to 1.5899 mya).

Part III.

Material and Methods

6. Sampling

For this study, we sampled two species from the Canary laurel forest: The widespread tree species *Laurus novocanariensis* and *Ixanthus viscosus*, a perennial herbaceous understory plant (for details see Introduction). The primary focus of this study lies on the island of Tenerife, thus the biggest amount of samples derived from there. The other Western Canary Islands and Sao Miguel (Azores) were only sampled exemplarily for comparison and not exhaustive.

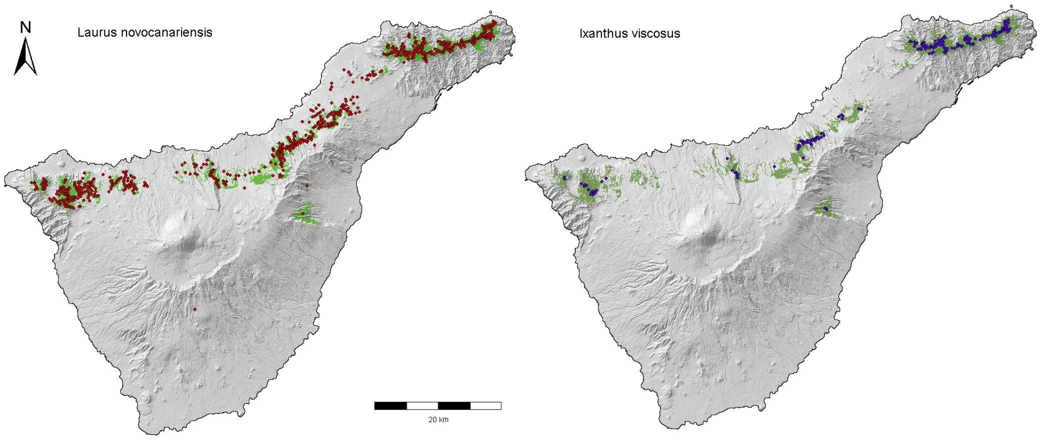

Figure 6.1.: Sampling for both species
Laurus novocanariensis (left map) and *Ixanthus viscosus* (right map). The dots are indicating the sample locations, the green area shows the actual occurrence of monteverde (laurisilva and his substitution communities) as defined by del Arco et al. (2003). Digital elevation model by GrafCan (also used in the following figures).

Most of the plant material used in this study has been sampled during two field trips in January and March 2010 on Tenerife (Spain). Additional material has been collected by Arnoldo Santos-Guerra, Alfredo Reyes-Betancourt (both Instituto Canario de Investigaciones Agrarias, Jardín de Aclimatación de La Orotava) and Mike Thiv (Staatliches Naturkundemuseum Stuttgart) between 2010 and 2012 on several excursions on the Canary Islands La Palma, El Hierro, La Gomera and Gran Canaria as well as on the Azores (Sao Miguel). The complete accession list is provided with Appendix A.

For the exhaustive sampling of the complete laurel forest area, a sampling raster of 350 meters has been created based on maps of the actual distribution of the laurel forest (del Arco et al., 2003). If present, samples from young leaves of both species were taken in each of these squares. Additionally, all other nearby areas were checked for the occurrence of the two species, to gain a covering sampling over the complete species distribution area.

Of the sampling locations, GPS coordinates were taken by using a digital map with an elevation model to determine height above sea level as exact as possible. Picked leaf material was stored in silica gel instantly in the field and dried quickly.

On Figure 6.1 the sampling locations are indicated by red *(Laurus)* and green *(Ixanthus)* dots. Altogether, 690 samples of *Laurus* (648 on Tenerife, 38 on the other Canary Islands, 4 on Sao Miguel (Azores)) and 199 samples of *Ixanthus* (181 on Tenerife, 18 on the other western Canary Islands) were collected.

7. Laboratory Procedure

7.1. DNA Extraction

Total genomic DNA was obtained from silica material after the standard cTAB protocol from Doyle and Doyle (1987) with some modifications as described below.

Tissue was ground with an automatic swing mill (PeqLab Precellys 24 homogeniser, Bertin Technologies) by adding three glass beads to 2 ml tubes. The homogenised material was incubated for 30 minutes at 60 °C on a thermoblock (Eppendorf) with 800 µl cTAB extraction buffer (including 2 % (w/v) CTAB, 100 mM Tris-HCl, 1.4 M NaCl, 20 mM Na-EDTA, pH = 8.0 and freshly added 0.2 % beta-Mercaptoethanol). After adding 500 µl cold chloroform-isopropanol (1:24, v/v), the mixture was incubated for 15 minutes at 4 °C and then centrifuged at maximum speed for 5 minutes. The upper phase (500 µl to 600 µl) were mixed with 500 µl of cool isopropanol and precipitated at -20 °C for 15 minutes. After 10 minutes of centrifugation and dismissing of the isopropanol, the pellets were washed twice with 300 µl of 70 % ethanol. After drying, 50 µl of water and 2 U of RNase were added and RNA was digested for 1 hour at 37 °C on a thermomix.

Concentration of the extracted DNA was measured on a Nanodrop ND-1000 Spectrophotometer (Nanodrop Technologies) and all samples were diluted to a final DNA concentration of 100 ng/µl for the AFLP procedure.

7.2. AFLP Procedure

AFLP analysis procedure followed mainly the protocol after Vos et al. (1995) with some modifications as in Paule (2010) and Landau (2009).

7.2.1. Restriction and Ligation

Approximately 550 ng of genomic DNA for *Laurus* and 275 ng for *Ixanthus* (using an slightly improved protocol) were digested during the restriction and ligation reaction for 3 hours at 37 °C in a volume of 15 µl containing 1x T4 buffer, 1x ATP, 50 mM NaCl, 75 µg BSA, T4 ligase (1.5 U), MseI (1 U), EcoRI-HF (5 U) and 0.4 µM Eco-RI adapter and

3.4 µM MseI adapter. Reaction was stopped by an inactivation step of 10 minutes at 65 °C and then holds at 10 °C. The product was diluted tenfold for the following PCR step.

7.2.2. Preselective PCR

For preselective PCR, 2.5 µl of diluted restriction ligation product were amplified in a 12.5 µl volume containing 1x PCR buffer II (Applied Biosystems), 0.25U AmpliTaq polymerase, 2 mM $MgCl_2$, 0.8 mM dNTPs, 0.2 µM Eco-RI-A primer with one selective base (5'-GACTGCGTACCAATTCA-A-3') and MseI-C-primer (5'-GATGAGTCCTGAGTAAC-C-3') each. PCR started with an initial denaturation step at 72 °C for 2 minutes, followed by 20 cycles of 94 °C for 20 seconds, 56 °C for 30 seconds, 72 °C for 120 seconds, a final elongation at 60 °C for 30 seconds and a hold at 10 °C on a PTC Peltier Thermal Cycler (MJ Research). The PCR products were checked on a 1.5 % agarose gel for good amplification. For the following PCR step, products were diluted tenfold.

7.2.3. Selective PCR

For the selective PCR, 2.5 µl of the diluted preselective PCR product were used in a reaction volume of 12.5 µl containing 1× GoldTaq buffer (Applied Biosystems), 0.5 U AmpliTaq Gold (Applied Biosystems), 2.5 mM $MgCl_2$, 0.8 mM dNTPs, 0.08 µM EcoRI primer and 0.2 µM MseI primer (Eco primer fluorescence labelled). The touchdown PCR programme consisted of 36 cycles: 94 °C for 15 minutes, 13 cycles (94 °C for 30 seconds, 65 °C for 60 seconds, where temperature drops from 72 °C to 56 °C in steps of -0.7 °C, 72 °C for 90 seconds), followed by 23 cycles (94 °C for 30 seconds, 56 °C for 60 seconds, 72 °C for 90 seconds) and a final elongation (8 minutes at 72 °C). The PCR products were checked on a 1.5 % agarose gel for good amplification.

Previous to the analysis of all samples, 64 different primer combinations were tested for amount of polymorphisms, reproducibility and readability of the fingerprints for both species, to choose that ones with the best overall quality. Following primer combinations were chosen for genotyping.

- *Laurus*:
  I FAM-EcoRI-ACA/MseI-CAC,
  II HEX-EcoRI-ACC/MseI-CAG,

III FAM-EcoRI-ACA/MseI-CTA.

- *Ixanthus*:

  I FAM-EcoRI-ACA/MseI-CAC,

  II TET-EcoRI-ACG/MseI-CTG,

  III TAMRA-EcoRI-AGC/MseI-CTG.

7.2.4. Genotyping

Slightly different approaches were chosen for the genotyping of the two species. For *Laurus*, 2 µl FAM-labelled, 2 µl TET-labelled and 6 µl HEX-labelled product were multiplexed and diluted with 50 µl highly pure water. 1 µl of the multiplex was used together with 0.2 µl ET-ROX size standard and 5.8 µl highly pure water for electrophoresis in a MegaBace 500/1000 DNA capillary sequencer (Amersham Biosciences) using the following run parameters: sample injection voltage: 3 KV, sample injection time: 90 seconds, run voltage: 9 KV, run time: 100 minutes, GT dye set 1. For *Ixanthus*, 1.5 µl of each selective PCR product were cleaned using a Nucleofast-PCR clean-up plate (Machery-Nagel) by two cycles of adding 100 µl of water and 20 minutes of centrifugation at 4500 g. For genotyping, 1.2 µl of the purified, multiplexed product were mixed with 0.05 µl of ET-ROX size standard and 5.15 µl of highly pure water. Samples were electrophoretically separated on a MegaBace 1000 (Amersham Biosciences) with sample injection voltage of 3 KV, sample injection time of 45 seconds, run voltage of 8 KV, run time of 120 minutes using GT dye set 2.

Control samples and replicates were routinely included to check for reproducibility and consistence of the AFLP fingerprints. On each plate, one negative control containing no DNA was included to check for contamination and moreover, one DNA control was placed twice to ensure the consistency within each run. Additionally, one sample was genotyped in every run to compare the consistency between the runs. To check the error rate, replicated samples (double extracted and PCR-processed) were genotyped following the method of Bonin et al. (2004).

7.3. Scoring

Raw data was visualised using GeneMarker 1.90 (SoftGenetics LLC, USA) and scored half-manually. The software-implemented automatic scoring has been used together with a scoring panel, but all peaks were manually validated and adjusted in case of not recognised, but distinct peaks. Unclear peaks and thus with a large range in fluorescence intensity were excluded from analysis, as well as peaks under 60 bp and over 545 bp.

Scored data were exported and converted into a binary presence/absence matrix for further analysis.

7.4. High Resolution Melting

In addition to AFLP fingerprinting, we chose to scan for chloroplastic variation in Tenerifes *Laurus* population. For chloroplast marker genotyping, five chloroplast markers in *Laurus* were sequenced for six individuals and checked for SNPs.

Primers were chosen according to Shaw et al. (2005) and the following five markers were amplified and sequenced:

- **rps16** rps16For 5'-ACT TCA GGA AAC AGC TAT GAC GTA GCG GGA ATC GAA CCC GCA TC-3'
  rps16Rev 5'-TGT TTT CCC AGT CAC GAC AAC ATC WAT TGC AAS GAT TCG ATA-3'

- **matK/psbA** matK8F 5'-ACT TCA GGA AAC AGC TAT GAC TCG ACT TTC TTG TGC TAG AAC TTT-3'
  psbA5'R 5'-TGT TTT CCC AGT CAC GAC AAC CAT CCA ATG TAA AGA CGG TTT-3'

- **psbA/trnH** psbAf 5'-ACT TCA GGA AAC AGC TAT GAC GTT ATG CAT GAA CGT AAT GCG C-3'
  trnH(GUG) 5'-TGT TTT CCC AGT CAC GAC CGC GCA TGG TCG ATT CAC AAT CC-3'

- **trnS/5'trnL** trnT ugu 2F 5'-TGT TTT CCC AGT CAC GAC CAA ATG CGA TGC TCT AAC CT-3'
  5'trnL uaaR TabB 5'-ACT TCA GGA AAC AGC TAT GAC TCT ACC GAT TTC GCC ATA TC-3'

- **trnL/trnF IGS** 5'-TGT AAA ACG AGC CAG TCG AAA TCG GTA GAC GCT ACG-3'
  5'-CAG GAA ACA GAT GAC CGA TTT TCA GTC CTC TGC TCT ACC-3'

The amplification was performed on a PTC Peltier Thermal Cycler (MJ Research) using the following conditions: 3 minutes at 95 °C, 35 times (30 seconds at 95 °C, 30 seconds at 54 °C to 64 °C (depending on primer pair) and 30 seconds at 72 °C), and 5 minutes final elongation at 72 °C. Prior to sequencing, PCR products were cleaned using the Wizard SV Gel & PCR Cleanup System (Promega) following the producers instructions.

For HRM, rps16 were chosen and genotyped for all individuals. Primers were designed following the suggestions of Corbett Research (2006): rps16for (5'-ATG ACT CAA ATC ATA GTC TAA TTG ATG ATT TTG TGG A-3'/rps16rev 5'-TTT CGA GCC GTA CGA GGA GAA-3'), these internal rps16 primers are flanking the region of interest. The amplified marker region covered 39 bp (97 bp with primers included) with the SNP at position 14 (51). Using the SensiMix HRM Kit (Bioline), in a total reaction volume of 12.5 µl, 1 µl DNA (100 ng/µl), SensiMix (1x), primer mix (25 µM) and 0.5 µl EvaGreen were mixed and amplified using a RotorGene6000 real time cycler (Corbett Research). For verification, six different individuals were sequenced after the first HRM experiment to check for the reliability of the melting curves. In the following experiments, these six samples were always used as standard samples for the comparison of the melting temperatures.

8. Data Analysis

8.1. AFLP and HRM Data Analysis

8.1.1. Error Rate and General Analysis

The error rate of the AFLP fingerprints was obtained after the suggestions of Bonin et al. (2004). For calculating the error rate the number of mismatches was divided by the number of total comparisons out of replicated DNA samples. Untrustworthy markers were rejected and fragment sizes that also showed up in the no-DNA samples were deleted from the complete data set. Fingerprints with an obvious aberration were not used and the genotyping process was repeated.

General analysis (fragment numbers, fragment frequencies, private alleles) were made using the script AFLPdat (Ehrich, 2006), a series of functions written in R (R version 2.15.2, R Development Core Team (2006), www.r-project.org), and GeneAlEx 6.5.3b, an add-in for Microsoft Office Excel Peakall and Smouse (2012), Peakall and Smouse (2006).

8.1.2. Network Analysis

AFLP genotype phylogenies of both species were visualised in a neighbournet analysis as implemented in the software Splitstree 4.12.3 by Huson and Bryant (2006). For network construction, uncorrected p-values and equal-angle visualisation were used. For a better overview, geographic regions or structure population association were highlighted or only subsets of the complete data included.

8.1.3. Similarity Patterns

In order to analyse the similarity between individuals of both species, the software GenAlEx 6.5.3b was employed with calculating a principal coordinate analysis (PCoA) based on a distance matrix of pairwise distances. The first three axes were calculated using standardised covariances. Visualisation of the first two co-ordinate's scatterplot was performed using SPSS 19 (IBM, SPSS Statistics).

8.1.4. Population Structure

To have a closer look at the population structure, both datasets were analysed using the software STRUCTURE 2.3.3. Pritchard et al. (2000) with the function for dominant markers by Falush et al. (2007) and correlated allele frequencies Falush et al. (2003). For both species, the complete dataset was analysed. The Tenerife data was additionally analysed separately. Additionally, for *Laurus*, a sub-dataset containing 15 individuals from the different main Tenerife gene pools (according to analysis of the complete data) and all samples from other islands, to overcome biased results caused by imbalance of the sample density. AFLPdat Ehrich (2006) was used to obtain the input data file with a top-row of zeros to account for the recessive alleles, as required by Falush et al. (2007). As suggested by Pritchard et al. (2000), the admixture model with correlated allele frequencies was used, and compared with the results from the non-admixture model. Analyses were run ten times from $K = 1$ to $K = 10$ ($K = 15$ for *Laurus*) with a burn-in of 200k and 1000k repeats.

The R-script STRUCTURE-Sum 2.2 (Ehrich et al. (2007), update 2009) was employed with the analysis of the evaluation of the most likely K after the method of Evanno's deltaK (Evanno et al., 2005), additionally, similarity after Rosenberg et al. (2002) was incorporated. To compare the runs, CLUMPP version 1.1.2b (Jakobsson and Rosenberg, 2007) was used to match-up the clusters of replicate runs and to calculate the average of cluster distribution over all similar run results. To compare different models, the non-admixture model and independent alleles were tried, as well.

Barplots were visualised in SPSS 19 and plotted on maps using the geographic information system software ArcMap 9.3.1 (ESRI Inc.).

The distribution of the molecular variance within and between different populations was tested with a non-hierarchical AMOVA (Analysis of molecular variance) implemented in the program Arlequin 3.5.1.3 (Excoffier et al., 2005), (Excoffier and Lischer, 2010). AMOVA based on Euclidean pairwise square distances. Compared populations were chosen according to their geographic location.

Additionally, populations of approximately 20 individuals were defined artificially from the exhaustive sampling (see also the passage "genetic diversity on population level") to calculate pairwise F_{st} with Arlequin 3.5.1.3. Results were plotted with the R-script R-lequin (Rcmd function implemented in Arlequin Excoffier and Lischer (2010)).

8.1.5. Geographic Patterns

A Mantel test (Mantel, 1967) was carried out using the function in Alleles in Space (Miller, 2005) to find out about if there is isolation by distance (IBD) or a geographic structure in the genetic variation of AFLP genotypes in the two model species.

Barrier analysis were carried out using the software Barrier 2.2 (Manni and Guérard, 2004), (Manni et al., 2004) to find putative barriers for genetic exchange between geographic regions for both model species, as well as for the complete data as for subdata only. Standard Voronoi tessellation and Delauney triangulation was used as well as standard and manually adapted virtual points to describe the map borders.

8.1.6. HRM Data Analysis

Data analysis was made using the HRM function of the RotorGene6000 Series Software 1.7 according to the manual of Corbett Research (2006). Using the three standard samples each as examples for the the two genotypes found, genotypes of all individuals were auto-called using a threshold of 90 %. Dubious samples were manually validated using the difference plot function and retested in the case of poor data quality, all other samples were assigned to one of the two genotypes.

8.2. Hotspots — Diversity in Geographic Space

8.2.1. Genetic Diversity on Individual Level and Diversity Map

The fact that *Laurus* and more or less *Ixanthus*, too, are continuously distributed over the middle elevation slopes on Tenerife's north implies difficulties with the use of the established, population-based analyses approaches. With other words, different methods would be more exacting to analyse the dataset without the loss of detailed geographic information.

The present exhaustive sampling covers the complete distribution area of both species. Hence, analysis methods using not distant populations with many individuals but single individuals per sample location over a continuous geographic space could be applied. Miller (2005) uses the same approach in his software Alleles in Space (AIS) by doing a landscape shape interpolation to visualize spatial pattern of genetic diversity. In order to analyse the genetic differences between single individuals in our exhaustive sampling and not just in between "artificial" populations, the AIS software was used to calculate a Delauney triangulation based connectivity network between geographically neighboured individuals. Between all pairs of neighbours, AIS calculates the simple genetic distance as the proportion of mismatches and plots them in between the associated sample locations using the formula

$$D_{ij} = \sum_{k=1}^{n} \frac{d_k}{n}$$

To avoid IBD effects, genetic distances between all not directly neighboured individuals caused by the U-shape of Tenerife's northern shore were deleted manually afterwards. With this, genetic distances between distant individuals were excluded from the analysis.

The genetic distances (in AIS referred as "surface heights") were used for plotting them on a geographic map similar to the methodical approach in the Genetic Landscape GIS Toolbox by Perry et al. (2010), which only deals with distinct populations. Therefore, distance values from AIS were plotted in ArcMap (ESRI Inc.) and interpolated across the topography using the inverse distance weight algorithm (implemented in the Spatial Analyst Tool). It determines cell values according to linear decreasing weight of the input point values. The resulting surface of diversity was grouped into ten classes of diversity for visualisation and clipped to a layer of the recent occurrence of the two species, which are based on our sampling area and the potential area of the laurel forest as mapped by del Arco et al. (2003) (available from GrafCan, Gobierno de Canarias, tiendavirtual.grafcan.es/index.jsf, downloaded in 12/2009. The same is valid for the digital elevation model used in the depicted maps as layer).

8.2.2. Genetic Diversity on Population Level

To perform classical population genetic analysis, populations were defined in both datasets due to sampling location. It was aimed to define populations of approximately the same sample size (about 20 individuals) in an area as small as possible and without putative barriers included. Shannon index and Nei's diversity were calculated for all populations using the software Popgene 1.32 (Yeh et al., 1997) and AFLPdat (Ehrich, 2006). Basic statistical analyses (e.g. private alleles, allele number, proportion of polymorphic alleles) were performed for all populations using GenAlEx (Peakall and Smouse, 2012), (Peakall and Smouse, 2006).

In order to test the reliability of the chosen population assignment, populations were shifted across the map and defined in a second way and calculations were compared.

8.3. Ecology — Ecological and Bioclimatic Analysis

8.3.1. Ecological Analysis

In order to understand if genetic variance and divergence is connected to ecological parameters, several approaches were used in search for connections between variance and diversity levels and population structure and environmental influences.

For each sample location the actual main vegetation type (Monteverde, Fayal-Brezal, pine forest, scrubland, plantation or urban area), the type of disturbance (natural vegetation, substitution community, plantations or urban area) and the potential natural vegetation (PNV; mainly Monteverde higrófilo, húmedo and seco, Fayal of high altitude and Monteverde-Pinar transition zone) and altitude were evaluated. The obtained data was used to search for similarities between AFLP variation plus actual and potential natural vegetation in PCoA (see section above).

8.3.2. Bioclimatic Analysis

Ecological parameters are defining species towards their distribution range, therefore we aimed to find out which parameters are limiting the suitable areas for both model species. To achieve this, the complete sampled areas of *Laurus* and *Ixanthus* were used for an "inverse ecological niche modelling" using the software DIVA-GIS 5.2 (Hijmans et al., 2005), a freeware tool for mapping and analysing spatial data and especially to do ecological niche modelling (ENM) by including the WORLDCLIM databases (Hijmans et al. (2005), downloadable from http://www.worldclim.org).

Traditionally, ENM means the modelling of a geographic distribution of a species by the ecological parameters of a part of their known range. Contrary we used the complete distribution area from Tenerife of both species to extract the range of the 19 bioclimatic values and elevation. Central questions were to find out

- about the potential distribution range
- if the two model species occupy different ecological niches as suggested by their actual distribution
- which bioclimatic values are influencing the (actual) distribution area most
- if there are Bioclim values that explain the genetic diversity

For this, the 19 Bioclim values (11 derived parameters connected to temperature, 8 derived parameters connected to precipitation) in 30 arc seconds grids (one square kilometre) and elevation from the GPS data were included in the Bioclim modelling function. For every sample location, data from the climate database was extracted and used for further analysis in SPSS. Every Bioclim value and altitude were analysed using basic descriptive statistics and their frequencies visualised and compared in histogram plots. Comparison of the ecological niches of the two species was supported with statistical test (t-Test and Wilcoxon-Mann-Whitney-U-test) in SPSS 19 (IBM Statistics).

For both species, a PCoA was conducted with those 20 values to get insight in the variables that are contributing most to the variation in the dataset and about the distribution of genetic diversity in connection with temperature and precipitation.

Part IV.

Results

9. AFLP Analyses for Both Model Species

Complete AFLP fingerprints consisting of three scored primer combinations and geocoordinates,were successfully achieved for 672 (635 from Tenerife) individuals of *Laurus* and 180 (164 from Tenerife) individuals of *Ixanthus*. The three primer combinations for *Laurus* resulted in 249 (FAMI: 135, HEX: 59, FAMII: 55) clearly scorable fragment sizes (in the following addressed as markers) in the range from 60 to 545 bp in total, of which 94.4 % were polymorphic. For *Ixanthus*, three primer combinations resulted in 121 (FAM: 54, TAMRA: 31, TET: 36) clearly scorable markers, of which 56.2 % were polymorphic.

The binary matrices are provided with Appendix C on CD.

Calculation of the error rate following the suggestions of Bonin et al. (2004) yielded in a good reliability and reproducibility of the fingerprints of 1.19 % for *Laurus* (45 observed differences in 3787 comparisons) and 0.83 % for *Ixanthus* (18 observed differences in 2165 comparisons), which is more than sufficient for good AFLP reproducibility according to Pompanon et al. (2005).

9.1. Population Structure and Geographic Patterns

For Tenerife datasets, the Bayesian clustering algorithm of STRUCTURE produced similar results for both correlated and uncorrelated allele frequencies, the same holds true for analysis of the all-islands *Laurus* data (Tenerife and other islands). Therefore, for all analysis, results of the correlated frequencies model (Pritchard et al., 2000) were chosen for the following depictions.

For *Laurus*, the most likely ΔK in the Tenerife analysis was $K = 5$ (Evanno et al. (2005), Rosenberg et al. (2002)) for those, also the similarity was highest (figure 9.1 c and b). Genetic clusters of Tenerife are describing an unclear gradient from west to east over the island (figure 9.1 e) and therefore a geographic influenced distribution of different gene pools (figure 9.1 d). The biggest cluster (shown in green) is distributed in and dominating the western part from the Teno mountains over Icod, Orotava to the La

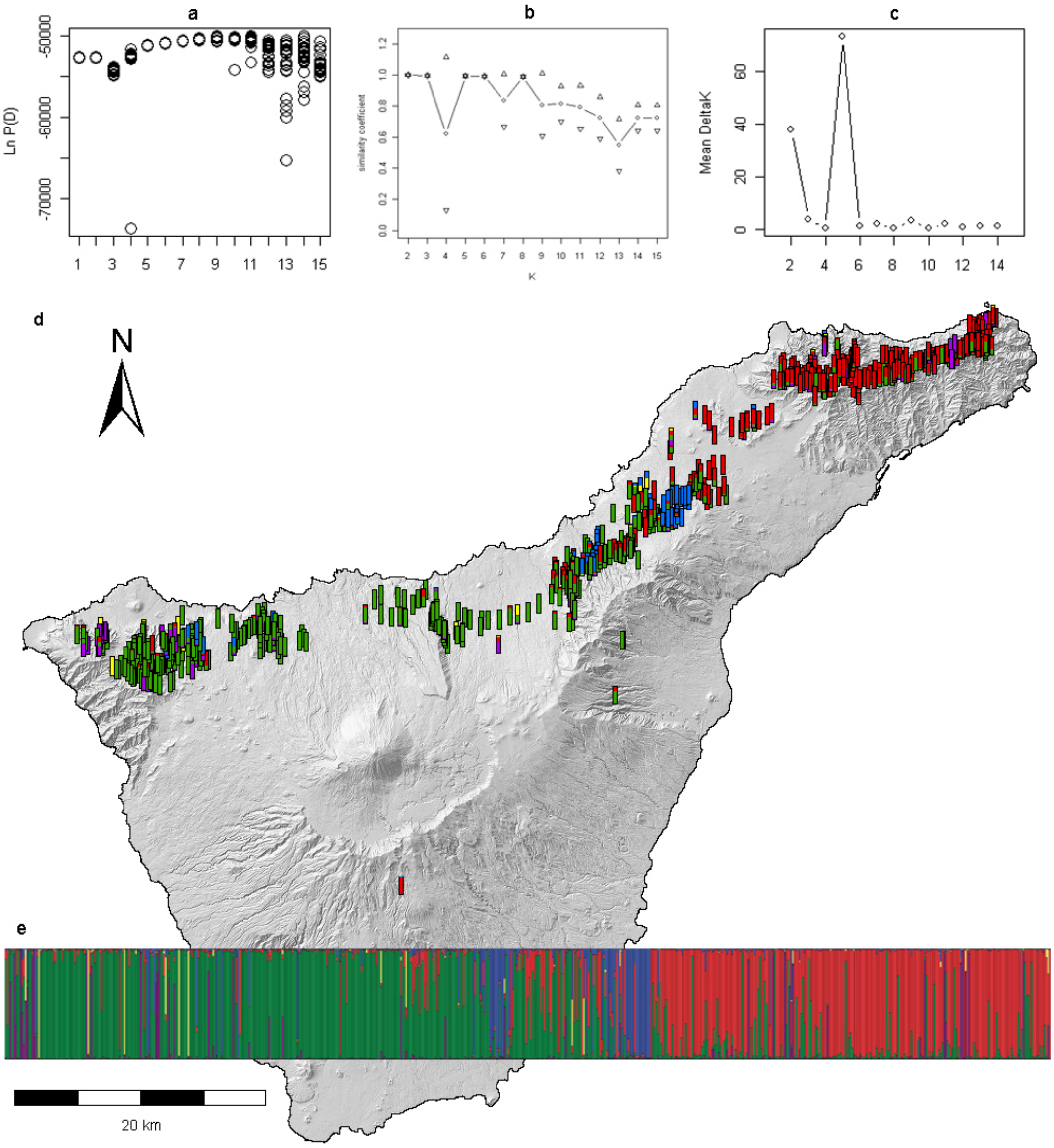

Figure 9.1.: Genetic structure of Tenerife's *Laurus novocanariensis* populations *Laurus* population structure as detected by the STRUCTURE admixture algorithm for $K = 5$. Above, the output of StructureSum for evaluating the most likely K is show (a: logarithmic probability of K from 1 to 15, b: similarity after Rosenberg et al. (2002), c: mean ΔK after Evanno et al. (2005)). d: locations of clusters. e: Barplots are showing the proportion of population assignment of all samples from west to east.

Matanza area, the second biggest cluster (depicted in red) is distributed in the easternmost regions (La Laguna area and Anaga mountains). The smaller genetic clusters are covering the whole area, whereas the violet cluster is most present in Teno and Anaga and the blue gene pool is prevailing in the area of Esperanza. Few of the individuals are non-admixed, most are of mixed population origin.

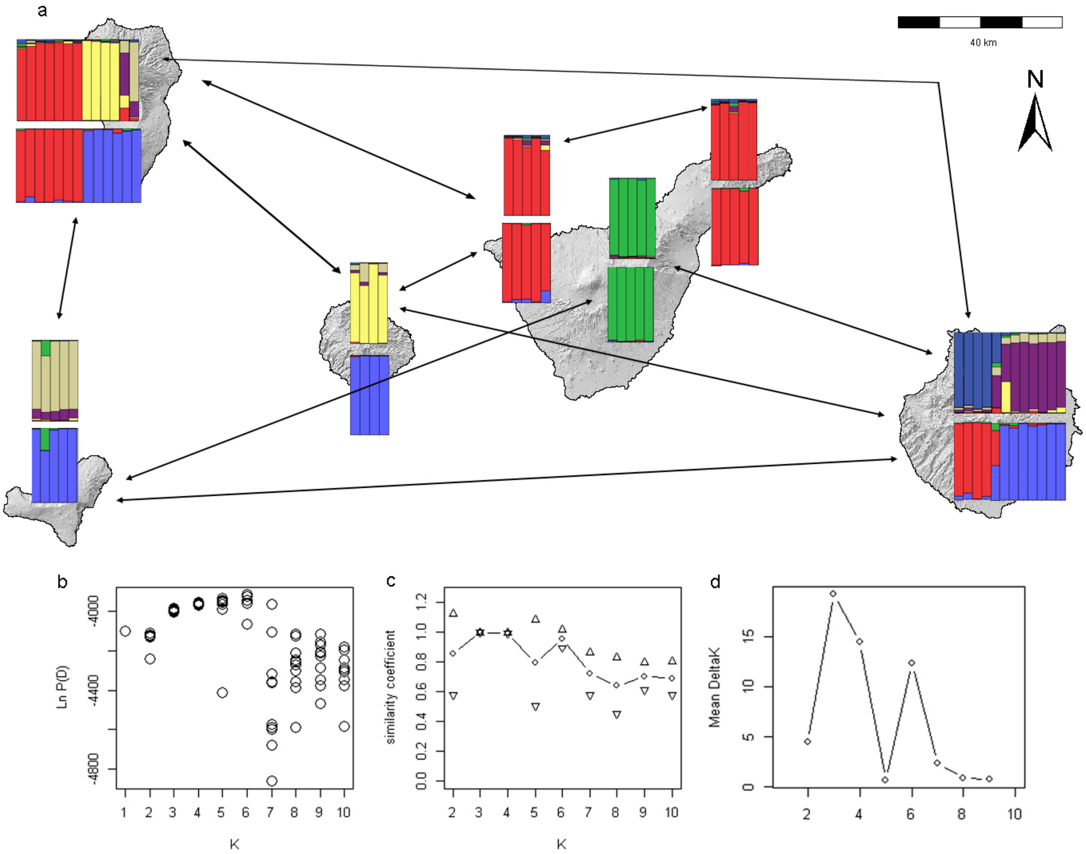

Figure 9.2.: Genetic structure of *Laurus* on the Canary islands
For Tenerife, exemplary individuals from the different clusters of figure 9.1 were taken. The most likely $K = 6$ (upper barplots) $K = 3$ (lower barplots) are depicted, arrows are indicating islands that share proportions of their population origin. Determination of K: see figure 9.1.

Mixed populations and gene flow between rather distant regions were also present in the clustering analysis of laurel populations on all Canary Islands. The highest ΔK value proved to be $K = 3$, but also $K = 6$ has got a high similarity and ΔK (figure 9.2 b–d). Therefore, both options are shown in fig. 9.2 a. The blue cluster of $K = 3$

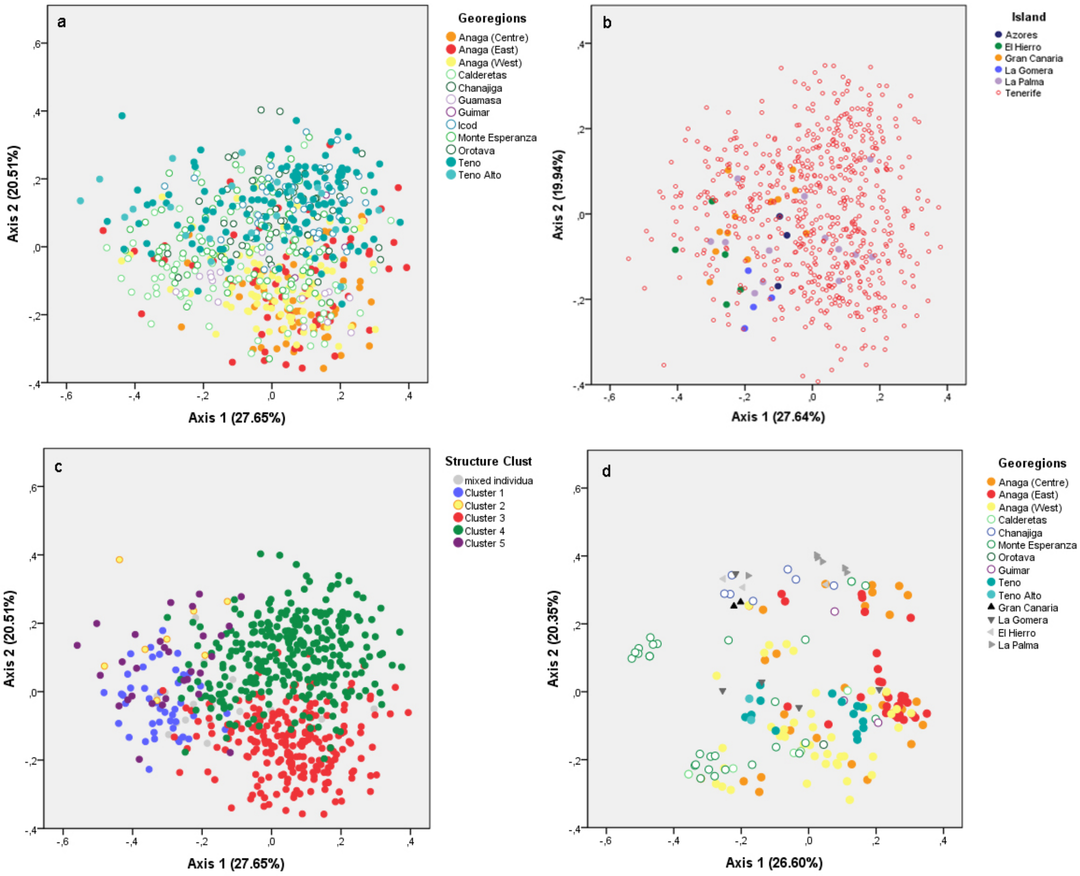

Figure 9.3.: Principal Coordinate Analysis (PCoA) of AFLP data (a–c): *Laurus*, (d): *Ixanthus*. (a) Colouring according to geographic origin. Filled circles are indicating eastern (Anaga) and western (Teno) end of the island, open circles are originating from middle Tenerife. (b) The other islands are displayed with different coloured filled circles. (c) Colours according to the main proportion of STRUCTURE clusters. (d): like (a), for *Ixanthus*.

splits up in three clusters in $K = 6$ (yellow, violet and brown), the red cluster in $K = 3$ is corresponding to the red and the blue cluster in $K = 6$, and the green cluster of Tenerife is consisting of the same individuals in both analysis. On island level, some individuals are not admixed, but all populations show smaller proportions of different origin populations. This gives an idea of recent and ongoing gene flow even between distant islands, for example Gran Canaria and El Hierro (violet gene pool). Because of this, the admixture model was used despite the island locations; the non-admixture model was not capable to resolve the population structure in this case.

Neighbournet of *Laurus* shows very little differentiation and a star-like structure which does not contribute to the resolving of the population structure. As the AFLP data suggests, there are lots of polymorphisms between the genotypes, but no clear clustering of genetic groups.

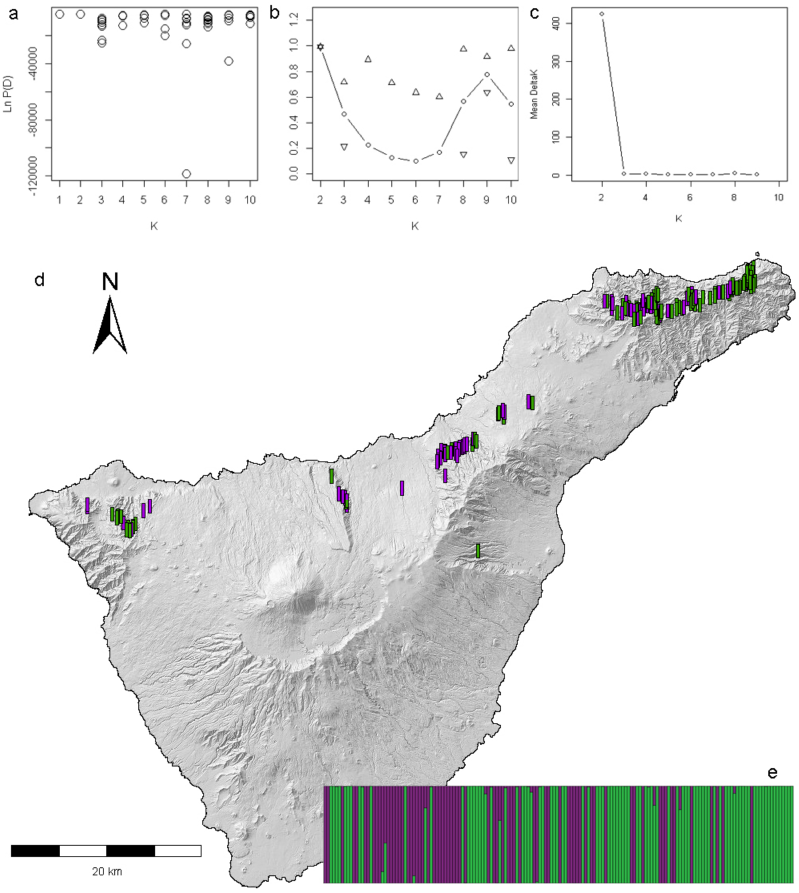

Figure 9.4.: Genetic structure of Tenerife's *Ixanthus viscosus* populations (a–c) Evaluation of the most likely K (see figure 9.1). (d) Barplots of STRUCTURE no-admixture algorithm for the most likely $K = 2$ are displayed. (e) Barplots are showing the proportion of population assignment of all samples from west to east.

First two axis of the principal co-ordinate analysis for Tenerifes *Laurus* AFLP genotypes are displaying 48 % of data variation (first axis 27.65 %, second axis 20.51 %, third axis 7 %, therefore not shown), for the complete data (Tenerife and other islands) the values are slightly smaller. The PCoA is reflecting the uniformity of the data similar to the neighbournet and does not show a grouping in clear distinct clusters, but grouping of the individuals is congruent to the clusters in the STRUCTURE analysis. In figure 9.3, PCoA is shown in different colourings corresponding either to the geographic region or the island the samples derive from. Even samples from the other islands show no clear separation from the Tenerife samples, especially samples from La Palma are included in the Tenerife cluster.

Contrastingly, *Ixanthus* shows a very different pattern in distribution of population clusters. The most likely K value was assigned to $K = 2$ in both analysis of the Tenerife individuals and the individuals from all islands (figure 9.4, only Tenerife data shown) using the non-admixture model with $K = 2$.

In the admixture model, $K = 3$ was most likely with a very scarce part of the third population and slightly no admixture in the individuals, therefore the non-admixture model was chosen, also because the population assignment of the individuals was similar. There is no obvious geographic distribution in the genetic cluster assignment of the samples, both populations are distributed more or less randomly across the island. Admixture between the two gene pools seems to be lower than in *Laurus*, although the gene pools are in closest neighbourhood.

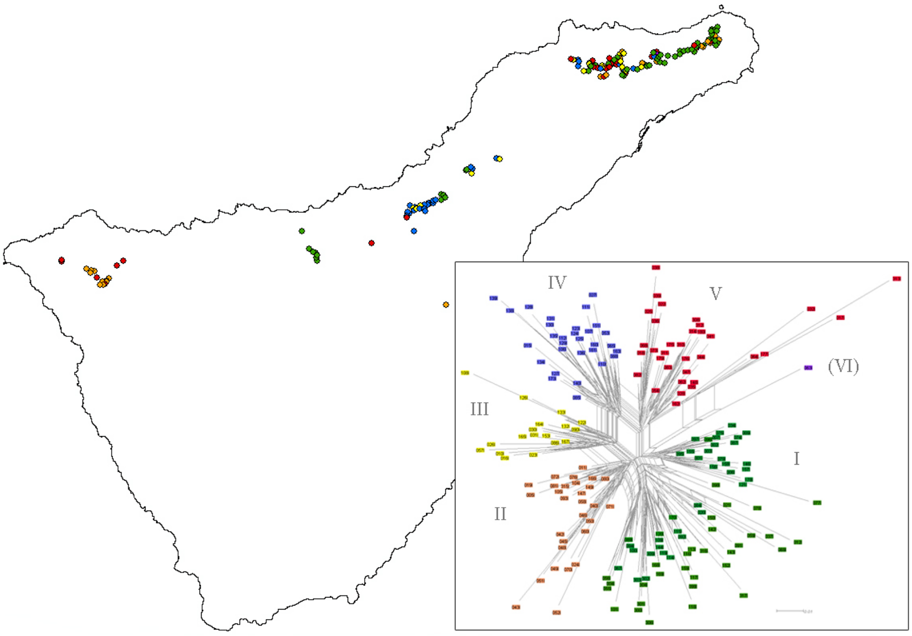

Figure 9.5.: Neighbournet analysis of *Ixanthus viscosus*
Colours in the map match the colouring of the groups in the Splitstree neighbournet to display the geographic distribution.

Nevertheless, the neighbournet for *Ixanthus* differentiates five major groups instead of two, which were distributed in different geographic regions on Tenerife (see figure

9.5), although only few splits are separating the groups. Groups in the neighbournet are corresponding mostly to the STRUCTURE clusters and give therefore more detailed information about the geographic patterns in population structure.

PCoA shows 46.95 % of the variation in the first two axes (first axis 26.6 %, second axis 20.35 %) and although the complete distribution range was sampled, clustering is stronger than in *Laurus*.

10. *Laurus*: High Resolution Melting (HRM) Analysis

Genetic variation in *Laurus* and the whole family of Lauraceae is considered as very scarce (Chanderbali et al. (2001), Rohwer (2000)) due to its evolutionary history. According to the low plasticity level in chloroplast markers in *Laurus* as reported by Rodríguez-Sánchez et al. (2009), only one single SNP in all analysed chloroplast markers could be discovered: in rps16 (40S ribosomal protein) one A/C polymorphism was found (addressed as A and C chloroplast types).

Nevertheless, the High Resolution Melt could be performed for all samples. Melting temperature T_m was approximately 0.4 °C higher for individuals with the C chloroplast type as indicated by Venter et al. (2001). They could be identified clearly using the normalised plot (normalised fluorescence to temperature) and the difference plot (normalised fluorescence minus A or C melting curve) as described by Corbett Research (2006).

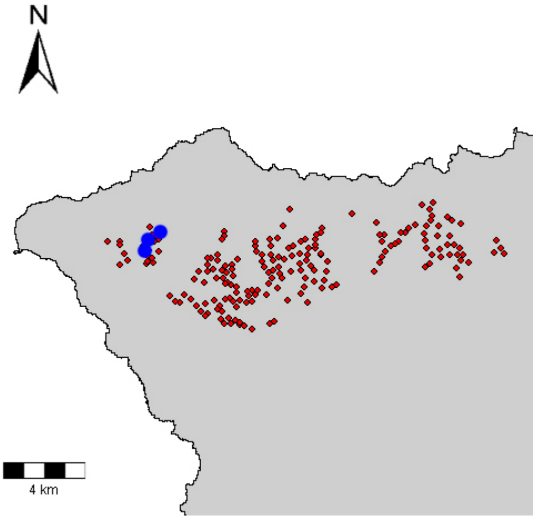

Figure 10.1.: HRM (High Resolution Melting) of *Laurus*
Map detail of western Tenerife (Teno mountains). Blue spots are indicating individuals with cytosine at the rps16 SNP position, red spots are samples with adenine.

After the first melting experiment, reliability of the HRM could be successfully consolidated with the sequence information of six individuals. Finally, three out of 672 individuals with AFLP fingerprints showed the C chloroplast type, all others belonging to the type A. All these C type individuals are originating from a small region in the

Teno mountain range (see figure 10.1).

Therefore, this supposedly recent mutation is limited in its range and has not spread across the island, yet.

11. Hotspot Analysis

11.1. Diversity on Population Level

The calculation of Shannon index and Nei's gene diversity for the two different population assignments of the Tenerife *Laurus* and *Ixanthus* resulted in the same regions with a higher diversity, previously the Anaga and the Teno mountain range. When comparing results for the different population assignments, absolute values as well as geographic location of the populations with highest and lowest diversity were correlating, therefore, in the following description pertains to only one assignment per species. Due to geographic location, not all populations are containing the same number of individuals. Populations with less than 10 individuals were not included into the analysis and tagged on the map (e. g. southern population).

Range of Shannon's gene diversity index of populations with more than ten individuals were 0.1371 to 0.2233 for *Laurus* and from 0.0742 to 0.1295 for *Ixanthus*. For Nei's diversity, lowest values were 0.0905 for *Laurus* and 0.0494 for *Ixanthus*, highest values were 0.1454 and 0.0863. All results (Shannon, Nei, number of individuals, proportion of polymorphic markers) are given with the tables 11.3 and 11.2. Comparability of the absolute numbers for the two species is not given due to the different number of scored fragments.

In figure 11.1, results for Shannon's index are depicted. For both species, values were classified (8 classes) and visualised using gradually colouring. For *Laurus*, populations of highest diversity are located in the Teno mountains and eastern Anaga, a low diversity is found in populations in Icod, Chanajiga, near Monte Esperanza and Guamasa (for names of geographic regions see map 14.1). For *Ixanthus*, the highest values of Shannon's index are found in western Anaga and in the Calderetas-Esperanza region, average high diversity in Teno mountains and eastern Anaga. The populations with the lowest diversity level are located in and around the Orotava valley.

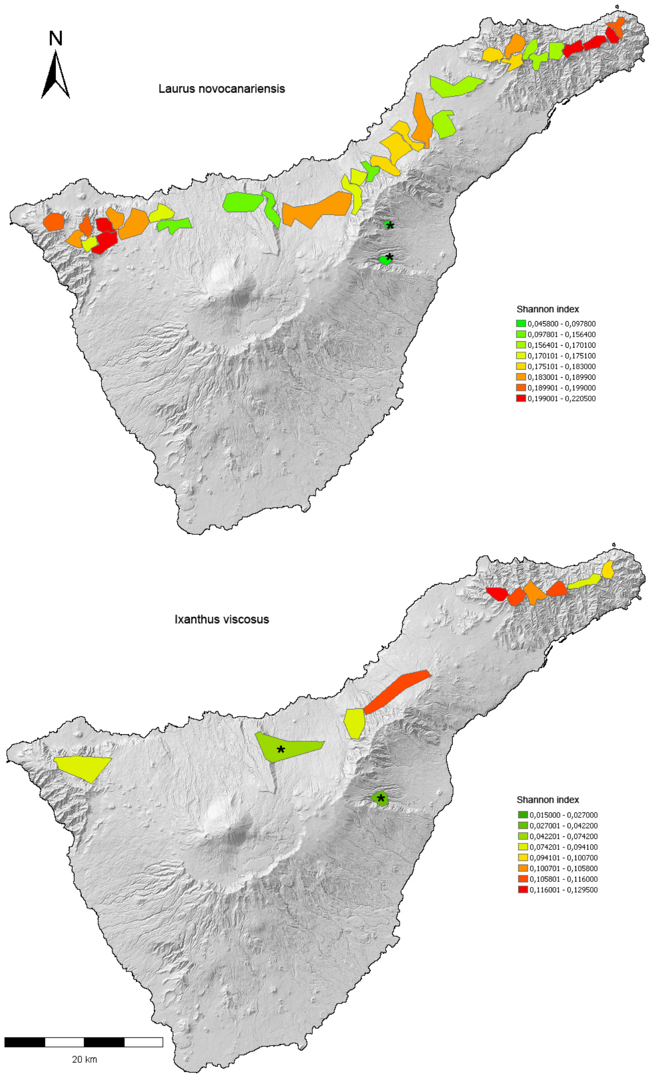

Figure 11.1.: Population diversity
Shannon index for populations about 20 individuals. Green depicts a low, red a high diversity. Populations with less than 12 individuals are marked by an asterisk, see also the following tables.

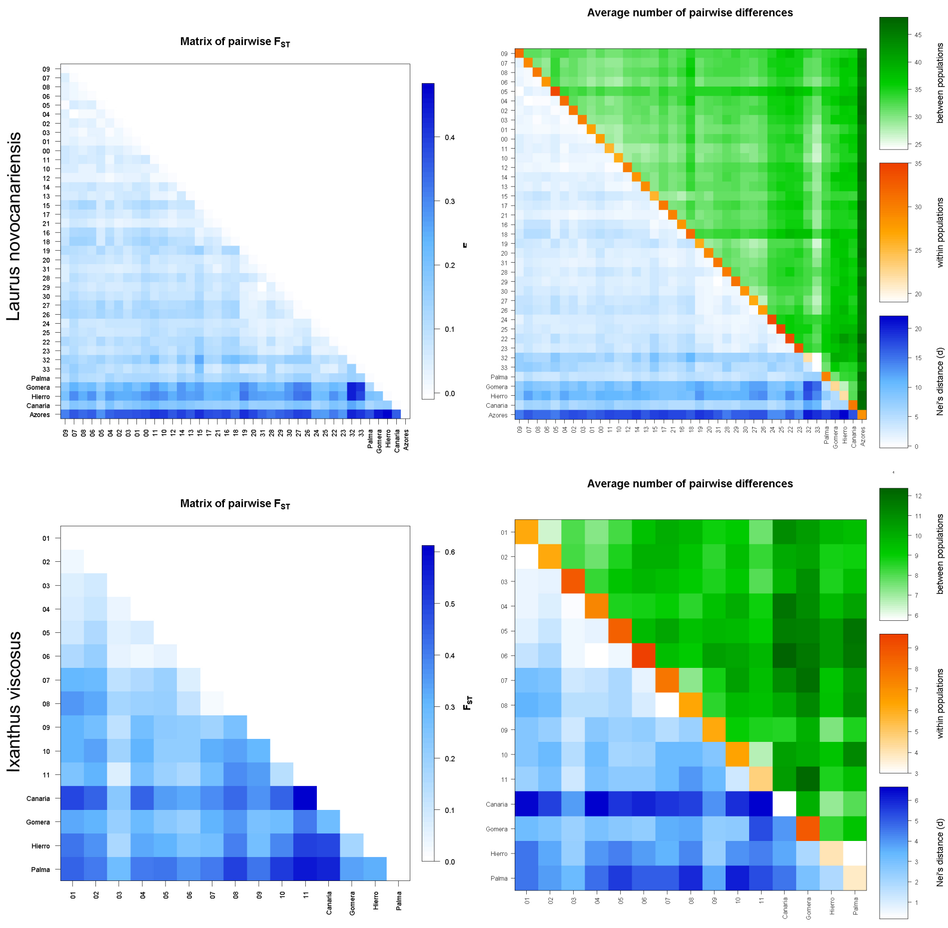

Figure 11.2.: Pairwise F_{st} and number of pairwise differences
Values are displayed for *Laurus* (top) and *Ixanthus* (bottom). Populations are displayed from West to East, the other islands at the bottom of the figures.

Pairwise F_{st} were calculated for both species with Arlequin. Figure 11.2 shows the results in a clear form, while the table (on CD) contains detailed numbers. Additionally, numbers for pairwise differences within and between the populations are displayed. For populations with more than ten individuals, pairwise F_{st} values range between nearly zero (populations 31 and 29) and 0.156 (populations 15 and 23) for *Laurus* and 0.023 (populations 07 and 08) and 0.358 (populations 01 and 08) for *Ixanthus*. Statistics for all populations are shown in table 11.2 and 11.3. Analysis of molecular variance (AMOVA) finds most of the variation within the populations for both species: for *Laurus*, 91.28 % are within populations, for *Ixanthus* 77.7 %. Similar results are obtained for the geographic regions as source for variance (see table 11.1).

Table 11.1.: Analysis of Molecular Variance (AMOVA) of *Laurus* and *Ixanthus* based on population and georegion level

Source of variation	**d.f.**	**Sum of squares**	**Variance components**	**Fixation index**	**Percentage of variation**
A Laurus Georegions				0.05232	
Among Populations	11	638.317	0.84168		5.23
Within Populations	622	9483.452	15.24671		94.77
B Ixanthus Georegions				0.18574	
Among Populations	7	139.538	0.85254		18.57
Within Populations	156	583.023	3.73732		81.43
C Laurus Populations				0.08719	
Among Populations	38	1490.527	1.41875		8.72
Within Populations	633	9402.526	14.85391		91.28
D Ixanthus Populations				0.22298	
Among Populations	14	220.829	1.03489		22.3
Within Populations	165	595.021	3.60619		77.7

Table 11.2.: Population analysis of *Ixanthus*

Population ID	**Number of Individuals**	**Number of Polymorphic Loci**	**Percentage of Polymorphic Loci**	**Nei Index**	**Shannon Index**
01	17	27	22.31	0.065	0.1007
02	16	22	18.18	0.0586	0.0886
03	17	26	21.49	0.0779	0.116
04	21	27	22.31	0.0677	0.1041
05	16	27	22.31	0.0757	0.1139
06	15	32	26.45	0.0863	0.1295
07	18	27	22.31	0.077	0.1153
08	17	22	18.18	0.0607	0.0911
09	8	18	14.88	0.0494	0.0742
10	16	23	19.01	0.0623	0.0941
11	3	7	5.79	0.022	0.0326
Canaria	2	3	2.48	0.0103	0.015
Gomera	5	20	16.53	0.0747	0.1058
Hierro	3	6	4.96	0.018	0.027
Palma	6	9	7.44	0.0289	0.0422

Table 11.3.: Populations analysis of *Laurus*

Population ID	**Number of Individuals**	**Number of Polymorphic Loci**	**Percentage of Polymorphic Loci**	**Nei Index**	**Shannon Index**
00	20	87	34.66	0.1010	0.1549
01	20	92	36.65	0.1146	0.1747
02	19	104	41.43	0.1233	0.1883
03	21	108	43.03	0.1235	0.1899
04	20	117	46.61	0.1356	0.2089
05	20	122	48.61	0.1375	0.2113
06	20	106	42.23	0.1114	0.1731
07	15	99	39.44	0.1223	0.1867
08	20	114	45.42	0.1285	0.199
09	20	112	44.62	0.1275	0.1962
10	20	92	36.65	0.1009	0.1564
11	12	71	28.29	0.0928	0.1398
12	21	104	41.43	0.1204	0.1855
13	20	96	38.25	0.1138	0.1733
14	19	99	39.44	0.1133	0.1751
15	20	90	35.86	0.1011	0.1553
16	19	98	39.04	0.1174	0.179
17	19	103	41.04	0.1182	0.1817
18	21	110	43.82	0.1221	0.1891
19	20	96	38.25	0.1082	0.1663
20	16	92	36.65	0.1096	0.1673
21	23	103	41.04	0.1173	0.1803
22	22	109	43.43	0.1358	0.2064
23	20	114	45.42	0.1267	0.1966
24	21	129	51.39	0.1426	0.2205
25	20	118	47.01	0.1410	0.2146
26	21	95	37.85	0.1094	0.1669
27	20	91	36.25	0.1112	0.1701
28	20	110	43.82	0.1197	0.1843
29	21	105	41.83	0.1146	0.1781
30	20	95	37.85	0.1084	0.1667
31	21	109	43.43	0.1180	0.183
32	2	22	8.76	0.0363	0.053
33	2	19	7.57	0.0314	0.0458
Palma	14	82	32.67	0.1020	0.1547
Gomera	6	41	16.33	0.0640	0.0938
Hierro	5	45	17.93	0.0659	0.0978
Canaria	12	97	38.65	0.1112	0.1721
Azores	3	43	17.13	0.0723	0.1045

11.2. Genetic Diversity on Individual Level

Values for genetic distances D_{ij} ranged from -0.090 to 0.0926 for *Laurus* -0.068 to 0.070 for *Ixanthus*.

Values were imported and plotted in ArcMap, and after deletion of distances that are not connecting direct neighbours, inverse distance weight algorithm were applied. Classified to ten classes shaded from green (low diversity) to red (high diversity), interpolated areas were visualised (figure 11.3). For *Laurus*, genetic distances are shown for the whole area of potential distribution of laurel forest vegetation as defined by del Arco et al. (2003), for *Ixanthus*, parts of the potential distribution were excluded from the analysis because of the absence of *Ixanthus* from widespread parts of this area. We chose this way because over larger distances with no samples of one species, IBD effects are overlaying the existing diversity and diversity should only be displayed for regions with the species abundant. In Mantel test, the correlation of genetic and geographical distances (r) was similar for both model species: $r = 0.16$ for *Laurus* and $r = 0.18$ for *Ixanthus*, therefore, there is a slight isolation by distance in both species detectable. But nevertheless, the distribution gaps for *Ixanthus* were much wider than for *Laurus* and have therefore more influence on the evaluation of diversity patterns in geographic space.

Both species show centres of diversity in their distribution ranges. Genetic hotspots for *Laurus* are located in Teno mountains, in the eastern Orotava valley, near Guamasa and in western and eastern Anaga mountains. Highest diversity classes for *Ixanthus* were found also in Teno mountains and the Orotava region, hotspots in the Anaga mountains are more in the western and middle regions. In Orotava valley, sample density is very low due to scarce occurrence of laurel forest vegetation, therefore isolation by distance effects could not be excluded for this area. Nevertheless, genetic distances between the eastern and the western slopes of the Orotava valley and the single sample in the valley that could be found are relatively high. Areas between the Chanajiga region and Teno as well as the area around Guamasa were excluded because of wide gaps in the species distribution.

Consequently, hotspots of genetic diversity are similar in both species apart from regions were *Ixanthus* is not distributed any longer. Results are comparable to calculations at population level especially in *Laurus*, whereas the smaller population sizes and bigger ranges of the population area seems to influence the results of population diversity in *Ixanthus* (appears to be smaller in Teno and higher in the Esperanza region than in the individual approach).

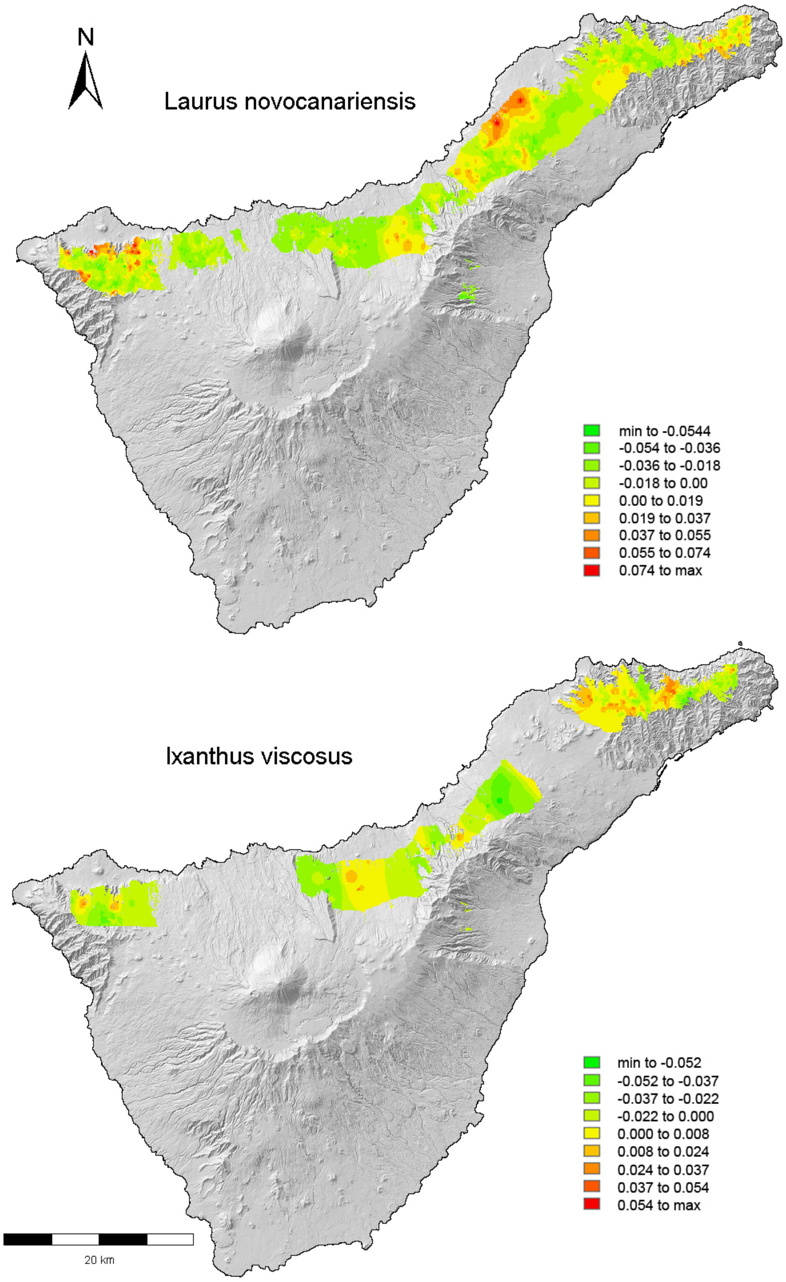

Figure 11.3.: Maps of genetic hotspots
Inter-individual genetic distances D_{ij} plotted using inverse distance weight interpolation. Interpolated area refers to the potential laurel forest area (del Arco et al., 2003) and to current species distribution.

12. Ecological Analysis

This paragraph shows the connection of the two species to the actual and potential distribution of vegetation on Tenerife. For all samples, data for current vegetation communities, the PNV and the degree of disturbance have been extracted from maps del Arco et al. (2003). The analysis aimed to find out about the differences in the distribution of the model species.

It is obvious that the emphasis of the distribution of the two model species is slightly different when looking at the background of the vegetation community the samples derive from. With the area-wide sampling of both species and the defined sample density, our collection should exemplary represent the occurrence of *Laurus* and *Ixanthus* within their current distribution range.

In the tables 12.1, 12.2 and 12.3, the origin of the accessions of both *Laurus* and *Ixanthus* is indicated using total sample numbers and percentage for the actual main vegetation, type of disturbance and for the PNV.

With a focus on the main vegetation from which the samples derived, the biggest proportion (44 %) of the *Laurus* samples come from Fayal-Brezal (*Ixanthus*: 47 %), 22 % from urban area (*Ixanthus*: none), contrastingly, only 16 % are sampled in the laurel forest communities (*Ixanthus*: 45 %). In comparison it becomes clear that most of the *Laurus* samples derived from areas with substitution forms of the primary forest (Fayal-Brezal), with a secondary focus on the urban affected areas. In contrast to this, *Ixanthus* secondarily grows in the remaining laurisilva vegetation, mostly in the high elevations and humid monteverde, while it is not present in the urban areas, were *Laurus* is common as well.

When classifying the sample area in natural vegetation versus substitution communities, these patterns become more clear: the prevailing amount of samples were collected in substitution communities for both species, but the proportion of samples from natural vegetation (here monteverde) is prevalent in *Ixanthus*, whereas *Laurus* is also present in urban areas and agricultural areas (plantations). In this areas, *Ixanthus* is not distributed at all.

Focusing on the potential natural vegetation, more than 90 % of *Laurus* and 82 % of *Ix-*

Table 12.1.: Ecological Analysis — Main Vegetation

	Laurus		**Ixanthus**	
Fayal-brezal	277	(43.7 %)	77	(47.0 %)
Monteverde (dry)	12	(1.9 %)	6	(3.7 %)
Monteverde (high elevation)	39	(6.2 %)	27	(16.5 %)
Monteverde (humid)	50	(7.9 %)	39	(23.8 %)
Monteverde (wet)	2	(0.3 %)	1	(0.6 %)
Natural pine forest	13	(2.1 %)	0	(0.0 %)
Plantations	64	(10.1 %)	13	(7.9 %)
Scrubland	36	(5.7 %)	1	(0.6 %)
Urban area	141	(22.2 %)	0	(0.0 %)

Table 12.2.: Ecological Analysis — Type Of Disturbance

	Laurus		**Ixanthus**	
Natural vegetation (Monteverde)	103	(16.2 %)	76	(46.3 %)
Natural vegetation (Pinar)	13	(2.1 %)	0	(0.0 %)
Substitution communities	314	(49.5 %)	88	(53.7 %)
Plantations	63	(9.9 %)	0	(0.0 %)
Urban area	141	(22.2 %)	0	(0.0 %)

Table 12.3.: Ecological Analysis — Potential Natural Vegetation

	Laurus		**Ixanthus**	
Fayal (high altitude)	2	(0.3 %)	0	(0.0 %)
Brezal (crests)	44	(6.9 %)	28	(17.1 %)
Monteverde higrófilo	42	(6.6 %)	14	(8.5 %)
Monteverde húmedo	383	(60.4 %)	101	(61.6 %)
Monteverde seco	120	(18.9 %)	15	(9.1 %)
Monteverde-Pinar	31	(4.9 %)	6	(3.7 %)
others	6	(0.9 %)		(0.0 %)
Pinar	6	(0.9 %)	0	(0.0 %)

anthus derived from areas of the potential distribution of the different laurisilva community areas (Monteverde higrófilo, Monteverde húmedo, Monteverde seco and Monteverde-Pinar). The PNV Fayal-Brezal of the ridges harboured both species, but *Ixanthus* in a huger proportion. Other PNV areas are not important for the natural distribution of the two monteverde species (most likely artefacts of samples close to the border).

In PCoA with AFLP data, no obvious pattern gives a hint that genetic variance in the datasets and the origin of the samples vegetation units are connected, the same is true for altitude (data not shown).

Furthermore, we aimed to investigate the bioclimatic limits for species distribution and to find out about putative differences between *Laurus* and *Ixanthus* to explain the different geographical extent of the distribution ranges.

For all samples of both model species, the 19 bioclimatic data plus altitude could be extracted for 1 square kilometre grids. Table 12.4 compares the minimum, maximum and median value for all these values for both species. Detailed frequency plots are shown in figure 19.2 (in Appendix B). T-test and Mann-Whitney-U-test showed for approximately only half of the bioclim parameters a significant difference.

Overall, the range in all ecological parameters is broader in *Laurus* than in *Ixanthus*. For instance, laurel samples ranged in their altitude between 374 and 1455 meters (range 1081 m), *Ixanthus* is distributed between 577 and 1193 meter above sea level (range 616 m), also the ranges of isothermality (bio3) and of seasonality (bio4) are broader for *Laurus* than for *Ixanthus*. Contrastingly, values for annual mean temperature (bio1) and annual mean precipitation (bio12) are more or less equal. Ranges of *Ixanthus* are covering 79 % to 100 % of the ranges of *Laurus* for the bioclimatic parameters. Contrastingly, for altitude *Ixanthus* is only covering 57 % (616 meters) of the *Laurus* range (1081 meters).

In a PCoA with the bioclim values, the first two coordinates are explaining 95 % of the variability in the data. Due to the connectivity of the parameters, which derive from temperature and precipitation data, all bioclimatic parameters are contributing more or less equally to the resolution of the data (see figure 19.1 in Appendix B). All temperature connected values (bio1 to bio11) contributed to the loading of the first coordinate, precipitation connected parameters are contributing to the second coordinate or to both. Altitude is more correlated to temperature than to precipitation.

Table 12.4.: Bioclimatic values: Comparison of the descriptive statistics

BIO	**Range**		**Minimum**		**Maximum**		**Median**		**Standard Deviation**	
	L.n.	**I.v.**	**L.n.**	**I.v.**	**L.n.**	**I.v.**	**L.n.**	**I.v.**	**L.n.**	**I.v.**
bio1	7.1	6.3 (89 %)	11.9	12.6	19.0	18.9	15.4	15.7	1.3	1.4
bio2	0.6	0.4 (79 %)	6.9	6.9	7.5	7.4	7.1	7.1	0.1	0.1
bio3	8.1	6.9 (86 %)	39.0	40.1	47.1	47.1	44.1	44.7	1.9	2.0
bio4	140.6	111.2 (79 %)	275.2	276.6	415.7	387.8	315.3	307.2	29.0	30.0
bio5	4.3	4.10 (95 %)	23.1	23.30	27.4	27.4	24.6	24.8	0.8	0.9
bio6	8.7	7.60 (87 %)	3.9	4.90	12.6	12.5	8.4	8.8	1.6	1.8
bio7	4.4	3.60 (82 %)	14.8	14.80	19.2	18.4	16.2	15.9	0.9	1.0
bio8	8.6	7.5 (87 %)	8.3	9.3	17.0	16.8	12.8	13.2	1.6	1.8
bio9	4.7	4.4 (95 %)	17.2	17.4	21.9	21.8	18.9	19.0	0.9	1.0
bio10	5.0	4.7 (93 %)	17.6	18.0	22.7	22.6	19.6	19.8	0.9	1.0
bio11	8.5	7.4 (87 %)	7.5	8.4	16.0	15.9	11.9	12.3	1.6	1.8
bio12	216	207 (96 %)	364	373	580	580	518	519	38	45
bio13	37	35 (95 %)	72	74	109	109	100	99	7	8
bio14	2	2 (100 %)	1	1	3	3	1.67	1.91	0.71	0.71
bio15	9.8	8.2 (83 %)	80.3	80.3	90.2	88.6	84.6	83.9	2.2	2.2
bio16	106	100 (94 %)	196	202	302	302	277.8	276.1	19.1	23.1
bio17	10	10 (100 %)	6	6	16	16	10.9	11.6	2.5	2.7
bio18	12	12 (100 %)	9	9	21	21	17.3	17.5	2.4	2.8
bio19	115	111 (97 %)	145	149	260	260	238.6	236.1	19.7	25.6
Altitude	1081	616 (57 %)	374	577	1455	1193	838	861	189	134

L.n. = *Laurus novocanariensis*, I.v. = *Ixanthus viscosus*. Parameters: bio1 = Annual Mean Temperature, bio2 = Mean Diurnal Range (Mean of monthly (max temp - min temp)), bio3 = Isothermality (bio2/bio7) (* 100), bio4 = Temperature Seasonality (standard deviation *100), bio5 = Max Temperature of Warmest Month, bio6 = Min Temperature of Coldest Month, bio7 = Temperature Annual Range (bio5-bio6), bio8 = Mean Temperature of Wettest Quarter, bio9 = Mean Temperature of Driest Quarter, bio10 = Mean Temperature of Warmest Quarter, bio11 = Mean Temperature of Coldest Quarter, bio12 = Annual Precipitation, bio13 = Precipitation of Wettest Month, bio14 = Precipitation of Driest Month, bio15 = Precipitation Seasonality (Coefficient of Variation), bio16 = Precipitation of Wettest Quarter, bio17 = Precipitation of Driest Quarter, bio18 = Precipitation of Warmest Quarter, bio19 = Precipitation of Coldest Quarter, Altitude = Meters above sea level. % values display the percentage of *Ixanthus* ranges within *Laurus* ranges.

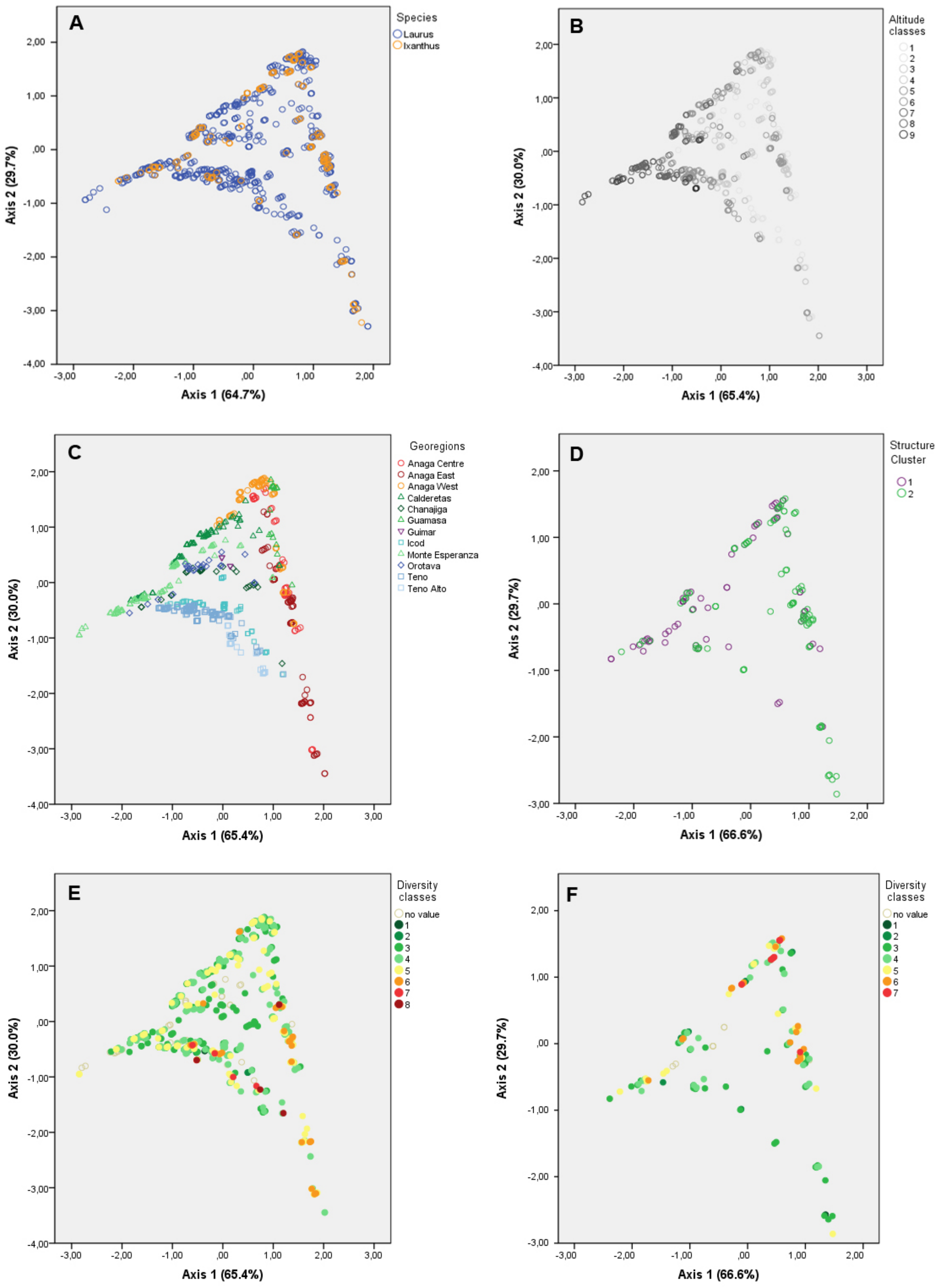
A
Species
Laurus
Ixanthus
Axis 2 (29.7%)
Axis 1 (64.7%)
B
Altitude classes
1
2
3
4
5
6
7
8
9
Axis 2 (30.0%)
Axis 1 (65.4%)
C
Georegions
Anaga Centre
Anaga East
Anaga West
Calderetas
Chanajiga
Guamasa
Guimar
Icod
Monte Esperanza
Orotava
Teno
Teno Alto
Axis 2 (30.0%)
Axis 1 (65.4%)
D
Structure Cluster
1
2
Axis 2 (29.7%)
Axis 1 (66.6%)
E
Diversity classes
no value
1
2
3
4
5
6
7
8
Axis 2 (30.0%)
Axis 1 (65.4%)
F
Diversity classes
no value
1
2
3
4
5
6
7
Axis 2 (29.7%)
Axis 1 (66.6%)
2,00
1,00
,00
-1,00
-2,00
-3,00
-4,00
-3,00
-2,00
-1,00
,00
1,00
2,00
3,00

Figure 12.1.: PCoA of Bioclim parameters

A: Comparison of both species, B: Altitude classes for *Laurus*, C: Geographic regions for *Laurus*, D: STRUCTURE clustering for *Ixanthus*, E: *Laurus* diversity classes, F: *Ixanthus* diversity classes.
Altitude classes were chosen as following: 1: 370 m to 499 m, 2: 500 m to 599 m, 3: 600 m to 699 m, 4: 700 m to 799 m, 5: 800 m to 899 m, 6: 900 m to 999 m, 7: 1000 m to 1099 m, 8: 1100 m to 1199 m, 9: 1200 m to 1500 m. Geographic regions are referring to figure 14.1. Diversity classes are referring to figure 11.3, the neighboured diversity class has been extracted from the surrounding area and associated with the sample.

Part V.

Discussion

13. Phylogeography and Biogeography

The laurel forest may be restricted to a closely defined niche on the Canary Islands, but within this range it acts as a highly dynamic vegetation complex. Being included in the monteverde together with the heath scrubs, it displays its dynamics in time through changes in species composition since the Miocene as well as in space. In former times forest fires induced the changes on its distribution range and extent, while in later times the Canary population had a massive influence on the laurel forest, on its distribution range and extent. In future climate changes may be a major driver of laurel forest dynamics. As disturbances play a key role in shaping biodiversity (Banks et al., 2013), knowledge of diversity patterns is essential for understanding the dynamics of the laurel forest communities throughout time.

13.1. Intra-Island Population Structure on Tenerife

Ranging immediately right behind the Hawaiian archipelago, the flora and fauna of the Canary Islands is the second-best understood worldwide (Sanmartín et al., 2008) and phylogenies have been published for many species from the Canary Islands and Macaronesia. The studied species are mostly Canary Island endemics and groups that have radiated on the islands. Contrastingly, there are no detailed analyses on phylogeography of the more common, typical Canarian species, like for example the laurel forest tree species. Phylogeographic studies of the last few years for *Laurus* show less (Arroyo-García et al., 2001) or no resolution within the Canary Islands (Rodríguez-Sánchez et al., 2009) at all, and no population genetics or intra-Canary Islands studies are available for the endemic *Ixanthus*, although it is widely distributed on the western Canary Islands laurel forests and a laurel forest character species. Hence no data on microgeographic resolution is present for this taxa, and if there are detailed small scale analyses, they focus on endangered endemics with smaller distribution ranges, which are not representative for the laurel forest genetic structure.

With respect to the interest of the Canarian laurel forest as an endemic, endangered ecosystem, we want to discuss phylogeographic patterns of two comparatively widespread laurel forest species on intra-island level to gain insight into potentially general diversity patterns helpful for conservation management.

For our two model species we found different, albeit related patterns in population structure for Tenerife: both display a differentiation in an eastern and a western gene pool. In *Ixanthus* two clusters are distributed across Tenerife with no geographic pattern, whereas the emphasis of the two gene pools is reflected the pattern in *Laurus*. *Ixanthus* shows a more mixed and unclear pattern in STRUCTURE results, exhibiting more details in Splitstree neighbournet analysis. From the range of both species, the more fragmented distribution area of *Ixanthus* suggests theoretically a more distinctive pattern due to decreased gene flow in isolated populations, but this is apparently not the case. What explains the similar patterns in both species?

When analysing Canarian species distribution and phylogenetics, a common pattern has been found for Tenerife, showing a divergence on different levels affiliated with the mountain ranges of Anaga and Teno (Juan et al., 2000), in animals as well as in plant taxa. Vicariant sister taxa in these areas are present in different animal species, for instance in lizards, skinks, beetles (genera of *Calanthus* and *Pimelia*), mites, spiders (Dyseridae, (Macías-Hernández et al., 2013)) and cockroaches (Juan et al., 2000). For example, the lizard *Gallotia gallotti* shows a similar mitochondrial haplotype pattern across the north of Tenerife like our two model species. The timing in the split of lizard lineages is consistent with the geological hypothesis, that Anaga linked to the rest of the island only less than one million years ago, maybe only 100.000 years bp (Thorpe et al., 1995). Of course, there are many examples in plants with similar phylogenetic patterns on Tenerife, for instance in *Olea europaea guanchica* on population level (García-Verdugo et al., 2010), *Festuca* species (Díaz-Pérez et al., 2012), the endemic *Anagyris latifolia* (González-Pérez et al., 2009), *Bystropogon* taxa (Trusty et al., 2005). Most authors mention the complex geological history of Tenerife with the three paleo-islands (Ancochea, 1990), of which two, the Anaga and the Teno, are important for the laurel forest phylogenetic history. Used markers in the mentioned studies were nucleotide and chloroplast sequences as well as RAPD, causing different levels of divergence between the sister lineages in the studied taxa. But in all these cases the pattern has been connected with the volcanic genesis of Tenerife (Juan et al., 2000), whereas the pattern sometimes is more complicated due to lineage divergence, secondary contact and several colonisation events of and between the islands, as found by Désamoré et al. (2011) for *Erica arborea*, the heath scrubs of the Fayal-Brezal.

Therefore, we might suggest similar reasons for the phylogeographic patterns. As the ages of the species are important for this pattern, at least *Laurus* would be old enough to be influenced by the island's genesis one million years ago (Kondraskov et al., in prep.). In *Ixanthus* the picture is slightly different. Due to the finding of only two gene pools in STRUCTURE and the radial structure in neighbournet, it is more likely that *Ixanthus* is a young species (Talavera et al., 2013), which would be consistent with the findings of Kondraskov et al. (around 0.8 mya). Thus *Ixanthus* is not a Tertiary relict species, but possibly old enough to be influenced by the geologic history of Tenerife.

Nevertheless, it is remarkable that colonisation events this old seem to be present in AFLP markers until today despite all changes in forest structure (de Nascimento et al., 2009) and distribution area reduction due to agricultural land use changes. Commonly, AFLP is used for resolving population structures which are not recognisable in nuclear or chloroplast markers that evolve too slowly to reveal recent patterns in population divergence. Following this we have to consider different reasons for the putative paleo-island population structure.

A second reason that could lead to a genetic differentiation or a genetic gradient apart from colonisation might be a limited gene flow due to distance and genetic barriers such as gaps in the distribution area or mountain ranges and rivers. A correlation of genetic and geographic distances is present in both species. Although it is not a strong signal, it has to be considered while interpreting results of clustering and divergence analyses. In BARRIER analysis, we could not locate distinct barriers to gene flow. Most likely, the fragmentation of the laurel forests, which started to become more intense 600 years ago, is still too recent to leave its imprint on population differentiation until today, considering also the long generation time and seed dispersion strategy for at least the laurel tree.

We speculate that the belt-like potential and current distribution area of both species on Tenerife results in a genetic gradient from West to East through IBD over time, although the area has been a continuous one for long times. Recent fragmentation may result in a more distinctive population pattern in the future due to genetic erosion and increased barriers to gene flow as it is hinted in *Ixanthus* neighbournet analysis. But until today, general low pairwise F_{st} values between populations on Tenerife suggest an ongoing gene flow and no isolation even between distant regions in both model species, for *Laurus* more than for *Ixanthus.* This is also visible in PCoA, showing a continuous scattering of individuals with no isolated groups and no clear separation of gene pools, regions and even islands.

Ixanthus' pairwise F_{st} values are considerably higher than *Laurus*' and also a higher percentage of molecular variance is located between the populations of *Ixanthus* (see AMOVA analysis, 11.1). This accounts for higher isolation and less gene flow between the populations due to higher fragmentation of the distribution area. In the large distribution gap between La Esperanza and Anaga West a higher divergence between the individuals could be detected.

Taken together, the prevailing lack of private AFLP fragments and of heterogeneity between geographic regions or populations, the radial neighbournets and non-separating populations in PCoA lead us to the assumption that the observed patterns are not relics from island emergence, but more recent events, like a quick radiation or range expansion with subsequent genetic differentiation due to IBD effects for both species.

13.2. *Laurus* Population Structure on the Western Canary Islands and Gene Flow on Tenerife and Between Islands

Of course, this study can neither provides answers to the question of island colonisation nor to the origin of gene pools, lacking the sampling of mainland populations of both species. But the inclusion of populations from the other Western Canary Islands for comparison with our main study area Tenerife provide many interesting and new glimpses in the inter-island structure especially of Canarian *Laurus novocanariensis*.

For *Laurus*, in Arroyo-García et al. (2001) a close connection to the Iberian Peninsular populations has been found, in Rodríguez-Sánchez et al. (2009). The Canary Islands shared one haplotype with Morocco and Madeira, pointing to a subsequent colonisation of the Iberian Peninsular from Macaronesia.

When incorporating the situation in the Lauraceae family, it has to be considered that the lack of diversity and heterogeneity in the species *Laurus novocanariensis* is connected with the uniformity at family level, as it was shown and discussed in the phylogenetic studies by Chanderbali et al. (2001) and Rohwer (Rohwer (2000), Rohwer and Rudolph (2005)). Also other groups, like Rodríguez-Sánchez et al. (2009) were not able to obtain chloroplast markers which could resolve the laurel phylogenetic history on the Canary Islands, while the Mediterranean lineages show at least a few polymorphisms, which is consensual with our findings in chloroplast sequences for HRM analysis. Therefore, the AFLP method is well suited for resolving minor population structures on Canary Island level.

As it is depicted in the inter-island STRUCTURE analysis, there are no gene pools that are exclusively for one island. In other words, no island harbours its own subpopulation of laurel trees. Small proportions of the gene pools are present in admixt individuals and gene pools are shared between islands in both STRUCTURE scenarios. On island level the admixture of the gene pools is even more obvious. Additionally, the occurrence of individuals from a distant main gene pool can be observed in another region of Tenerife, incorporated in individuals from the local main gene pool. The mixing of gene pools from different regions is also visible in the PCoA analysis. In conclusion, gene flow between different regions within the island and between the islands does occur.

The Lauraceae, including *Laurus novocanariensis*, have fleshy and oil-rich fruits, which are eaten by different animals, especially in the tropical and subtropical forests, what might be an approach for understanding the distribution of *Laurus* gene pools between the Western Canary Islands. Moreover, *Laurus* is only one of 15 tree species from the Macaronesian laurel forest, which fruits are bird-propagated (Arévalo et al., 2007). Therefore, the pattern we observed in *Laurus* is likely not unique in the Macaronesian region, although the mechanisms of dispersal by birds on oceanic islands are poorly understood until now (Nogales et al., 2012). The ability to long distance dispersal is well known in the Lauraceae, as they occur on remote islands and even dispersion history of *Laurus* in the Mediterranean seems to be driven by dispersal over longer distances and back colonisation events (Fernández-Palacios and de Nascimento (2011), Arroyo-García et al. (2001), Rodríguez-Sánchez et al. (2009)).

For bird propagated tree species a moderate to high level of genetic diversity and a weak population structure across islands are typical, as Sosa et al. (2013) indicated for some Macaronesian *Ilex* species. The *Ilex* genus is endemic for the laurel forest with fruits foraged by birds, just like *Laurus*. The much higher F_{st} values in Sosa et al. (2013) for *Ilex* might occur due to the use of a different marker system (microsatellites). As it has been found by Gaudeul et al. (2004), genetic differentiation in AFLPs is higher than in microsatellites, differentiation between the islands is much more smaller in *Laurus* than in the *Ilex* species.

Forfang and Olesen (1998) reported that the pollination of *Laurus* is achieved by insects of the Hymenoptera (Halictinae), Diptera (*Tachina canariensis*) and, in much smaller proportions, by others (e.g. Lepidoptera and Coleoptera). As a consequence, pollen of *Laurus* is not transported as far as that of wind-pollinated tree species. However, bigger bird species as well as mammals feed on the seeds of *Laurus*. This is known for the endemic pigeons that inhabit the laurel forests of the Western Canary Islands, Bolle's Pigeon *Columba bollii* and the Laurel Pigeon, *Columba junoniae* (Hernández and Martín (2003), Gonzalez et al. (2009)), the Common Raven (*Corvus corax*, Nogales et al. (1999)), and the Blackbird (*Turdus merula*, at least regarding the Mediterranean *L. nobilis*, Hampe (2003)). Even smaller birds seem to forage on *L. nobilis* seeds, but for *Laurus novocanariensis* the main dispersers may be the laurel forest pigeons like on Madeira (Oliveira et al., 2002), because the pigeons are seen as the original seed dispersers of the tertiary lauroid vegetation (Hampe, 2003). For other birds, like the Common Raven, the successful germination from faeces has not been observed (Nogales et al., 1999) yet. The same is true for predatory birds as secondary seed dispersers (Padilla et al., 2012). Other seed foraging animals are introduced rats (*Rattus rattus*, (Delgado García, 2000)).

However, many bird species that have settled down on oceanic islands, have split into separate lineages due to missing gene flow even between adjacent and near islands, for example the Blue Tits (*Parus teneriffae*-group) on the Canary Islands (Dietzen et al., 2008). For the larger, putative fruit dispersers of *Laurus* seeds, *C. bollii* and *C. junoniae*, no splitting into subspecies is known for the Canary Islands. Therefore, gene flow between the pigeon populations is most likely, and consequently seed transportation between the laurel forests of the different Canary Islands or between distant parts of one island does occur, for example between western and eastern parts of Tenerife. This seed dispersal over longer distances appears to happen regularly enough to maintain gene flow and the mixing of populations, but rarely enough to allow differentiation, a positive correlation between geographic distance and genetic distance and increased F_{st} values between different island populations.

For *Ixanthus* we could not resolve the inter-islands pattern at all, as two STRUCTURE populations were the most likely scenario again (data not shown). Therefore, the population patterns we observed are not so old enough to develop distant lineages, or gene flow between the islands is still sufficient to maintain the gene flow between the populations. Due to the usage of fewer AFLP markers in *Ixanthus* compared to *Laurus* and to a lower degree of polymorphy, a higher amount of markers may be helpful to resolve more precise patterns in population structure, provided that there is more to see.

14. Where is Diversity Highest? Localisation of Genetic Hotspots

Genetic diversity is affecting all levels of biodiversity: the fitness of individuals and populations, population viability and the ability to adapt to changes in environment, the development of new species, community structures and the functionality of ecosystems (Banks et al., 2013). This is why genetic diversity is as important as species diversity to protect and should be considered in conservation management.

Genetic diversity is not distributed equally in space, hence it depends on past colonisation patterns and population dynamics. Banks et al. (2013) discussed disturbance as the major driver in shaping biodiversity and genetic diversity through direct and indirect effects, thus it is interesting to study the situation of genetic diversity in the highly fragmented and range-limited laurel forest of Tenerife, which has lost about 90 % of its original range due to logging (del Arco Aguilar et al., 2010). The reduced population size leads to less allelic richness and disturbance in general leads to changes in differentiation through altered genetic drift and migration patterns (Banks et al., 2013).

We chose two different approaches to develop a map of genetic diversity, based on populations respectively on individuals, and compared the final outcomes. The first one is the traditional approach, which has been used by population geneticists for nearly 80 years to investigate genetic variation in populations (Manel et al., 2003). The second one does not have the pre-assumption of distinct populations, which is common in the field of landscape genetics (Manel et al. (2003), Manel et al. (2007)). However, after ten years of landscape genetics, studies of plants are in general still under-represented in this field (Manel and Holderegger (2013), Holderegger et al. (2010)). Nevertheless, landscape genetic approaches are useful tools to discover hotspots in geographical space, for both populations and individuals, even for more than one species at the same time, as it was shown by Vandergast et al. (2008) in order to answer conservation issues.

In both our model species it is obvious that the patterns of genetic diversity are highly comparable, whether achieved with the population-based or the individual-based approach. This confirms that the approach based on individuals is well suited for our fine-scale sampling and AFLP fingerprinting, the latter being widely used in this field. So we could take advantage of the full resolution this kind of sampling provides in contrast to a sampling of distinct populations.

Moreover, the hotspots of both species are overlaying each other in most cases, showing that the emphasis of genetic divergences are similar in two — for laurel forest means — quite different species with even different current distribution ranges.

For both species, hotspots in genetic diversity are located in the Teno mountain range in western Tenerife and in the Anaga mountain range in the East. Figure 14.1 shows that these are the less fragmented remnants of laurel forest on the island. In the centres and the steepest parts of these mountains there has been less agriculture, and the biggest patches of intact forest communities remained in these areas. Today, big parts of Anaga and Teno are protected by law. This may lead to the assumption that fragmentation and logging have reduced the genetic diversity in the other parts of the island. That is true at least for *Ixanthus*, which has disappeared from most smaller laurel stands in the agricultural area. Where it is still present, the diversity is rather low.

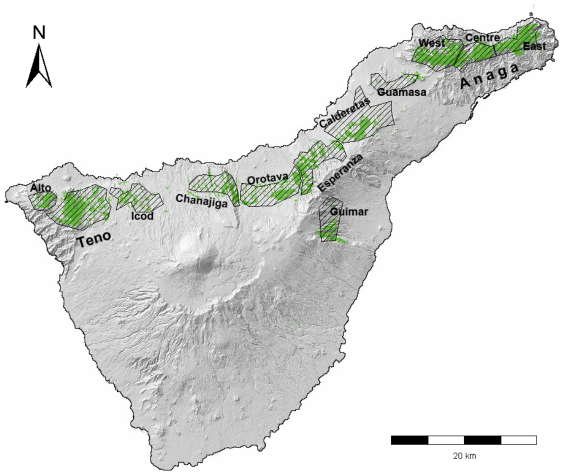

Figure 14.1.: Geographic regions and Current Distribution of Laurel Forest

Hatched: regions that have been defined for analysis and the location names used. Green: current distribution of monteverde vegetation (del Arco et al., 2003).

Laurus has a centre of diversity in the region between Guamasa and Calderetas, an urban affected area with no laurel forest, but only scattered remnants of laurel trees in an agricultural or rural environment with wide distribution gaps and the lack of saplings. In population analysis, both regions separately display low diversity indices, which implicates the impact of IBD effects for this area. Besides that it is possible that trees from roadsides or in urban areas are not remnants from logging left for shade, but planted, although this is not common (Alfredo Reyes-Betancort, pers. comm.). Therefore this region should not be considered as a natural biodiversity hotspot.

Taken together, Teno and Anaga can be addressed as the genetic hotspots in *Laurus* and in *Ixanthus*. These centres of diversity are consistent with the study of Reyes-Betancort et al. (2008) dealing with the Canary Islands endemics, who states that endemic species richness, range size rarity and phylogenetic diversity are all highest in Teno and Anaga region as well as Ladera de Güimar, caused by their big ranges in altitude and humidity. Although we could not provide numbers for the overall species diversity apart from endemics, these parts of Tenerife are likely to be hotspots in species richness as they are in genetic diversity. Parts of the mountains are currently under protection of the category of *Parque Rural*, which focuses on sustainable ecosystem use and landscape protection, but not on species and diversity protection (Reyes-Betancort et al., 2008). Some special, smaller sites within the *Parque Rural* are more strictly protected, but they do not include all endemic species and only a small proportion of the genetic diversity.

Nevertheless, the overlapping of genetic diversity and endemic richness is convenient to designate these areas for conservation in the future.

15. Ecology Analysis

In this section the ecology of the two model species is discussed, and whether observed differences are natural or are caused by human degradation of the laurel forest ecosystem.

Figure 15.1 shows the current distribution of *Laurus novocanariensis* and *Ixanthus viscosus*. As both are species from the laurel forest communities, the difference in the distribution can be caused by two reasons: the spatial more limited *Ixanthus* could have a smaller ecological amplitude or degradation could have led to the shrinking of the distribution areas.

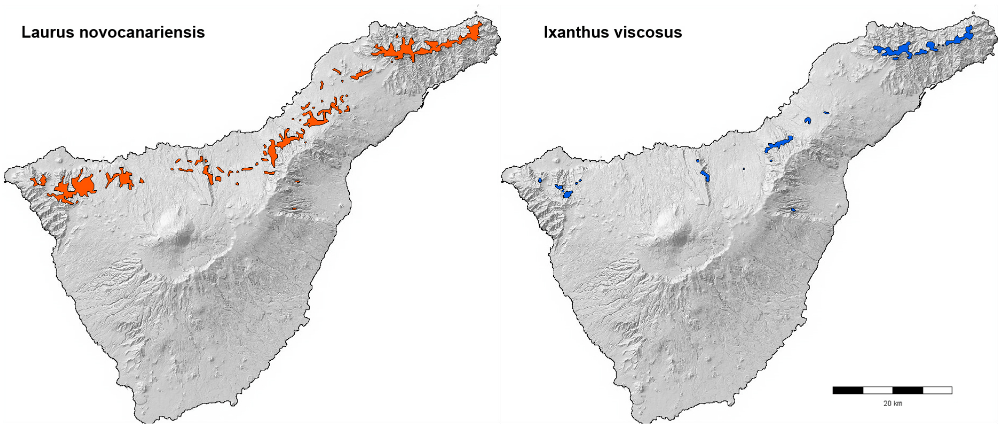

Figure 15.1.: Current species distribution
Distribution maps of *Laurus novocanariensis* (left map) and *Ixanthus viscosus* (right map) based on area-wide, grid square sampling.

To answer this question, we analysed the biological relevant abiotic climate factors (so-called bioclimate values) related to temperature, precipitation and elevation and compared the ranges, in which the species were found. In all cases, the *Ixanthus* ranges are situated within the ranges of *Laurus*, and half of the bioclim parameters differ statistically significantly. The biggest differences in range distribution were observed for elevation, upper and lower boundary of *Ixanthus* were lower respectively higher than in *Laurus*, but the median elevation was equal in both species. When interpreting these data, one has to be careful with biased statistic, as the current distribution ranges are of course not the same as the potential distribution ranges, most likely they were reduced in their upper and lower boundaries due to forest exploitation and destruction. As the bioclimatic limits of *Ixanthus* are always within *Laurus* limits and differences are in most cases below 20 % there is no indication of different ecological niches concerning temperature and precipitation in the two species. This is also visible on figure 19.2 A, also no connection between bioclimatic parameters and diversity classes could be found. The figures 19.2 B and 19.2 C show the correlation between altitude and geographic regions. These are differing in temperature and precipitation regimes, what could cause a biased correlation between gene pools and climate, because climate is differing in the geographic regions (figure 19.2 D).

We conclude from our data, that the range differences observed between *Ixanthus* and *Laurus* are not due to different limits in temperature and precipitation.

Because samples were taken in defined grid squares, which were the same for both species, it is possible to compare the distribution of the species quantitative (absolute sample numbers) as well as qualitative (sample origin). As 648 samples were taken for *Laurus* and 181 for *Ixanthus* on Tenerife, *Ixanthus* is present in around 28 % of the grid cells *Laurus* is occupying. In other words, because *Ixanthus* is a character species for the laurel forest, it is interesting to know why it has not been found in the complete laurel distribution range.

Ixanthus is only distributed in present-days monteverde. More or less half the samples were collected in laurel forest and half in fayal-brezal, but not in urban areas and in agricultural used areas, were *Laurus* is additionally distributed. Therefore, we could not agree with the statement of Stierstorfer (2005), that *Ixanthus* is mostly found in the moistest and shadiest places of the laurel forests. It might be the character species of the Ixantho viscosae-Laurion novocanariensis, but it is no indicator species for primary and undisturbed laurel forest, as it was our first impression. Moreover, *Ixanthus* is mostly missing in humid laurel forest (Ocotea communities) and in the shadiest places (pers. obs.). As the current distribution of *Ixanthus* is reduced compared to *Laurus* and it is missing in urban areas, its existence seems to be connected to advanced succession of fayal-brezal, as it is missing in the early, that means younger than 20 years, stages of succession (Fernández-Palacios and Arévalo (1998), Arévalo et al. (2008), Evers (2003)). But most studies concerning laurel forest regeneration are focused exclusively on tree species, therefore, precise data are not available. Due to our observations, it is only present in secondary forests when laurel saplings or trees are established, therefore the species seems to depend on soil regeneration or more shady places (R. Pott, pers. comm.). Therefore, not the abiotic parameters are the most important for the existence of *Ixanthus*, but the biotic ones. Consequently, as regeneration in the degenerated monteverde areas proceeds, this endemic plant species is likely to extent its current distribution range again, as it might be for other endemics depending on the laurel forest.

16. Future Threats and Conservation Opportunities — Diversity and Land Use Changes

The main events that threaten the laurel forests of the Canary Islands in its continued existence are the shrinking of the natural habitat due to human activities and the changing of the climate, in the past as well as in the future.

Although climate change is crucial to this endemic and very restricted vegetation complex, climate models were not part of this study. But first approaches were made in the analyses by Still et al. (1999), Sperling et al. (2004) and Rodríguez-Sánchez and Arroyo (2008), showing the range dynamics of the laurel forest throughout time and giving forecasts for the consequences of the shifting in the trade wind cloud layer, that will of course affect the future potential distribution of the laurel forests, as their current distribution range is closely connected with the direct and horizontal precipitation from the trade wind clouds. This might be quite important, as montane cloud forests on islands are considered among the most sensitive ecosystems to climate change due to their steep microclimatic gradients (Loope and Giambelluca, 1998). But currently, detailed prognoses for Tenerife and the other Canary Islands are hard to achieve due to the resolution of climate data and the high relief differences, that make it hard to interpolate data from bigger grids to fine scale.

The direct human influence on the natural vegetation is at least as much important. The most drastic deforestation period is over since 1988, when the protection state was achieved for certain areas. In the last years, only illegal logging has lead to smaller losses of primary forests, as well as fires — natural or through arson, for example in the laurel forest areas of La Gomera in 2012 — but main human disturbances has been stopped since nearly 50 years (Arévalo et al., 2007). Parts of laurel forests remnants on Tenerife, were approximately 10 % of the former area is left today according to del Arco Aguilar et al. (2010), are under protection already, but as discussed by Fernández-Palacios and de Nascimento (2011), are the conservation issue and its enforcement always underlying political trends and vicissitude.

Over 50 years ago, the main focus of Tenerife's economics have started to shift from agriculture, which affected huge proportions of the laurel forest regions, to tourism, which is more abundant in the coastal regions. This caused many of the vegetable patches in higher elevations go fallow, leaving areas for the laurel forest to recolonise. These very dynamic processes are currently in the focus of geographic research (Günthert et al. (2012) and PhD thesis (2014)).

For the recolonisation of former laurel forest areas, diversity — on species as well as on genetic level — in the surrounding areas is important. The questions, which geographic potential is developing due to land use changes on Tenerife and how this is connected to genetic diversity in this regions, are subject of an interdisciplinary project, were we connect the fields of geography and biology very closely, gaining insights in the highly dynamic interface of spatial patterns and genetic diversity.

17. Outlook

For a better understanding of the population dynamics and future developments of the laurel forest's diversity and extent there are some more steps to be taken.

This work does not resolve the issue of colonisation history of the two analysed species on the Canary Islands. To answer this question for *Laurus* would be a great step in understanding the history of the laurel forest in Macaronesia. For *Ixanthus* it would clarify the population structure of a Canary Island endemic taxon, which is hardly understood up to now.

For the purposeful conservation coordination, it would be of great interest to compare overall species diversity with genetic diversity. This work is a first step in understanding genetic hotspots on species level for the vegetation of the laurel forest.

Furthermore, bringing together genetic diversity, species diversity, land use change and climatic influences to understand the dynamics of the laurel forest will be subject in the future for giving the best interdisciplinary scientific counsel for effective conservation planning of this unique ecosystem.

Bibliography

Aboal, J. R., M. S. Jiménez, D. Morales, and J. M. Hernández
2002. Net below canopy fluxes in Canarian laurel forest canopies. *Journal of Hydrology*, 264:201–212.

Ancochea, E.
1990. Volcanic evolution of the island of Tenerife (Canary Islands) in the light of new K-Ar data. *J. Volcanol. Geotherm. Res.*, 44:231–249.

Arroyo-García, R., J. M. Martínez-Zapater, J. A. Fernández Prieto, and R. Álvarez Arbesú
2001. AFLP evaluation of genetic similarity among laurel populations (Laurus L.). *Euphytica*, 122:155–164.

Arévalo, J. and J. Fernández-Palacios
2000. Seed bank analysis of tree species in two stands of the Tenerife laurel forest (Canary Islands). *Forest Ecology and Management*, 130:177–185.

Arévalo, J. R., J. D. Delgado, and J. M. Fernández-Palacios
2007. Variation in fleshy fruit fall composition in an island laurel forest of the Canary Islands. *Acta Oecologica*, 32(2):152–160.

Arévalo, J. R., M. Dolores Peraza, C. Álvarez, A. Bermúdez, J. Domingo Delgado, A. Gallardo, and J. María Fernández-Palacios
2008. Laurel forest recovery during 20 years in an abandoned firebreak in Tenerife, Canary Islands. *Acta Oecologica*, 33:1–9.

Axelrod, D. I.
1975. Evolution and Biogeography of the Madrean-Tethyan Sklerophyllous Flora. *Annals of the Missouri Botanical Garden*, 62:280–334.

Banks, S. C., G. J. Cary, A. L. Smith, I. D. Davies, D. A. Driscoll, A. M. Gill, D. B.

Lindenmayer, and R. Peakall
2013. How does ecological disturbance influence genetic diversity? *Trends in Ecology & Evolution*, 28(11):670–679.

Bonin, A., E. Bellemain, P. B. Eidesen, F. Pompanon, C. Brochmann, and P. Taberlet
2004. How to track and assess genotyping errors in population genetics studies. *Molecular Ecology*, 13:3261–3273.

Bramwell, D.
1976. The Endemic Flora of the Canary Islands; Distribution, Relationships and Phytogeography. In *Biogeography and Ecology in the Canary Islands*, G. Kunkel, ed., volume 30 of *Monographiae Biologicae*, Pp. 207–240. Springer Netherlands.

Bravo, L. and M. D. Herrera
1995. Effects of Ixanthus viscosus extracts on the central nervous system. *Planta Med*, 61:71–72.

Castilho, P., M. do Céu Costa, A. Rodrigues, and A. Partidário
2005. Characterization of laurel fruit oil from Madeira Island, Portugal. *Journal of the American Oil Chemists' Society*, 82(12):863–868.

Caujapé-Castells, J., I. Sabbagh, J. J. Castellano, R. Ramos, V. Henríquez, F. M. Quintana, D. A. Medina, J. Toledo, F. Ramírez, and J. F. Rodríguez
2013. Transformer-4 version 2.0.1, a free multi-platform software to quickly reformat genotype matrices of any marker type, and archive them in the Demiurge information system. *Mol Ecol Resour*, 13(3):484–493.

Caujapé-Castells, J., A. Tye, D. J. Crawford, A. Santos-Guerra, A. Sakai, K. Beaver, W. Lobin, F. V. Florens, M. Moura, R. Jardim, I. Gómes, and C. Kueffer
2010. Conservation of oceanic island floras: Present and future global challenges. *Perspectives in Plant Ecology, Evolution and Systematics*, 12:107–129.

Chanderbali, A. S., H. van der Werff, and S. S. Renner
2001. Phylogeny and Historical Biogeography of Lauraceae: Evidence from the Chloroplast and Nuclear Genomes. *Annals of the Missouri Botanical Garden*, 88:104–134.

Coello, J.
1992. Evolution of the eatsern volcanic ridge of the Canary Islands based on new K-Ar data. *J. Volcanol. Geotherm. Res.*, 53:251–274.

Corbett Research
2006. *High Resolution Melt - Assay Design and Analysis: CorProtocol.*

Darias, V., L. Bravo, R. Rabanal, C. Sánchez Mateo, R. González Luis, and A. Hernández Pérez
1989. New contribution to the ethnopharmacological study of the Canary Islands. *J Ethnopharmacol.*, 25:77–92.

Díaz-Pérez, A. J., M. Sequeira, A. Santos-Guerra, and P. Catalán
2012. Divergence and biogeography of the recently evolved Macaronesian red Festuca (Gramineae) species inferred from coalescence-based analyses. *Molecular Ecology*, 21(7):1702–1726.

de Nascimento, L., K. J. Willis, J. M. Fernández-Palacios, C. Criado, and R. J. Whittaker
2009. The long-term ecology of the lost forests of La Laguna, Tenerife (Canary Islands). *Journal of Biogeography*, 36:499–514.

del Arco, M., P. L. Perez-de Paz, J. R. Acebes, J. M. Gonzalez-Mancebo, J. A. Reyes-Betancort, J. A. Bermejo, S. de Armas, and R. Gonzalez-Gonzalez
2006. Bioclimatology and climatophilous vegetation of Tenerife (Canary Islands). *Annales Botanici Fennici*, 43 (3):167–192.

del Arco, M., W. Wildpret, P. P. de Paz, O. Rodríguez, J. Acebes, A. García, V. E. Martín, J. A. Reyes, M. Salas, M. Díaz, J. Bermejo, R. González, M. Cabrera, and S. García
2003. Cartografía 1:25.000 de la Vegetación Canaria. GRAFCAN S.A. Santa Cruz de Tenerife.

del Arco Aguilar, M.-J., R. González-González, V. Garzón-Machado, and B. Pizarro-Hernández
2010. Actual and potential natural vegetation on the Canary Islands and its conservation status. *Biodiversity and Conservation*, 19:3089–3140.

del Carmen Machado Yanes, M., M. del Carmen del Arco Aguilar, J.-L. Vernet, and J.-M. Ourcival
1997. Man and vegetation in northern Tenerife (Canary Islands, Spain), during the prehispanic period based on charcoal analyses. *Vegetation History and Archaeobotany*, 6:187–195.

Delgado García, J.
2000. Selection and treatment of fleshy fruits by the Ship Rat (Rattus rattus L.) in the Canarian laurel forest. *Mammalia*, 64:11–18.

Dietzen, C., E. Garcia-del Rey, G. Delgado Castro, and M. Wink
2008. Phylogeography of the blue tit (Parus teneriffae-group) on the Canary Islands based on mitochondrial DNA sequence data and morphometrics. *J. Ornithol*, 149:1–12.

Doyle, J. J. and J. L. Doyle
1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical Bulletin*, 19:11–15.

Désamoré, A., B. Laenen, N. Devos, M. Popp, J. M. González-Mancebo, M. A. Carine, and A. Vanderpoorten
2011. Out of Africa: north-westwards Pleistocene expansions of the heather Erica arborea. *Journal of Biogeography*, 38:164–176.

Désamoré, A., B. Laenen, J. M. González-Mancebo, R. Jaén Molina, N. Bystriakova, E. Martinez-Klimova, M. A. Carine, and A. Vanderpoorten
2012. Inverted patterns of genetic diversity in continental and island populations of the heather Erica scoparia s.l. *Journal of Biogeography*, 39:574–584.

Ehrich, D.
2006. AFLPdat: a collection of R functions for convenient handling of AFLP data. *Mol. Ecol. Notes*, 6:603–604.

Ehrich, D., M. Gaudeul, A. Assefa, M. A. Koch, K. Mummenhoff, S. Nemomissa, I. Consortium, and C. Brochmann
2007. Genetic consequences of Pleistocene range shifts: contrast between the Arctic, the Alps and the East African mountains. *Molecular Ecology*, 16:2542–2559.

Emerson, B. C.
2003. Genes, geology and biodiversity: faunal and floral diversity on the island of Gran Canaria. *Animal Biodiversity and Conservation*, 26:9–20.

Evanno, G., S. Regnaut, and J. Goudet
2005. Detecting the number of clusters of individuals using the software STRUCTURE: a simulation study. *Molecular Ecology*, 14:2611–2620.

Evers, M.
2003. Die Vegetationsstruktur auf unterschiedlich alten Lorbeerwaldregenerationsflächen im Norden der Kanareninsel Teneriffa. Master's thesis, Johannes-Gutenberg-Universität Mainz.

Excoffier, L., G. Laval, and S. Schneider
2005. Arlequin ver. 3.0: An integrated software package for population genetics data analysis. *Evolutionary Bioinformatics Online*, 1:47–50.

Excoffier, L. and H. E. L. Lischer
2010. Arlequin suite ver 3.5: a new series of programs to perform population genetics analyses under Linux and Windows. *Molecular Ecology Resources*, 10:564–567.

Falush, D., M. Stephens, and J. K. Pritchard
2003. Inference of Population Structure Using Multilocus Genotype Data: Linked Loci and Correlated Allele Frequencies. *Genetics*, 164:1567–1587.

Falush, D., M. Stephens, and J. K. Pritchard
2007. Inference of population structure using multilocus genotype data: dominant markers and null alleles. *Molecular Ecology Notes*, 7:574–578.

Fernández-Palacios, J. and L. de Nascimento
2011. Opinion: Political erosion dismantles the conservation network existing in the Canary Islands. *Frontiers of Biogeography*, 3:106–110.

Fernández-Palacios, J. M.
1992. Climatic responses of plant species on Tenerife, The Canary Islands. *Journal of Vegetation Science*, 3:595–603.

Fernández-Palacios, J. M. and J. R. Arévalo
1998. Regeneration strategies of tree species in the laurel forest of Tenerife (The Canary Islands). *Plant Ecology*, 137:21–29.

Fernández-Palacios, J. M., L. de Nascimento, R. Otto, J. D. Delgado, E. García-del Rey, J. R. Arévalo, and R. J. Whittaker
2011. A reconstruction of Palaeo-Macaronesia, with particular reference to the long-term biogeography of the Atlantic island laurel forests. *Journal of Biogeography*, 38:226–246.

Fernández-Palacios, J. M. and J. P. Nicolás
1995. Altitudinal pattern of vegetation variation on Tenerife. *Journal of Vegetation Science*, 6 (2):183–190.

Fernández-Palacios, J. M., R. Otto, J. Domingo Delgado, J. R. Arévalo, A. Naranjo, F. González Atiles, C. Morici, and R. Barone
2008. Los Bosques Termófilos de Canarias. *Cabildo Insular de Tenerife. Santa Cruz de Tenerife*, Proyecto LIFE04/NAT/ES/000064 Excmo.:192.

Fernández-Palacios, J. M. and R. J. Whittaker
2008. The Canaries: an important biogeographical meeting place. *Journal of Biogeography*, 35:379–387.

Ferreira, R., R. Piredda, F. Bagnoli, R. Bellarosa, M. Attimonelli, S. Fineschi, B. Schirone, and M. Simeone
2011. Phylogeography and conservation perspectives of an endangered macaronesian endemic: Picconia azorica (Tutin) Knobl. (Oleaceae). *European Journal of Forest Research*, 130:181–195.

Forfang, A.-S. and J. M. Olesen
1998. Male-biased sex ratio and promiscuous pollination in the dioecious island tree-Laurus azorica (Lauraceae). *Plant Systematics and Evolution*, 212:143–157.

Francisco-Ortega, J., A. Santos-Guerra, S.-C. Kim, and D. J. Crawford
2000. Plant genetic diversity in the Canary Islands: a conservation perspective. *Am. J. Bot.*, 87:909–919.

Fuertes-Aguilar, J., M. F. Ray, J. Francisco-Ortega, A. Santos-Guerra, and R. K. Jansen
2002. Molecular Evidence from Chloroplast and Nuclear Markers for Multiple Colonizations of Lavatera (Malvaceae) in the Canary Islands. *Systematic Botany*, 27:74–83.

García-Verdugo, C., A. D. Forrest, M. F. Fay, and P. Vargas
2010. The relevance of gene flow in metapopulation dynamics of an oceanic island endemic, Olea europaea subsp. guanchica. *Evolution*, 64(12):3525–3536.

Gaudeul, M., I. Till-Bottraud, F. Barjon, and S. Manel
2004. Genetic diversity and differentiation in Eryngium alpinum L. (Apiaceae): comparison of AFLP and microsatellite markers. *Heredity*, 92:508–518.

Günthert, S., S. Naumann, and A. Siegmund
2012. Detection and assessment of land use dynamics on Tenerife (Canary Islands):

the agricultural development between 1986 and 2010. *Proc. SPIE, Earth Resources and Environmental Remote Sensing/GIS Applications III*, 3538:853804–853804–7.

Gonzalez, J., G. Delgado Castro, E. Garcia-del Rey, C. Berger, and M. Wink
2009. Use of mitochondrial and nuclear genes to infer the origin of two endemic pigeons from the Canary Islands. *J Ornithol*, 150(2):357–367.

González-Pérez, M., P. A. Sosa, and F. J. Batista
2009. Genetic variation and conservation of the endangered endemic Anagyris latifolia Brouss. ex Willd. (Leguminosae) from the Canary Islands. *Plant Systematics and Evolution*, 279:59–68.

González-Rodríguez, A. M., D. Morales, and M. S. Jiménez
2001. Gas exchange characteristics of a Canarian laurel forest tree species (Laurus azorica) in relation to environmental conditions and leaf canopy position. *Tree Physiology*, 21:1039–1045.

Guimarães, A. and C. Olmeda
2008. *Management of Natura 2000 habitat. 9360 Macaronesian laurel forests (Laurus, Ocotea)*. European Commission.

Hampe, A.
2003. Frugivory in European Laurel: how extinct seed dispersers have been substituted: Capsule Extinction of ancient frugivores during the Quaternary has led to a depauperated seed disperser community for Laurus nobilis and a tight mutualism between the plant and the Blackbird Turdus merula. *Bird Study*, 50(3):280–284.

Hernández, M. and A. Martín
2003. BWP update. In *The birds of western Palearctic*, volume 5, P. 215–228. Oxford University Press, Oxford.

Hijmans, R. J., S. E. Cameron, J. L. Parra, P. G. Jones, and A. Jarvis
2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, 25:1965–1978.

Holderegger, R., D. Buehler, F. Gugerli, and S. Manel
2010. Landscape genetics of plants. *Trends in Plant Science*, 15(12):675 – 683.

Holik, J.
1991. Effects of Canary hotspot volcanism on structure of oceanic crust off Morocco. *J. Geophy. Res.*, 96:12039–12067.

Huson, D. and D. Bryant
2006. Application of Phylogenetic Networks in Evolutionary Studies. *Molecular Biology and Evolution*, 23:254–267.

Jakobsson, M. and N. A. Rosenberg
2007. CLUMPP: a cluster matching and permutation program for dealing with label switching and multimodality in analysis of population structure. *Bioinformatics*, 23:1801–1806.

Jimenez, M. S., N. Nadezhdina, J. Cermak, and D. Morales
2000. Radial variation in sap flow in five laurel forest tree species in Tenerife, Canary Islands. *Tree Physiol*, 20:1149–1156.

Juan, C., B. C. Emerson, P. Oromí, P., and G. M. Hewitt
2000. Colonization and diversification: towards a phylogeographic synthesis for the Canary Islands. *Trends in Ecology & Evolution*, 15:104–109.

Kämmer, F.
1974. Klima und Vegetation auf Tenerife, besonders im Hinblick auf den Nebelniederschlag. *Scripta Geobotanica*, 7:1–77.

Kunkel, G.
1993. *Die Kanarischen Inseln und ihre Pflanzenwelt.* Stuttgart: Fischer.

Landau, A.
2009. Geographic differentiation of central European Hypericum perforatum L. by the means of AFLP analysis (Diploma Thesis).

Loope, L. L. and T. W. Giambelluca
1998. Vulnerability of Island Tropical Montane Cloud Forests to Climate Change, with Special Reference to East Maui, Hawaii. *Climate Change*, 39(2-3):503–517.

Macías-Hernández, N., L. Bidegaray-Batista, B. C. Emerson, P. Oromí, and M. Arnedo
2013. The Imprint of Geologic History on Within-Island Diversification of Woodlouse-Hunter Spiders (Araneae, Dysderidae) in the Canary Islands. *Journal of Heredity*, 104(3):341–356.

Manel, S., F. Berthoud, E. Bellemain, M. Gaudeul, G. Luikart, J. Swenson, L. Waits, P. Taberlet, et al.
2007. A new individual-based spatial approach for identifying genetic discontinuities in natural populations. *Molecular Ecology*, 16:2031–2043.

Manel, S. and R. Holderegger
2013. Ten years of landscape genetics. *Trends in Ecology & Evolution*, 28(10):614–621.

Manel, S., M. Schwartz, G. Luikart, and P. Taberlet
2003. Landscape genetics: combining landscape ecology and population genetics. *Trends Ecol. Evol.*, 18:189–197.

Manni, F. and E. Guérard
2004. *Barrier vs. 2.2. Manual of the user.*

Manni, F., E. Guérard, and E. Heyer
2004. Geographic patterns of (genetic, morphologic, linguistic) variation: how barriers can be detected by "Monmonier's algorithm". *Human Biology*, 76:173–190.

Mantel, N.
1967. The Detection of Disease Clustering and a Generalized Regression Approach. *Cancer Research*, 27:209–220.

Martín, J. L., J. Bethencourt, and E. Cuevas-Agulló
2012. Assessment of global warming on the island of Tenerife, Canary Islands (Spain). Trends in minimum, maximum and mean temperatures since 1944. *Climate Change*, 114:343–355.

Marzol Jaen, M. V.
2002. Fog water collection in a rural park in the Canary Islands (Spain). *Atmospheric Research*, 64:239–250.

Médail, Frédéric; Quézel, P.
1999. Biodiversity hotspots in the Mediterranean Basin: setting global conservation priorities. *Conservation biology*, 13.6:1510–1513.

Miller, M. P.
2005. Alleles In Space (AIS): Computer Software for the Joint Analysis of Interindividual Spatial and Genetic Information. *J Hered*, 96:722–724.

Morales, D., M. S. Jiménez, A. M. González-Rodríguez, and J. Cermák
2002. Laurel forests in Tenerife, Canary Islands: Xylem structure in stems and petioles of Laurus azorica trees. *Trees*, 16:529–537.

Nogales, M., R. Heleno, A. Traveset, and P. Vargas
2012. Evidence for overlooked mechanisms of long-distance seed dispersal to and between oceanic islands. *New Phytologist*, 194(2):313–317.

Nogales, M., E. C. Hernández, and F. Valdés
1999. Seed dispersal by common ravens Corvus corax among island habitats (Canarian Archipelago). *Ecoscience*, 6:56–61.

Nogué, S., L. de Nascimento, J. M. Fernández-Palacios, R. J. Whittaker, and K. J. Willis
2013. The ancient forests of La Gomera, Canary Islands, and their sensitivity to environmental change. *Journal of Ecology*, 101:368–377.

Oliveira, P., P. Marrero, and M. Nogales
2002. Diet Of The Endemic Madeira Laurel Pigeon And Fruit Resource Availability: A Study Using Microhistological Analyses. *The Condor*, 104:811–822.

Ortega, E. P., R. E. López-García, R. M. Rabanal, and V. D. S. Valverde
1988. Two xanthones from Ixanthus viscosus. *Phytochemistry*, 27(6):1912 –1913.

Padilla, D. P., A. Gonzáles-Castro, and M. Nogales
2012. Significance and extent of secondary seed dispersal by predatory birds on oceanic islands: the case of the Canary archipelago. *Journal of Ecology*, 100:416–427.

Parsons, J. J.
1981. Human Influences on the Pine and Laurel Forests of the Canary Islands. *Geographical Review*, 71:253–271.

Paule, J.
2010. *Evolutionary Patterns and Processes in the genus Potentilla L. (Rosaceae)*. PhD thesis, Universität Heidelberg.

Peakall, R. and P. Smouse
2006. GenAlEx 6: Genetic analysis in Excel. Population genetic software for teaching and research. *Mol. Ecol. Notes*, 6:288–295.

Peakall, R. and P. Smouse
2012. GenAlEx 6.5: Genetic analysis in Excel. Population genetic software for teaching and research - an update. *Bioinformatics*, 28:2537–2539.

Perry, W., R. Lugo, S. A. Hathaway, and A. G. Vandergast
2010. *Genetic Landscapes GIS Toolbox: Tools to create genetic divergence and diversity landscapes in ArcGIS.* U.S. Geological Survey.

Pompanon, F., A. Bonin, E. Bellemain, and P. Taberlet
2005. Genotyping errors: causes, consequences and solutions. *Nat. Rev. Genet.*, 6:847–859.

Pott, R.
2006. *Allgemeine Geobotanik - Biogeosysteme und Biodiversität. Warmtemperate Feucht- und Lorbeerwälder.* Springer Berlin Heidelberg.

Pott, R., J. Hüppe, and W. Wildpret de la Torre
2003. *Die Kanarischen Inseln. Natur- und Kulturlandschaften.* Stuttgart: Ulmer.

Prada, S., M. Menezes de Sequeira, C. Figueira, and M. O. da Silva
2009. Fog precipitation and rainfall interception in the natural forests of Madeira Island (Portugal). *Agricultural and Forest Meteorology*, 149:1179–1187.

Pritchard, J. K., M. Stephens, and P. Donnelly
2000. Inference of Population Structure Using Multilocus Genotype Data. *Genetics*, 155:945–959.

R Development Core Team
2006. A language and environment for statistical computing.

Regalado, C. M. and A. Ritter
2010. Comment on "Fog precipitation and rainfall interception in the natural forests of Madeira Island (Portugal)". *Agricultural and Forest Meteorology*, 150:133–134.

Reyes-Betancort, J., A. Santos Guerra, I. Guma, C. Humphries, and M. Carine
2008. Diversity, rarity and the evolution and conservation of the Canary Islands endemic flora. *Anales Jardin Botanico de Madrid*, 65:25–45.

Rivas-Martínez, S., T. Díaz, F. Fernández-González, J. Izco, J. Loidi, M. Lousã, and A. Penas
2002. Vascular plant communities of Spain and Portugal. Addenda to the Syntaxonomical checklist of 2001. *Itinera Geobotanica*, 1-2:5–922.

Rivas-Martínez, S., W. Wildpret, M. Arco, O. Rodríguez, P. Pérez De Paz, A. García Gallo, J. Acebes, T. Díaz, and F. Fernández González
1993. Las communidas vegetales de la Isla de Tenerife (Islas canarias). *Itinera Geobotanica*, 7:169–474.

Rivera, D. and C. Obón
1995. The ethnopharmacology of Madeira and Porto Santo Islands, a review. *Journal of Ethnopharmacology*, 46(2):73–93.

Rodríguez-Sánchez, F. and J. Arroyo
2008. Reconstructing the demise of Tethyan plants: climate-driven range dynamics of Laurus since the Pliocene. *Global Ecology and Biogeography*, 17 (6):685–695.

Rodríguez-Sánchez, F., B. Guzmán, A. Valido, P. Vargas, and J. Arroyo
2009. Late Neogene history of the laurel tree (Laurus L., Lauraceae) based on phylogeographical analyses of Mediterranean and Macaronesian populations. *Journal of Biogeography*, 36 (7):1270–1281.

Rohwer, J. G.
1990. Lauraceae. In *The Families and genera of vascular plants, Band 2: Flowering Plants – Dicotyledons – Magnoliid, Hamamelid and Caryophyllid Families*, K. K. et al., ed. Springer Verlag.

Rohwer, J. G.
2000. Toward a Phylogenetic Classification of the Lauraceae: Evidence from matK Sequences. *Systematic Botany*, 25:60–71.

Rohwer, J. G. and B. Rudolph
2005. Jumping Genera: The Phylogenetic Positions of Cassytha, Hypodaphnis, and Neocinnamomum (Lauraceae) Based on Different Analyses of trnK Intron Sequences. *Annals of the Missouri Botanical Garden*, 92:153–178.

Rosenberg, N. A., J. K. Pritchard, J. L. Weber, H. M. Cann, K. K. Kidd, L. A. Zhivotovsky, and M. W. Feldman
2002. Genetic Structure of Human Populations. *Science*, 298:2381–2385.

Sanmartín, I., P. van der Mark, and F. Ronquist
2008. Inferring dispersal: a Bayesian approach to phylogeny-based island biogeography, with special reference to the Canary Islands. *Journal of Biogeography*, 35(3):428–449.

Schönfelder, P. and I. Schönfelder
1997. *Die Kosmos-Kanarenflora : über 850 Arten der Kanarenflora und 48 tropische Ziergehölze.* Stuttgart: Franckh-Kosmos.

Seidel, D.
1978. Vegetationszonen auf den Kanarischen Inseln - Halbwüste und Nebelwald in enger Nachbarschaft. *Biologie in unserer Zeit*, 8:161–167.

Shaw, J., E. B. Lickey, J. T. Beck, S. B. Farmer, W. Liu, J. Miller, K. C. Siripun, C. T. Winder, E. E. Schilling, and R. L. Small
2005. The tortoise and the hare II: relative utility of 21 noncoding chloroplast DNA sequences for phylogenetic analysis. *American Journal of Botany*, 92:142–166.

Silvertown, J.
2004. The ghost of competition past in the phylogeny of island endemic plants. *Journal of Ecology*, 92:168–173.

Sosa, P. A., E. A. González-González, M. A. González-Pérez, and P. L. Pérez de Paz
2013. Contrasting patterns of genetic differentiation in Macaronesian lineages of Ilex (Aquifoliaceae). *Botanical Journal of the Linnean Society*, 173(2):258–268.

Sperling, F. N., R. Washington, and R. J. Whittaker
2004. Future Climate Change of the Subtropical North Atlantic: Implications for the Cloud Forests of Tenerife. *Climatic Change*, 65:103–123.

Stierstorfer, C.
2005. The Vascular Plant Vegetation in the Forest Belt of El Hierro (Canary Islands). In *Dissertationes Botanicae*, volume 393. J. Cramer Gebrüder Borntraeger Verlagsbuchhandlung Berlin Stuttgart.

Still, C. J., P. N. Foster, and S. H. Schneider
1999. Simulating the effects of climate change on tropical montane cloud forests. *Nature*, 398:608–610.

Suda, J., T. Kyncl, and V. Jarolímová
2005. Genome size variation in Macaronesian angiosperms: forty percent of the Canarian endemic flora completed. *Plant Systematics and Evolution*, 252(3-4):215–238.

Sziemer, P.
2000. *Madeira's Natural History in a Nutshell.* Francisco Ribeiro & Filhos, Lda.

Talavera, M., L. Navarro-Sampedro, P. L. Ortiz, and M. Arista
2013. Phylogeography and seed dispersal in islands: the case of Rumex bucephalophorus subsp. canariensis (Polygonaceae). *Annals of Botany*, 111(2):249–260.

Thiv, M., L. Struwe, and J. W. Kadereit
1999. The phylogenetic relationships and evolution of the Canarian laurel forest endemic Ixanthus viscosus (Aiton) Griseb. (Gentianaceae): Evidence frommatK and ITS sequences, and floral morphology and anatomy. *Plant Systematics and Evolution*, 218:299–317.

Thorpe, R. S., A. Malhotra, H. Black, J. C. Daltry, and W. Wuster
1995. Relating Geographic Pattern to Phylogenetic Process. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 349:61–68.

Trusty, J. L., R. G. Olmstead, A. Santos-Guerra, S. Sa-Fontinha, and J. Francisco-Ortega
2005. Molecular phylogenetics of the Macaronesian-endemic genus Bystropogon (Lamiaceae): palaeo-islands, ecological shifts and interisland colonizations. *Mol Ecol*, 14:1177–89.

Unknown
2013. Plan de Acción. Reserva de la Biosfera del Macizo de Anaga.

Vandergast, A. G., A. J. Bohonak, S. A. Hathaway, J. Boys, and R. N. Fisher
2008. Are hotspots of evolutionary potential adequately protected in southern California? *Biological Conservation*, 141(6):1648–1664.

Vargas, P.
2007. Are Macaronesian islands refugia of relict plant lineages? A molecular survey. In *Phylogeography of Southern European Refugia*, S. Weiss and N. Ferrand, eds., Pp. 297–314. Springer Netherlands.

Venter, J. C., M. D. Adams, E. W. Myers, P. W. Li, R. J. Mural, G. G. Sutton, H. O. Smith, M. Yandell, C. A. Evans, R. A. Holt, et al.
2001. The sequence of the human genome. *Science*, 291:1304–1351.

Voggenreiter, V.
1974. Geobotanische Untersuchungen an der natürlichen Vegetation der Kanareninsel Tenerife als Grundlage für den Naturschutz. In *Dissertationes Botanicae*, volume 26, Pp. 1–718. J. Cramer Gebrüder Borntraeger Verlagsbuchhandlung Berlin Stuttgart.

Vos, P., R. Hogers, M. Bleeker, M. Reijans, T. van de Lee, M. Hornes, A. Frijters, J. Pot, J. Peleman, and M. Kuiper
1995. AFLP: A new technique for DNA fingerprinting. *Nucleic Acids Res.*, 23:4407–4414.

Whittaker, R. J., K. A. Triantis, and R. J. Ladle
2008. A general dynamic theory of oceanic island biogeography. *Journal of Biogeography*, 35:977–994.

Wildpret de la Torre, W; Martín Osorio, V.
1997. Laurel Forest in the Canary Island: Biodiversity, Historical Use and Conservation. *Tropics*, 6:371–381.

Yeh, F. C., R. C. Yang, T. B. J. Boyle, Z. H. Ye, and J. X. Mao
1997. *POPGENE, the user-friendly shareware for population genetic analysis.*

Zeltner, L.
1970. Recherches de biosystématique sur les genres Blackstonia Huds. et Centaurium Hill. *Bull. Soc. Neuchâtel. Sci. Nat.*, 93:4–164.

Part VI.

Appendices

18. Appendix A — List of Plant Material

Table 18.1.: Accession List of *Laurus*

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
001L	N28°34.237	W16°09.602	475	05.01.2010	AB, MT	T	Anaga-East	32	23
002L	N28°34.319	W16°09.660	531	05.01.2010	AB, MT	T	Anaga-East	32	23
003L	N28°34.357	W16°09.725	567	05.01.2010	AB, MT	T	Anaga-East	32	23
004L	N28°34.304	W16°09.425	529	05.01.2010	AB, MT	T	Anaga-East	33	23
005L	N28°34.442	W16°09.345	562	05.01.2010	AB, MT	T	Anaga-East	33	23
006L	N28°34.580	W16°09.227	637	05.01.2010	AB, MT	T	Anaga-East		
007L	N28°34.535	W16°09.404	674	05.01.2010	AB, MT	T	Anaga-East	33	23
008L	N28°34.475	W16°09.628	711	05.01.2010	AB, MT	T	Anaga-East	33	23
009L	N28°34.406	W16°09.898	729	05.01.2010	AB, MT	T	Anaga-East	32	23
010L	N28°34.313	W16°10.085	689	05.01.2010	AB, MT	T	Anaga-East	32	23
011L	N28°34.307	W16°10.148	607	05.01.2010	AB, MT	T	Anaga-East	32	23
012L	N28°34.205	W16°09.932	587	05.01.2010	AB, MT	T	Anaga-East	32	23
013L	N28°34.173	W16°09.769	553	05.01.2010	AB, MT	T	Anaga-East	32	23
014L	N28°33.993	W16°09.437	600	05.01.2010	AB, MT	T	Anaga-East	32	23
015L	N28°33.787	W16°09.409	556	05.01.2010	AB, MT	T	Anaga-East	32	23
016L	N28°33.714	W16°09.709	622	05.01.2010	AB, MT	T	Anaga-East	32	22
017L	N28°33.588	W16°09.822	663	05.01.2010	AB, MT	T	Anaga-East	31	22
018L	N28°33.434	W16°09.821	739	05.01.2010	AB, MT	T	Anaga-East	31	22
019L	N28°33.387	W16°09.908	764	05.01.2010	AB, MT	T	Anaga-East	31	22
020L	N28°33.367	W16°09.946	769	05.01.2010	AB, MT	T	Anaga-East	31	22
021L	N28°33.481	W16°10.185	814	05.01.2010	AB, MT	T	Anaga-East	31	22
022L	N28°33.429	W16°10.485	798	05.01.2010	AB, MT	T	Anaga-East	31	25
023L	N28°33.391	W16°10.662	808	05.01.2010	AB, MT	T	Anaga-East	31	25
024L	N28°33.303	W16°15.886	643	06.01.2010	AB, MT	T	Anaga-West	27	30
025L	N28°32.971	W16°15.996	619	06.01.2010	AB, MT	T	Anaga-West	27	30
026L	N28°32.904	W16°15.915	642	06.01.2010	AB, MT	T	Anaga-West	27	30
027L	N28°32.805	W16°16.036	660	06.01.2010	AB, MT	T	Anaga-West	27	30
028L	N28°32.650	W16°16.027	693	06.01.2010	AB, MT	T	Anaga-West	26	30
029L	N28°32.627	W16°16.202	723	06.01.2010	AB, MT	T	Anaga-West	27	30
030L	N28°32.668	W16°16.407	716	06.01.2010	AB, MT	T	Anaga-West	27	30
031L	N28°33.081	W16°16.616	633	06.01.2010	AB, MT	T	Anaga-West	27	28
032L	N28°32.933	W16°16.648	650	06.01.2010	AB, MT	T	Anaga-West	27	28
033L	N28°32.151	W16°18.745	825	06.01.2010	AB, MT	T	Anaga-West	22	31
034L	N28°32.215	W16°18.547	789	06.01.2010	AB, MT	T	Anaga-West	22	31
035L	N28°32.346	W16°18.607	769	06.01.2010	AB, MT	T	Anaga-West	22	31
036L	N28°32.456	W16°18.744	735	06.01.2010	AB, MT	T	Anaga-West	22	31
037L	N28°32.582	W16°18.767	636	06.01.2010	AB, MT	T	Anaga-West	22	31
038L	N28°32.469	W16°18.885	771	06.01.2010	AB, MT	T	Anaga-West	22	31
039L	N28°32.643	W16°19.274	755	06.01.2010	AB, MT	T	Anaga-West	22	31
040L	N28°32.710	W16°19.261	723	06.01.2010	AB, MT	T	Anaga-West	22	31
041L	N28°32.562	W16°19.361	743	06.01.2010	AB, MT	T	Anaga-West	22	31
042L	N28°32.451	W16°19.233	751	06.01.2010	AB, MT	T	Anaga-West	22	31
043L	N28°22.374	W16°30.817	754	07.01.2010	AB, MT	T	Orotava	12	12
044L	N28°21.999	W16°31.342	873	07.01.2010	AB, MT	T	Orotava	12	12
045L	N28°21.906	W16°31.849	818	07.01.2010	AB, MT	T	Orotava	12	12
046L	N28°21.863	W16°32.179	879	07.01.2010	AB, MT	T	Orotava	12	12
047L	N28°21.681	W16°32.677	922	07.01.2010	AB, MT	T	Orotava	12	12
048L	N28°21.644	W16°33.258	861	07.01.2010	AB, MT	T	Orotava	12	12
049L	N28°21.647	W16°33.518	816	07.01.2010	AB, MT	T	Orotava	12	12
050L	N28°21.376	W16°33.569	931	07.01.2010	AB, MT	T	Orotava	12	12
051L	N28°21.659	W16°34.078	766	07.01.2010	AB, MT	T	Orotava	12	12

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Table 18.1 – continued from previous page

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
052L	N28°21.743	W16°34.338	717	07.01.2010	AB, MT	T	Orotava	11	12
053L	N28°21.995	W16°34.658	651	07.01.2010	AB, MT	T	Orotava	11	12
054L	N28°21.995	W16°34.658	652	07.01.2010	AB, MT	T	Orotava	11	12
055L	N28°32.121	W16°17.931	856	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
056L	N28°32.186	W16°17.761	845	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
057L	N28°32.170	W16°17.564	837	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	29
058L	N28°32.071	W16°17.514	830	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	29
059L	N28°32.015	W16°17.299	837	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	29
060L	N28°32.158	W16°17.187	848	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	29
061L	N28°32.084	W16°17.073	854	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	29
062L	N28°32.008	W16°16.916	848	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	29
063L	N28°32.858	W16°17.873	524	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
064L	N28°32.565	W16°17.726	548	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
065L	N28°32.459	W16°17.762	639	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
066L	N28°32.602	W16°17.954	688	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
067L	N28°32.438	W16°17.929	744	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
068L	N28°32.298	W16°18.015	780	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
069L	N28°32.262	W16°18.036	788	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
070L	N28°32.078	W16°17.772	908	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	28
071L	N28°31.877	W16°17.670	899	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	23	29
072L	N28°31.853	W16°17.492	905	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	29
073L	N28°32.259	W16°16.500	852	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	30
074L	N28°32.286	W16°16.618	845	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	30
075L	N28°32.275	W16°16.790	819	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	29
076L	N28°32.091	W16°16.678	865	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	24	30
077L	N28°33.326	W16°16.712	633	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	27	28
078L	N28°32.841	W16°16.666	662	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	27	28
079L	N28°32.626	W16°16.842	802	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	27	28
080L	N28°32.474	W16°16.588	840	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	27	30
081L	N28°21.562	W16°46.125	545	09.01.2010	AB, MT	T	Icod	7	3
082L	N28°21.211	W16°46.947	657	09.01.2010	AB, MT	T	Teno	6	2
083L	N28°19.549	W16°48.456	1013	09.01.2010	AB, MT	T	Teno	5	4
084L	N28°19.649	W16°48.716	1025	09.01.2010	AB, MT	T	Teno	5	4
085L	N28°19.666	W16°48.852	1007	09.01.2010	AB, MT	T	Teno	5	4
086L	N28°19.539	W16°48.784	1002	09.01.2010	AB, MT	T	Teno	5	4
087L	N28°19.506	W16°48.964	974	09.01.2010	AB, MT	T	Teno	3	6
088L	N28°19.398	W16°48.858	1007	09.01.2010	AB, MT	T	Teno	3	6
089L	N28°19.352	W16°48.997	985	09.01.2010	AB, MT	T	Teno	3	6
090L	N28°19.397	W16°49.203	968	09.01.2010	AB, MT	T	Teno	3	6
091L	N28°19.251	W16°49.297	987	09.01.2010	AB, MT	T	Teno	2	6
092L	N28°19.384	W16°49.391	970	09.01.2010	AB, MT	T	Teno	3	6
093L	N28°19.591	W16°49.296	930	09.01.2010	AB, MT	T	Teno	3	6
094L	N28°19.736	W16°49.283	919	09.01.2010	AB, MT	T	Teno	3	6
095L	N28°19.782	W16°49.433	904	09.01.2010	AB, MT	T	Teno	3	8
096L	N28°19.840	W16°49.552	892	09.01.2010	AB, MT	T	Teno	3	8
097L	N28°19.814	W16°49.595	936	09.01.2010	AB, MT	T	Teno	3	8
098L	N28°19.951	W16°49.657	916	09.01.2010	AB, MT	T	Teno	3	8
099L	N28°20.088	W16°49.561	901	09.01.2010	AB, MT	T	Teno	1	8
100L	N28°20.131	W16°49.710	876	09.01.2010	AB, MT	T	Teno	1	8
101L	N28°19.954	W16°49.843	894	09.01.2010	AB, MT	T	Teno	1	7
102L	N28°20.152	W16°49.959	842	09.01.2010	AB, MT	T	Teno	1	8
103L	N28°20.433	W16°50.008	792	09.01.2010	AB, MT	T	Teno	1	8
104L	N28°20.413	W16°50.111	755	09.01.2010	AB, MT	T	Teno	1	8
105L	N28°20.271	W16°50.099	825	09.01.2010	AB, MT	T	Teno	1	8
106L	N28°20.100	W16°50.107	836	09.01.2010	AB, MT	T	Teno	1	7
107L	N28°20.107	W16°50.350	799	09.01.2010	AB, MT	T	Teno	1	7
108L	N28°19.835	W16°50.197	799	09.01.2010	AB, MT	T	Teno	1	7
109L	N28°19.913	W16°50.475	757	09.01.2010	AB, MT	T	Teno	1	7
110L	N28°20.584	W16°51.438	670	09.01.2010	AB, MT	T	Teno Alto	0	9
111L	N28°20.309	W16°51.596	784	09.01.2010	AB, MT	T	Teno Alto	0	9
112L	N28°20.401	W16°51.637	809	09.01.2010	AB, MT	T	Teno Alto	0	9
113L	N28°20.455	W16°51.768	844	09.01.2010	AB, MT	T	Teno Alto	0	9
114L	N28°20.269	W16°51.798	880	09.01.2010	AB, MT	T	Teno Alto	0	9
115L	N28°20.328	W16°52.308	825	09.01.2010	AB, MT	T	Teno Alto	0	9
116L	N28°20.495	W16°52.414	805	09.01.2010	AB, MT	T	Teno Alto	0	9
117L	N28°20.796	W16°52.852	760	09.01.2010	AB, MT	T	Teno Alto	0	9

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
118L	N28°20.808	W16°52.545	714	09.01.2010	AB, MT	T	Teno Alto	0	9
119L	N28°20.716	W16°52.540	717	09.01.2010	AB, MT	T	Teno Alto	0	9
120L	N28°21.852	W16°43.905	458	10.01.2010	AB, MT	T	Icod	7	1
121L	N28°21.810	W16°44.193	486	10.01.2010	AB, MT	T	Icod	7	1
122L	N28°21.706	W16°44.000	518	10.01.2010	AB, MT	T	Icod	7	1
123L	N28°21.534	W16°43.931	548	10.01.2010	AB, MT	T	Icod	7	1
124L	N28°21.437	W16°43.953	595	10.01.2010	AB, MT	T	Icod	8	1
125L	N28°21.504	W16°43.484	570	10.01.2010	AB, MT	T	Icod	8	1
126L	N28°21.344	W16°43.118	516	10.01.2010	AB, MT	T	Icod	8	1
127L	N28°21.435	W16°43.374	552	10.01.2010	AB, MT	T	Icod	8	1
128L	N28°20.961	W16°42.131	638	10.01.2010	AB, MT	T	Icod	9	0
129L	N28°20.780	W16°42.013	715	10.01.2010	AB, MT	T	Icod	9	0
130L	N28°20.627	W16°41.906	763	10.01.2010	AB, MT	T	Icod	9	0
131L	N28°20.672	W16°42.197	751	10.01.2010	AB, MT	T	Icod	9	0
132L	N28°21.063	W16°43.420	757	10.01.2010	AB, MT	T	Icod	8	1
133L	N28°20.843	W16°43.310	794	10.01.2010	AB, MT	T	Icod	8	0
134L	N28°20.597	W16°43.068	832	10.01.2010	AB, MT	T	Icod	9	0
135L	N28°20.754	W16°43.142	807	10.01.2010	AB, MT	T	Icod	9	0
136L	N28°20.609	W16°43.217	856	10.01.2010	AB, MT	T	Icod	8	0
137L	N28°20.050	W16°43.136	1017	10.01.2010	AB, MT	T	Icod	9	0
138L	N28°20.275	W16°43.246	954	10.01.2010	AB, MT	T	Icod	9	0
139L	N28°20.460	W16°43.104	888	10.01.2010	AB, MT	T	Icod	9	0
140L	N28°20.400	W16°42.913	892	10.01.2010	AB, MT	T	Icod	9	0
141L	N28°20.606	W16°43.434	887	10.01.2010	AB, MT	T	Icod	8	0
142L	N28°20.837	W16°43.490	814	10.01.2010	AB, MT	T	Icod	8	0
143L	N28°20.714	W16°43.707	884	10.01.2010	AB, MT	T	Icod	8	0
144L	N28°20.585	W16°43.905	943	10.01.2010	AB, MT	T	Icod	8	0
145L	N28°20.383	W16°43.967	991	10.01.2010	AB, MT	T	Icod	8	0
146L	N28°20.287	W16°44.097	1021	10.01.2010	AB, MT	T	Icod	8	0
147L	N28°20.547	W16°43.655	943	10.01.2010	AB, MT	T	Icod	8	0
148L	N28°21.059	W16°43.770	807	10.01.2010	AB, MT	T	Icod	8	1
149L	N28°21.291	W16°43.740	699	10.01.2010	AB, MT	T	Icod	8	1
150L	N28°21.107	W16°44.145	774	10.01.2010	AB, MT	T	Icod	8	1
151L	N28°20.736	W16°44.072	912	10.01.2010	AB, MT	T	Icod	8	0
152L	N28°20.948	W16°44.104	841	10.01.2010	AB, MT	T	Icod	8	1
153L	N28°21.281	W16°44.086	699	10.01.2010	AB, MT	T	Icod	8	1
154L	N28°21.304	W16°44.380	698	10.01.2010	AB, MT	T	Icod	7	1
155L	N28°21.236	W16°44.575	731	10.01.2010	AB, MT	T	Icod	7	1
156L	N28°21.128	W16°44.642	750	10.01.2010	AB, MT	T	Icod	7	1
157L	N28°21.115	W16°44.793	778	10.01.2010	AB, MT	T	Icod	7	1
158L	N28°20.912	W16°44.847	829	10.01.2010	AB, MT	T	Icod	7	1
159L	N28°20.855	W16°44.927	833	10.01.2010	AB, MT	T	Icod	7	3
160L	N28°20.790	W16°45.062	860	10.01.2010	AB, MT	T	Icod	7	3
161L	N28°20.660	W16°45.212	892	10.01.2010	AB, MT	T	Icod	7	3
162L	N28°20.529	W16°45.296	928	10.01.2010	AB, MT	T	Icod	7	3
163L	N28°20.154	W16°45.502	999	10.01.2010	AB, MT	T	Icod	7	3
164L	N28°20.896	W16°45.294	818	10.01.2010	AB, MT	T	Icod	7	3
165L	N28°21.063	W16°45.253	767	10.01.2010	AB, MT	T	Icod	7	3
166L	N28°21.047	W16°45.375	763	10.01.2010	AB, MT	T	Icod	7	3
167L	N28°21.355	W16°45.446	685	10.01.2010	AB, MT	T	Icod	7	3
168L	N28°21.102	W16°46.986	702	10.01.2010	AB, MT	T	Teno	6	2
169L	N28°20.915	W16°47.403	759	10.01.2010	AB, MT	T	Teno	4	2
170L	N28°20.695	W16°47.318	810	10.01.2010	AB, MT	T	Teno	6	2
171L	N28°20.581	W16°47.569	832	10.01.2010	AB, MT	T	Teno	4	2
172L	N28°20.540	W16°47.330	856	10.01.2010	AB, MT	T	Teno	6	2
173L	N28°20.416	W16°47.388	885	10.01.2010	AB, MT	T	Teno	6	2
174L	N28°20.165	W16°47.525	926	10.01.2010	AB, MT	T	Teno	4	5
175L	N28°19.969	W16°47.412	1005	10.01.2010	AB, MT	T	Teno	5	4
176L	N28°19.752	W16°47.415	1085	10.01.2010	AB, MT	T	Teno	5	4
177L	N28°19.729	W16°46.933	1083	10.01.2010	AB, MT	T	Teno	6	3
178L	N28°19.817	W16°46.531	1080	10.01.2010	AB, MT	T	Teno	6	3
179L	N28°19.769	W16°46.647	1084	10.01.2010	AB, MT	T	Teno	6	3
180L	N28°19.924	W16°46.885	1035	10.01.2010	AB, MT	T	Teno	6	3
181L	N28°20.136	W16°46.802	977	10.01.2010	AB, MT	T	Teno	6	3
182L	N28°20.400	W16°46.792	908	10.01.2010	AB, MT	T	Teno	6	3
183L	N28°20.557	W16°46.979	872	10.01.2010	AB, MT	T	Teno	6	2

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
184L	N28°20.696	W16°47.144	831	10.01.2010	AB, MT	T	Teno	6	2
185L	N28°31.664	W16°16.864	909	11.01.2010	AB, MT	T	Anaga-West	24	29
186L	N28°20.934	W16°47.127	764	10.01.2010	AB, MT	T	Teno	6	2
187L	N28°31.854	W16°16.785	978	11.01.2010	AB, MT	T	Anaga-West	24	29
188L	N28°31.935	W16°15.768	979	11.01.2010	AB, MT	T	Anaga-Centre	26	27
189L	N28°31.875	W16°15.674	952	11.01.2010	AB, MT	T	Anaga-Centre	26	27
190L	N28°31.734	W16°15.686	891	11.01.2010	AB, MT	T	Anaga-Centre	26	27
191L	N28°31.591	W16°15.785	812	11.01.2010	AB, MT	T	Anaga-Centre	26	27
192L	N28°31.631	W16°15.910	715	11.01.2010	AB, MT	T	Anaga-Centre	26	27
193L	N28°31.537	W16°15.634	809	11.01.2010	AB, MT	T	Anaga-Centre	26	27
194L	N28°31.459	W16°15.662	861	11.01.2010	AB, MT	T	Anaga-Centre	26	27
195L	N28°31.323	W16°15.633	819	11.01.2010	AB, MT	T	Anaga-Centre	26	27
196L	N28°31.820	W16°15.663	880	11.01.2010	AB, MT	T	Anaga-Centre	26	27
197L	N28°32.015	W16°16.006	992	11.01.2010	AB, MT	T	Anaga-Centre	26	27
198L	N28°32.144	W16°16.197	1013	11.01.2010	AB, MT	T	Anaga-West	26	27
199L	N28°20.877	W16°26.756	827	12.01.2010	AB, MT, ARB, AS	T	Guimar	34	32
200L	N28°20.879	W16°26.790	848	12.01.2010	AB, MT, ARB, AS	T	Guimar	34	32
201L	N28°18.547	W16°27.148	912	12.01.2010	AB, MT, ARB, AS	T	Guimar	35	33
202L	N28°18.530	W16°27.150	911	12.01.2010	AB, MT, ARB, AS	T	Guimar	35	33
203L	N28°27.368	W16°22.995	999	12.01.2010	AB, MT, ARB, AS	T	Calderetas	20	19
204L	N28°27.212	W16°23.110	985	12.01.2010	AB, MT, ARB, AS	T	Calderetas	19	19
205L	N28°27.268	W16°23.234	966	12.01.2010	AB, MT, ARB, AS	T	Calderetas	19	19
206L	N28°27.384	W16°23.430	920	12.01.2010	AB, MT, ARB, AS	T	Calderetas	19	19
207L	N28°27.525	W16°23.607	914	12.01.2010	AB, MT, ARB, AS	T	Calderetas	19	18
208L	N28°27.213	W16°23.677	970	12.01.2010	AB, MT, ARB, AS	T	Calderetas	19	18
209L	N28°27.668	W16°23.470	870	12.01.2010	AB, MT, ARB, AS	T	Calderetas	20	19
210L	N28°28.126	W16°23.255	786	12.01.2010	AB, MT, ARB, AS	T	Calderetas	20	19
211L	N28°28.313	W16°22.101	755	12.01.2010	AB, MT, ARB, AS	T	Calderetas	20	19
212L	N28°32.623	W16°13.614	808	13.01.2010	AB, MT	T	Anaga-Centre	29	24
213L	N28°32.842	W16°13.646	768	13.01.2010	AB, MT	T	Anaga-Centre	29	26
214L	N28°32.990	W16°13.683	696	13.01.2010	AB, MT	T	Anaga-Centre	29	26
215L	N28°32.828	W16°13.850	747	13.01.2010	AB, MT	T	Anaga-Centre	29	26
216L	N28°32.699	W16°13.987	669	13.01.2010	AB, MT	T	Anaga-Centre	29	26
217L	N28°32.702	W16°13.847	659	13.01.2010	AB, MT	T	Anaga-Centre	29	26
218L	N28°33.032	W16°13.903	626	13.01.2010	AB, MT	T	Anaga-Centre	29	26
219L	N28°32.984	W16°14.057	588	13.01.2010	AB, MT	T	Anaga-Centre	29	26
220L	N28°32.848	W16°14.104	559	13.01.2010	AB, MT	T	Anaga-Centre	29	26
221L	N28°32.835	W16°14.284	523	13.01.2010	AB, MT	T	Anaga-Centre	29	26
222L	N28°32.205	W16°14.271	783	13.01.2010	AB, MT	T	Anaga-Centre	28	26
223L	N28°32.292	W16°14.466	727	13.01.2010	AB, MT	T	Anaga-Centre	28	26
224L	N28°32.330	W16°14.638	733	13.01.2010	AB, MT	T	Anaga-Centre	28	26
225L	N28°32.126	W16°14.046	780	13.01.2010	AB, MT	T	Anaga-Centre	28	26
226L	N28°32.353	W16°13.154	826	13.01.2010	AB, MT	T			
227L	N28°33.954	W16°10.032	807	13.01.2010	AB, MT	T	Anaga-East	32	22
228L	N28°34.023	W16°10.137	793	13.01.2010	AB, MT	T	Anaga-East	32	22
229L	N28°33.600	W16°10.246	811	13.01.2010	AB, MT	T	Anaga-East	31	22
230L	N28°33.749	W16°10.232	808	13.01.2010	AB, MT	T	Anaga-East	31	22
231L	N28°33.726	W16°10.060	823	13.01.2010	AB, MT	T	Anaga-East	31	22
232L	N28°34.173	W16°10.214	780	13.01.2010	AB, MT	T	Anaga-East	32	22
233L	N28°33.739	W16°10.366	842	13.01.2010	AB, MT	T	Anaga-East	31	22
234L	N28°33.597	W16°10.405	893	13.01.2010	AB, MT	T	Anaga-East	31	22
235L	N28°33.524	W16°10.531	919	13.01.2010	AB, MT	T	Anaga-East	31	25
236L	N28°33.302	W16°10.729	768	13.01.2010	AB, MT	T	Anaga-East	31	25
237L	N28°29.814	W16°21.118	569	14.01.2010	AB, MT	T	Guamasa	21	20
238L	N28°29.825	W16°21.271	536	14.01.2010	AB, MT	T	Guamasa	21	20
239L	N28°29.941	W16°21.691	479	14.01.2010	AB, MT	T	Guamasa	21	20
240L	N28°30.120	W16°21.189	463	14.01.2010	AB, MT	T	Guamasa	21	20
241L	N28°30.219	W16°20.983	497	14.01.2010	AB, MT	T	Guamasa	21	20
242L	N28°30.132	W16°20.943	539	14.01.2010	AB, MT	T	Guamasa	21	20
243L	N28°30.475	W16°20.675	510	14.01.2010	AB, MT	T	Guamasa	21	20
244L	N28°30.241	W16°20.401	621	14.01.2010	AB, MT	T	Guamasa	21	20
245L	N28°30.146	W16°20.580	613	14.01.2010	AB, MT	T	Guamasa	21	20
246L	N28°30.539	W16°19.803	635	14.01.2010	AB, MT	T	Guamasa	21	20
247L	N28°30.309	W16°20.680	525	14.01.2010	AB, MT	T	Guamasa	21	20
248L	N28°30.431	W16°19.989	700	14.01.2010	AB, MT	T	Guamasa	21	20
249L					AB, MT	T			

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
250L	N28°32.104	W16°16.125	998	14.01.2010	AB, MT	T	Anaga-West	26	27
251L	N28°32.437	W16°16.252	918	14.01.2010	AB, MT	T	Anaga-West	26	30
252L	N28°32.103	W16°16.398	985	14.01.2010	AB, MT	T	Anaga-West	24	30
253L	N28°32.261	W16°16.025	928	14.01.2010	AB, MT	T	Anaga-West	26	27
254L	N28°32.100	W16°15.814	889	14.01.2010	AB, MT	T	Anaga-Centre	26	27
255L	N28°32.487	W16°16.391	905	14.01.2010	AB, MT	T	Anaga-West	27	30
256L	N28°32.003	W16°15.619	854	14.01.2010	AB, MT	T	Anaga-Centre	26	27
257L	N28°33.059	W16°14.336	386	14.01.2010	AB, MT	T	Anaga-Centre	29	26
258L	N28°33.055	W16°14.512	427	14.01.2010	AB, MT	T	Anaga-Centre	29	26
259L	N28°32.423	W16°14.851	547	14.01.2010	AB, MT	T	Anaga-Centre	28	27
260L	N28°32.186	W16°15.131	640	14.01.2010	AB, MT	T	Anaga-Centre	28	27
261L	N28°32.095	W16°15.375	707	14.01.2010	AB, MT	T	Anaga-Centre	28	27
262L	N28°32.017	W16°15.190	774	14.01.2010	AB, MT	T	Anaga-Centre	28	27
263L	N28°31.990	W16°14.914	797	14.01.2010	AB, MT	T	Anaga-Centre	28	27
264L	N28°32.102	W16°14.650	822	14.01.2010	AB, MT	T	Anaga-Centre	28	26
265L	N28°32.155	W16°14.333	842	14.01.2010	AB, MT	T	Anaga-Centre	28	26
266L	N28°32.272	W16°13.956	841	14.01.2010	AB, MT	T	Anaga-Centre	28	26
267L	N28°32.358	W16°13.958	840	14.01.2010	AB, MT	T	Anaga-Centre	28	26
268L	N28°32.474	W16°13.803	840	14.01.2010	AB, MT	T	Anaga-Centre	28	26
269L	N28°32.415	W16°13.692	852	14.01.2010	AB, MT	T	Anaga-Centre	28	26
270L	N28°32.404	W16°13.456	866	14.01.2010	AB, MT	T	Anaga-Centre	28	24
271L	N28°32.338	W16°13.155	825	14.01.2010	AB, MT	T	Anaga-Centre	28	24
272L	N28°32.681	W16°13.083	732	14.01.2010	AB, MT	T	Anaga-Centre	29	24
273L	N28°32.788	W16°12.946	733	14.01.2010	AB, MT	T	Anaga-Centre	29	24
274L	N28°32.838	W16°12.715	733	14.01.2010	AB, MT	T	Anaga-East	29	24
275L	N28°32.738	W16°12.486	710	14.01.2010	AB, MT	T	Anaga-East	29	24
276L	N28°33.004	W16°12.109	705	14.01.2010	AB, MT	T	Anaga-East	30	25
277L	N28°33.041	W16°11.885	716	14.01.2010	AB, MT	T	Anaga-East	30	25
278L	N28°33.101	W16°11.686	711	14.01.2010	AB, MT	T	Anaga-East	30	25
279L	N28°33.115	W16°11.471	736	14.01.2010	AB, MT	T	Anaga-East	30	25
280L	N28°32.989	W16°11.295	764	14.01.2010	AB, MT	T	Anaga-East	30	25
281L	N28°33.040	W16°10.975	777	14.01.2010	AB, MT	T	Anaga-East	30	25
282L	N28°33.226	W16°11.135	802	14.01.2010	AB, MT	T	Anaga-East	30	25
283L	N28°33.319	W16°10.827	808	14.01.2010	AB, MT	T	Anaga-East	31	25
284L	N28°32.858	W16°12.201	578	14.01.2010	AB, MT	T	Anaga-East	30	24
285L	N28°21.769	W16°29.340	1166	15.01.2010	AB, MT, ARB	T			
286L	N28°21.658	W16°29.181	1150	15.01.2010	AB, MT, ARB	T	Monte Esperanza	12	14
287L	N28°24.307	W16°29.176	819	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
288L	N28°24.218	W16°29.174	867	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
289L	N28°24.142	W16°29.340	893	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
290L	N28°23.935	W16°29.432	930	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
291L	N28°23.996	W16°29.173	1034	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
292L	N28°23.828	W16°29.276	1053	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
293L	N28°23.692	W16°29.348	1046	15.01.2010	AB, MT, ARB	T	Monte Esperanza	13	13
294L	N28°23.634	W16°29.519	1047	15.01.2010	AB, MT, ARB	T	Monte Esperanza	13	13
295L					AB, MT, ARB	T			
296L	N28°23.569	W16°29.483	1102	15.01.2010	AB, MT, ARB	T	Monte Esperanza	13	13
297L	N28°23.445	W16°29.091	1156	15.01.2010	AB, MT, ARB	T	Monte Esperanza	13	13
298L	N28°23.646	W16°29.209	1119	15.01.2010	AB, MT, ARB	T	Monte Esperanza	13	13
299L	N28°23.780	W16°29.219	1098	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
300L	N28°23.945	W16°29.036	1060	15.01.2010	AB, MT, ARB	T	Monte Esperanza	14	13
301L	N28°24.914	W16°28.645	617	15.01.2010	AB, MT, ARB	T	Monte Esperanza	15	15
302L	N28°24.790	W16°28.533	697	15.01.2010	AB, MT, ARB	T	Monte Esperanza	15	15
303L	N28°24.571	W16°28.378	842	15.01.2010	AB, MT, ARB	T	Monte Esperanza	15	15
304L	N28°24.625	W16°28.425	794	15.01.2010	AB, MT, ARB	T	Monte Esperanza	15	15
305L	N28°19.525	W16°50.736	741	16.01.2010	AB, MT	T	Teno	2	7
306L	N28°19.313	W16°50.146	870	16.01.2010	AB, MT	T	Teno	2	7
307L	N28°19.395	W16°49.910	1003	16.01.2010	AB, MT	T	Teno	2	6
308L	N28°19.274	W16°49.758	1043	16.01.2010	AB, MT	T	Teno	2	6
309L	N28°19.181	W16°49.808	1057	16.01.2010	AB, MT	T	Teno	2	6
310L	N28°19.133	W16°49.667	1095	16.01.2010	AB, MT	T	Teno	2	6
311L	N28°18.952	W16°49.720	1140	16.01.2010	AB, MT	T	Teno	2	6
312L	N28°18.957	W16°49.498	1178	16.01.2010	AB, MT	T	Teno	2	6
313L	N28°18.840	W16°49.607	1210	16.01.2010	AB, MT	T	Teno	2	6
314L	N28°18.827	W16°49.438	1242	16.01.2010	AB, MT	T	Teno	2	6
315L	N28°18.803	W16°49.189	1259	16.01.2010	AB, MT	T	Teno	3	4

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
316L	N28°18.864	W16°49.200	1238	16.01.2010	AB, MT	T	Teno	3	4
317L	N28°18.906	W16°49.312	1199	16.01.2010	AB, MT	T	Teno	2	6
318L	N28°19.058	W16°50.090	987	16.01.2010	AB, MT	T	Teno	2	7
319L	N28°19.020	W16°50.148	988	16.01.2010	AB, MT	T	Teno	2	7
320L	N28°19.124	W16°50.250	925	16.01.2010	AB, MT	T	Teno	2	7
321L	N28°19.250	W16°50.386	818	16.01.2010	AB, MT	T	Teno	2	7
322L	N28°19.424	W16°50.552	756	16.01.2010	AB, MT	T	Teno	2	7
323L	N28°19.332	W16°50.859	804	16.01.2010	AB, MT	T	Teno	2	7
324L	N28°19.482	W16°51.141	810	16.01.2010	AB, MT	T	Teno	2	7
325L	N28°19.352	W16°50.959	816	16.01.2010	AB, MT	T	Teno	2	7
326L	N28°18.909	W16°48.241	1108	16.01.2010	AB, MT	T	Teno	3	4
327L	N28°18.714	W16°48.848	1183	16.01.2010	AB, MT	T	Teno	3	4
328L	N28°18.784	W16°49.053	1215	16.01.2010	AB, MT	T	Teno	3	4
329L	N28°18.839	W16°48.349	1123	16.01.2010	AB, MT	T	Teno	3	4
330L	N28°19.418	W16°47.873	1127	16.01.2010	AB, MT	T	Teno	5	4
331L	N28°19.580	W16°47.501	1119	16.01.2010	AB, MT	T	Teno	5	4
332L	N28°19.897	W16°47.164	1060	16.01.2010	AB, MT	T	Teno	6	3
333L	N28°20.161	W16°47.161	989	16.01.2010	AB, MT	T	Teno	6	3
334L	N28°20.284	W16°47.257	941	16.01.2010	AB, MT	T	Teno	6	2
335L	N28°20.324	W16°47.545	900	16.01.2010	AB, MT	T	Teno	4	2
336L	N28°20.128	W16°47.806	938	16.01.2010	AB, MT	T	Teno	5	5
337L	N28°19.724	W16°48.173	1003	16.01.2010	AB, MT	T	Teno	5	4
338L	N28°19.951	W16°48.304	974	16.01.2010	AB, MT	T	Teno	5	4
339L	N28°20.165	W16°48.298	946	16.01.2010	AB, MT	T	Teno	5	5
340L	N28°20.245	W16°48.146	916	16.01.2010	AB, MT	T	Teno	5	5
341L	N28°20.071	W16°48.093	960	16.01.2010	AB, MT	T	Teno	5	4
342L	N28°20.436	W16°47.973	871	16.01.2010	AB, MT	T	Teno	4	5
343L	N28°20.519	W16°47.785	842	16.01.2010	AB, MT	T	Teno	4	5
344L	N28°21.142	W16°34.430	879	17.01.2010	AB, MT	T	Orotava	11	12
345L	N28°21.176	W16°34.736	908	17.01.2010	AB, MT	T	Orotava	11	12
346L	N28°20.620	W16°35.140	1166	17.01.2010	AB, MT	T	Chanajiga	11	10
347L	N28°20.827	W16°35.222	1167	17.01.2010	AB, MT	T	Chanajiga	11	10
348L	N28°21.244	W16°35.351	1147	17.01.2010	AB, MT	T	Chanajiga	11	10
349L	N28°21.356	W16°35.445	1152	17.01.2010	AB, MT	T	Chanajiga	11	10
350L	N28°20.923	W16°35.306	1160	17.01.2010	AB, MT	T	Chanajiga	11	10
351L	N28°21.046	W16°35.373	1143	17.01.2010	AB, MT	T	Chanajiga	11	10
352L	N28°21.408	W16°35.584	1171	17.01.2010	AB, MT	T	Chanajiga	11	10
353L	N28°21.533	W16°35.761	1184	17.01.2010	AB, MT	T	Chanajiga	11	10
354L	N28°21.588	W16°35.856	1195	17.01.2010	AB, MT	T	Chanajiga	11	10
355L	N28°21.582	W16°35.979	1217	17.01.2010	AB, MT	T	Chanajiga	11	10
356L	N28°20.880	W16°34.451	1043	17.01.2010	AB, MT	T	Orotava	11	12
357L	N28°21.005	W16°34.683	982	17.01.2010	AB, MT	T	Orotava	11	12
358L	N28°21.096	W16°34.442	941	17.01.2010	AB, MT	T	Orotava	11	12
359L	N28°22.589	W16°35.743	543	17.01.2010	AB, MT	T	Chanajiga	10	10
360L	N28°22.880	W16°36.253	666	17.01.2010	AB, MT	T	Chanajiga	10	10
361L	N28°22.553	W16°36.325	770	17.01.2010	AB, MT	T	Chanajiga	10	11
362L	N28°22.515	W16°36.599	791	17.01.2010	AB, MT	T	Chanajiga	10	11
363L	N28°22.260	W16°36.818	842	17.01.2010	AB, MT	T	Chanajiga	10	11
364L	N28°21.697	W16°37.206	916	17.01.2010	AB, MT	T	Chanajiga	10	11
365L	N28°21.764	W16°37.413	885	17.01.2010	AB, MT	T	Chanajiga	10	11
366L	N28°21.718	W16°37.858	898	17.01.2010	AB, MT	T	Chanajiga	10	11
367L	N28°21.823	W16°38.327	843	17.01.2010	AB, MT	T	Chanajiga	10	11
368L	N28°21.833	W16°39.108	768	17.01.2010	AB, MT	T	Chanajiga	10	11
369L	N28°22.457	W16°38.649	526	17.01.2010	AB, MT	T	Chanajiga	10	11
370L	N28°22.648	W16°38.379	529	17.01.2010	AB, MT	T	Chanajiga	10	11
371L	N28°22.555	W16°37.544	627	17.01.2010	AB, MT	T	Chanajiga	10	11
372L	N28°22.321	W16°37.437	664	17.01.2010	AB, MT	T			
373L	N28°22.497	W16°37.252	657	17.01.2010	AB, MT	T	Chanajiga	10	11
374L	N28°26.238	W16°27.322	547	19.01.2010	AB, MT	T	Calderetas	17	21
375L	N28°26.174	W16°26.630	742	19.01.2010	AB, MT	T	Calderetas	17	21
376L	N28°25.737	W16°26.241	957	19.01.2010	AB, MT	T	Calderetas	16	21
377L	N28°25.876	W16°26.039	1006	19.01.2010	AB, MT	T	Calderetas	17	21
378L	N28°26.125	W16°25.826	1021	19.01.2010	AB, MT	T	Calderetas	17	21
379L	N28°26.204	W16°25.782	1027	19.01.2010	AB, MT	T	Calderetas	17	21
380L	N28°26.016	W16°25.804	1029	19.01.2010	AB, MT	T	Calderetas	17	21
381L	N28°25.768	W16°25.625	1112	19.01.2010	AB, MT	T	Calderetas	18	21

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Table 18.1 – continued from previous page

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
382L	N28°25.651	W16°25.749	1099	19.01.2010	AB, MT	T	Calderetas	18	21
383L	N28°25.212	W16°26.265	1057	19.01.2010	AB, MT	T	Monte Esperanza	16	21
384L	N28°24.987	W16°26.336	1095	19.01.2010	AB, MT	T	Monte Esperanza	16	21
385L	N28°24.965	W16°26.576	1067	19.01.2010	AB, MT	T	Monte Esperanza	16	21
386L	N28°24.901	W16°26.678	1063	19.01.2010	AB, MT	T	Monte Esperanza	16	17
387L	N28°24.604	W16°26.769	1032	19.01.2010	AB, MT	T	Monte Esperanza	16	17
388L	N28°24.513	W16°26.818	1018	19.01.2010	AB, MT	T	Monte Esperanza	16	17
389L	N28°24.809	W16°26.714	1054	19.01.2010	AB, MT	T	Monte Esperanza	16	17
390L	N28°25.107	W16°26.921	913	19.01.2010	AB, MT	T	Monte Esperanza	16	17
391L	N28°25.385	W16°26.474	951	19.01.2010	AB, MT	T	Monte Esperanza	16	21
392L	N28°25.805	W16°25.406	1122	19.01.2010	AB, MT	T	Calderetas	18	21
393L	N28°25.950	W16°25.581	1083	19.01.2010	AB, MT	T	Calderetas	18	21
394L	N28°26.252	W16°25.186	1023	19.01.2010	AB, MT	T	Calderetas	18	16
395L	N28°26.096	W16°25.274	1033	19.01.2010	AB, MT	T	Calderetas	18	21
396L	N28°26.337	W16°25.562	971	19.01.2010	AB, MT	T	Calderetas	17	21
397L	N28°26.285	W16°25.374	976	19.01.2010	AB, MT	T	Calderetas	18	16
398L	N28°26.404	W16°25.384	962	19.01.2010	AB, MT	T	Calderetas	17	16
399L	N28°26.690	W16°25.577	878	19.01.2010	AB, MT	T	Calderetas	17	16
400L	N28°26.516	W16°25.535	920	19.01.2010	AB, MT	T	Calderetas	17	16
401L	N28°26.023	W16°25.492	1084	19.01.2010	AB, MT	T	Calderetas	18	21
402L	N28°25.853	W16°25.123	1147	19.01.2010	AB, MT	T	Calderetas	18	21
403L	N28°25.864	W16°24.833	1160	19.01.2010	AB, MT	T	Calderetas	18	16
404L	N28°25.867	W16°24.686	1170	19.01.2010	AB, MT	T	Calderetas	18	16
405L	N28°25.944	W16°24.479	1176	19.01.2010	AB, MT	T	Calderetas	18	16
406L	N28°26.081	W16°24.019	1179	19.01.2010	AB, MT	T	Calderetas	18	18
407L	N28°25.986	W16°24.335	1188	19.01.2010	AB, MT	T	Calderetas	18	16
408L	N28°26.201	W16°24.257	1119	19.01.2010	AB, MT	T	Calderetas	18	16
409L	N28°26.119	W16°24.543	1110	19.01.2010	AB, MT	T	Calderetas	18	16
410L	N28°26.055	W16°24.690	1110	19.01.2010	AB, MT	T	Calderetas	18	16
411L	N28°26.082	W16°24.946	1104	19.01.2010	AB, MT	T	Calderetas	18	16
412L	N28°26.477	W16°24.279	1070	19.01.2010	AB, MT	T	Calderetas	18	18
413L	N28°26.692	W16°24.327	1037	19.01.2010	AB, MT	T	Calderetas	18	18
414L	N28°26.836	W16°24.271	1018	19.01.2010	AB, MT	T	Calderetas	19	18
415L	N28°26.930	W16°24.104	1017	19.01.2010	AB, MT	T	Calderetas	19	18
416L				19.01.2010	AB, MT	T			
417L	N28°26.835	W16°23.857	1034	19.01.2010	AB, MT	T	Calderetas	19	18
418L	N28°26.793	W16°23.698	1053	19.01.2010	AB, MT	T	Calderetas	19	18
419L	N28°27.013	W16°24.007	1013	19.01.2010	AB, MT	T	Calderetas	19	18
420L	N28°26.994	W16°23.869	1004	19.01.2010	AB, MT	T	Calderetas	19	18
421L	N28°27.045	W16°23.723	998	19.01.2010	AB, MT	T	Calderetas	19	18
422L	N28°27.035	W16°24.295	994	19.01.2010	AB, MT	T	Calderetas	19	18
423L	N28°27.017	W16°24.515	974	19.01.2010	AB, MT	T	Calderetas	19	18
424L	N28°26.887	W16°24.593	983	19.01.2010	AB, MT	T	Calderetas	19	18
425L	N28°26.816	W16°24.715	964	19.01.2010	AB, MT	T	Calderetas	19	18
426L	N28°26.664	W16°24.925	979	19.01.2010	AB, MT	T	Calderetas	19	18
427L	N28°27.639	W16°25.749	688	19.01.2010	AB, MT	T	Calderetas	17	16
428L	N28°27.373	W16°26.027	679	19.01.2010	AB, MT	T	Calderetas	17	16
429L	N28°27.140	W16°26.297	629	19.01.2010	AB, MT	T	Calderetas	17	16
430L	N28°27.221	W16°26.535	584	19.01.2010	AB, MT	T	Calderetas	17	16
431L	N28°25.328	W16°27.837	534	20.01.2010	AB, MT	T	Monte Esperanza	15	17
432L	N28°25.263	W16°28.033	536	20.01.2010	AB, MT	T	Monte Esperanza	15	17
433L	N28°25.158	W16°28.087	609	20.01.2010	AB, MT	T	Monte Esperanza	15	17
434L	N28°25.014	W16°28.011	681	20.01.2010	AB, MT	T			
435L	N28°24.748	W16°28.082	796	20.01.2010	AB, MT	T	Monte Esperanza	15	17
436L	N28°24.937	W16°28.071	708	20.01.2010	AB, MT	T	Monte Esperanza	15	17
437L	N28°24.587	W16°28.009	885	20.01.2010	AB, MT	T	Monte Esperanza	15	15
438L	N28°24.416	W16°27.995	980	20.01.2010	AB, MT	T	Monte Esperanza	15	15
439L	N28°24.445	W16°28.118	929	20.01.2010	AB, MT	T	Monte Esperanza	15	15
440L	N28°24.307	W16°28.047	1001	20.01.2010	AB, MT	T	Monte Esperanza	15	15
441L	N28°24.239	W16°28.106	1002	20.01.2010	AB, MT	T	Monte Esperanza	14	15
442L	N28°24.264	W16°28.249	995	20.01.2010	AB, MT	T	Monte Esperanza	14	15
443L	N28°24.154	W16°28.274	983	20.01.2010	AB, MT	T	Monte Esperanza	14	15
444L	N28°24.151	W16°28.498	993	20.01.2010	AB, MT	T	Monte Esperanza	14	13
445L	N28°24.130	W16°28.739	1026	20.01.2010	AB, MT	T	Monte Esperanza	14	13
446L	N28°23.938	W16°28.768	1083	20.01.2010	AB, MT	T	Monte Esperanza	14	13
447L	N28°24.028	W16°28.526	1093	20.01.2010	AB, MT	T	Monte Esperanza	14	13

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
448L	N28°23.788	W16°28.411	1080	20.01.2010	AB, MT	T	Monte Esperanza	14	15
449L	N28°23.996	W16°28.366	1086	20.01.2010	AB, MT	T	Monte Esperanza	14	15
450L	N28°23.967	W16°28.157	1138	20.01.2010	AB, MT	T	Monte Esperanza	14	15
451L	N28°24.113	W16°28.012	1093	20.01.2010	AB, MT	T	Monte Esperanza	14	15
452L	N28°24.264	W16°27.902	1053	20.01.2010	AB, MT	T	Monte Esperanza	15	15
453L	N28°24.459	W16°27.907	966	20.01.2010	AB, MT	T	Monte Esperanza	15	15
454L	N28°24.304	W16°27.714	929	20.01.2010	AB, MT	T	Monte Esperanza	15	15
455L	N28°24.536	W16°27.688	935	20.01.2010	AB, MT	T	Monte Esperanza	15	15
456L	N28°24.523	W16°27.523	911	20.01.2010	AB, MT	T	Monte Esperanza	15	15
457L	N28°24.436	W16°27.437	908	20.01.2010	AB, MT	T	Monte Esperanza	15	15
458L	N28°24.708	W16°27.453	918	20.01.2010	AB, MT	T	Monte Esperanza	16	17
459L	N28°24.723	W16°27.274	946	20.01.2010	AB, MT	T	Monte Esperanza	16	17
460L	N28°24.582	W16°27.180	976	20.01.2010	AB, MT	T	Monte Esperanza	16	17
461L	N28°24.661	W16°27.021	1009	20.01.2010	AB, MT	T	Monte Esperanza	16	17
462L	N28°24.566	W16°26.933	1023	20.01.2010	AB, MT	T	Monte Esperanza	16	17
463L	N28°24.842	W16°26.579	1109	20.01.2010	AB, MT	T	Monte Esperanza	16	17
464L	N28°24.811	W16°26.425	1157	20.01.2010	AB, MT	T	Monte Esperanza	16	21
465L	N28°24.709	W16°26.430	1176	20.01.2010	AB, MT	T	Monte Esperanza	16	17
466L	N28°24.263	W16°26.102	1349	20.01.2010	AB, MT	T	Monte Esperanza	16	17
467L	N28°27.077	W16°21.922	911	20.01.2010	AB, MT	T	Calderetas	20	19
468L	N28°26.991	W16°22.281	988	20.01.2010	AB, MT	T	Calderetas	20	19
469L	N28°26.914	W16°22.669	1066	20.01.2010	AB, MT	T	Calderetas	19	19
470L	N28°26.827	W16°22.845	1092	20.01.2010	AB, MT	T	Calderetas	19	19
471L	N28°27.054	W16°22.775	1072	20.01.2010	AB, MT	T	Calderetas	19	19
472L	N28°27.101	W16°22.957	1047	20.01.2010	AB, MT	T	Calderetas	19	19
473L	N28°27.568	W16°23.363	898	20.01.2010	AB, MT	T	Calderetas	20	19
474L	N28°27.652	W16°23.201	886	20.01.2010	AB, MT	T	Calderetas	20	19
475L	N28°27.948	W16°23.169	814	20.01.2010	AB, MT	T	Calderetas	20	19
476L	N28°28.320	W16°22.532	766	20.01.2010	AB, MT	T	Calderetas	20	19
477L	N28°27.802	W16°22.488	871	20.01.2010	AB, MT	T	Calderetas	20	19
478L	N28°27.424	W16°22.055	910	20.01.2010	AB, MT	T	Calderetas	20	19
479L	N28°28.080	W16°22.728	855	20.01.2010	AB, MT	T	Calderetas	20	19
480L	N28°27.816	W16°24.536	758	20.01.2010	AB, MT	T	Calderetas	19	18
481L	N28°27.245	W16°25.349	826	20.01.2010	AB, MT	T	Calderetas	17	16
482L	N28°27.054	W16°25.603	802	20.01.2010	AB, MT	T			
483L	N28°26.916	W16°25.783	795	20.01.2010	AB, MT	T	Calderetas	17	16
484L	N28°26.783	W16°25.978	775	20.01.2010	AB, MT	T	Calderetas	17	21
485L	N28°26.688	W16°26.138	742	20.01.2010	AB, MT	T	Calderetas	17	21
486L	N28°26.646	W16°26.341	698	20.01.2010	AB, MT	T	Calderetas	17	21
487L	N28°23.960	W16°30.075	519	21.01.2010	AB, MT, ARB	T	Monte Esperanza	13	14
488L	N28°23.825	W16°30.004	467	21.01.2010	AB, MT, ARB	T	Monte Esperanza	13	14
489L	N28°23.793	W16°30.016	475	21.01.2010	AB, MT, ARB	T	Monte Esperanza	13	14
490L	N28°23.430	W16°30.123	512	21.01.2010	AB, MT, ARB	T	Orotava	13	14
491L	N28°23.217	W16°29.964	567	21.01.2010	AB, MT, ARB	T	Orotava	13	14
492L	N28°22.661	W16°29.805	782	21.01.2010	AB, MT, ARB	T	Orotava	12	12
493L	N28°22.773	W16°30.228	709	21.01.2010	AB, MT, ARB	T	Orotava	12	12
494L	N28°20.622	W16°32.701	1236	21.01.2010	AB, MT, ARB	T	Orotava	12	12
495L	N28°28.908	W16°24.641	521	21.01.2010	AB, MT, ARB	T	Calderetas	20	18
496L	N28°29.175	W16°24.568	495	21.01.2010	AB, MT, ARB	T	Calderetas	20	18
497L	N28°29.478	W16°24.578	466	21.01.2010	AB, MT, ARB	T	Calderetas	20	18
498L	N28°30.616	W16°23.420	379	21.01.2010	AB, MT, ARB	T	Guamasa	20	20
499L	N28°30.436	W16°22.977	440	21.01.2010	AB, MT, ARB	T	Guamasa	20	20
500L	N28°30.193	W16°22.803	564	21.01.2010	AB, MT, ARB	T	Guamasa	20	20
501L	N28°29.584	W16°22.544	613	21.01.2010	AB, MT, ARB	T	Guamasa	20	20
502L	N28°31.267	W16°17.730	661	22.01.2010	AB, MT	T	Anaga-West	24	29
503L	N28°31.577	W16°17.331	727	22.01.2010	AB, MT	T	Anaga-West	24	29
504L	N28°31.614	W16°17.020	788	22.01.2010	AB, MT	T	Anaga-West	24	29
505L	N28°31.518	W16°17.300	762	22.01.2010	AB, MT	T	Anaga-West	24	29
506L	N28°32.107	W16°17.912	910	22.01.2010	AB, MT	T	Anaga-West	23	28
507L	N28°31.853	W16°17.309	899	22.01.2010	AB, MT	T	Anaga-West	24	29
508L	N28°32.153	W16°18.273	868	22.01.2010	AB, MT	T	Anaga-West	23	31
509L	N28°32.110	W16°18.612	838	22.01.2010	AB, MT	T	Anaga-West	22	31
510L	N28°32.067	W16°18.340	835	22.01.2010	AB, MT	T	Anaga-West	23	31
511L	N28°31.902	W16°18.123	799	22.01.2010	AB, MT	T	Anaga-West	23	29
512L	N28°31.856	W16°18.005	785	22.01.2010	AB, MT	T	Anaga-West	23	29
513L	N28°31.896	W16°18.332	705	22.01.2010	AB, MT	T	Anaga-West	23	29

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
514L	N28°31.802	W16°18.469	648	22.01.2010	AB, MT	T	Anaga-West	22	31
515L	N28°31.943	W16°18.161	806	22.01.2010	AB, MT	T	Anaga-West	23	29
516L	N28°31.850	W16°16.963	939	22.01.2010	AB, MT	T	Anaga-West	24	29
517L	N28°32.898	W16°12.424	680	22.01.2010	AB, MT	T	Anaga-East	30	24
518L	N28°32.512	W16°13.261	768	22.01.2010	AB, MT	T	Anaga-Centre	29	24
519L	N28°32.592	W16°12.338	595	22.01.2010	AB, MT	T	Anaga-East	30	24
520L	N28°32.775	W16°12.105	524	22.01.2010	AB, MT	T	Anaga-East	30	24
521L	N28°32.668	W16°12.005	500	22.01.2010	AB, MT	T	Anaga-East	30	25
522L	N28°33.101	W16°12.304	557	22.01.2010	AB, MT	T	Anaga-East	30	24
523L	N28°33.217	W16°12.333	527	22.01.2010	AB, MT	T	Anaga-East	30	24
524L	N28°33.644	W16°09.969	746	22.01.2010	AB, MT	T	Anaga-East	31	22
525L	N28°33.337	W16°11.084	834	22.01.2010	AB, MT	T	Anaga-East	30	25
526L	N28°33.288	W16°11.194	801	22.01.2010	AB, MT	T	Anaga-East	30	25
527L	N28°33.142	W16°11.416	784	22.01.2010	AB, MT	T	Anaga-East	30	25
528L	N28°21.689	W16°30.037	1103	23.01.2010	AB, MT	T	Orotava	12	12
529L	N28°19.954	W16°48.037	985	23.01.2010	AB, MT	T	Teno	5	4
530L	N28°21.661	W16°47.866	563	23.01.2010	AB, MT	T	Teno	6	2
531L	N28°21.244	W16°48.035	508	23.01.2010	AB, MT	T	Teno	4	2
532L	N28°24.391	W16°29.481	705	24.01.2010	AB, MT	T	Monte Esperanza	14	13
533L	N28°23.752	W16°29.583	952	24.01.2010	AB, MT	T	Monte Esperanza	13	13
534L	N28°23.557	W16°29.659	958	24.01.2010	AB, MT	T	Monte Esperanza	13	13
535L	N28°23.405	W16°29.634	961	24.01.2010	AB, MT	T	Monte Esperanza	13	14
536L	N28°23.186	W16°29.449	974	24.01.2010	AB, MT	T	Monte Esperanza	13	14
537L	N28°23.010	W16°29.360	978	24.01.2010	AB, MT	T	Monte Esperanza	13	14
538L	N28°22.816	W16°29.244	981	24.01.2010	AB, MT	T	Monte Esperanza	13	14
539L	N28°22.654	W16°29.172	989	24.01.2010	AB, MT	T	Monte Esperanza	12	14
540L	N28°22.637	W16°29.322	994	24.01.2010	AB, MT	T	Monte Esperanza	12	14
541L	N28°22.437	W16°29.190	1137	24.01.2010	AB, MT	T	Monte Esperanza	12	14
542L	N28°22.986	W16°28.906	1455	24.01.2010	AB, MT	T	Monte Esperanza	13	14
543L	N28°23.112	W16°29.015	1371	24.01.2010	AB, MT	T	Monte Esperanza	13	14
544L	N28°23.216	W16°29.125	1296	24.01.2010	AB, MT	T	Monte Esperanza	13	14
545L	N28°23.408	W16°29.325	1199	24.01.2010	AB, MT	T	Monte Esperanza	13	14
546L	N28°21.231	W16°35.232	1061	18.03.2010	AB	T	Chanajiga	11	10
547L					AB	T			
548L	N28°34.660	W16°09.087	604	19.03.2010	AB	T	Anaga-East	33	23
549L	N28°34.670	W16°09.229	589	19.03.2010	AB	T	Anaga-East	33	23
550L	N28°34.787	W16°09.278	600	19.03.2010	AB	T	Anaga-East	33	23
551L	N28°34.395	W16°10.367	465	19.03.2010	AB	T	Anaga-East	32	23
552L	N28°21.590	W16°29.353	1161	21.03.2010	AB	T	Monte Esperanza	12	14
553L	N28°22.127	W16°29.092	1221	21.03.2010	AB	T	Monte Esperanza	12	14
554L	N28°32.488	W16°15.971	872	23.03.2010	AB	T	Anaga-West	26	30
555L	N28°32.763	W16°15.950	768	23.03.2010	AB	T	Anaga-West	26	30
556L	N28°32.884	W16°15.853	714	23.03.2010	AB	T	Anaga-West	26	30
557L	N28°33.206	W16°15.896	683	23.03.2010	AB	T	Anaga-West	27	30
558L	N28°33.094	W16°15.833	635	23.03.2010	AB	T	Anaga-West	27	30
559L	N28°32.951	W16°15.705	661	23.03.2010	AB	T	Anaga-West	27	30
560L	N28°32.708	W16°13.533	751	24.03.2010	AB	T	Anaga-Centre	29	24
561L	N28°32.824	W16°13.412	575	24.03.2010	AB	T	Anaga-Centre	29	24
562L	N28°32.985	W16°13.414	438	24.03.2010	AB	T	Anaga-Centre	29	24
563L	N28°19.635	W16°48.987	859	25.03.2010	AB	T	Teno	3	6
564L	N28°19.449	W16°49.484	1049	25.03.2010	AB	T	Teno	3	6
565L	N28°19.433	W16°49.591	1095	25.03.2010	AB	T	Teno	3	6
566L					AB	T			
567L	N28°20.011	W16°49.403	740	25.03.2010	AB	T	Teno	1	8
568L	N28°20.253	W16°49.609	850	25.03.2010	AB	T	Teno	1	8
569L	N28°20.283	W16°49.421	793	25.03.2010	AB	T	Teno	1	8
570L	N28°21.208	W16°35.302	1139	26.03.2010	AB	T	Chanajiga	11	10
571L	N28°21.755	W16°35.924	1161	26.03.2010	AB	T	Chanajiga	11	10
572L	N28°21.863	W16°35.865	1118	26.03.2010	AB	T	Chanajiga	10	10
573L	N28°21.994	W16°35.808	1101	26.03.2010	AB	T	Chanajiga	10	10
574L	N28°22.107	W16°35.649	883	26.03.2010	AB	T	Chanajiga	10	10
575L	N28°22.032	W16°35.681	988	26.03.2010	AB	T	Chanajiga	10	10
576L	N28°21.955	W16°35.878	1083	26.03.2010	AB	T	Chanajiga	10	10
577L	N28°33.610	W16°10.268	809	27.03.2010	AB	T	Anaga-East	31	22
578L	N28°33.608	W16°10.268	809	27.03.2010	AB	T	Anaga-East	31	22
579L	N28°33.481	W16°09.283	618	27.03.2010	AB	T	Anaga-East	32	23

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ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
580L	N28°33.548	W16°09.507	654	27.03.2010	AB	T	Anaga-East	32	22
581L	N28°33.776	W16°09.567	589	27.03.2010	AB	T	Anaga-East	32	23
582L	N28°32.328	W16°13.529	846	27.03.2010	AB	T	Anaga-Centre	28	24
583L	N28°32.227	W16°13.380	874	27.03.2010	AB	T	Anaga-Centre	28	24
584L	N28°32.272	W16°13.310	886	27.03.2010	AB	T	Anaga-Centre	28	24
585L	N28°32.130	W16°18.925	827	27.03.2010	AB	T	Anaga-West	22	31
586L	N28°31.935	W16°19.209	800	27.03.2010	AB	T	Anaga-West	22	31
587L	N28°31.892	W16°19.319	782	27.03.2010	AB	T	Anaga-West	22	31
588L	N28°31.909	W16°19.423	763	27.03.2010	AB	T	Anaga-West	22	31
589L	N28°31.973	W16°19.694	716	27.03.2010	AB	T	Anaga-West	22	31
590L	N28°32.047	W16°19.049	812	27.03.2010	AB	T	Anaga-West	22	31
591L	N28°32.029	W16°18.868	812	27.03.2010	AB	T	Anaga-West	22	31
592L	N28°32.427	W16°18.442	747	27.03.2010	AB	T			
593L	N28°33.638	W16°17.289	607	28.03.2010	AB	T	Anaga-West	27	28
594L	N28°33.532	W16°17.257	580	28.03.2010	AB	T	Anaga-West	27	28
595L	N28°33.425	W16°17.301	515	28.03.2010	AB	T	Anaga-West	27	28
596L	N28°33.384	W16°17.296	486	28.03.2010	AB	T	Anaga-West	27	28
597L	N28°20.876	W16°47.524	774	28.03.2010	MG	T	Teno	4	2
598L	N28°20.743	W16°47.743	795	28.03.2010	MG	T	Teno	4	2
599L	N28°20.693	W16°47.855	816	28.03.2010	MG	T	Teno	4	5
600L	N28°19.383	W16°47.321	1171	28.03.2010	MG	T	Teno	5	4
601L	N28°20.135	W16°46.804	998	28.03.2010	MG	T	Teno	6	3
602L	N28°20.389	W16°46.792	931	28.03.2010	MG	T	Teno	6	3
603L	N28°20.565	W16°46.980	889	28.03.2010	MG	T	Teno	6	2
604L	N28°20.789	W16°47.148	823	28.03.2010	MG	T	Teno	6	2
605L	N28°21.028	W16°47.117	752	28.03.2010	MG	T	Teno	6	2
606L	N28°20.370	W16°45.343	960	28.03.2010	MG	T	Icod	7	3
607L	N28°21.060	W16°43.422	772	28.03.2010	MG	T	Icod	8	1
608L	N28°20.588	W16°51.716	823	29.03.2010	AB	T	Teno Alto	0	9
609L	N28°20.804	W16°51.570	806	29.03.2010	AB	T	Teno Alto	0	9
610L	N28°20.861	W16°51.456	810	29.03.2010	AB	T	Teno Alto	0	9
611L	N28°20.946	W16°51.521	782	29.03.2010	AB	T	Teno Alto	0	9
612L	N28°20.979	W16°51.658	749	29.03.2010	AB	T	Teno Alto	0	9
613L	N28°21.154	W16°51.714	687	29.03.2010	AB	T	Teno Alto	0	9
614L	N28°20.871	W16°51.764	687	29.03.2010	AB	T	Teno Alto	0	9
615L	N28°20.705	W16°51.875	722	29.03.2010	AB	T	Teno Alto	0	9
616L	N28°20.320	W16°51.751	872	01.04.2010	AB	T	Teno Alto	0	9
617L	N28°20.232	W16°52.518	904	01.04.2010	AB	T	Teno Alto	0	9
618L	N28°33.352	W16°11.257	711	03.04.2010	AB	T	Anaga-East	30	25
619L	N28°33.542	W16°11.091	569	03.04.2010	AB	T	Anaga-East	31	25
620L	N28°32.865	W16°11.151	775	03.04.2010	AB	T	Anaga-East	30	25
621L	N28°32.898	W16°11.203	740	03.04.2010	AB	T	Anaga-East	30	25
622L	N28°20.475	W16°48.140	788	04.04.2010	AB	T	Teno	4	5
623L	N28°20.535	W16°48.371	753	04.04.2010	AB	T	Teno	4	5
624L	N28°20.757	W16°48.371	701	04.04.2010	AB	T	Teno	4	5
625L	N28°20.907	W16°48.407	653	04.04.2010	AB	T	Teno	4	5
626L	N28°20.947	W16°48.188	607	04.04.2010	AB	T	Teno	4	5
627L	N28°20.394	W16°48.307	821	04.04.2010	AB	T	Teno	4	5
628L	N28°20.738	W16°48.787	513	04.04.2010	AB	T	Teno	4	5
629L	N28°20.863	W16°48.776	481	04.04.2010	AB	T	Teno	4	5
630L	N28°19.823	W16°48.409	949	04.04.2010	AB	T	Teno	5	4
631L	N28°20.107	W16°48.418	837	04.04.2010	AB	T	Teno	5	5
632L	N28°20.221	W16°48.520	768	04.04.2010	AB	T	Teno	5	5
633L	N28°20.364	W16°48.607	697	04.04.2010	AB	T	Teno	5	5
634L	N28°20.529	W16°48.614	608	04.04.2010	AB	T	Teno	4	5
635L	N28°20.601	W16°48.751	551	04.04.2010	AB	T	Teno	4	5
636L	N28°10.404	W16°37.213	1700	29.03.2010	MT	T			
637L	N28°33.267	W16°09.591	586	27.03.2010	MT	T	Anaga-East	31	22
638L	N28°33.349	W16°09.624	565	27.03.2010	MT	T	Anaga-East	31	22
639L	N28°33.448	W16°09.573	590	27.03.2010	MT	T	Anaga-East	32	22
640L	N28°33.559	W16°09.612	619	27.03.2010	MT	T	Anaga-East	32	22
641L	N28°21.077	W16°49.640	374	30.03.2010	MT	T	Teno	1	8
642L	N28°20.980	W16°49.666	418	30.03.2010	MT	T	Teno	1	8
643L	N28°20.889	W16°49.717	521	30.03.2010	MT	T	Teno	1	8
644L	N28°20.506	W16°49.814	590	30.03.2010	MT	T	Teno	1	8
645L	N28°20.373	W16°49.839	638	30.03.2010	MT	T	Teno	1	8

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Table 18.1 – continued from previous page

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop. 1	Pop. 2
646L	N28°20.161	W16°49.436	769	30.03.2010	MT	T	Teno	1	8
647L	N28°20.403	W16°49.259	710	30.03.2010	MT	T	Teno	1	8
648L			550	13.03.2010	AS	T			
800L	N27°58.000	W15°36.000	1000	16.01.2010	AS	GC			39
801L	N27°58.000	W15°36.000	400	16.01.2010	AS	GC			39
802L	N27°58.000	W15°36.000	1100	16.01.2010	AS	GC			39
803L	N27°58.000	W15°36.000	1105	16.01.2010	AS	GC			39
804L	N27°58.000	W15°36.000	595	16.01.2010	AS	GC			39
805L	N28°47.299	W17°51.629		23.01.2010	AS	LP			35
806L	N28°47.299	W17°51.629		23.01.2010	AS	LP			35
807L	N28°47.299	W17°51.629	500	24.01.2010	AS	LP			35
808L	N28°47.299	W17°51.629	555	24.01.2010	AS	LP			35
809L	N28°47.299	W17°51.629	500	24.01.2010	AS	LP			35
810L	N28°47.299	W17°51.629		24.01.2010	AS	LP			35
811L	N28°47.299	W17°51.629	1180	19.02.2010	AS	LP			35
812L	N28°47.299	W17°51.629		19.02.2010	AS	LP			35
813L	N28°43.190	W17°46.288	643	2012	MT, DB	LP			35
814L	N28°46.243	W17°46.327	389	2012	MT, DB	LP			35
815L	N28°38.556	W17°49.128	1103	2012	MT, DB	LP			35
816L	N28°49.277	W17°53.816	774	2012	MT, DB	LP			35
817L	N28°47.567	W17°48.084	646	2012	MT, DB	LP			35
818L	N28°05.216	W15°34.295	522	2012	MT, DB	GC			39
819L	N28°02.786	W15°35.277	885	2012	MT, DB	GC			39
820L	N28°04.297	W15°37.412	974	2012	MT, DB	GC			39
821L	N28°03.915	W15°36.576	934	2012	MT, DB	GC			39
822L	N28°05.801	W15°36.260	693	2012	MT, DB	GC			39
823L	N28°04.397	W15°32.774	680	2012	MT, DB	GC			39
824L	N28°01.872	W15°33.558	915	2012	MT, DB	GC			39
825L	N27°45.553	W17°58.929	1103	2012	MT, DB	EH			37
826L	N27°43.850	W18°01.522	1139	2012	MT, DB	EH			37
827L	N27°44.626	W18°06.563	859	2012	MT, DB	EH			37
828L	N27°43.989	W18°04.387	979	2012	MT, DB	EH			37
829L	N27°48.512	W17°55.648	787	2012	MT, DB	EH			37
830L	N28°09.383	W17°09.624	739	2012	MT, DB	LG			36
831L	N28°07.927	W17°11.303	865	2012	MT, DB	LG			36
832L	N28°07.507	W17°12.655	849	2012	MT, DB	LG			36
833L	N28°09.429	W17°14.735	1001	2012	MT, DB	LG			36
834L	N28°08.872	W17°17.147	1006	2012	MT, DB	LG			36
835L	N28°06.860	W17°12.747	1045	2012	MT, DB	LG			36
836L	N28°37.551	W17°48.528	874	2012	MT, DB	LP			35
837L				2012	MT, DB	GC			39
900L	N37°44.653	W25°21.183	522	22.09.2010	AB, MT	AZ			40
901L	N37°48.764	W25°09.731	482	22.09.2010	AB, MT	AZ			40
902L	N37°46.158	W25°29.240	673	22.09.2010	AB, MT	AZ			
903L	N37°51.116	W25°46.588	474	28.09.2010	AB, MT	AZ			40

Islands: T = Tenerife, EH = El Hierro, GC = Gran Canaria, LG = La Gomera, LP = La Palma, AZ = Azores.

Collectors: AB = Anja Betzin, AS = Arnoldo Santos, ARB = Alfredo Reyes-Betancort, DB = Desiree Braun, MT = Mike Thiv, MG = Michaela Grein.

Columns **Pop. 1** and **Pop. 2** refer to the assignment in population-based diversity analysis.

Table 18.2.: Accession List of *Ixanthus*

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop.
001I	N28°34.449	W16°09.814	708	05.01.2010	AB, MT	T	Anaga-East	4
002I	N28°34.304	W16°10.147	606	05.01.2010	AB, MT	T	Anaga-East	4
003I	N28°34.252	W16°10.023	629	05.01.2010	AB, MT	T	Anaga-East	4
004I	N28°34.191	W16°09.824	577	05.01.2010	AB, MT	T	Anaga-East	4
005I	N28°33.699	W16°09.696	626	05.01.2010	AB, MT	T	Anaga-East	4
006I	N28°33.516	W16°09.788	703	05.01.2010	AB, MT	T	Anaga-East	4
007I	N28°33.386	W16°09.908	766	05.01.2010	AB, MT	T	Anaga-East	4
008I	N28°33.407	W16°10.513	804	05.01.2010	AB, MT	T	Anaga-East	

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Table 18.2 – continued from previous page

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop.
009I	N28°33.397	W16°10.656	790	05.01.2010	AB, MT	T	Anaga-East	5
010I	N28°32.806	W16°16.035	661	06.01.2010	AB, MT	T	Anaga-West	7
011I	N28°32.588	W16°16.039	706	06.01.2010	AB, MT	T	Anaga-West	7
012I	N28°32.628	W16°16.201	723	06.01.2010	AB, MT	T	Anaga-West	7
013I	N28°32.692	W16°16.419	714	06.01.2010	AB, MT	T	Anaga-West	
014I	N28°32.350	W16°18.614	768	06.01.2010	AB, MT	T	Anaga-West	
015I	N28°32.485	W16°18.739	713	06.01.2010	AB, MT	T	Anaga-West	9
016I	N28°32.498	W16°19.035	754	06.01.2010	AB, MT	T	Anaga-West	9
017I	N28°32.507	W16°19.169	736	06.01.2010	AB, MT	T	Anaga-West	9
018I	N28°21.928	W16°31.841	817	07.01.2010	AB, MT	T	Valle de Orotava	1
019I	N28°32.119	W16°17.929	855	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
020I	N28°32.182	W16°17.756	846	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
021I	N28°32.157	W16°17.594	839	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
022I	N28°32.027	W16°17.503	830	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
023I	N28°32.167	W16°17.175	839	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
024I	N28°32.087	W16°17.066	854	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
025I	N28°32.001	W16°16.904	848	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
026I	N28°32.046	W16°17.182	841	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
027I	N28°31.986	W16°17.307	843	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
028I	N28°32.448	W16°17.805	643	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
029I	N28°32.432	W16°17.926	752	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	
030I	N28°32.303	W16°18.009	778	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
031I	N28°32.267	W16°18.014	787	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
032I	N28°32.080	W16°17.773	907	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	9
033I	N28°31.900	W16°17.673	901	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	
034I	N28°32.358	W16°16.536	861	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
035I	N28°32.261	W16°16.498	852	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
036I	N28°32.297	W16°16.635	844	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
037I	N28°32.281	W16°16.789	816	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
038I	N28°32.082	W16°16.694	867	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
039I	N28°32.570	W16°16.744	816	08.01.2010	AB, MT, ARB, AS	T	Anaga-West	8
040I	N28°19.743	W16°48.631	1035	09.01.2010	AB, MT	T	Teno	0
041I	N28°19.601	W16°48.792	1005	09.01.2010	AB, MT	T	Teno	0
042I	N28°19.543	W16°48.785	1003	09.01.2010	AB, MT	T	Teno	0
043I	N28°19.560	W16°49.078	895	09.01.2010	AB, MT	T	Teno	0
044I	N28°19.417	W16°48.901	993	09.01.2010	AB, MT	T	Teno	0
045I	N28°19.350	W16°49.002	985	09.01.2010	AB, MT	T	Teno	0
046I	N28°19.390	W16°49.203	968	09.01.2010	AB, MT	T	Teno	0
047I	N28°19.784	W16°49.430	904	09.01.2010	AB, MT	T	Teno	0
048I	N28°20.135	W16°49.591	891	09.01.2010	AB, MT	T	Teno	0
049I	N28°20.161	W16°49.789	873	09.01.2010	AB, MT	T	Teno	0
050I	N28°20.061	W16°49.839	861	09.01.2010	AB, MT	T	Teno	0
051I	N28°20.266	W16°50.105	827	09.01.2010	AB, MT	T	Teno	0
052I	N28°31.966	W16°15.820	991	11.01.2010	AB, MT	T	Anaga-Centre	7
053I	N28°31.935	W16°15.717	977	11.01.2010	AB, MT	T	Anaga-Centre	7
054I	N28°31.745	W16°15.700	903	11.01.2010	AB, MT	T	Anaga-Centre	7
055I	N28°31.600	W16°15.791	800	11.01.2010	AB, MT	T	Anaga-Centre	7
056I	N28°31.636	W16°15.869	734	11.01.2010	AB, MT	T	Anaga-Centre	7
057I	N28°31.866	W16°15.660	923	11.01.2010	AB, MT	T	Anaga-Centre	7
058I	N28°18.410	W16°26.839	950	12.01.2010	AB, MT, ARB, AS	T	South	10
059I	N28°18.420	W16°26.909	944	12.01.2010	AB, MT, ARB, AS	T	South	10
060I	N28°18.485	W16°27.008	944	12.01.2010	AB, MT, ARB, AS	T	South	10
061I				12.01.2010	AB, MT, ARB, AS	T		
062I	N28°32.978	W16°13.700	710	13.01.2010	AB, MT	T	Anaga-Centre	6
063I	N28°32.838	W16°13.694	740	13.01.2010	AB, MT	T	Anaga-Centre	6
064I	N28°32.706	W16°13.989	668	13.01.2010	AB, MT	T	Anaga-Centre	6
065I	N28°32.701	W16°13.847	660	13.01.2010	AB, MT	T	Anaga-Centre	6
066I	N28°32.872	W16°13.912	712	13.01.2010	AB, MT	T	Anaga-Centre	
067I	N28°32.944	W16°13.885	640	13.01.2010	AB, MT	T	Anaga-Centre	6
068I	N28°32.195	W16°14.182	800	13.01.2010	AB, MT	T	Anaga-Centre	6
069I	N28°32.252	W16°14.457	729	13.01.2010	AB, MT	T	Anaga-Centre	6
070I	N28°32.330	W16°14.631	734	13.01.2010	AB, MT	T	Anaga-Centre	6
071I	N28°32.353	W16°13.154	826	13.01.2010	AB, MT	T	Anaga-Centre	6
072I	N28°33.525	W16°10.234	822	13.01.2010	AB, MT	T	Anaga-East	4
073I	N28°33.608	W16°10.273	810	13.01.2010	AB, MT	T	Anaga-East	4
074I	N28°33.744	W16°10.250	805	13.01.2010	AB, MT	T	Anaga-East	4

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Table 18.2 – continued from previous page

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop.
075I	N28°33.733	W16°10.050	822	13.01.2010	AB, MT	T	Anaga-East	4
076I	N28°33.920	W16°09.959	812	13.01.2010	AB, MT	T	Anaga-East	4
077I	N28°34.019	W16°10.141	793	13.01.2010	AB, MT	T	Anaga-East	4
078I	N28°34.184	W16°10.216	772	13.01.2010	AB, MT	T	Anaga-East	4
079I	N28°33.711	W16°10.364	845	13.01.2010	AB, MT	T	Anaga-East	4
080I	N28°33.596	W16°10.404	892	13.01.2010	AB, MT	T	Anaga-East	4
081I	N28°33.304	W16°10.720	769	13.01.2010	AB, MT	T	Anaga-East	5
082I	N28°32.233	W16°16.262	983	14.01.2010	AB, MT	T	Anaga-West	8
083I	N28°32.436	W16°16.256	917	14.01.2010	AB, MT	T	Anaga-West	7
084I	N28°32.486	W16°16.397	905	14.01.2010	AB, MT	T	Anaga-West	7
085I	N28°32.259	W16°16.028	927	14.01.2010	AB, MT	T	Anaga-West	7
086I	N28°32.091	W16°15.921	901	14.01.2010	AB, MT	T	Anaga-Centre	7
087I	N28°31.980	W16°15.593	849	14.01.2010	AB, MT	T	Anaga-Centre	7
088I	N28°32.017	W16°15.190	775	14.01.2010	AB, MT	T	Anaga-Centre	7
089I	N28°31.992	W16°14.944	794	14.01.2010	AB, MT	T	Anaga-Centre	7
090I	N28°32.105	W16°14.653	817	14.01.2010	AB, MT	T	Anaga-Centre	7
091I	N28°32.142	W16°14.293	844	14.01.2010	AB, MT	T	Anaga-Centre	6
092I	N28°32.216	W16°14.155	816	14.01.2010	AB, MT	T	Anaga-Centre	6
093I	N28°32.441	W16°13.696	848	14.01.2010	AB, MT	T	Anaga-Centre	6
094I	N28°32.400	W16°13.461	865	14.01.2010	AB, MT	T	Anaga-Centre	6
095I	N28°32.342	W16°13.185	830	14.01.2010	AB, MT	T	Anaga-Centre	6
096I	N28°32.785	W16°12.953	733	14.01.2010	AB, MT	T	Anaga-Centre	5
097I	N28°32.735	W16°12.496	716	14.01.2010	AB, MT	T	Anaga-East	5
098I	N28°33.025	W16°12.209	692	14.01.2010	AB, MT	T	Anaga-East	5
099I	N28°33.058	W16°11.937	725	14.01.2010	AB, MT	T	Anaga-East	5
100I	N28°33.099	W16°11.683	711	14.01.2010	AB, MT	T	Anaga-East	5
101I	N28°32.996	W16°11.299	763	14.01.2010	AB, MT	T	Anaga-East	5
102I	N28°33.046	W16°10.970	777	14.01.2010	AB, MT	T	Anaga-East	
103I				14.01.2010	AB, MT	T	Anaga-East	
104I	N28°33.227	W16°11.136	801	14.01.2010	AB, MT	T	Anaga-East	5
105I	N28°33.316	W16°10.825	808	14.01.2010	AB, MT	T	Anaga-East	5
106I	N28°24.096	W16°29.394	902	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
107I	N28°24.040	W16°29.131	1007	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
108I	N28°23.983	W16°29.204	1036	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
109I	N28°23.672	W16°29.498	1042	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
110I	N28°23.632	W16°29.551	1044	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
111I	N28°23.646	W16°29.446	1056	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
112I	N28°23.839	W16°29.133	1083	15.01.2010	AB, MT, ARB	T	Monte de la Esperanza	3
113I	N28°20.928	W16°35.303	1160	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
114I	N28°21.106	W16°35.359	1138	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
115I	N28°21.357	W16°35.414	1150	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
116I	N28°21.406	W16°35.565	1168	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
117I	N28°21.580	W16°35.853	1193	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
118I	N28°21.208	W16°35.330	1167	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
119I	N28°22.555	W16°36.324	770	17.01.2010	AB, MT	T	Llanos de Chanajiga	1
120I	N28°26.125	W16°25.828	1021	19.01.2010	AB, MT	T	Monte de la Esperanza	2
121I	N28°26.207	W16°25.802	1020	19.01.2010	AB, MT	T	Monte de la Esperanza	2
122I	N28°25.949	W16°25.499	1077	19.01.2010	AB, MT	T	Monte de la Esperanza	2
123I	N28°26.248	W16°25.417	1004	19.01.2010	AB, MT	T	Monte de la Esperanza	2
124I	N28°26.334	W16°25.559	974	19.01.2010	AB, MT	T	Monte de la Esperanza	2
125I	N28°26.851	W16°23.926	1027	19.01.2010	AB, MT	T	Monte de la Esperanza	2
126I	N28°26.794	W16°23.696	1053	19.01.2010	AB, MT	T	Monte de la Esperanza	2
127I	N28°24.308	W16°28.042	1001	20.01.2010	AB, MT	T	Monte de la Esperanza	2
128I	N28°24.237	W16°28.106	1003	20.01.2010	AB, MT	T	Monte de la Esperanza	2
129I	N28°24.261	W16°28.252	995	20.01.2010	AB, MT	T	Monte de la Esperanza	2
130I	N28°24.149	W16°28.289	985	20.01.2010	AB, MT	T	Monte de la Esperanza	2
131I	N28°24.155	W16°28.491	992	20.01.2010	AB, MT	T	Monte de la Esperanza	3
132I	N28°24.128	W16°28.741	1026	20.01.2010	AB, MT	T	Monte de la Esperanza	3
133I	N28°23.952	W16°28.995	1048	20.01.2010	AB, MT	T	Monte de la Esperanza	3
134I	N28°23.949	W16°28.787	1084	20.01.2010	AB, MT	T	Monte de la Esperanza	3
135I	N28°23.915	W16°28.467	1078	20.01.2010	AB, MT	T	Monte de la Esperanza	3
136I	N28°23.787	W16°28.411	1078	20.01.2010	AB, MT	T	Monte de la Esperanza	3
137I	N28°24.106	W16°28.028	1097	20.01.2010	AB, MT	T	Monte de la Esperanza	
138I	N28°24.276	W16°27.927	1039	20.01.2010	AB, MT	T	Monte de la Esperanza	2
139I	N28°24.386	W16°27.918	988	20.01.2010	AB, MT	T	Monte de la Esperanza	2
140I	N28°24.439	W16°27.786	951	20.01.2010	AB, MT	T	Monte de la Esperanza	2

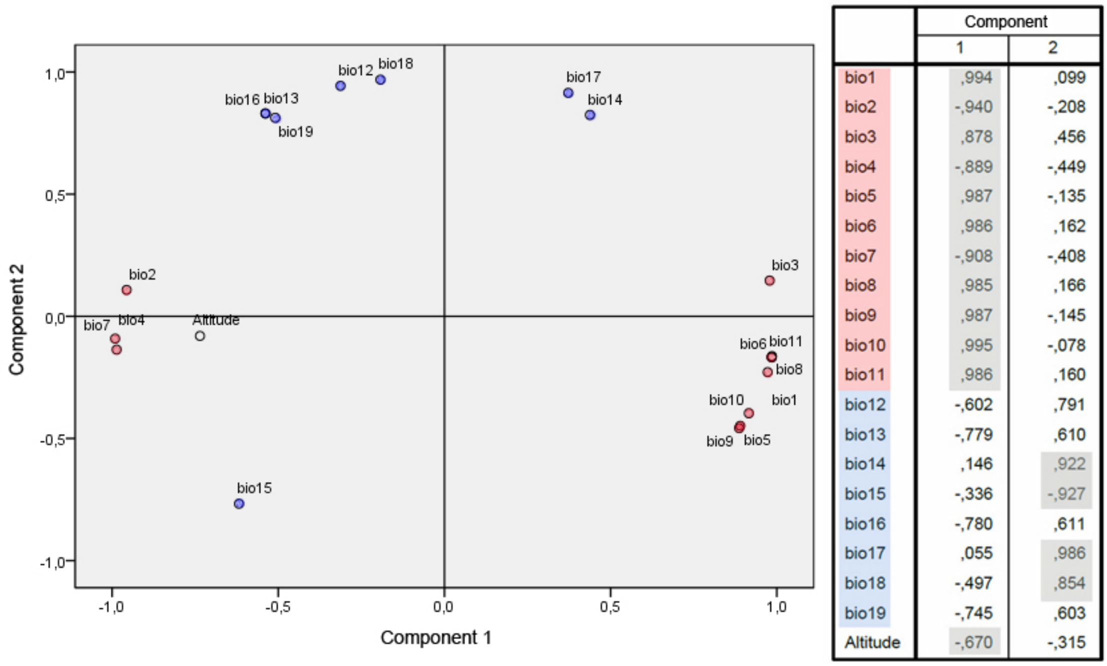
Continued on next page

Table 18.2 – continued from previous page

ID	Pos. North	Pos. West	Alt.	Coll. Date	Collector	Island	Region	Pop.
141I	N28°24.285	W16°27.690	931	20.01.2010	AB, MT	T	Monte de la Esperanza	
142I	N28°24.432	W16°27.425	908	20.01.2010	AB, MT	T	Monte de la Esperanza	2
143I	N28°24.744	W16°27.415	926	20.01.2010	AB, MT	T	Monte de la Esperanza	2
144I	N28°24.742	W16°27.281	944	20.01.2010	AB, MT	T	Monte de la Esperanza	2
145I					AB, MT	T	Monte de la Esperanza	
146I	N28°24.585	W16°27.185	975	20.01.2010	AB, MT	T	Monte de la Esperanza	2
147I	N28°31.524	W16°17.282	762	22.01.2010	AB, MT	T	Anaga-West	8
148I	N28°31.537	W16°17.073	838	22.01.2010	AB, MT	T	Anaga-West	8
149I	N28°31.638	W16°16.920	862	22.01.2010	AB, MT	T	Anaga-West	8
150I	N28°32.110	W16°17.887	910	22.01.2010	AB, MT	T	Anaga-West	9
151I	N28°32.117	W16°18.739	836	22.01.2010	AB, MT	T	Anaga-West	9
152I	N28°31.857	W16°18.066	758	22.01.2010	AB, MT	T	Anaga-West	9
153I	N28°31.868	W16°18.352	684	22.01.2010	AB, MT	T	Anaga-West	9
154I	N28°31.955	W16°18.150	807	22.01.2010	AB, MT	T	Anaga-West	
155I	N28°32.867	W16°12.193	589	22.01.2010	AB, MT	T	Anaga-East	5
156I	N28°33.643	W16°09.967	746	22.01.2010	AB, MT	T	Anaga-East	4
157I	N28°33.336	W16°11.086	832	22.01.2010	AB, MT	T	Anaga-East	5
158I	N28°33.289	W16°11.192	801	22.01.2010	AB, MT	T	Anaga-East	5
159I	N28°33.142	W16°11.416	784	22.01.2010	AB, MT	T	Anaga-East	5
160I	N28°23.751	W16°29.583	952	24.01.2010	AB, MT	T	Monte de la Esperanza	3
161I	N28°23.516	W16°29.613	959	24.01.2010	AB, MT	T	Monte de la Esperanza	3
162I	N28°23.428	W16°29.627	961	24.01.2010	AB, MT	T	Monte de la Esperanza	3
163I	N28°22.660	W16°29.148	988	24.01.2010	AB, MT	T	Monte de la Esperanza	3
164I	N28°32.440	W16°15.979	899	23.03.2010	AB	T	Anaga-West	7
165I	N28°32.877	W16°15.855	714	23.03.2010	AB	T	Anaga-West	7
166I	N28°32.965	W16°15.925	716	23.03.2010	AB	T	Anaga-West	7
167I	N28°32.889	W16°15.808	671	23.03.2010	AB	T	Anaga-West	7
168I	N28°32.586	W16°13.622	857	24.03.2010	AB	T	Anaga-Centre	6
169I	N28°32.706	W16°13.535	761	24.03.2010	AB	T	Anaga-Centre	6
170I	N28°32.802	W16°13.412	597	24.03.2010	AB	T	Anaga-Centre	6
171I	N28°19.661	W16°48.988	887	25.03.2010	AB	T	Teno	
172I	N28°32.356	W16°13.415	873	27.03.2010	AB	T	Anaga-Centre	
173I	N28°32.388	W16°18.682	767	27.03.2010	AB	T	Anaga-West	9
174I	N28°32.410	W16°18.472	755	27.03.2010	AB	T	Anaga-West	
175I	N28°20.744	W16°47.735	793	28.03.2010	MG	T	Teno	0
176I	N28°20.639	W16°51.704	822	29.03.2010	AB	T	Teno	0
177I	N28°20.761	W16°51.701	765	29.03.2010	AB	T	Teno	0
178I	N28°33.525	W16°11.085	577	03.04.2010	AB	T	Anaga-East	5
179I	N28°33.351	W16°11.256	711	03.04.2010	AB	T	Anaga-East	5
180I	N28°20.474	W16°48.141	786	04.04.2010	AB	T	Teno	0
181I			550	13.03.2010	AS	T	Anaga-West	
300I			500	24.01.2010	AS	LP	other islands	13
301I			555	24.01.2010	AS	LP	other islands	13
302I	N28°47.299	W17°51.629	1180	19.02.2010	AS	LP	other islands	13
303I				19.02.2010	AS	LP	other islands	13
304I	N28°46.031	W17°46.686	473	2012	MT, DB	LP	other islands	13
305I	N28°49.273	W17°53.824	766	2012	MT, DB	LP	other islands	
306I	N28°38.448	W17°49.070	1109	2012	MT, DB	LP	other islands	13
307I	N28°47.438	W17°48.122	541	2012	MT, DB	LP	other islands	
308I	N27°45.416	W17°59.026	1034	2012	MT, DB	EH	other islands	14
309I	N27°44.630	W18°06.570	858	2012	MT, DB	EH	other islands	14
310I	N27°44.155	W18°05.126	920	2012	MT, DB	EH	other islands	14
311I	N28°09.386	W17°09.765	710	2012	MT, DB	LG	other islands	12
312I	N28°07.928	W17°11.290	868	2012	MT, DB	LG	other islands	12
313I	N28°07.508	W17°12.395	924	2012	MT, DB	LG	other islands	12
314I	N28°08.748	W17°17.174	1058	2012	MT, DB	LG	other islands	12
315I	N28°07.771	W17°15.284	1213	2012	MT, DB	LG	other islands	12
316I	N28°04.394	W15°32.863	686	2012	MT, DB	GC	other islands	11
317I				2012	MT, DB	GC	other islands	11

Islands: T = Tenerife, EH = El Hierro, GC = Gran Canaria, LG = La Gomera, LP = La Palma, AZ = Azores.
Collectors: AB = Anja Betzin, AS = Arnoldo Santos, ARB = Alfredo Reyes-Betancort, DB = Desiree Braun, MT = Mike Thiv, MG = Michaela Grein.
Columns **Pop. 1** and **Pop. 2** refer to the assignment in population-based diversity analysis.

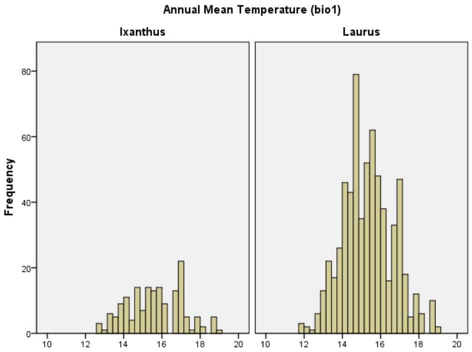
19. Appendix B — Supplementary Material

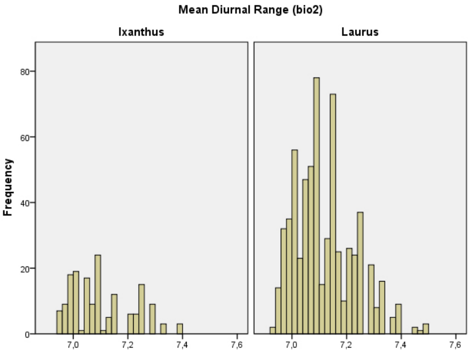


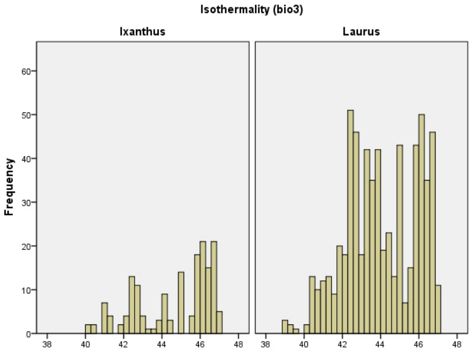
	Component	
	1	2
bio1	,994	,099
bio2	-,940	-,208
bio3	,878	,456
bio4	-,889	-,449
bio5	,987	-,135
bio6	,986	,162
bio7	-,908	-,408
bio8	,985	,166
bio9	,987	-,145
bio10	,995	-,078
bio11	,986	,160
bio12	-,602	,791
bio13	-,779	,610
bio14	,146	,922
bio15	-,336	-,927
bio16	-,780	,611
bio17	,055	,986
bio18	-,497	,854
bio19	-,745	,603
Altitude	-,670	-,315

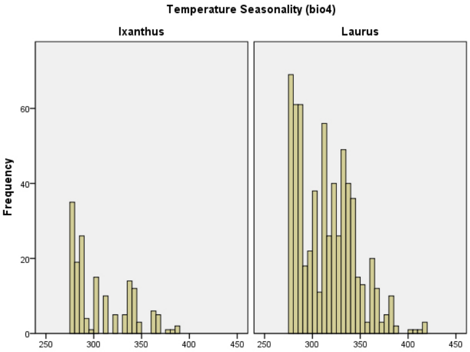
Figure 19.1.: Rotation diagram of *Laurus* principal coordinate analysis for bioclimatic parameters

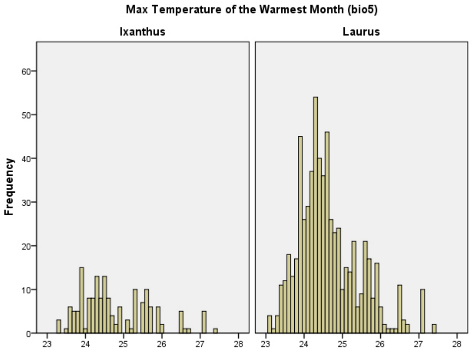
The diagram shows the factor loadings for the two main coordinates for temperature (red highlighted), precipitation (blue highlighted) depended parameters and altitude. Bioclim parameters 1 to 11 (temperature) are contributing to coordinate 1, Bioclim 12 to 19 (precipitation) prevailingly to coordinate 2 or both equally, as altitude, too.

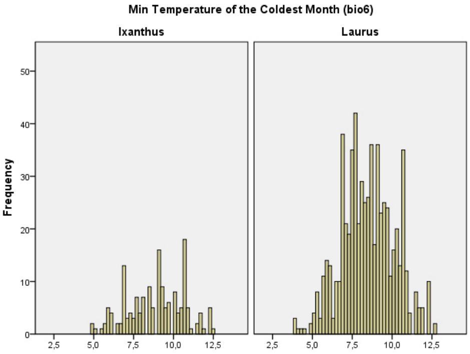

Annual Mean Temperature (bio1)
Ixanthus
Laurus
Frequency
0
20
40
60
80
10
12
14
16
18
20

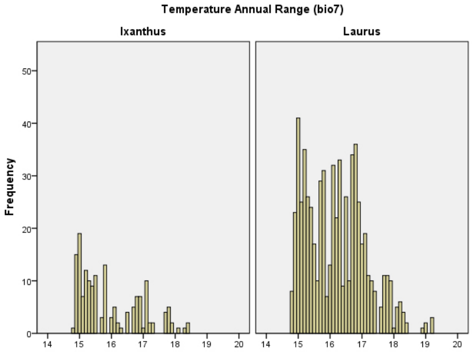

Mean Diurnal Range (bio2)
Ixanthus
Laurus
Frequency
0
20
40
60
80
7,0
7,2
7,4
7,6

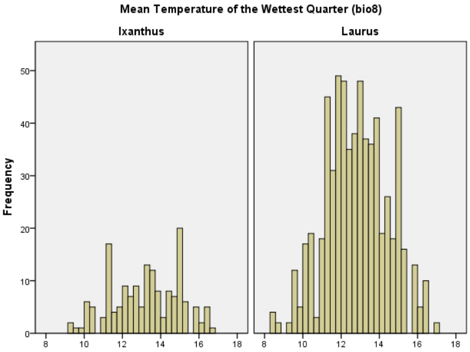

Isothermality (bio3)
Ixanthus
Laurus
Frequency
0
10
20
30
40
50
60
38
40
42
44
46
48

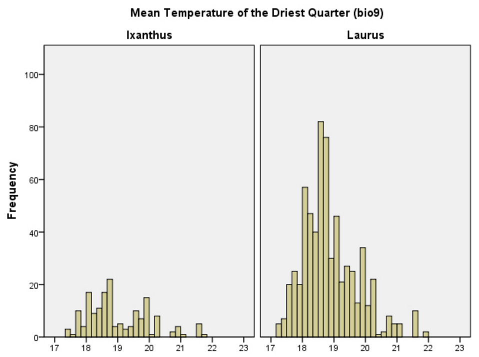

Temperature Seasonality (bio4)
Ixanthus
Laurus
Frequency
0
20
40
60
250
300
350
400
450

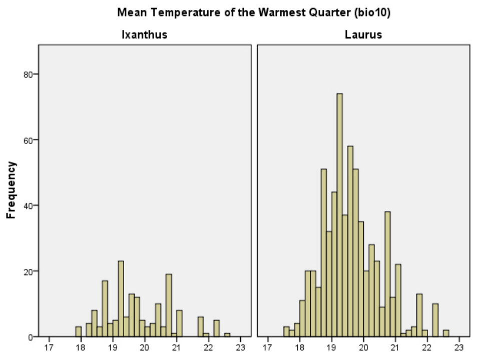

Max Temperature of the Warmest Month (bio5)
Ixanthus
Laurus
Frequency
0
10
20
30
40
50
60
23
24
25
26
27
28

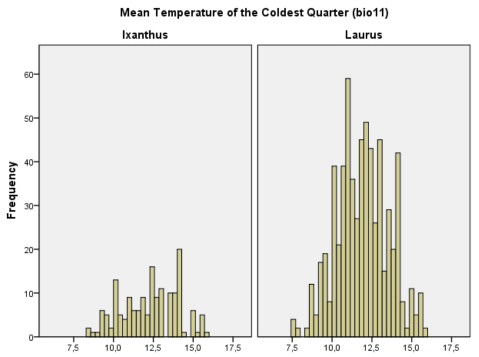

Min Temperature of the Coldest Month (bio6)
Ixanthus
Laurus
Frequency
0
10
20
30
40
50
2,5
5,0
7,5
10,0
12,5

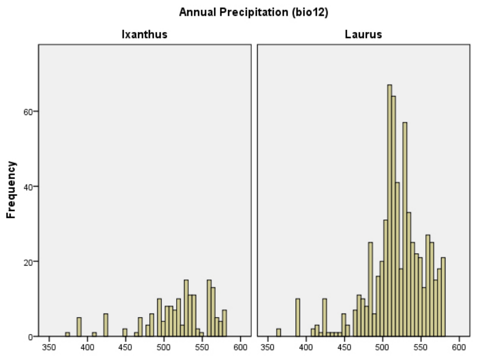

Temperature Annual Range (bio7)
Ixanthus
Laurus
Frequency
0
10
20
30
40
50
14
15
16
17
18
19
20

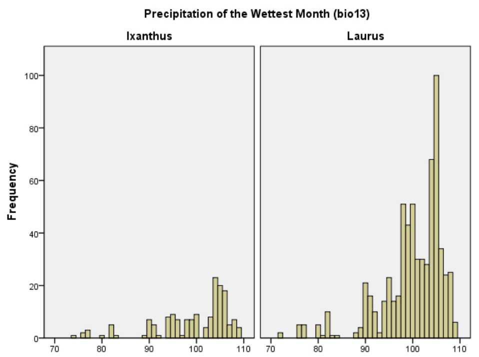

Mean Temperature of the Wettest Quarter (bio8)
Ixanthus
Laurus
Frequency
0
10
20
30
40
50
8
10
12
14
16
18

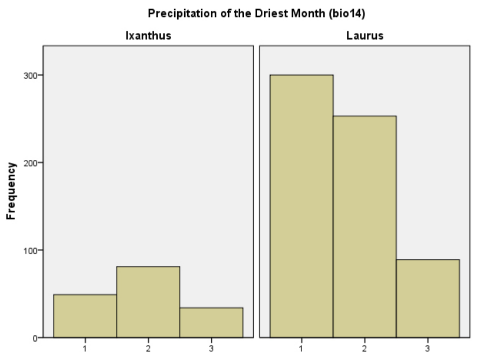

Mean Temperature of the Driest Quarter (bio9)

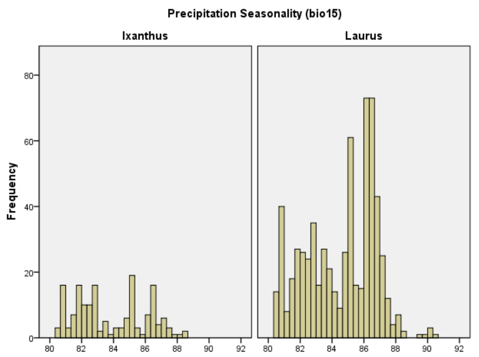

Mean Temperature of the Warmest Quarter (bio10)

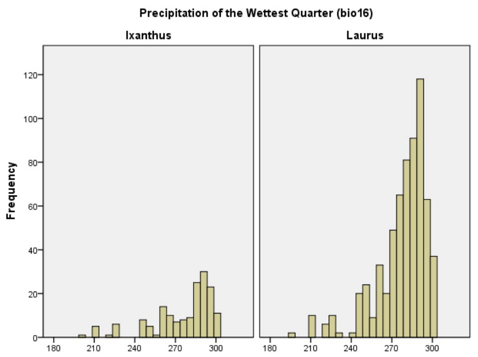

Mean Temperature of the Coldest Quarter (bio11)


Annual Precipitation (bio12)


Precipitation of the Wettest Month (bio13)


Precipitation of the Driest Month (bio14)


Precipitation Seasonality (bio15)


Precipitation of the Wettest Quarter (bio16)

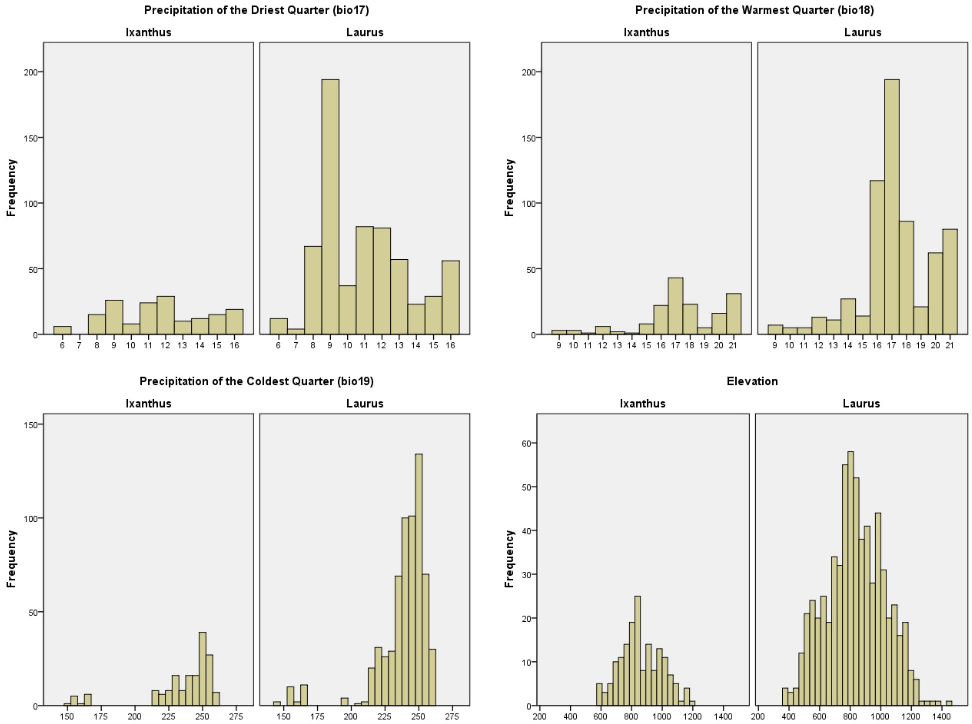


Figure 19.2.: Bioclimatic values frequencies
(continued)
Comparison of the frequencies for all 19 bioclimatic values (1–11: temperature-dependent values, 12–19: precipitation-dependent values) and elevation for all collected *Laurus* and *Ixanthus* accessions. For subsumed results see also table 12.4.

20. Appendix C — Supplementary Material on CD

Thesis.pdf

Accession lists.xlsx

AFLP binary matrices.xlsx

Pairwise Fst.txt

21. Acknowledgements

No PhD thesis is the work of one person alone, therefore I'd like to express my gratitude to all who were involved in this work.

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