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Bioclimatology and climatophilous vegetation of Tenerife (Canary Islands)

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A bioclimatic study of Tenerife, supported and clarified by PCA and DCA analyses, was performed in order to map the bioclimates, ombrotypes, thermotypes, bioclimatic belts and climatophilous vegetation series. Commentaries and synoptic tables of the terminal communities of each climatophilous series are given. A new map of the potential natural vegetation shows significant differences from the climatophilous series map, mainly due to salic substrates and recent lava flows.

Key words: bioclimatology, Canary Islands, phytosociology, syntaxonomy, Tenerife, vegetation analysis

Introduction

This paper attempts to establish the relation between the bioclimatic belts and climatophilous vegetation series of Tenerife, and also to explain their edaphophilous behaviour where it occurs and the concurrence of other edaphophilous communities in shaping the potential natural vegetation map of the island. This is one of a series of papers dealing with the bioclimatology and vegetation of the Canary Islands: Tenerife (Rivas-Martínez *et al*. 1993a), Hierro and La Palma (Del-Arco *et al*. 1996, 1999a), Gran Canaria (Del-Arco 2002), Lanzarote (Reyes-Betancort *et al*. 2001), and Fuerteventura (Rodríguez-Delgado *et al*. 2005).

An overall phytosociological survey of the vegetation of Tenerife was first approached by Oberdorfer (1965) and Rivas-Martínez *et al*. (1993b). The latter also included a preliminary bioclimatological study, which is here extended and revised using data from 85 meteorological stations (Fig. 1), to differentiate 26 bioclimatic belts and correlate them with the climatophilous vegetation series and potential natural vegetation of the island.

Study site

Tenerife is situated 28°35´15´´–27°59´59´´N and 16°5´27´´–16°55´4´´W, near the centre of the Canary archipelago, off the African continent. It is the largest and highest island, with a surface area of 2034 km^2 and rising to 3718 m a.s.l. near

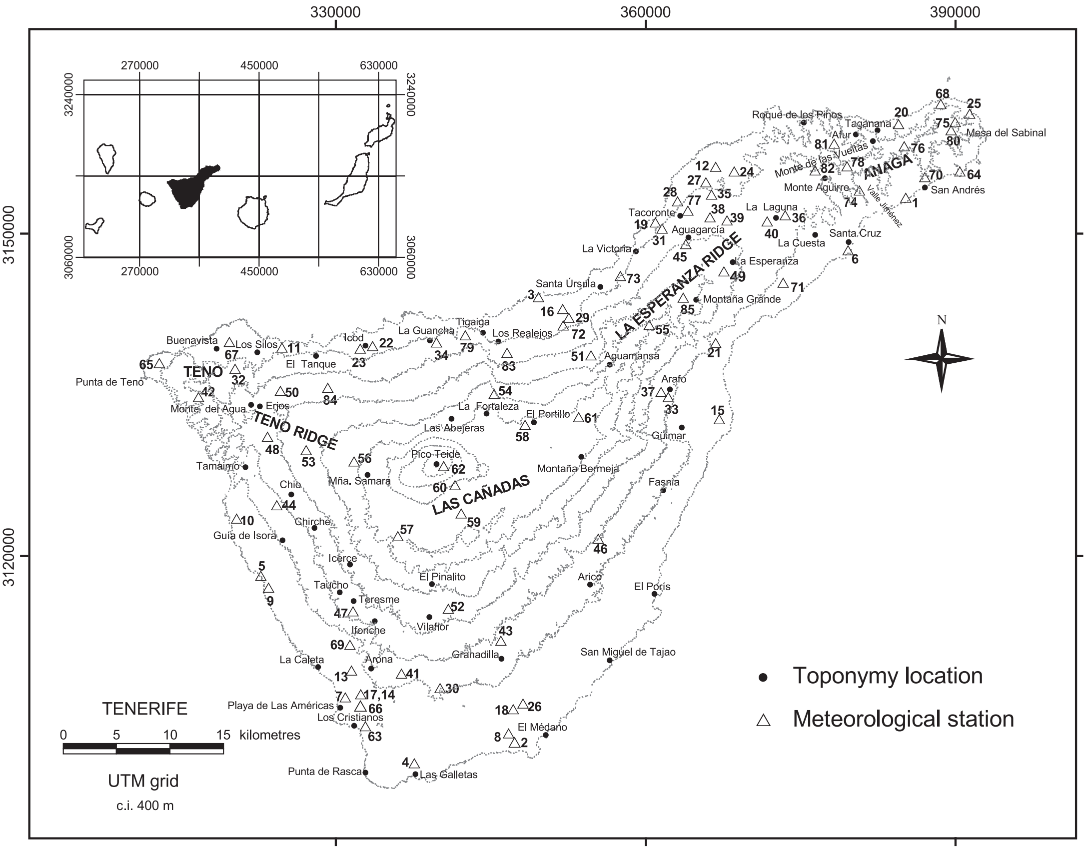


Fig. 1. Toponymic map and location of meteorological stations on Tenerife.

its centre (Pico Teide). It has a more or less triangular shape stretched out to the NE in the Anaga Peninsula, and its main axes are 80 km (NE–SW) between Anaga (NE) and Punta de Rasca (S) and 40 km between the latter and Punta de Teno (NW). It resembles a truncated tetrahedron, with Las Cañadas circus and the dormant volcanic cone of Mt. Teide resting on top, from where three main ridges descend (Teno ridge NW–SE, La Esperanza ridge NE–SW, south ridge N–S), with steep slopes scored with many deep ravines. In the NE, Anaga massif constitutes an independent edifice, with a NE–SW ridge and N and S slopes cut with numerous deep radial ravines (Afonso *et al.* 1988, Del-Arco *et al.* 1996, Afonso 1997, Morales & Pérez 2000).

Like the rest of the Canaries, Tenerife is a volcanic oceanic island, whose oldest datings range between 6.5 and 11.6 Ma (Ancochea *et al.* 1990). The N coast is the steepest, with its highest cliffs in Teno massif (in the NW) and Anaga, sometimes reaching up to 500 m. A few sandy beaches are to be found mainly at the ravine mouths, others are formed of pebbles or black basaltic shingle; in the south only, there are some light-coloured sand beaches formed basically by disintegration of salic materials like trachytic and phonolithic pyroclasts and ash flows (Los Cristianos, El Médano, etc.). The oldest parts of the island are the basaltic massifs of Anaga (NE), Teno (NW) and some territories in Adeje (SW), where materials of the first volcanic cycle (Miocene) are dominant, showing a high degree of erosion. The rest of the island has been covered with diverse basaltic and salic volcanic emissions over the old island core. The salic strata are predominant in the south (Afonso *et al.* 1988). The island is subject to a trade-wind regime generating clouds over its N half (Ceballos & Ortuño 1951, Huetz de Lemps 1969, Marzol-Jaén 1988).

The current vascular plant flora has a high degree of Canary endemism (over 26%), though the Mediterranean influence is dominant (LaRoche & Rodríguez-Piñero 1994, Wells & Lindacher 1994, Marrero & Pérez de Paz 1998, Izquierdo *et al*. 2001). The different zonal vegetation belts of the island, in order of altitude, are: *Euphorbia* scrub, African Rand Flora origin, juniper woodland, Mediterranean origin, evergreen laurel forest (only on the trade-wind facing slopes), Thetian-Tertiary origin, pine woodland, Mediterranean origin, and summit broom scrub, Mediterranean North African affinity (Wildpret & Del-Arco 1987, Del-Arco & Rodríguez-Delgado 1999). From a biogeographical point of view, Tenerife is a sector of the Western Canary Province, Canary subregion, Mediterranean region (Rivas-Martínez *et al*. 1993a).

Material and methods

Data and bioclimatic classification system

The data from 59 thermopluviometric meteorological stations, 3 temperature stations, and 23 additional pluviometric stations operated by the National Meteorological Institute (Table 1) were used in this bioclimatic study. Thermopluviometric diagrams were drawn for some stations selected as representative of the different bioclimatic combinations (Fig. 2).

According to the World Bioclimatic Classification System (Rivas-Martínez 1995), the Canary Islands fit within the Mediterranean macrobioclimate, which is an extratropical macrobioclimate characterized, among other features, by aridity (P < 2T) for at least two months after the summer solstice. Only three of its seven constituent bioclimates can be recognized in the Canary Islands: oceanic-desertic, oceanic-xeric and oceanic-pluviseasonal. Ic (Continentality index), Io (Ombrothermic index) and P > 2T ratio are used to define them. This classification provides a basis for establishing the bioclimatic belts of any territory by using a combination of thermotype, bioclimate and ombrotype.

Thermotypes are the spaces within an Itc (Compensated thermicity index) gradient. Ombrotypes are the spaces within an Io gradient. Bioclimatic belts are defined as the successive types or groups of physical media along an altitudinal or latitudinal cliseries. They are not the same as vegetation belts, which are the plant community complexes or vegetation series in steps up an altitudinal cliseries.

In addition to the above combination used in the bioclimatic formula, we include the presence or absence of clouds (Peinado *et al*. 1997, Del-Arco *et al*. 1999a, 2002) to refine the characterization of bioclimatic belts. This allows apparently similar belts on north-facing slopes under the influence of trade-wind clouds to be differentiated from those on dry south-facing slopes.

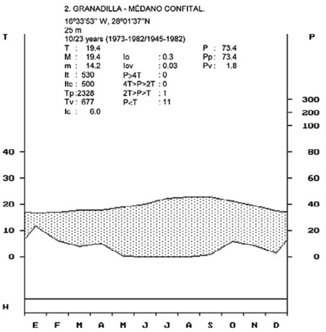
A few simple indices are used to establish thermotypes, bioclimates and ombrotypes. Itc, used to establish thermotypes, is defined as follows: Itc = It ± C, given that It (thermicity index) = $(T + M + m) \times 10$, where T = mean annual temperature, and M and m are the mean maximum and minimum temperatures in the coldest month. C is the compensation value: when the Continentality index (Ic = difference between mean temperatures of the warmest and coldest months of the year) is smaller than 9 (oceanic) or greater than 18 (continental), a compensation value (C) is respectively subtracted from or added to the It value to obtain Itc. This value is used in the extratropical territories of the Earth (north of 27°N and south of 27°S) to compensate for the extra winter cold of highly continental territories or the extra winter warmth in highly oceanic ones, so that the resulting compensated thermicity index (Itc) is comparable all around the Earth. In the territory studied, only compensations for values of C smaller than 9 are needed. This compensation value is obtained from: C = (9.0 – Ic) × 10.

Io, used to establish bioclimates and ombrotypes, is defined as follows: Io = (Pp/Tp) × 10, where Pp (Positive rainfall) is the annual rainfall in mm, taking into account only the months with mean temperature higher than 0 °C. Since this is the case for all the thermopluviometric weather stations on the island, Pp has the same value as P; Tp (Positive temperature) is the value in tenths of degrees resulting from the sum of the mean temperatures of the months with a mean higher than 0 °C. Io is one of the indices that best fit the altitudinal limits of the vegeta-

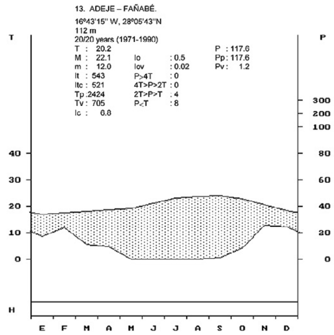
Table 1. Climatic and bioclimatic data from the 59 thermopluviometric (1–2, 4–59, 61), 3 thermometric (3, 60, 62) and 23 (63–85) pluviometric studied stations (Tenerife). *T* = mean annual temperature (°C); *M* = mean maximum temperature of the coldest month; *m* = mean minimum temperature of the coldest month; It = thermicity index; Ic = continentality index; Itc = compensated thermicity index; Tp = positive temperature; Tv = summer temperature; P = annual rainfall in mm; Pp = positive rainfall; Pv = summer rainfall; P > 4T = months in which the rainfall value (in mm) is greater than four times the temperature value (°C); 4T > P > 2T = months in which the rainfall value is between twice and four times the temperature value; 2T > P > T = months in which the rainfall value is greater than temperature value but smaller than two times this value; P < T = months in which the rainfall value is smaller than the temperature value; Io = ombrothermic index; Iov = summer ombrothermic index; Mist = area with trade-wind clouds; B.B. and V.S.: bioclimatic belt and vegetation series according to Table 5; Period and years T-P: recording period and the number of available annual data of T and P (in parentheses). R.S.: reference stations. Numbers set in italics (missing thermometric data for rainfall stations and vice versa) were obtained by extrapolation from the appropriate gradients (column R.S.: reference stations). Source: National Meteorological Institute (Spain).

No.	Station	Height	*T*	*M*	*m*	It	Ic	Itc	Tp	Tv	Pp	Pv	P > 4T	4T > P > 2T	2T > P > T	P < T	Io	Iov	Mist	B. B.	V.S.	Years T-P	R.S.
1	Anaga-San Andrés	20	20.6	20.6	14.3	555	6.9	534	2472	719	251.9	9.6	–	4	1	7	1.0	0.13	–	3	2	1960–1996(35)/1959–2002(41)	
2	Granadilla-Médano Confital	25	19.4	19.4	14.2	530	6.0	500	2328	677	73.4	1.8	–	–	1	11	0.3	0.03	–	1	1	1973–1982(10)/1945–1982(23)	
3	Puerto Cruz-Ayuntamiento	25	19.5	19.6	13.0	521	6.5	496	2340	673	*301.8*	*8.2*	–	–	–	–	*1.3*	*0.12*	–	3	2	1944–2000(18)	11–16
4	Arona-Galletas Fraile Nuevo	30	19.2	19.4	13.5	521	6.0	491	2304	661	73.8	0.7	–	–	1	11	0.3	0.01	–	1	1	1974–1982(9)/1975–1982(8)	
5	Guía de Isora-Playa San Juán	30	20.6	21.2	13.9	557	6.1	528	2472	702	123.7	2.7	–	1	1	10	0.5	0.04	–	2	1	1970–2000(21)/1986–2002(17)	
6	Santa Cruz de Tenerife	36	21.0	20.7	14.8	565	7.2	547	2520	738	236.4	5.7	–	2	4	6	0.9	0.08	–	2	1	1930–2002(73)/1930–2002(73)	
7	Adeje-Playa Américas	40	22.0	22.9	15.5	604	6.2	576	2640	745	87.8	1.9	–	–	1	11	0.3	0.03	–	1	1	1986–2000(15)/1986–1999(15)	
8	Reina Sofia Aeropuerto Tfe S	64	21.3	21.6	15.2	581	6.3	554	2556	729	114.1	3.4	–	–	2	10	0.4	0.05	–	2	1	1980–2002(23)/1980–2002(23)	
9	Guía de Isora-Alcalá Chiquita	70	19.1	18.8	13.8	517	6.2	489	2292	659	47.4	0.0	–	–	–	12	0.2	0.00	–	1	1	1974–1982(9)/1975–1982(8)	
10	Guía de Isora-Cueva Polvo	80	20.1	20.6	15.0	557	5.0	517	2412	677	131.6	3.8	–	1	2	9	0.5	0.06	–	2	1	1991–1999(9)/1990–1999(10)	
11	Silos	95	19.4	20.8	13.1	533	5.9	502	2328	672	339.3	8.2	1	3	3	5	1.5	0.12	–	4	3	1961–2000(29)/1947–2002(32)	
12	Valle Guerra-Pajalillos	110	19.6	20.4	13.3	533	6.2	505	2352	677	357.5	18.7	1	4	2	5	1.5	0.28	–	4	3	1974–1999(25)/1945–1999(35)	
13	Adeje-Fañábé	112	20.2	22.1	12.0	543	6.8	521	2424	705	117.6	1.2	–	–	4	8	0.5	0.02	–	2	1	1971–1990(20)/1971–1990(20)	
14	Adeje-Caldera A	115	20.4	21.4	13.2	550	6.7	527	2448	710	134.4	4.1	–	1	3	8	0.5	0.06	–	2	1	1975–2000(15)/1989–2000(14)	
15	Güímar-Planta	120	19.6	20.4	13.0	530	6.4	504	2352	687	162.3	4.6	–	–	4	8	0.7	0.07	–	2	1	1974–1999(26)/1972–2000(29)	
16	Puerto Cruz-Paz-Botánico	120	19.2	20.6	12.6	524	5.8	492	2304	661	352.7	11.4	1	3	3	5	1.5	0.17	–	4	3	1951–1999(39)/1944–2000(50)	
17	Adeje-Caldera B	135	19.5	22.1	10.0	516	7.7	503	2340	700	157.0	4.6	–	2	2	8	0.7	0.07	–	2	1	1975–2000(15)/1988–2002(15)	
18	Arona-Casa Blanca	170	19.4	19.9	13.5	528	7.2	510	2328	698	111.0	1.9	–	–	2	10	0.5	0.03	–	2	1	1974–1982(9)/1974–1982(9)	
19	Sauzal-Ángeles	200	19.4	20.2	13.4	530	6.9	509	2328	779	404.3	28.7	–	5	2	5	1.7	0.37	–	4	3	1983–1991(9)/1982–1989(8)	
20	Anaga-Taganana Azanos	220	19.6	18.4	14.9	529	6.7	506	2352	678	348.5	14.3	–	4	3	5	1.5	0.21	–	4	3	1985–2000(16)/1984–2002(19)	
21	Candelaria-Igueste	220	20.5	20.2	15.0	557	6.6	533	2460	732	315.6	11.8	1	2	3	6	1.3	0.16	–	3	2	1987–1994(8)/1987–1991(5)	
22	Icod A	230	18.2	19.5	11.0	487	6.4	461	2184	638	432.2	17.1	2	4	1	5	2.0	0.27	–	4	3	1946–1980(27)/1944–1980(30)	
23	Icod B	230	18.8	19.2	15.5	535	6.9	514	2256	656	436.6	12.8	2	4	1	5	1.9	0.20	–	4	3	1931–1965(27)/1930–1980(30)	
24	Laguna-Tejina Pico	232	19.1	19.3	13.3	517	6.7	494	2292	661	383.9	14.5	–	5	2	5	1.7	0.22	–	4	3	1990–1998(9)/1945–1999(37)	
25	Anaga-Faro	235	19.0	18.4	13.5	509	6.3	482	2280	651	325.3	15.2	–	4	3	5	1.4	0.23	–	3	2	1945–2000(28)/1945–2002(50)	
26	Granadilla-San Isidro Salones	255	18.8	20.0	12.2	510	7.3	493	2256	679	133.2	1.2	–	–	3	9	0.6	0.02	–	2	1	1974–1982(9)/1945–1982(19)	
27	Valle Guerra-Isamar	295	18.3	18.5	13.0	498	6.3	471	2196	637	437.0	25.5	1	5	1	5	2.0	0.40	–	4	3	1963–1999(27)/1970–2000(31)	
28	Tacoronte-A S.E.A.	327	17.9	18.2	11.6	477	6.4	451	2148	628	424.3	25.3	2	4	1	5	2.0	0.40	–	4	3	1962–2000(33)/1962–2002(35)	
29	Orotava	335	17.7	18.8	10.7	472	6.2	444	2124	605	434.7	18.6	2	5	1	4	2.0	0.31	+	9	4	1972–1987(16)/1972–1987(16)	
30	Arona-Valle San Lorenzo Jama	435	19.3	19.2	11.8	503	7.5	488	2316	675	197.5	7.7	–	1	4	7	0.9	0.11	–	2	1	1982–2000(19)/1982–2002(21)	
31	Sauzal	455	17.5	18.7	10.6	468	6.4	442	2100	622	462.1	27.1	2	5	1	4	2.2	0.44	+	10	4	1953–1983(21)/1945–1983(23)	
32	Buenavista-Palmar	470	15.6	15.7	9.4	407	8.8	405	1872	608	486.8	10.7	4	2	1	5	2.6	0.18	+	10	4	1986–1994(9)/1983–1993(11)	
33	Arafo	485	17.3	17.0	8.9	432	9.1	432	2076	640	298.4	9.1	2	2	3	5	1.4	0.14	–	7	3	1944–1977(16)/1944–2002(52)	
34	Guancha-Asomada	500	16.0	17.4	9.2	426	6.1	397	1920	566	517.1	24.6	4	3	1	4	2.7	0.43	+	10	4	1945–2000(45)/1958–2002(45)	
35	Valle Guerra-Garimba	500	16.6	16.4	11.0	440	6.7	417	1992	598	476.2	31.0	2	5	2	3	2.4	0.52	+	10	4	1974–1999(25)/1974–1999(26)	

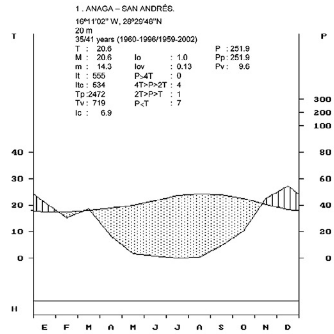
36	Laguna-Instituto	560	16.0	15.7	8.8	405	8.5	400	1920	600	522.2	20.9	5	2	1	4	2.7	0.35	+	10	4	1930–1996(39)/1930–2002(52)	
37	Arafo-Añavingo	565	17.9	17.3	10.3	455	8.8	453	2148	666	361.6	10.5	3	1	3	5	1.7	0.16	–	4	3	1975–1998(24)/1975–2000(25)	
38	Tacoronte-Naranjeros	585	16.2	15.9	9.1	412	7.9	401	1944	597	726.2	36.9	6	1	2	3	3.7	0.62	+	12	5	1953–1999(24)/1972–2002(36)	
39	Laguna-Guamasa	610	16.3	18.3	7.8	424	6.8	402	1956	587	727.4	49.7	5	3	2	2	3.7	0.85	+	12	5	1959–1979(21)/1966–1979(34)	
40	Rodeos Aeropuerto Tfe N	617	16.0	15.6	9.6	412	7.6	398	1920	591	589.6	33.8	5	2	2	3	3.1	0.57	+	12	5	1944–2002(59)/1951–2002(52)	
41	Arona	620	18.1	18.5	11.4	480	7.6	466	2172	654	199.7	11.1	..	1	6	5	0.9	0.17	–	2	1	1988–2000(13)/1974–1982(24)	
42	Buenavista-Carrizal	660	17.6	17.1	11.2	459	8.6	455	2112	662	521.8	16.5	3	3	2	4	2.5	0.25	–	5	3	1985–1998(13)/1985–2001(17)	
43	Granadilla	690	16.8	17.2	8.9	429	8.9	428	2016	639	246.3	15.7	1	3	2	6	1.2	0.25	–	7	3	1944–1979(17)/1944–2001(36)	
44	Guía de Isora-Chío C.F.	715	17.6	17.3	9.9	448	8.6	444	2112	653	270.8	4.5	1	3	2	6	1.3	0.07	–	7	3	1977–2000(20)/1945–2001(36)	
45	Tacoronte-Aguagarcía C.F.	798	14.1	13.8	6.3	342	8.9	341	1692	558	740.3	40.3	7	1	2	2	4.4	0.72	+	12	5	1975–1994(15)/1975–1997(22)	
46	Arico Bueno A	830	15.3	14.4	8.6	383	10.0	383	1836	603	245.8	15.1	1	3	4	4	1.3	0.25	–	7	3	1988–2000(13)/1984–2002(19)	
47	Adeje-Taucho	910	15.9	15.2	8.7	398	10.7	398	1908	644	262.2	10.0	1	3	2	6	1.4	0.16	–	7	3	1986–2000(15)/1983–2002(20)	
48	Santiago del Teide	940	16.1	14.8	6.4	373	12.6	373	1932	658	552.3	6.1	5	2	–	5	2.9	0.09	–	13	6	1989–2000(12)/1945–2002(41)	
49	Esperanza-Casa Forestal	965	14.3	13.2	6.0	335	11.7	335	1716	604	839.1	39.1	7	1	1	3	4.9	0.65	+	18	5	1985–2000(16)/1959–1996(30)	
50	Tanque-Erjos C.F.	1010	14.2	13.8	7.1	351	9.3	351	1704	562	672.6	21.3	6	2	–	4	3.9	0.38	+	18	5	1983–2000(12)/1972–2002(21)	
51	Orotava-Aguamansa C.F.	1080	13.9	13.9	5.6	334	9.0	334	1668	540	785.8	26.6	6	2	1	3	4.7	0.49	+	18	5	1959–2000(27)/1948–2001(43)	
52	Vilaflor	1378	15.0	13.6	5.4	340	13.3	340	1800	650	401.6	9.1	4	3	–	5	2.2	0.14	–	17	6	1944–2000(34)/1945–2002(50)	
53	Santiago del Teide-Chinyero	1475	14.6	12.8	3.8	312	14.8	312	1752	646	418.8	4.5	4	2	1	5	2.4	0.07	–	17	6	1985–2000(16)/1985–2001(17)	
54	Realejos-Piedra Pastores	1610	11.6	10.9	3.6	261	13.6	261	1392	579	562.4	17.4	7	–	1	4	4.0	0.30	–	22	6	1985–1994(10)/1985–1995(11)	
55	Victoria-Gaitero	1747	12.6	10.7	4.4	277	13.2	277	1512	573	914.2	59.9	8	2	–	2	6.0	1.05	–	23	6	1985–2000(16)/1985–1997(12)	
56	Guía de Isora-Samara	1900	11.1	10.8	1.0	229	15.1	229	1332	582	476.0	6.9	5	2	–	5	3.6	0.12	–	22	6	1986–2000(15)/1985–2002(18)	
57	Cañadas-Boca Tauce A	2030	12.2	11.3	1.0	245	13.7	245	1464	559	405.0	7.3	5	2	–	5	2.8	0.13	–	21	6	1985–2000(16)/1985–2002(18)	
58	Realejos C.V. (T)/Portillo (P)	2050/2118	10.6	9.1	–0.7	190	14.8	190	1272	527	335.8	11.4	6	1	–	5	2.6	0.22	–	24	7	1986–2000(12)/1971–2002(32)	
59	Cañadas-Parador	2160	11.4	11.7	–0.5	226	13.7	226	1368	539	349.4	7.2	5	1	–	6	2.6	0.13	–	21	6	1985–2000(16)/1983–2002(20)	
60	Cañadas-Base Teide Teleférico	2345	12.7	11.8	2.1	266	13.0	266	1524	568	349.4	7.2	–	–	–	–	2.3	0.13	–	21	6	1990–2000(11)	59
61	Izaña	2371	9.6	7.4	0.9	179	13.6	179	1152	496	460.4	17.5	6	1	2	3	4.0	0.35	–	25	7	1930–2001(72)/1930–2001(72)	
62	Cañadas-Pico Teide	3530	3.5	1.3	–5.6	–8	8.5	–13	477	277	95.2	7.2	–	–	–	–	2.0	0.25	–	26	7	1989–2000(12)	59
63	Arona-Cristianos	20	22.1	23	15.6	607	6.1	578	2652	748	82.6	1.6	–	–	–	–	0.3	0.02	–	1	1	1966–2002(27)	7–41
64	Anaga-Igueste	60	20.8	20.4	14.6	558	7	538	2496	727	263.4	6.8	–	–	–	–	1.1	0.09	–	3	2	1971–1994(22)	6–25
65	Buenavista-Punta Teno	75	19.5	20.9	13.2	536	5.8	504	2340	672	243.6	7.9	–	–	–	–	1.0	0.12	–	3	2	1945–1993(24)	11–42
66	Adeje-Caldera	105	21.6	22.4	15.0	590	6	560	2592	735	117.5	2.9	–	–	–	–	0.5	0.04	–	2	1	1974–2000(19)	7–41
67	Buenavista	125	19.2	20.6	12.9	527	6	497	2304	668	267	8.6	–	–	–	–	1.2	0.13	–	3	2	1945–1998(17)	11–50
68	Anaga-Draguillo	180	19.9	18.4	15.6	539	6.7	516	2388	687	272.7	10.6	–	–	–	–	1.1	0.15	–	3	2	1985–2002(17)	20–39
69	Adeje	266	19.4	20.8	11.4	516	7.5	501	2328	693	141.2	2.9	–	–	–	–	0.6	0.04	–	2	1	1944–2002(47)	13–47
70	Anaga-Polvorín E.R.T.	300	18.2	18.1	11.4	477	7.7	464	2184	657	358.8	15.4	–	–	–	–	1.6	0.23	–	4	3	1985–2000(15)	1–36
71	Rosario-Barranco Grande	320	19	18.4	12.1	495	8.6	491	2280	697	243.2	15.9	–	–	–	–	1.1	0.23	–	3	2	1989–1998(10)	6–49
72	Orotava-Centro	355	17.6	18.6	10.5	467	6.2	439	2112	600	455.4	19.3	–	–	–	–	2.2	0.32	+	10	4	1946–2002(39)	16–29
73	Victoria-Ayuntamiento	390	17.4	18.7	10.3	464	6.1	435	2088	593	403.1	21.2	–	–	–	–	1.9	0.36	+	9	4	1988–2002(15)	3–29
74	Anaga-Valle Jiménez	425	17.2	16.9	10.2	443	8.1	434	2064	630	382.1	18.1	–	–	–	–	1.9	0.29	–	8	3	1984–2002(19)	1–36
75	Anaga-Chamorga	460	17.6	18.3	10.5	464	6.8	442	2112	622	581.4	36.1	–	–	–	–	2.8	0.58	+	10	4	1985–1994(10)	20–39
76	Anaga-Taganana Fajanetas	480	16.7	16.4	9.6	427	8.3	420	2004	618	682.2	19.2	–	–	–	–	3.4	0.31	+	12	5	1946–1994(35)	1–36
77	Tacoronte	515	16.7	16.5	10.0	432	7.5	417	2004	607	592.5	34.1	–	–	–	–	3.0	0.56	+	10	4	1945–2002(58)	38–27
78	Anaga-Caserío Catalanes	575	15.9	15.6	8.6	401	8.6	397	1908	598	682.7	21.2	–	–	–	–	3.6	0.35	+	12	5	1988–2000(12)	25–36
79	Guancha-Casa Forestal	580	15.7	16.9	8.8	414	6.6	390	1884	567	497.7	24.1	–	–	–	–	2.6	0.43	+	10	4	1975–1998(19)	34–54
80	Anaga-Bodegas	600	16.4	18.3	8.0	427	6.8	405	1968	589	605.6	48.8	–	–	–	–	3.1	0.83	+	12	5	1986–1994(9)	20–39
81	Anaga-Carboneras	600	16.2	15.7	9.8	417	7.6	403	1944	594	696.9	33.0	–	–	–	–	3.6	0.56	+	12	5	1985–1994(10)	20–40
82	Anaga-Mercedes	670	15.3	14.8	8.2	383	8.4	377	1836	585	839.3	34.5	–	–	–	–	4.6	0.59	+	12	5	1945–1999(47)	20–45
83	Realejos-Icod Alto	670	15.3	16.4	8.3	400	7.2	382	1836	568	565.3	23.5	–	–	–	–	3.1	0.41	+	12	5	1982–1995(14)	34–54
84	Garachico-Montañeta	960	14.2	14.7	6.9	358	9.2	358	1704	571	654.7	21.6	–	–	–	–	3.8	0.38	+	12	5	1983–1998(15)	34–54
85	Matanza-Lagunetas	1400	13.4	11.8	5.1	303	12.5	303	1608	587	928	50.7	–	–	–	–	5.8	0.86	+	20	5	1983–2001(16)	49–55



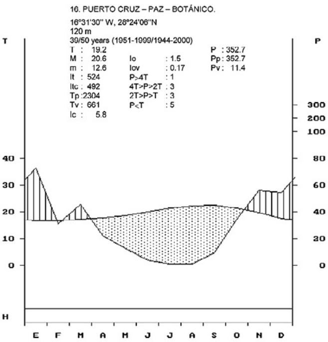
Hyperarid Desertic Inframediterranean
Ceropegio fuscae-Euphorbio balsamiferae S.



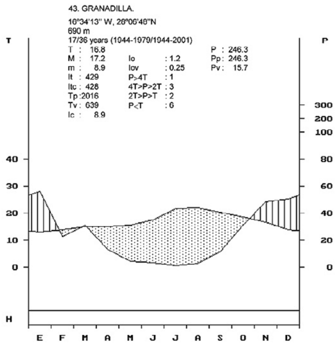
Arid Desertic Inframediterranean
Ceropegio fuscae-Euphorbio balsamiferae S.



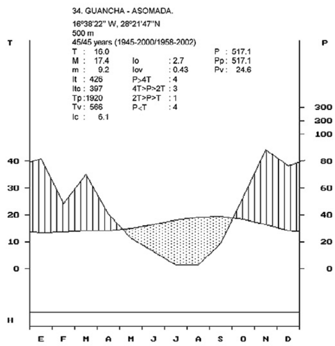
Lower-Semiarid Xeric Inframediterranean
Periploco laevigatae-Euphorbio canariensis S.



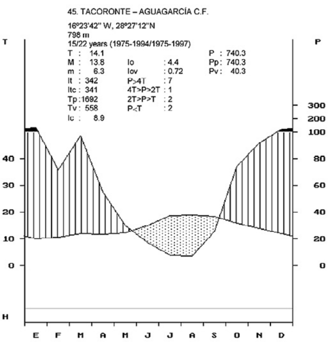
Upper-Semiarid Xeric Inframediterranean
Junipero canariensis-Oleo cerasiformis S.



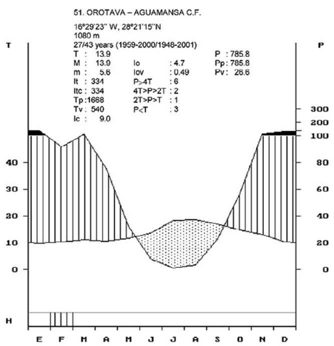
Lower-Semiarid Xeric Thermomediterranean
Junipero canariensis-Oleo cerasiformis S.



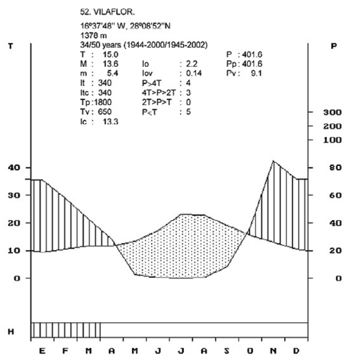
Dry Pluviseasonal Thermomediterranean
(with trade-wind clouds)
Visneo mocanerae-Arbuto canariensis S.



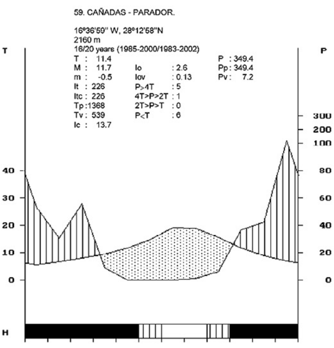
Subhumid pluviseasonal Thermomediterranean
(with trade-wind clouds)
Lauro novocanariensis-Perseo indicae S.



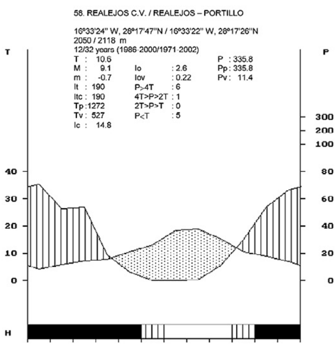
Subhumid Pluviseasonal Lower-Mesomediterranean
(with trade-wind clouds)
Lauro novocanariensis-Perseo indicae S.



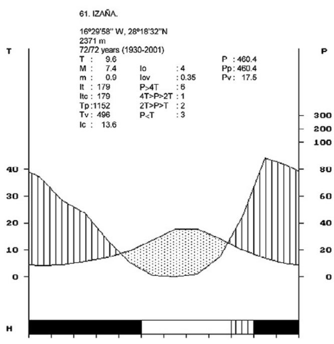
Dry Pluviseasonal Lower-Mesomediterranean
(without trade-wind clouds)
Sideritido solutae-Pino canariensis S.



Dry Pluviseasonal Upper-Mesomediterranean
(without trade-wind clouds)
Sideritido solutae-Pino canariensis S. (climatophilous sere)
Spartocytiso supranubii S. (edaphophilous potential community)



Dry Pluviseasonal Supramediterranean
Spartocytiso supranubii S.



Subhumid Pluviseasonal Supramediterranean
Spartocytiso supranubii S.

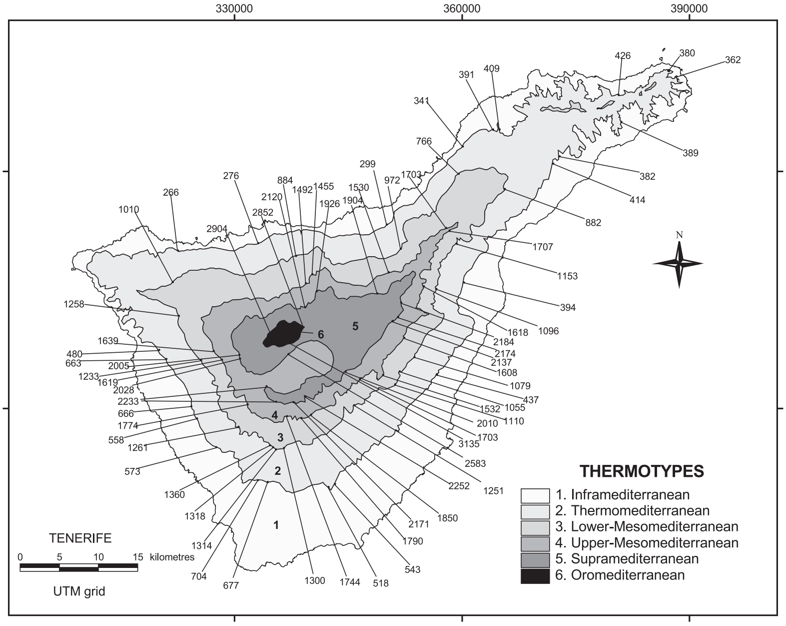


Fig. 3. Thermotype map of Tenerife.

tion series. Further explanation can be found in Rivas-Martínez (1995, 1997) and Del-Arco *et al.* (1996,1999a, 2002).

The bioclimatic maps (Figs. 3–5) were drawn according to the indices obtained for the meteorological stations, and the threshold values of the indices which delimit thermotype, bioclimate and ombrotype (Table 2).

The curves showing the key values of change in these were then traced from the appropriate gradients on the different slopes (Tables 3 and 4). The bioclimatic belt map was made by overlapping the thermotype, bioclimate and ombrotype maps, considering the area influenced by trade-wind clouds (Huetz de Lemps 1969, Kämmer 1974, Marzol-Jaén 1988). In any subsequent colouring of the maps the criteria of Del-Arco *et al.* (1999b) should preferably be followed.

Table 2. Threshold values for thermotypes, bioclimates and ombrotypes according to Rivas-Martínez (1997).

	Itc	Tp
Thermotype		
Inframediterranean	450–580	> 2450
Thermomediterranean	350–450	2150–2450
Mesomediterranean	210–350	1500–2150
Supramediterranean	80–210	900–1500
Oromediterranean	–	450–900
	Io	
Bioclimate		
Oceanic-desertic	0.1–0.9	
Oceanic-xeric	0.9–2.0	
Oceanic-pluviseasonal	> 2.0	
Ombrotype		
Hyperarid	0.1–0.3	
Arid	0.3–0.9	
Semiarid	0.9–2.0	
Dry	2.0–3.0	
Subhumid	3.0–5.5	
Humid	5.5–11	

Fig. 2 [on the previous page]. Climatic, bioclimatic and symphytosociological data from some representative meteorological stations in Tenerife. Years = recording periods of temperature and rainfall. T = mean annual temperature (°C); M = mean maximum temperature of the coldest month; m = mean minimum temperature of the coldest month; It = thermicity index; Itc = compensated thermicity index; Tp = positive temperature; Tv = summer temperature; Ic = continentality index; Io = ombrothermic index; Iov = summer ombrothermic index; P > 4T = months when the rainfall value (mm) is greater than four times the temperature value (°C); 4T > P > 2T = months when the rainfall value (mm) is between twice and four times the temperature value (°C); 2T > P > T = months when the rainfall value (mm) is greater than temperature value (°C) but smaller than two times this value; P < T = months when the rainfall value (mm) is smaller than the temperature value (°C); P = annual rainfall (mm); Pp = positive rainfall; Pv = summer rainfall; H = frost period. [Blank = frost-free period (m'_i > 2 °C); hatched = probable frosts (0 °C < m'_i < 2 °C); black = frosts certain (m'_i < 0 °C); m'_i = mean temperature of monthly minimum absolute temperature].

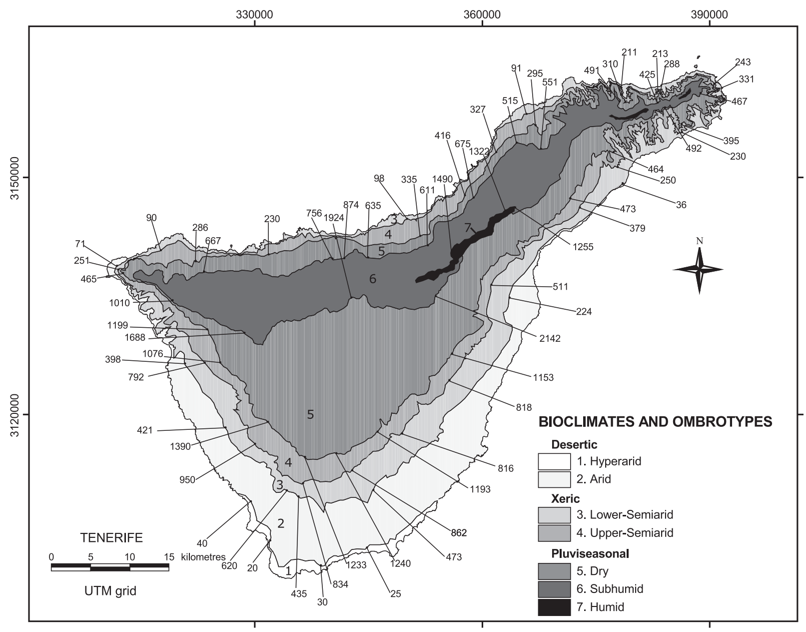


Fig. 4. Bioclimate and ombrotype map of Tenerife.

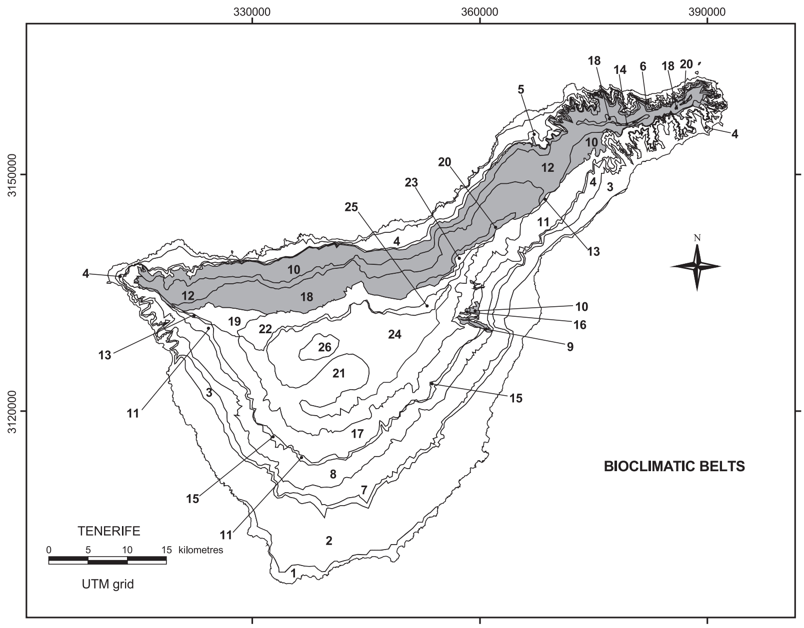


Fig. 5. Bioclimatic belts of Tenerife. 1 = Hyperarid desertic Inframediterranean; 2 = Arid desertic Inframediterranean; 3 = Lower-semiarid xeric Inframediterranean; 4 = Upper-semiarid xeric Inframediterranean; 5 = Dry pluviseasonal Inframediterranean (–); 6 = Dry pluviseasonal Inframediterranean (+); 7 = Lower-semiarid xeric Thermomediterranean; 8 = Upper-semiarid xeric Thermomediterranean (–); 9 = Upper-semiarid xeric Thermomediterranean (+); 10 = Dry pluviseasonal Thermomediterranean (+); 11 = Lower-dry pluviseasonal Thermomediterranean (–); 12 = Subhumid pluviseasonal Thermomediterranean (+); 13 = Upper-dry pluviseasonal Thermomediterranean (–); 14 = Humid pluviseasonal Thermomediterranean (+); 15 = Upper-semiarid xeric lower-Mesomediterranean (–); 16 = Dry pluviseasonal lower-Mesomediterranean (+); 17 = Dry pluviseasonal lower-Mesomediterranean (–); 18 = Subhumid pluviseasonal lower-Mesomediterranean (+); 19 = Subhumid pluviseasonal lower-Mesomediterranean (–); 20 = Humid pluviseasonal lower-Mesomediterranean (+); 21 = Dry pluviseasonal upper-Mesomediterranean (–); 22 = Subhumid pluviseasonal upper-Mesomediterranean (–); 23 = Humid pluviseasonal upper-Mesomediterranean (–); 24 = Dry pluviseasonal Supramediterranean; 25 = Subhumid pluviseasonal Supramediterranean; 26 = Dry pluviseasonal Oromediterranean. + = with trade-wind clouds; – = without trade-wind clouds.

Table 3. References for constructing the bioclimatic maps (Tenerife): thermotypes.

Station[1]	Height difference (m)	Itc difference	Height (m) of transition between thermotypes[2]				
			Infra-thermo (Itc = 450)	Thermo-meso (Itc = 350)	Lower-meso–Upper-meso (Itc = 280)	Meso-supra (Itc = 210)	Supra-oro (Itc = 80)
25–36	325	82	362				
25–40	382	84	380				
20–40	397	108	426				
12–27	185	34	409				
27–39	315	69	391				
28–31	128	9	341				
3–29	310	52	299				
22–34	270	64	276				
11–22	135	41	266				
10–48	860	144	480				
10–44	635	73	663				
5–44	685	84	666				
5–47	880	130	558				
13–47	798	123	573				
7–41	580	110	704				
38–45	213	60		766			
29–51	745	110		972			
45–55	949	64			1703		
51–61	1291	155			1530		
34–54	1110	136		884	1455		
58–62	1480	203				1904	2852
54–58	440	71			1492	1926	
53–56	425	83			1639		
11–50	915	151		1010			
54–62	2055	325				2120	
42–53	815	143		1258			
44–56	1185	215		1233	1619	2005	
47–57	1120	153		1261	1774		
41–57	1410	221		1360			
41–52	758	126		1318			
30–52	943	148	677	1314			
43–52	688	88	518	1300			
26–43	435	65	543				
15–46	710	121	437				
15–33	365	72	394				
6–40	581	149	414				
6–36	524	147	382				
1–36	540	134	359				
1–40	597	136	389				
46–52	548	43		1251			
56–62	1630	242				2028	2904
57–62	1500	258				2233	
62–60	1185	279				2583	3135
52–62	2152	353			1744	2171	
52–59	782	114			1790		
59–62	1370	239			1850	2252	
46–59	1330	157		1110	1703		
46–62	2700	396		1055	1532	2010	
46–61	1541	204		1079	1608	2137	
33–61	1886	253		1096	1618		
33–55	1262	155		1153			
40–49	348	63		882			
49–55	782	58			1707		
55–61	624	98				2174	
61–62	1159	192				2184	

[1]Station number according to Table 1. [2]Height of transition between thermotypes is used for isolines in Fig. 3.

Table 4. References for constructing the bioclimatic maps (Tenerife). Bioclimates and ombrotypes.

			Height (m) of transition between bioclimates[2]					
			Desertic (Io = 0.9)		Xeric (Io = 2)		Pluviseasonal	
					Upper height (m) of ombrotype			
Station[1]	Height difference (m)	Io difference	Hyperarid (Io = 0.3)	Arid (Io = 0.9)	Lower-semiarid (Io = 1.45)	Upper-semiarid (Io = 2)	Dry (Io = 3)	Subhumid (Io = 5.5)
7			40					
63			20					
4			30					
2			25					
11–65	20	0.5		71				
10–44	635	0.8		398				
5–47	880	0.9		421				
41				620				
25–75	225	1.4			243	331		
20–76	260	1.9			213	288	425	
20–81	380	2.1			211	310	491	
12–27	185	0.5			91			
27						295		
28						327		
29						335		
35–39	110	1.3					551	
77							515	
49–85	435	0.9						1255
73–85	1010	3.9				416	675	1322
51–55	667	1.3						1490
29–51	745	2.7					611	
72–83	315	0.9					635	
54–79	1030	1.4					874	
34–54	1110	1.3					756	
16–29	215	0.5			98	335		
22						230		
11–50	915	2.4				286	667	
42–48	280	0.4					1010	
11–67	30	0.3			90			
42–65	585	1.5			251	465		
44–53	760	1.1				1199		
44–56	1185	2.3			792	1076		
53–56	425	1.2					1688	
54–58	440	1.4					1924	
58–61	321	1.4					2142	
47–57	1120	1.4			950	1390		
30–52	943	1.3		435	834	1233		
43–52	688	1			862	1240		
46–52	548	0.8			816	1193		
46–61	1541	2.5			818	1153		
30				435				
26–43	435	0.6		473				
15–33	365	0.7		224	511			
6				36				
49–71	645	3.8			379	473		
6–74	389	1			250	464		
1–70	280	0.6			230			
36–70	260	1.1				395		
70–78	275	2					492	
75–76	20	0.6					467	

[1]Station number according to Table 1. [2]Height of transition between thermotypes is used for isolines in Fig. 4.

To identify the climatophilous vegetation units we used the phytosociological method (Braun-Blanquet 1979). Synoptic tables taken from our previous work (Rivas-Martínez *et al*. 1993b) were added to characterize them. Vegetation series were characterized according to the criteria laid down by Géhu and Rivas-Martínez (1981). The terms climatophilous, edaphoxerophilous and edaphohygrophilous are used throughout the text according to Rivas-Martínez (1995). The climax represents the final stage of balance in the geobotanic succession. It may be recognized as the final stage or stable association of a vegetation series.

At least three series are recognized depending on the amount of water in the soil, which comes mainly from precipitation. The climatophilous series is in accordance with ombroclimate; the edaphohygrophilous series is wetter because of percolation or run-off; the edaphoxerophilous series is drier due to relief.

Statistical analysis

Ordination techniques aid in explaining community variation (Gauch 1982), and they can be used to evaluate trends through time as well as space (ter Braak & Šmilauer 2002). We used Principal Component Analysis (PCA, using CANOCO; ter Braak & Šmilauer 2002) to examine the relationships among the altitude, climatic and bioclimatic parameters of the meteorological stations, according to Table 1 (Height, *T*, *M*, *m*, Tp, It, Itc, Ic, Pp, Pv, Io, Iov and Mist), and bioclimatic belts and vegetation series, according to Table 5.

We used Detrended Correspondence Analysis (DCA; Hill & Gauch 1980) to examine how sample plots are grouped in to the main gradients, in accordance with the different bioclimatic belts.

Nomenclature

The phytosociological nomenclature follows that of Rivas-Martínez *et al*. (2001, 2002); below association level, Rodríguez-Delgado *et al*. (1998) may be consulted. The taxonomic nomenclature is mainly according to Hansen and Sunding (1993).

Results

Thermotypes, bioclimates and ombrotypes

Five thermotypes (Inframediterranean, Thermomediterranean, Mesomediterranean, Supramediterranean, Oromediterranean; Fig. 3), three bioclimates (oceanic-desertic, oceanic-xeric, oceanic-pluviseasonal; Fig. 4), and six ombrotypes (hyperarid, arid, semiarid, dry, subhumid, humid; Fig. 4), were found to be present on the island. Toponymic features shown in Fig. 1 aim at guiding the reader about the location of changes in thermotype, bioclime and ombrotype.

Bioclimatic belts and vegetation series

Upon overlapping the thermotype, bioclimate and ombrotype, and taking into account the absence or presence of trade-wind clouds, 26 bioclimatic belts were demarcated (Fig. 5) as hosts to the seven climatophilous vegetation series found on the island (Fig. 6 and Table 5).

Ordination of the climatic and bioclimatic parameters with a PCA revealed two main tendencies (Fig. 7). The most important parameters are related to temperature variations in relation to altitude, and are closely related with axis 1, which discriminates bioclimatic belts and vegetation series located at different altitudes (with different thermotypes). Differences due to precipitation and humidity conditions (mist precipitation) are well discriminated and ordinated by axis 2, where bioclimatic belts and vegetation series are separated according to the different ombrotypes.

The DCA was also very consistent in discriminating the bioclimatic belts (Fig. 8). Along axis 1, plots were discriminated into different groups (Inframediterranean, Thermomediterranean, Mesomediterranean, Supramediterranean and Oromediterranean belts) according to altitude and parameters related with temperature (*T*, *M*, *m*, It, Itc, Ic, Tp, Tv). Sample scores were correlated with these parameters ($p < 0.001$). Axis 2 separates different plot groups into each bioclimatic belts, according to precipitation parameters (Pp, Pv, Io, Iov and Mist). Sample scores were correlated with these parameters ($p < 0.001$).

Along axis 2, the distance between sample plots of Inframediterranean, Thermomediterranean and Mesomediterranean belts increases from the left to the right of the graph, as temperature diminishes. To clarify the relationship between bioclimatic belts and vegetation series, in Fig. 9 the latter are marked with different plot symbols. Generally, there is a close relation between bioclimatic belts and vegetation series along both gradients: temperature (axis 1) and

Table 5. Correspondence between bioclimatic belts and climatophilous vegetation series in Tenerife.

Bioclimatic belt	Climatophilous vegetation series
1. Hyperarid desertic Inframediterranean	1. *Ceropegio fuscae–Euphorbio balsamiferae sigmetum*
2. Arid desertic Inframediterranean	1. *Ceropegio fuscae–Euphorbio balsamiferae sigmetum*
3. Lower-semiarid xeric Inframediterranean	2. *Periploco laevigatae–Euphorbio canariensis sigmetum*
4. Upper-semiarid xeric Inframediterranean	3. *Junipero canariensis–Oleo cerasiformis sigmetum*
5. Dry pluviseasonal Inframediterranean (without trade-wind clouds)	3. *Junipero canariensis–Oleo cerasiformis sigmetum*
6. Dry pluviseasonal Inframediterranean (with trade-wind clouds)	4. *Visneo mocanerae–Arbuto canariensis sigmetum*
7. Lower-semiarid xeric Thermomediterranean	3. *Junipero canariensis–Oleo cerasiformis sigmetum*
8. Upper-semiarid xeric Thermomediterranean (without trade-wind clouds)	3. *Junipero canariensis–Oleo cerasiformis sigmetum*
9. Upper-semiarid xeric Thermomediterranean (with trade-wind clouds)	4. *Visneo mocanerae–Arbuto canariensis sigmetum*
10. Dry pluviseasonal Thermomediterranean (with trade-wind clouds)	4. *Visneo mocanerae–Arbuto canariensis sigmetum*
11. Lower-dry pluviseasonal Thermomediterranean (without trade-wind clouds)	3. *Junipero canariensis–Oleo cerasiformis sigmetum*
12. Subhumid pluviseasonal Thermomediterranean (with trade-wind clouds)	5. *Lauro novocanariensis–Perseo indicae sigmetum*
13. Upper-dry pluviseasonal Thermomediterranean (without trade-wind clouds)	6. *Sideritido solutae–Pino canariensis sigmetum*
14. Humid pluviseasonal Thermomediterranean (with trade-wind clouds)	5. *Lauro novocanariensis–Perseo indicae sigmetum*
15. Upper-semiarid xeric lower-Mesomediterranean (without trade-wind clouds)	3. *Junipero canariensis–Oleo cerasiformis sigmetum*
16. Dry pluviseasonal lower-Mesomediterranean (with trade-wind clouds)	5. *Lauro novocanariensis–Perseo indicae sigmetum*
17. Dry pluviseasonal lower-Mesomediterranean (without trade-wind clouds)	6. *Sideritido solutae–Pino canariensis sigmetum*
18. Subhumid pluviseasonal lower-Mesomediterranean (with trade-wind clouds)	5. *Lauro novocanariensis–Perseo indicae sigmetum*
19. Subhumid pluviseasonal lower-Mesomediterranean (without trade-wind clouds)	6. *Sideritido solutae–Pino canariensis sigmetum*
20. Humid pluviseasonal lower-Mesomediterranean (with trade-wind clouds)	5. *Lauro novocanariensis–Perseo indicae sigmetum*
21. Dry pluviseasonal upper-Mesomediterranean (without trade-wind clouds)	6. *Sideritido solutae–Pino canariensis sigmetum*
22. Subhumid pluviseasonal upper-Mesomediterranean (without trade-wind clouds)	6. *Sideritido solutae–Pino canariensis sigmetum*
23. Humid pluviseasonal upper-Mesomediterranean (without trade-wind clouds)	6. *Sideritido solutae–Pino canariensis sigmetum*
24. Dry pluviseasonal Supramediterranean	7. *Spartocytiso supranubii sigmetum*
25. Subhumid pluviseasonal Supramediterranean	7. *Spartocytiso supranubii sigmetum*
26. Dry pluviseasonal Oromediterranean	7. *Spartocytiso supranubii sigmetum*

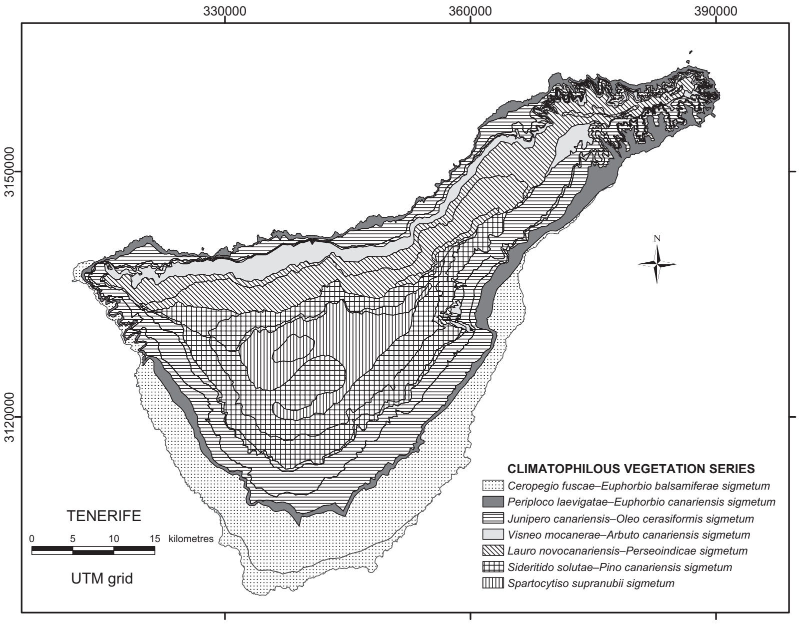


Fig. 6. Map of climatophilous vegetation series.

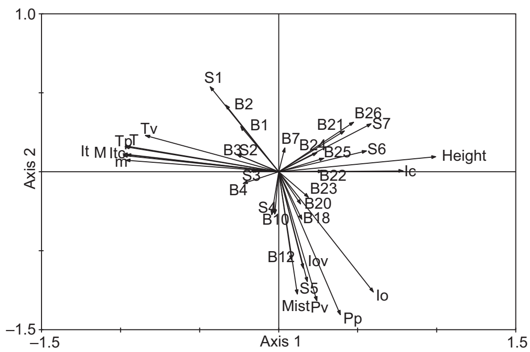


Fig. 7. Principal Component Analysis of all variables of the plots. Eigenvalues axis 1: 0.916 (91.6% of the cumulative percentage of variance), axis 2: 0.070 (98.6% of the c. p.v.). The variables with low influence were excluded from the figure. B = Bioclimatic belts according to Table 5, S = Vegetation series (S1 = *Ceropegio fuscae–Euphorbio balsamiferae sigmetum*, S2 = *Periploco laevigatae–Euphorbio canariensis sigmetum*, S3 = *Junipero canariensis–Oleo cerasiformis sigmetum*, S4 = *Visneo mocanerae–Arbuto canariensis sigmetum*, S5 = *Lauro novocanariensis–Perseo indicae sigmetum*, S6 = *Sideritido solutae–Pino canariensis sigmetum*, S7 = *Spartocytiso supranubii sigmetum*), T = mean annual temperature, M = mean maximum temperature of the coldest month, m = mean minimum temperature of the coldest month, It = thermicity index, Ic = continentality index, Itc = compensated thermicity index, Tp = positive temperature; Tv = summer temperature; P = annual rainfall in mm; Pp = positive rainfall; Pv = summer rainfall, Io = ombrothermic index, Iov = summer ombrothermic index.

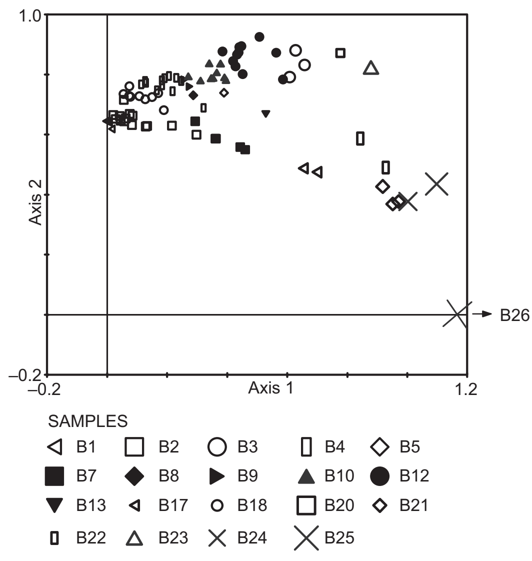


Fig. 8. Detrended Correspondence Analysis Axes I and II. Axis I eigenvalue: 0.40 (cumulative percentage of variance: 15.58) while 0.03 for axis II (c. p.v.: 72.7). Inframediterranean belt plots are indicated with empty symbols in straight lines; Thermomediterranean belt plots solid symbols; Mesomediterranean belt plots bold empty symbols, and Supramediterranean and Oromediterranean belt plots with different size crosses. (B = Bioclimatic belt).

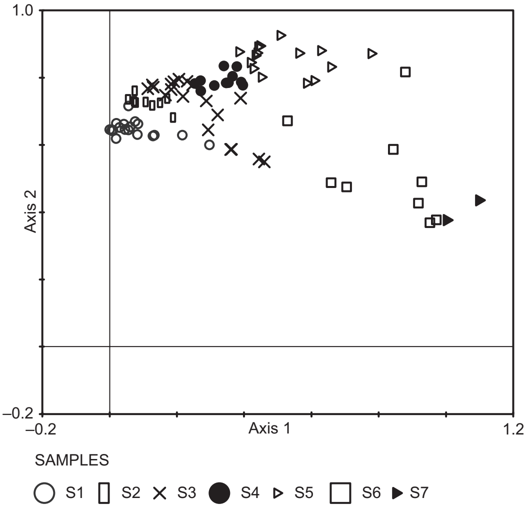


Fig. 9. Detrended Correspondence Analysis Axes I and II. Axis I eigenvalue: 0.40 (cumulative percentage of variance: 15.58) while 0.03 for axis II (c. p.v.: 72.7). Different symbols indicate vegetation series (S = Vegetation series) (S1 = *Ceropegio fuscae–Euphorbio balsamiferae sigmetum*, S2 = *Periploco laevigatae–Euphorbio canariensis sigmetum*, S3 = *Junipero canariensis–Oleo cerasiformis sigmetum*, S4 = *Visneo mocanerae–Arbuto canariensis sigmetum*, S5 = *Lauro novocanariensis–Perseo indicae sigmetum*, S6 = *Sideritido solutae–Pino canariensis sigmetum*, S7 = *Spartocytiso supranubii sigmetum*).

humidity (axis 2). However, vegetation series no. 3 (*Junipero canariensis–Oleo cerasiformis sigmetum*), located in the more humid Inframediterranean areas, is also found in the Thermomediterranean bioclimatic belt. Also, series no. 5 (*Lauro novocanariensis–Perseo indicae sigmetum*), located in the Thermomediterranean belt can rise into Mesomediterranean areas. Thermomediterranean and Mesomediterranean belts apparently show a wider range of humidity conditions (Fig. 8), than the Inframediterranean belt. Nevertheless, in both bioclimatic belts, especially Mesomediterranean, vegetation series show narrow variations related to precipitation and humidity factors. In the Thermomediterranean belt, the main differences in vegetation series along axis 2 are related with series no. 3 that protrudes out from the Inframediterranean belt. In this bioclimatic belt, three vegetation series are distributed along axis 2 being related to precipitation differences.

Potential natural vegetation map

As a complement to the climatophilous vegetation series map (Fig. 6), which represents rather a theoretical approach to vegetation distribution, we have drawn a potential natural vegetation map. This shows major differences, due to the influence of topographic, geomorphological, edaphological and geological factors (Fig. 10) affecting the expansion of edaphophilous vegetation (edaphophilous series and permanent vegetation), and represents a more accurate approach to the present vegetation (Fig. 11).

Climatophilous vegetation series

Several potential natural vegetation maps of Tenerife have been produced, among others, by Ceballos and Ortuño (1951), Santos and Fernández (1980), Walter (1994) and Santos (2000). The maps by Rivas-Martínez (1987) based on climatophilous macroseries, and Rivas-Matínez *et al*. (1993a) based on climatophilous series, use a similar approach to ours. The bioclimatic and climatophilous series maps of Rivas-Martínez *et al*. (1987) were supported by the data taken from 16 meteorological stations. Our maps present a more precise approach supported by data from 128 meteorological stations, of which 85 were finally considered (Table 1). There is a clear correspondence between the climatophilous series map, the distribution of their remnants, their characteristic substitute communities and distribution of bioindicative species. Seven climatophilous vegetation series are recognizable (Table 6).

Ceropegio fuscae–Euphorbietum balsamiferae Rivas-Matínez *et al.* 1993

This sweet spurge scrub is an association endemic to Tenerife, with a potential area corresponding to the hyperarid and arid desertic Inframediterranean belts. It is an oligospecific association, physiognomically characterized by the pachycaule species *Euphorbia balsamifera* (Marrero *et al*. 2001).

It corresponds to the terminal community

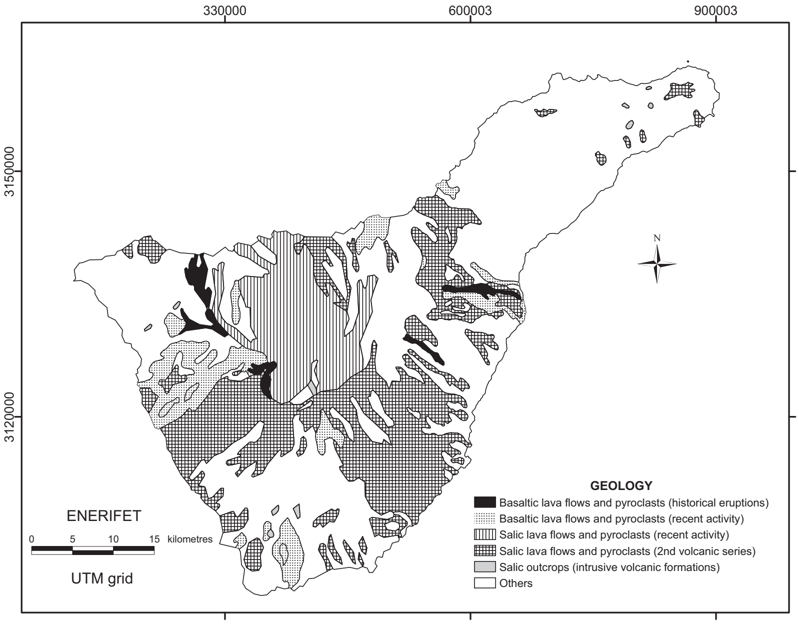


Fig. 10. Salic territories and historical and recent basaltic lava flows and pyroclastic deposition in Tenerife (modified from figure on pp. 12–13 in Carracedo 1988).

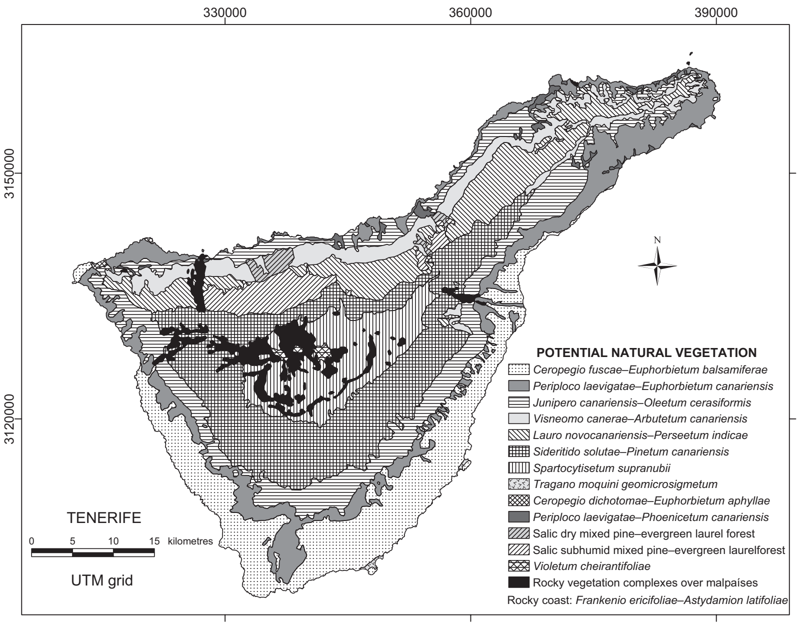


Fig. 11. Map of potential natural vegetation.

of the hyperarid and arid desertic Inframediterranean climatophilous series as well as the semiarid xeric Inframediterranean edaphophilous series (over pumice) of *E. balsamifera* in Tenerife (*Ceropegio-Euphorbio balsamiferae sigmetum*).

It extends from the NW tip of Punta de Teno along the SW, S and SE slopes as far as Santa Cruz, reaching its maximum altitude in the S (about 500 m a.s.l.) (Fig. 6). However, this area is not uniform and is sometimes interrupted by the edaphophilous descent of the *cardón* scrub *Periploco laevigatae–Euphorbio canariensis sigmetum* over recent lava flows (*malpaíses*) (Arafo, Güímar, Las Galletas, Guía de Isora), and on the cliffs of Teno. Also, *Ceropegio-*

Table 6. Synoptic table of terminal communities of the climatophilous vegetation series of Tenerife. 1 = *Ceropegio-Euphorbietum balsamiferae*, 2 = *Periploco-Euphorbietum canariensis*, 3 = *Junipero-Oleetum cerasiformis*, 4 = *Visneo-Arbutetum canariensis*, 5 = *Lauro-Perseetum indicae*, 6 = *Sideritido-Pinetum canariensis*, 7 = *Spartocytisetum supranubii*.

	1	2	3	4	5	6	7
Euphorbia balsamifera	V	–	–	–	–	–	–
Ceropegia fusca	V	–	–	–	–	–	–
Schizogyne sericea	IV	–	–	–	–	–	–
Lotus sessilifolius var. *pentaphyllus*	III	–	–	–	–	–	–
Reseda scoparia	II	–	–	–	–	–	–
Helianthemum canariense	II	–	–	–	–	–	–
Campylanthus salsoloides	II	–	–	–	–	–	–
Asparagus arborescens	I	–	–	–	–	–	–
Convolvulus floridus	–	II	–	–	–	–	–
Lavandula buchii	–	II	–	–	–	–	–
Justicia hyssopifolia	–	I	–	–	–	–	–
Juniperus turbinata ssp. *canariensis*	–	–	V	–	–	–	–
Olea cerasiformis	–	–	IV	–	–	–	–
Maytenus canariensis	–	–	II	–	–	–	–
Hypericum canariense	–	–	II	–	–	–	–
Euphorbia atropurpurea	–	–	I	–	–	–	–
Ceropegia dichotoma	–	–	I	–	–	–	–
Arbutus canariensis	–	–	–	V	–	–	–
Daphne gnidium	–	–	–	III	–	–	–
Bystropogon canariensis var. *smithianus*	–	–	–	II	–	–	–
Chamaecytisus proliferus var. *proliferus*	–	–	–	II	–	–	–
Pleiomeris canariensis	–	–	–	I	–	–	–
Rubia fruticosa ssp. *periclymenum*	–	–	–	I	–	–	–
Gennaria diphylla	–	–	–	I	–	–	–
Convolvulus canariensis	–	–	–	I	–	–	–
Smilax aspera	–	–	–	I	–	–	–
Asplenium onopteris	–	–	–	–	V	–	–
Persea indica	–	–	–	–	IV	–	–
Prunus lusitanica ssp. *hixa*	–	–	–	–	IV	–	–
Ixanthus viscosus	–	–	–	–	IV	–	–
Hedera canariensis	–	–	–	–	III	–	–
Dryopteris oligodonta	–	–	–	–	III	–	–
Heberdenia excelsa	–	–	–	–	III	–	–
Rhamnus glandulosa	–	–	–	–	III	–	–
Ilex perado ssp. *platyphylla*	–	–	–	–	II	–	–
Cedronella canariensis	–	–	–	–	II	–	–
Rubus ulmifolius	–	–	–	–	II	–	–
Brachypodium sylvaticum	–	–	–	–	II	–	–
Arisarum vulgare ssp. *subexertum*	–	–	–	–	II	–	–
Pericallis appendiculata	–	–	–	–	II	–	–
Pteridium aquilinum	–	–	–	–	II	–	–
Rubus bollei	–	–	–	–	I	–	–
Bystropogon canariensis var. *canariensis*	–	–	–	–	I	–	–
Polystichum setiferum	–	–	–	–	I	–	–
Luzula canariensis	–	–	–	–	I	–	–
Pinus canariensis	–	–	–	–	–	V	–
Chamaecytisus proliferus ssp. *angustifolius*	–	–	–	–	–	V	–
Argyranthemum adauctum ssp. *dugourii*	–	–	–	–	–	II	–
Bystropogon origanifolius	–	–	–	–	–	II	–
Sideritis soluta	–	–	–	–	–	II	–
Juniperus cedrus	–	–	–	–	–	I	–
Sideritis oroteneriffae	–	–	–	–	–	I	–
Lotus campylocladus	–	–	–	–	–	I	–
Carlina xeranthemoides	–	–	–	–	–	I	–
Plantago webbii	–	–	–	–	–	I	–
Polycarpaea tenuis	–	–	–	–	–	I	–

continued

Table 6. Continued.

	1	2	3	4	5	6	7
Descurainia gonzalezii	–	–	–	–	–	I	–
Spartocytisus supranubius	–	–	–	–	–	–	V
Descurainia bourgeauana	–	–	–	–	–	–	IV
Argyranthemum teneriffae	–	–	–	–	–	–	II
Arrhenatherum calderae	–	–	–	–		–	II
Echium wildpretii	–	–	–	–	–	–	II
Nepeta teydea	–	–	–	–	–	–	II
Pimpinella cumbrae	–	–	–	–	–	–	I
Plocama pendula	V	III	–	–	–	–	–
Launaea arborescens	IV	I	–	–	–	–	–
Neochamaelea pulverulenta	II	I	–	–	–	–	–
Lycium intricatum	II	I	–	–	–	–	–
Allagopappus dichotomus	I	II	–	–	–	–	–
Jasminum odoratissimum	–	I	III	–	–	–	–
Rhamnus crenulata	–	II	II	–	–	–	–
Asparagus umbellatus	–	II	II	–	–	–	–
Globularia salicina	–	I	II	–	–	–	–
Drimia maritima	–	I	II	–	–	–	–
Carlina salicifolia	–	I	II	–	–	–	–
Cistus monspeliensis	–	I	II	–	–	–	–
Rumex lunaria	–	I	II	–	–	–	–
Micromeria hyssopifolia	–	I	I	–	–	–	–
Euphorbia canariensis	III	V	I	–	–	–	–
Scilla haemorrhoidalis	III	II	I	–	–	–	–
Rubia fruticosa ssp. *fruticosa*	II	V	III	–	–	–	–
Kleinia neriifolia	III	IV	II	–	–	–	–
Euphorbia obtusifolia	III	IV	III	–	–	–	–
Hyparrhenia sinaica	III	III	II	–	–	–	–
Periploca laevigata	II	V	II	–	–	–	–
Lavandula canariensis	II	II	II	–	–	–	–
Micromeria varia ssp. *varia*	I	I	II	–	–	–	–
Visnea mocanera	–	–	III	IV	–	–	–
Laurus novocanariensis	–	–	–	II	V	–	–
Viburnum rigidum	–	–	–	IV	V	–	–
Erica arborea	–	–	–	V	V	–	–
Ilex canariensis	–	–	–	V	V	–	–
Myrica faya	–	–	–	IV	III	–	–
Picconia excelsa	–	–	–	III	III	–	–
Phyllis nobla	–	–	–	I	III	–	–
Hypericum grandifolium	–	–	–	I	IV	–	–
Apollonias barbujana	–	–	–	I	III	–	–
Isoplexis canariensis	–	–	–	II	I	–	–
Galium scabrum	–	–	–	I	III	–	–
Asplenium hemionitis	–	–	–	I	II	–	–
Cistus symphytifolius	–	–	I	–	–	III	–
Adenocarpus viscosus ssp. *viscosus*	–	–	–	–	–	IV	IV
Pterocephalus lasiospermus	–	–	–	–	–	II	III
Scrophularia glabrata	–	–	–	–	–	I	III
Erysimum scoparium	–	–	–	–	–	I	IV
Tolpis webbii	–	–	–	–	–	I	II
Andryala pinnatifida ssp. *teydensis*	–	–	–	–	–	I	I
Micromeria lachnophylla	–	–	–	–	–	I	I

Other taxa: In 1: *Cistus monspeliensis* +, *Asparagus umbellatus* +, *Rumex lunaria* +, *Micromeria hyssopifolia* +; in 2: *Sideritis cretica* +, *Retama rhodorhizoides* +, *Campylanthus salsoloides* +, *Asparagus arborescens* +, *Juniperus turbinata* ssp. *canariensis* +, *Olea cerasiformis* +; in 3: *Convolvulus floridus* +, *Allagopappus dichotomus* +, *Plocama pendula* +; in 4: *Rhamnus glandulosa* +, *Brachypodium sylvaticum* +; in 5: *Canarina canariensis* +; in 7: *Cheirolophus teydis* +, *Helianthemum juliae* +, *Pinus canariensis* +, *Juniperus cedrus* +, *Descurainia gonzalezii* +.
Sources: Rivas-Martínez *et al.* 1993b. 1: table 10, column 1; 2: table 10, column 3; 3: table 10, column 8; 4: table 14, rel. 1–16; 5: table 11, rel. 1–11; 6: table 20, column 2; 7: table 21, rel. 1–13.

Euphorbietum balsamiferae climbs up as edaphophilous within the bioclimatic belt above it (semiarid xeric Inframediterranean) over the abundant salic pyroclasts (mainly pumice) and salic lava flows in this south sector of the island (Figs. 10 and 11). Within its climatophilous area only a few small places on the coast (Güímar, El Porís, El Médano, Los Cristianos) are covered by the edaphophilous sabulicolous Inframediterranean western Canary geomicrosigmetum (Rivas-Martínez 2002) (*Euphorbio paraliae–Cyperetum capitati* Sunding 1972, *Polycarpaeo niveae-Lotetum lancerottensis* Esteve 1968, *Traganetum moquini* Sunding 1972) over sandy ground, with a finicolous meaning in the synchorology of this geomicrosigmetum within the Canary Archipelago. The rocky coastline of the island is mainly covered with edaphophilous communities of *Frankenio-Astydamion latifoliae*.

Nowadays the community has greatly retreated as a consequence of agricultural, urban, and industrial expansion over its area — with particular impact from tourism, but some good plots still remain, mainly on the SE coast. The main substitutional scrub is the nitrohalophilous *Launaeo arborescentis–Schizogynetum sericeae* Rivas-Martínez *et al*. 1993; also the herbaceous nitrohalophilous community *Mesembryanthemetum crystallini* Sunding 1972 is widely spread, mainly over abandoned tomato-growing areas, as well as subnitrophilous communities of *Resedo lanceolatae–Moricandion* F. Casas & M.E. Sánchez 1972 (Del-Arco *et al*. 1997).

Periploco laevigatae-Euphorbietum canariensis Rivas-Martínez *et al.* 1993

This is an association endemic to Tenerife, typical of the lower-semiarid xeric Inframediterranean belt. At its optimum with the physiognomy of *cardón* (*Euphorbia canariensis*) scrub, or when degraded, with the physiognomy of bitter spurge (*Euphorbia obtusifolia*, *sensu* Molero & Rovira 1998) scrub.

Its structure and physiognomy are that of xeric crassicaule scrubland, which is the terminal community of (a) the lower-semiarid xeric Inframediterranean climatophilous series; (b) the upper-semiarid xeric Inframediterranean, semiarid xeric Thermomediterranean, and lower-dry pluviseasonal Thermomediterranean (without trade-wind clouds) edaphophilous rupicolous series; and (c) the arid desertic Inframediterranean edaphohygrophilous series on *malpaíses*, of *Euphorbia canariensis* in Tenerife (*Periploco-Euphorbio canariensis sigmetum*).

Its climatophilous area (Fig. 6) encircles the island directly above the area of *Ceropegio-Euphorbietum balsamiferae*, its upper limit coinciding with the beginning of the area of the upper-semiarid ombrotype of the climatophilous series of *Junipero canariensis–Oleo cerasiformis sigmetum* at heights between 100–200 m a.s.l. in the N, which rise on the SW and SE slopes up to about 850 m in the south. This area is very narrow, especially in the N and S sector of the ring. The edaphophilous enlargement of its area, favoured by lava flows, steep slopes and cliffs, widens its territory (Fig. 11). It is particularly noticeable over the ancient massifs of Anaga, Teno, and Adeje; in the latter the *cardón* can coexist with occasional Canary pines. A good sample over lava flows can be seen in Malpaís de Güimar. The descent of cardonal into Inframediterranean desertic territories on *malpaíses*, has already been described (Del-Arco *et al*. 2002) and is attributed to a shielding effect of the solid lava flows which decrease the evaporation rate from the underlying soil, maintaining a favourable water balance and allowing this edaphohygrophilous movement.

Periploco-Euphorbietum canariensis subass. *euphorbietosum balsamiferae* Rivas-Martínez *et al*. 1993 is established in the N of the island, near the coast, with a physiognomy of sweet spurge scrub. In the NW, in the windy coastal area of Buenavista–Punta de Teno, the edaphoxeroaerophilous series of *tolda* (*Euphorbia aphylla*) is found (*Ceropegio dichotomae–Euphorbio aphyllae sigmetum*). *Periploco-Euphorbietum canariensis* subass. *jasminetosum odoratissimi* Rivas-Martínez *et al*. 1993, which presents thermophilous elements, occupies the contact area with thermophilous woodland (*Junipero canariensis–Oleetum cerasiformis* O. Rodríguez *et al*. 1990 corr. Rivas-Martínez *et al*. 1993).

The area of the *cardón* scrub has also been affected by agriculture, urban and industrial development, and has retreated greatly. Nowadays it is mainly confined to steep rocky slopes, scarps and *malpaíses*. Bitter spurge scrub, as an impoverished substitutional facies of the association is widely spread. Interspersed with it, *Artemisio thusculae–Rumicetum lunariae* Rivas-Martínez *et al*. 1993 is the main nitrophilous substitutional scrub. *Cenchro ciliaris–Hyparrhenietum sinaicae* Wildpret & O. Rodríguez *in* Rivas-Martínez *et al*. 1993 corr. Díez-Garretas & Asensi 1999 as substitutional perennial herbaceous layer represents a higher evolution level than the former and is also widely spread, not only in the area of this series but also in the sweet spurge series and *Junipero-Oleo cerasiformis sigmetum*.

Junipero canariensis-Oleetum cerasiformis O. Rodríguez *et al*. 1990 corr. Rivas-Martínez *et al.* 1993

This is an endemic association of Tenerife that includes the thermophilous juniper (*Juniperus turbinata* ssp. *canariensis* (Guyot *in* Mathou & Guyot) Rivas-Martínez, Wildpret & Pérez de Paz) woodland (Rodríguez-Delgado *et al*. 1991) and its less abundant physiognomic facies of wild olive (*Olea cerasiformis* woodland, and mastic (*Pistacia atlantica*) groves, characteristic of the upper-semiarid xeric Inframediterranean and semiarid xeric Thermomediterranean, and lower-dry pluviseasonal Thermomediterranean in territories without trade-wind clouds.

Its climatophilous area rings the island directly above the climatophilous area of *Periploco-Euphorbietum canariensis*, reaching the area of *Visneo mocanerae–Arbutetum canariensis* Rivas-Martínez *et al*. 1993 at about 300 m a.s.l. in the N except on the NW facing slopes of Tacoronte-Santa Úrsula at about 400 m; on the SW and SE slope it borders the area of pine woodland (*Sideritido solutae–Pinetum canariensis* Esteve 1973), except on the areas where clouds overflow the crest of the ridge, and in the local NE-facing area of Güímar where it borders the area of evergreen laurel forest (Fig. 6). The upper potential natural limit in these SW and SE sectors (Fig. 11) considerably varies from the theoretical climatophilous one. The presence of large areas dominated by salic lava flows (Fig. 10) makes the pine woodland area (*Sideritido-Pinetum canariensis*) descend into the territories of the upper-semiarid Thermomediterranean, the lower-dry pluviseasonal Thermomediterranean (without trade-wind clouds) and even the top of the lower semiarid xeric Thermomediterranean. In any case, a good proportion of these areas, principally that of the upper-semiarid xeric Thermomediterranean, are covered by *Sideritido-Pinetum canariensis* subass. *cistetosum monspeliensis* (Del Arco *et al*. 1983) Rivas-Martínez *et al*. 1993, which occupies the mixed territory of contact between juniper and pine woodland, where some dispersed remnants are still to be found.

The structure and physiognomy are those of open xeric woodland, the terminal community of the upper-semiarid xeric Inframediterranean, semiarid xeric Thermomediterranean and lower-dry pluviseasonal Thermomediterranean (without trade-wind clouds). This is the climatophilous series of juniper (*Juniperus turbinata* ssp. *canariensis*) and wild olive (*Olea cerasiformis*) in Tenerife (*Junipero canariensis–Oleo cerasiformis sigmetum*).

The current representation of the community has dramatically retreated because of the transformation of its territory by farming and urban development. Only scattered remnants exist and those of Anaga, especially Afur and Mesa del Sabinal, are noteworthy.

The Canary palm (*Phoenix canariensis*) community (*Periploco laevigatae–Phoenicetum canariensis* Rivas-Martínez *et al*. 1993) develops over slope debris in the area of juniper woodland, in the N and Anaga. *Rubo-Salicetum canariensis* J.C. Rodríguez *et al*. 1986, the typical Canary riparian willow community has its optimum in the potential territory of juniper woodland, but it also extends down into the area of *cardón* scrub, and upwards into the area of the other climatophilous series of the island (Rodríguez-Piñero *et al*. 1986).

Among the most representative substitution scrubs are rockrose scrub (*Cistetum symphytifolio-monspeliensis* Rivas-Martínez *et al*. 1993) on denuded soils; white broom scrub (*Echio aculeati-Retametum rhodorrhizoidis* Rivas-Martínez *et al*. 1993) on dry slope debris and abandoned fields, especially in Teno massif; the nitrophilous scrub *Artemisio thusculae–Rumice-*

tum lunariae Rivas-Martínez *et al*. 1993 on disturbed places; the bitter spurge scrub, whether as a facies of the latter or a recovering stage of the deforested woodland; and the perennial grassland of *Cenchro-Hyparrhenietum sinaicae*. Deforested zones near the *Visneo mocanerae-Arbutetum canariensis* area, are occupied by *Rhamno crenulatae–Hypericetum canariensis* Rivas-Martínez *et al*. 1993.

Visneo mocanerae–Arbutetum canariensis Rivas-Martínez *et al.* 1993

This is a western Canary endemic association, which in Tenerife includes the dry evergreen laurel forest (Ohsawa *et al*. 1999) of the dry pluviseasonal Inframediterranean and upper-semiarid and dry-pluviseasonal Thermomediterranean territories of the windward slopes directly exposed to the trade-wind clouds, or of the leeward slopes affected by overflowing clouds.

Its climatophilous territory (Fig. 6) extends along the N slope of the island, S Anaga and a small strip of SW Teno, above the area of *Junipero-Oleetum cerasiformis*. In the north its upper limit coincides with the beginning of the subhumid ombrotype, at an altitude of 425 m a.s.l. above Taganana in the NE, and up to 677 m a.s.l. above El Tanque in the NW. In the N of Anaga it reaches the area of humid evergreen laurel forest (*Lauro novocanariensis–Perseo indicae sigmetum*) or the area of ridge-crest evergreen laurel forest (*Ilici canariensis–Ericetum platycodonis* Rivas-Martínez *et al*. 1993) installed under the direct influence of clouds. On the south slope of Anaga it occupies areas under the effect of overflowing clouds as occurs in the mentioned SW strip of Teno. This climatophilous area also extends to the southern slopes of La Laguna–La Esperanza, in areas of overflowing clouds, and to the windward slopes of Güímar on the SE slopes of the island. There is a reduction of its potential area over the salic lava flows of La Guancha and Icod where a particular mixed community with *Pinus canariensis* develops (Fig. 11). Today this community, highly transformed, shows the physiognomy of pine woodland; fragments can also be observed on small salic outcrops like those in Tigaiga (Los Realejos).

Its structure and physiognomy are those of dense xerophilous forest, terminal community of dry pluviseasonal Infra- and Thermomediterranean belts with trade-wind clouds and upper-semiarid xeric Thermomediterranean belt with trade-wind clouds, series of the Canary strawberry tree (*Arbutus canariensis*) (*Visneo mocanerae–Arbuto canariensis sigmetum*).

Its current representation is much reduced and the best plots are to be found in Teno (Monte del Agua) and Anaga (lower part of Vueltas de Taganana, Monte Aguirre, etc.). Along its potential natural area, diverse small isolated fragments exist on ravine ledges, steep slopes, cliffs and outcrops. *Rhamno-Hypericetum canariensis*, typical scrub of forest margins is now widespread as a substitutional stage, mainly in the lower two thirds of its altitudinal range; the upper third is often covered by the anthropic substitutional scrub *Myrico fayae–Ericetum arboreae* Oberdorfer 1965. *Artemisio-Rumicetum lunariae* is also widespread as a substitutional nitrophilous scrub (Rivas-Martínez *et al*. 1993b, Del-Arco & Wildpret 1999, Nakamura *et al*. 2000).

Lauro novocanariensis-Perseetum indicae Oberdorfer *ex* Rivas-Martínez *et al.* 1977 corr. Rivas-Martínez *et al.* 2002

This is a western Canary endemic association that in Tenerife includes the humid evergreen laurel forest (Ohsawa *et al*. 1999) of subhumid-humid pluviseasonal Thermomediterranean and dry-humid pluviseasonal lower-Mesomediterranean territories on the windward slopes directly exposed to the trade-wind clouds.

Its climatophilous territory (Fig. 6) extends along the N slope of the island, NE slopes of S Anaga ravines and windward slopes of Güímar in the SE, above the area of *Visneo-Arbutetum canariensis*. In the N, on the crests of the Anaga ridge, its upper limit coincides with the ombrophilous community *Ilici-Ericetum platycodonis*, then on the crests of the NE–SW dorsal ridge; and in the rest of the N in the transition zone between lower and upper-Mesomediterranean thermotypes, at about 1500 m a.s.l. In Güímar, it occurs above the area of *Visneo-Arbutetum canariensis*, having its upper limit in the cloud dissipation area on the ridge of Ladera de Güímar, up to about 1500 m a.s.l. There is a considerable reduction in the potential area of *Lauro-Perseetum* "*typicum*" over the salic lava flows in Icod–La Guancha (deriving from the recent volcanic activity of Pico Teide a few thousand years ago) and salic rocks of Santa Úrsula–Cumbres de la Victoria (from the second Canary volcanic cycle < 5.1 Ma) forming a particular mixed community with *Pinus canariensis* (Figs. 10 and 11). The latter, highly transformed by human use (mainly forestry activities) nowadays shows the physiognomy of pine woodland, which also occurs on the salic outcrop of Roque de los Pinos in Anaga. There is, in addition, a reduction in its potential area on the ridge crests strongly affected by clouds all year round, even in summer. This is most noticeable in Anaga, in the edaphoxero-aerophilous ridge-crest evergreen laurel forest (*Ilici-Ericetum platycodonis*), a very rich ombrophilous dwarf tree community (Rivas-Martínez *et al*. 1993b, Del-Arco & Wildpret 1999). Reducts of the typical edaphohygrophilous evergreen broad-leaved community *Diplazio caudati–Ocoteetum foetentis* Rivas-Martínez *et al*. 1993 can still be observed within its territory.

Its structure and physiognomy are those of mesophytic forest, terminal community of the subhumid-humid pluviseasonal Thermomediterranean, and the dry-humid pluviseasonal lower-Mesomediterranean climatophilous series of *Persea indica*. (*Lauro novocanariensis–Perseo indicae sigmetum*) in areas with trade-wind clouds.

As in the rest of the western Canary Islands, the forest has considerably retreated over the centuries due mainly to tree-felling. Fortunately, several nuclei still persist and they are now included within the Canary Natural Reserve Network. The purest and most extensive reducts are in Anaga and Teno; they are protected by law and form part of Anaga Rural Park (and its Integral Reserves) and Teno Rural Park.

The main anthropic substitutional scrub *Myrico-Ericetum arboreae* is spread over a much wider area, interspersed with the broom scrub *Telinetum canariensis* Del-Arco & Wildpret 1983 in drier and sunny rocky sites, and bramble scrub *Rubio periclymeni–Rubetum* Oberdorfer 1965 and bracken facies of *Pteridium aquilinum* in damper places. The perennial herbaceous community *Piptathero miliacei–Foeniculetum vulgaris* Rivas-Martínez *et al*. 1993 also grows on deforested humid soils as do the nitrophilous meadows of *Galactito tomentosae–Brachypodietum distachyi* Rivas-Martínez *et al*. 1993 (Rivas-Martínez *et al*. 1993b, Del-Arco & Wildpret 1999, Nakamura *et al*. 2000).

As in other islands (La Palma, Hierro and Gomera) the upper territory of *Lauro-Perseetum indicae*, between 1300 and 1500 m a.s.l., shows a noticeable reduction in the number of species. A climax community may once have existed, dominated by *Myrica faya* together with the most cold-tolerant species of the evergreen laurel forest, among them *Ilex canariensis* and *Erica arborea*. This community in Tenerife is today greatly disturbed and transformed by afforestation, and is not easily recognizable. It should be considered a *Myrica faya* forest (cold evergreen laurel forest) at the top of *Lauro-Perseetum indicae*, which could be included in a generic "*Myricetum fayae*" yet to be defined, nothing to do with the *Myrico-Ericetum arboreae* reported by some authors (Santos 1983, 1999). This latter association is anthropic substitutional shrubland (*fayal-brezal*) described by Oberdorfer (1965: table 7) and lectotypified by Rivas-Martínez *et al*. 1993b, widely distributed throughout the degraded areas of evergreen laurel forest and obviously also within the potential area of this generic "*Myricetum fayae*". In this context, the *fayal-brezal* above *laurisilva sensu* Ceballos & Ortuño (1951) should be interpreted as including both "*Myricetum fayae*" and *Myrico-Ericetum arboreae*.

Further up , the "*Myricetum*" is substituted by *Sideritido solutae–Pinetum canariensis* subass. *ericetosum arboreae*, the humid pine woodland.

Sideritido solutae–Pinetum canariensis Esteve 1973

This is an association endemic to Tenerife which represents the Thermo- and Mesomediterranean pine woodland. Its climatophilous area (Fig. 6) rings the island above the potential area of *Lauro-Perseetum indicae* in the north and above the potential area of *Junipero-Oleetum cerasiformis* on the SW and SE slopes, except in

Güímar where it is in contact with the evergreen laurel forest. Its upper limit ranges between 1900 and 2100 m a.s.l. in the north; 2150–2250 m on the SE slope; and between 2000 and 2230 m on the SW slope; with its highest altitude in the south. The extension of its climatophilous area into Las Cañadas circus, between the south slopes of Pico Teide and the north-facing south wall of the circus (Fig. 6), is in accordance with the data from stations 57, 59 and 60, that place the zone within dry Mesomediterranean, and consequently in the *Sideritido solutae–Pinetum canariensis* climatophilous area (Del-Arco & Wildpret 1994). Indeed, today there is a reinvasion of pine woodland principally on the north-facing slopes (between Montaña Guajara and Boca Tauce), while *Spartocytisetum supranubii* Oberdorfer *ex* Esteve 1973 persists on the lava flows as edaphoxerophilous and on the sandy areas of Ucanca Valley where temperature inversion frequently causes frost (Höllermann 1982) and a resultant inversion of vegetation.

However, the potential area of the association is larger (Fig. 11). In the SE and SW sectors of the island the presence of salic lava flows makes pine woodland descend to the upper-semiarid xeric Thermomediterranean, lower-dry pluviseasonal Thermomediterranean, and even the uppermost area of lower-semiarid xeric Thermomediterranean. This area is mainly covered by *Sideritido-Pinetum canariensis* subass. *cistetosum monspeliensis*, a difficult area to study, which from the analyses of some remnants seems to belong in its mature stage to a mixed territory and community between juniper and pine woodlands (*Sideritido-Pinetum canariensis* subass. *pistacietosum atlanticae sensu* Del-Arco *et al.* 1992). Also, in the north, over salic lava flows (La Guancha–Icod, Los Realejos, Santa Úrsula) and dispersed salic outcrops, the pine woodland descends to and is intermixed with the areas of *Lauro-Perseetum indicae*, *Visneo-Arbutetum canariensis*, and *Junipero-Oleetum cerasiformis*.

The structure and physiognomy are those of oligospecific woodland, terminal community of the climatophilous series of upper-dry pluviseasonal Thermomediterranean, upper-semiarid, dry and subhumid pluviseasonal lower-Mesomediterranean, all without trade-wind clouds, and dry, subhumid and humid pluviseasonal upper-Mesomediterranean; along with the edaphoxerophilous series of salic upper-semiarid xeric Thermomediterranean and salic lower-dry pluviseasonal Thermomediterranean of the Canary pine (*Pinus canariensis*) in Tenerife (*Sideritido solutae–Pino canariensis sigmetum*).

Despite anthropic activity and forest fires, pine woodland is well represented because of afforestation within its potential territory. The oldest forests of Icod, Adeje, Vilaflor, Arico and Candelaria are today included within the complete ring which encircles the island, the "Corona Forestal" Nature Park (Del-Arco *et al.* 1992).

The *Chamaecytisus proliferus* ssp. *angustifolius* broom scrub is common in this territory; it grows mainly on stony ground, and *malpaíses* (Del-Arco *et al.* 1992). The scrub *Erysimo scoparii–Pterocephaletum lasiospermi* Rivas-Martínez *et al.* 1993 is also frequent over decapitated soils, lithosols and lapilli beds. Rockrose scrub (*Cistetum symphytifolio-monspeliensis*) is also present over decapitated soils of Thermomediterranean areas.

Spartocytisetum supranubii Oberdorfer *ex* Esteve 1973

This is an association endemic to Tenerife, the summit broom (*Spartocytisus supranubius*) scrub. Its structure and physiognomy correspond to montane legume scrub, terminal community of the dry and subhumid pluviseasonal Supramediterranean, and dry pluviseasonal Oromediterranean climatophilous series of Teide broom (*Spartocytisus supranubius*) in Tenerife (*Spartocytiso supranubii sigmetum*).

Its climatophilous area (Fig. 6) caps the summit above the area of *Sideritido-Pinetum canariensis* in Supramediterranean and Oromediterranean territories. This area is enlarged by the edaphophilous potential distribution of the community over the pumice and *malpaíses* in the S sector of Las Cañadas, within the dry pluviseasonal Mesomediterranean belt (Fig. 11). In the uppermost Oromediterranean territories on Pico Teide it has a scarce presence probably due to the territory's geological youth and cold climate, which have prevented the formation of sufficient soil to allow the community to become installed.

Some permanent vegetation complexes develop there, and are of note among the communities *Violetum cheiranthifoliae* Rivas-Martínez *et al.* 1993 on lapilli and screes, and *Vulpio myuri-Gnaphalietum teydei* Wildpret & O. Rodríguez *in* Rivas-Martínez *et al.* 1993 in fumaroles (Del-Arco & Wildpret 1994).

Although the community was strongly grazed in the past and repeatedly suffered the effects of fire, causing it to retreat, it nowadays shows optimal development. The inclusion of most of its area within the Teide National Park since 1949, the banning of grazing and control over hunting has facilitated this recovery process (Martínez de Pisón & Quirantes 1981, Castroviejo & García-Moral 1989).

Discussion

Tenerife is the most diverse of the Canary Islands, having the highest number of bioclimatic belts (26). All of these fall within the Mediterranean macrobioclimate as in the rest of the islands. The Canaries have a different bioclimatic character from the Madeira Archipelago further north, where two macrobioclimates can be differentiated: Mediterranean and Temperate (Submediterranean), both being present in its evergreen laurel forest area (Capelo *et al.* 1999). This feature and particularly the floristic and phytocoenotic differential components of these two archipelagos support the existence of two biogeographical provinces (Canarian and Madeiran Provinces) within the Canarian Subregion of the Mediterranean Region (Rivas-Martínez *et al.* 2002).

As for the nearby African continent, the neighbouring west coastal area of Morocco belongs to the Western Mediterranean Subregion (Rivas-Martínez 1995). Although it shows some floristic and phytocoenotic analogies with the Canaries in its Inframediterranean and Thermomediterranean belts, Médail and Quezel (1999) justify its separation from the Canary territory by the high percentage of indigenous Mediterranean phanerophytes and therophytes, and the low level of adaptative radiation in that SW Moroccan territory.

At the south tip of Tenerife a narrow fringe of the hyperarid ombrotype still exists, and the arid ombrotype is only present on the SE and SW coasts, entering the windy promontory of Teno a little in the N. This distribution fits within an E to W decreasing gradient of distribution of the desertic bioclimate (with hyperarid and arid ombrotypes), dominant in the eastern islands (Reyes-Betancort *et al.* 2001, Rodríguez-Delgado *et al.* 2003) and scarcely present in the westernmost (Del-Arco *et al.* 1999a).

The Oromediterranean (dry pluviseasonal Oromediterranean) is exclusively present in this island within the archipelago. The only two islands with a Supramediterranean belt are Tenerife and La Palma. The latter, more oceanic and humid, has subhumid and humid pluviseasonal Supramediterranean belts while in Tenerife the dry pluviseasonal Supramediterranean is more developed, and subhumid pluviseasonal Supramediterranean is scarcely discernible. The upper-Mesomediterranean thermotype of La Palma and Gran Canaria follows a similar pattern, where subhumid and humid ombrotypes dominate, while in Tenerife the dry ombrotype is also well developed.

The distribution of recent (a few thousand year-old) *malpaíses*, salic outcrops, and recent or subrecent (mainly Pliocene) lava-flows has altered the distribution pattern of the climatophilous communities. As we pointed out for Gran Canaria (Del-Arco *et al.* 2002), the different geological ages, structure and compositions give rise to noteworthy differences between climatophilous and potential natural vegetation distribution (Figs. 6–11). For instance, the recent Malpaís de Las Galletas has induced an unusual descent of *cardón* scrub (*Periploco-Euphorbietum canariensis*) into the Inframediterranean desertic territory dominated by sweet spurge scrub (*Ceropegio–Euphorbietum balsamiferae*). The shielding effect of this superficial lava flow, today almost covered elsewhere by urban and horticultural development, lowers the evaporation rate, allowing edaphohygrophilous behaviour of the overlying *cardón* scrub. The recent or subrecent salic (acidic) materials in the area of Icod–La Guancha and Ladera de Santa Úrsula–La Victoria, and the presence of salic outcrops elsewhere, has led to an expansion of pine woodland (*Sideritido-Pinetum canariensis*) down to low altitudes, giving rise to some particular mixed communities with evergreen laurel forest (*Visneo-Arbutetum canariensis* and *Lauro-Perseetum indicae*). On the SE and SW island slopes, salic subrecent lava-flows also make pine woodland descend forming a mixed community with juniper woodland. The historic lava flows and ash (lapilli) show permanent vegetation complexes with a composition depending on location. All these variations lead to obvious differences between the climatophilous and potential natural vegetation maps.

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