THE IMPACT OF FIRE IN CANARIAN ECOSYSTEMS 1983–1998*

With 3 figures and 1 photo (a–d)

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Zusammenfassung: Auswirkungen des Feuers in Ökosystemen der Kanarischen Inseln 1983–1998

Der Beitrag liefert einen kurzen Überblick 15-jähriger Studien in feuerbetroffenen Ökosystemen der Kanarischen Inseln. Auf den Inseln der Provinz S/C de Tenerife ereigneten sich zwischen 1983 und 1998 12 außer Kontrolle geratene Flächenbrände im Wald- und Buschland mit einem Gesamtareal von ca. 24 300 ha (Fig. 1). Das Vorherrschen von Bodenfeuern leichter bis mäßiger Intensität sowie die überaus wirksamen pyrophytischen Anpassungen der einheimischen Flora machen verständlich, warum bislang die Auswirkungen und geoökologischen Folgeerscheinungen der Brände insgesamt weder sonderlich tiefgreifend noch von langer Wirkungsdauer waren. In der Wald- und Gehölzstufe der zentralen und westlichen Kanarischen Inseln hat das Feuer seit jeher eine geoökologische Rolle gespielt und wird das auch weiterhin tun. Die weitgehende Degradation und Verdrängung kanarischer Wälder und Gehölze ist nicht vorrangig dem Feuer anzulasten, sondern schädlichen Eingriffen der Landnutzung und Waldwirtschaft in der Vergangenheit. Dennoch macht die Bedrohung menschlichen Lebens und Eigentums durch das Feuer wirksame Maßnahmen der Brandbekämpfung und des Feuer-Managements erforderlich. Besonders die in letzter Zeit stark angewachsenen Fälle von Brandstiftung geben zu Besorgnis Anlaß. Möglichkeiten einer Verbesserung des zukünftigen Feuer-Managements werden erörtert. Von der Iberischen Halbinsel oder anderen Mediterran-Ländern übertragene Erfahrungen sind nur begrenzt anwendbar, da auf den Kanaren andersartige und spezielle feuer-ökologische Bedingungen vorliegen. Das ökologische Hauptproblem besteht nicht im Auftreten und den Auswirkungen des Feuers in Kanarischen Ökosystemen schlechthin, sondern im Mißbrauch des Feuers durch den Menschen und den weitgehenden Eingriffen in die Landesnatur der Inseln.

Summary: The paper gives a brief report about 15 years of studies in fire-affected ecosystems of the Canary Islands. On the islands of the Province S/C de Tenerife 12 extensive wildfires took place between 1983 and 1998, with a total area of about 24,300 ha of forest and shrubland (Fig. 1). The dominance of light or moderate surface fires, as well as the very effective pyrophytic adaptions of the native flora can explain, that the fire impact and the geoecological consequences following fire were neither detrimental on a large scale nor long lasting. In the forest- and shrubland belt of the central and western Canary Islands fire impact was of geoecological importance at all times, and likewise will be in times to come. The extensive degradation of native Canarian forests and woodlands is not a matter of fire impact, but is due to detrimental land use practices and a heavy wood exploitation in the past. Nevertheless, fire as a menace to human property and lives requires effective measures of fire-fighting and fire management. Namely the recent escalation in the number of fires caused by arson is alarming. Concepts of future fire management are discussed. Experiences transferred from the Iberian Peninsula or from other Mediterranean countries are of restricted use only, because of the different and specific fire-ecological situation on the Canary Islands. The major ecological problem is not the occurrence and impact of fire in Canarian ecosystems in general, but the abuse of fire by man and the extensive human impact on the natural environments of the islands.

Introduction

Wildfires in forest and shrubland ecosystems are of particular ecological significance in subtropical countries with a summer-dry Mediterranean type climate. Here a wide variety of fire-generated habitats exist ("fire landscapes"). In the Mediterranean countries some estimated 600,000 ha of land are burnt over year after year (GOLDAMMER a. JENKINS 1990). Major fire events which ran out of control are often declared as "ecological disasters" or "natural catastrophes" in the communication media. Natural fires, however, have always played an important role in the function and structure of the fire-prone ecosystems; they even bring positive geoecological effects (e.g. accelerated remineralization of organic matter, stimulation of plant growth, natural rejuvenation and biodiversity). In the forest- and shrubland-belt of the central and western Canary Islands fire impact was of geoecological importance at all times and likewise will be in times to come. Nevertheless, the Canary Islands are in a special and delicate ecological position. Therefore Mediterranean experiences about the fire impact in ecosystems and in socio-economic systems are not transferable to the Canarian environment without strong reservations. The evaluation of fire impacts needs extensive and long-term local field studies, as well as the application of an integrative,

* Dedicated to CARL TROLL on the occasion of his 100th birthday

holistic geoecological approach. This contribution is based on field experiences of a 15 years period.

Frequency, areal extent, and causes of fires on the Canary Islands

The excellent fire-adaption of a great many of plants as well as the presence of charcoal in paleosoils demonstrate the ancient fire history of the Canary Islands. Natural fires even operated as a major force in the biologic evolution. Under natural conditions, fires were started by volcanic activities and lightnings, though only 2–3 thunderstorms per year can be expected in the Canarian forest belt on the average (reasons: small land area, cool marine waters). Natural fires had a low frequency, but were able to spread over large areas in the steep mountainous country.

Since the human occupancy of the archipelago and namely since the Spanish colonization in the 15th century the fire frequency increased. Consequently, the present fire regime is largely different from the natural regime. The fire statistics of the period 1983–1994 record a number of 82 fires and a burnt area of 2,117 ha per year on the average for the Canary Islands. On the islands of the Province S/C de Tenerife 12 extensive fires took place between 1983 and 1998, with a total area of about 24,300 ha of forest and shrubland (Fig. 1). That means a quota of 7% of the total island area and about 20% of the forest and shrubland area. Invasions of hot and dry Saharan air masses with gusty winds ("tiempo sur") promote the uncontrolled spreading of wildfires (DORTA et al. 1991; HÖLLERMANN 1993–1996). The most fire-affected island is La Palma, where nearly 14,000 ha of land were burned between 1988 and 1998 (= 20% of the total island area), mostly in Canarian pine forest. The climax of the Canarian fire season coincides with the peak of the arid season in July–September ("los meses negros"), when 2/3 of all fire events take place (for the seasonality of climatic data and the fire regime see HÖLLERMANN 1993 a. 1995). According to the statistics, negligence in handling with fire (28.3%), pyromania resp. arson (23.3%) and "unknown causes" (44.1%) are responsible for the great majority of the recent fires, while ignition by lightning is involved with 0.4% only. An estimated half of the unknown causes can be attributed to arson as well, and in some recent years the quota of arson and carelessness may reach a level of more than 95%.

A matter of serious concern is the marked increase in the number and areal extent of the fires. This can be demonstrated by the data of the Province S/C de Tenerife, though the early statistics may be incomplete and less reliable: 1968–1973 147 fires with a total forest/shrubland area of 1,757 ha, 1974–1980 250 fires (6,908 ha), 1981–1987 404 fires (11,825 ha), and 1988–1994 462 fires (12,391 ha). Doubtless, this recent increase is due to detrimental human activities. An effective reduction of these activities looks to be more important in the fire policy of the future than the direct struggle against the flames.

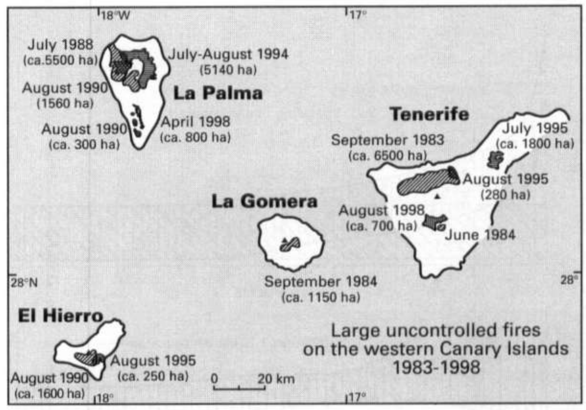


Fig. 1: Large uncontrolled fires on the western Canary Islands, 1983–1998

Große unkontrollierte Brände auf den westlichen Kanarischen Inseln 1983–1998

The impact of fire on the vegetation

The fire regime of the central and western Canary Islands shows an altitudinal distribution pattern in relation to the gradients of bioclimate, vegetation, and human activities. The main altitudinal belt of fire origin is situated below 1,000 m, where human activities are greatest and where the land use pattern of the "medianías" intermingles with shrubs, woodlands and forest ("medianías" = the belt of mixed and mainly subsistence-oriented agriculture in middle elevations, esp. 400–1,200 m a.s.l.). The uncontrolled flames spread uphill, so that the fire-affected areas find their maximal extension in altitudes between 800 and 1,600 m. This altitude corresponds largely with the belt of abundant biomass in the Canary pine forest and its transition to the heath shrubs and woodlands ("Monte verde"). The natural wet and cloudy Canarian laurel forest is not very fire prone, but the progressive degradation and destruction of the original laurel vegetation promote the flammability.

In the open Canary pine forest mature specimen of the endemic *Pinus canariensis* are protected by a very effective heat-insulating thick bark. Old mature pine stands are rarely affected by intense crown fires. The

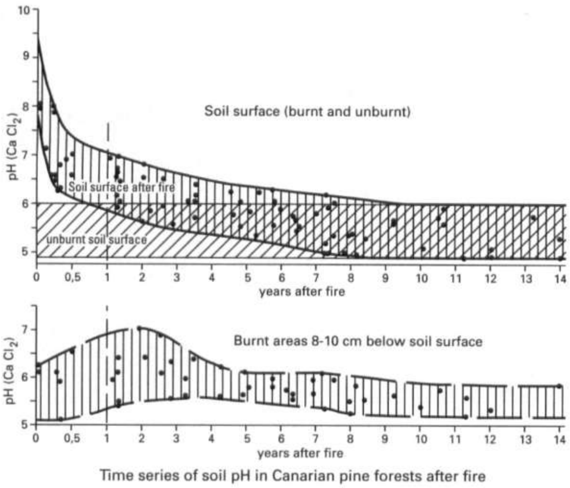


Fig. 2: Time series of soil pH in Canarian pine forests after fire (collective data set: Tenerife, La Palma, and El Hierro, 900–1,200 m)

Zeitliche Entwicklung der pH-Werte im Boden von kanarischen Kiefernwäldern nach einem Feuer (Datensammlung: Teneriffa, La Palma und El Hierro, 900–1200 m)

branching of the adult trees generally begins several meters above the ground, i.e. out of the reach of ground fires. The open forest structure and the accumulation of dry litter on the ground (mainly pine needles = "pinocha") support surface fires of low or medium intensity (fire intensities less than 1,200 kW/m; for calculation of fire intensities see HÖLLERMANN 1995, 37ff.). Following fire, the Canary pine develops many new sprouts from the base of the stem or from dormant buds of the trunk and branches. The fire-stimulated resprouting begins already three months after the fire; it brings about strange looking fire-column shapes ("bottle-brush type") of heavily burnt trees (e.g. Photo 1d). Furthermore, great numbers of pine-seedlings (up to > 20/m^{2} in the initial phase) follow a burn and find favourable conditions for establishment in the ash bed and upper soil layer with a concentration of available nutrients.

The dominant species of the heath forest or shrub (widespread even in the understory of some pine forests), namely "brezo" (*Erica arborea*) and "faya" (*Myrica faya*), have the ability for rapid basal sprouting a few months after the fire. The sprouting Monte verde shrubs attain a height of 1 m in 2 years and of 3–4 m in 7–8 years from the burn (Fig. 3). Most woody shrubs on the forest floor reproduce from seeds stimulated by fire (e.g. "codeso"= *Adenocarpus*, "escobon"= *Chamaecytisus*, "jara"= *Cistus*, or "taginaste" = *Echium*). The rare and endemic blue-flowering taginaste of La Gomera (*Echium acanthocarpum*) was promoted in reproduction by the September-fire in 1984 (BAÑARES BAUDET 1990).

Herbaceous geophytes recover from underground rhizomes, bulbs, or tubers (e.g. the "helechera"= *Pteridium aquilinum*, "gamón"= *Asphodelus sp.*, "albarrana"= *Urginea sp.*, or the endemic orchid *Habenaria tridactylites*). Anthracophytes (="ash plants") are attracted by the availability of nutrients in the ash layer (so many grasses or members of the pea family, e.g. the "corazoncillo"= *Lotus sp.*, or "tedera"= *Psoralea bituminosa*). On many burnt sites the vegetation cover achieves a higher density after the fire than before, which means an effective protection against erosion processes. Whether the reduction of allelopathic soil components by the fire contributes to the fast development of a plant cover on burnt surfaces, needs further studies ("allelopathics" prevent other plants from reproduction). Extensive shifts in species composition of Canarian pine forests were observed in a short period (1–2 years after the fire) only, as a rule, but are subject to local differences according to the specific site qualities. Longer lasting succession series are not unusual in shrub communities, however (for details see HÖLLERMANN 1995, 51ff.).

The regeneration of a fire-affected Canary pine forest with a substory of heath shrubs needs about 8–10 years. On more arid sites the forest and substory regeneration is retarded. Reforestations with the Californian Monterey pine (*Pinus radiata*) or Mediterranean pine species are easily killed by intense fires and are not able to resprout, while fire-damaged dead Canary pines are extremely rare or even absent on the burnt forest sites (Photo 1 a–d). Eucalyptus plantations (*Eucalyptus globulus*) form highly flammable monocultures and tend to accelerated soil erosion after fire, but a regeneration by sprouting takes place within a few years. Under the aspects of fire ecology, all plantations with exotic trees increase the fire hazard and should be replaced by native Canarian species.

Shrubland formations recover in 5–8 years, as a rule. In the high mountain environment above the upper timberline the complete regeneration needs more time, however. This is true for the Codeso formation (*Adenocarpus viscosus*) of High La Palma, which was burnt down periodically by pastoralists in the past, and which was subjected to extended and repeated fires even in recent years (1988, 1994, 1997).

The impact of fire on soils, water balance, and erosion

On the burnt soil surfaces the daily range of temperature and the seasonal variation of soil moisture proved to be more extreme than on unburned sites nearby. In

Photo 1: Regeneration of a Canarian pine forest after the fire of August 1994, northern slope of La Palma, about 1,400–1,500 m a.s.l.

Regeneration eines kanarischen Kiefernwaldes nach dem Feuer vom August 1994, Nordseite von La Palma, ca. 1400–1500 m ü. NN

1a: Heavily burnt forest 2 1/2 months after the fire
Photo: November 6, 1994

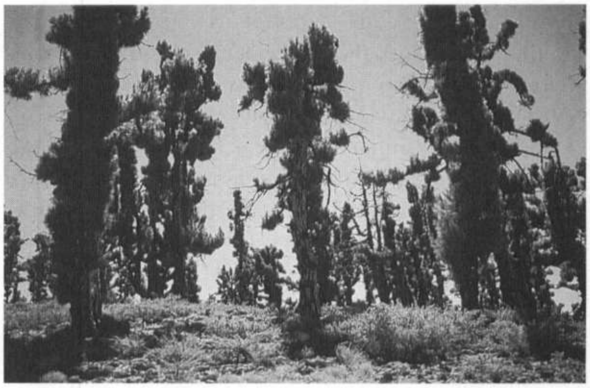
Stark verbrannter Wald 2 1/2 Monate nach dem Feuer

1b: Resprouting of young pine needles
Photo: October 12, 1995

Austreiben junger Kiefernnadeln

1c: Progressing needle sprouting and reproduction of the ground story, dominated by Codeso (*Adenocarpus viscosus*)
Photo: October 21, 1996

Fortschreitende Benadelung und Wiederaufkommen des Unterwuchses, beherrscht von Codeso (*Adenocarpus viscosus*)



1d: Further regeneration of the pine forest and the ground story
Photo: September 4, 1998

Weitere Regeneration des Kiefernwaldes und des Unterwuchses

the fresh ash layer and upper soil the supply of available nutrients as well as the soil pH are raised by the mineralization of biomass. The increase of soil pH near the soil surface has a temporary character, with a distinct decrease in the first six months following fire and a more gradual reduction over the following years (Fig. 2). 8–10 cm below the burnt surface the maximal post-fire pH-values appear after only 2–3 years (Fig. 2), which proves, that the fire-caused change in the soil nutrient status persists over several years. Thus no depletion of soil nutrients after fire can be proved. Fire brings abrupt and accelerated remineralization of organic matter in the nutrient cycle of ecosystems with seasonal aridity, where the normal decomposition and microbiological activity is reduced by the dry climate.

No serious or lasting disturbances of the forest water balance by fire were observed during the study campaign 1983–1998. The reduction of "fog-drip" resp. "horizontal precipitation" (water gain by exposed trees or shrubs out of drifting clouds) is of local importance only and should not be overestimated (KÄMMER 1974; SANTANA PÉREZ 1990). Less than 8% of the recently

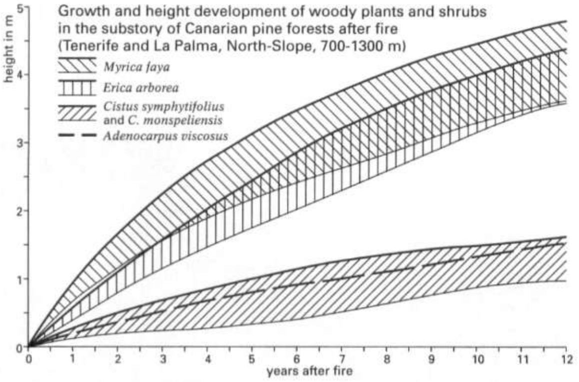


Fig. 3: Growth and height development of woody plants and shrubs in the substory of Canarian pine forests after fire (Tenerife and La Palma, North Slope, 700–1,300 m)

Wachstum und Höhenentwicklung von Gehölzen und Sträuchern im Unterwuchs von kanarischen Kiefernwäldern nach einem Feuer (Teneriffa und La Palma, Nordhang, 700–1300 m)

fire-affected areas are exposed to effective fog-drip. On the other hand, the low water demand of the fire-affected vegetation promotes an increased groundwater recharge in winter.

The thermal impact and heat flow downward into the soil is rather low during moderate-intensity surface fires. So most fires do not totally destroy the organic matter of the upper soil layer. Consequently, the infiltration capacity of the porous soils (namely andosols) and volcanic substrates is preserved. This explains, why the morphodynamic effects of the extensive fires in general were minimal only as compared with landscapes in the Mediterranean countries or California (Höllermann 1993–1995). The fast regeneration of the ground cover by plants and litter (esp. pine needles="pinocha") assist the control of water runoff and erosion on the burnt slopes. Even heavy rainstorms (> 100 mm/day) do not result in accelerated erosion in fire-affected terrain as compared to unburned sites, as a rule. Spectacular damages of the landscape (e.g. degradation of the vegetation cover and soils, accelerated erosion, soil movements) were generally due to direct human disturbance, and not attributable to fire. Fire-induced damages are rare; they are restricted to sites with high-intensity fires, to exotic afforestations with high flammability, or to extreme habitats (e.g. steep slopes, arid sites, or mountain ridges).

The 1998 fire on the steep and arid southern slopes of Tenerife above Vilaflor affected such a sensible habitat with a thin soil cover and a reduced regeneration capacity. The possible consequences remain to be seen, but look to be minor because of low rainfalls in the winter 1998/99.

Concluding remarks

After 15 years of studies in fire-affected ecosystems of the Canary Islands the author comes to the conclusion, that up to now the fire impact and the geoecological consequences following fire were neither detrimental on a large scale nor long lasting. The dominance of light and moderate surface fires as against intensive crown fires (relation about 90 : 10), as well as the amazing pyrophytic adaptions of the highly specialized forest and shrubland flora contribute to a major type of fire impact, that is merely light and not disastrous, as a rule. Hitherto, there is no reason to classify the forest and shrubland fires of the Canaries as "ecological catastrophes" and "ecodesasters", or to speak of a lamentable "forest destruction" in this context. Even in the area of widespread crown fires on the northern slope of La Palma in 1994, it is hardly possible to find fire-killed mature Canary pine trees (Photo 1a–d). The extensive degradation of native Canarian forests and woodlands is not a matter of fire impact, but is due to detrimental land use practices and a heavy wood exploitation in the past on the background of limited resources and space for living on the islands. The short-term recovery of the fire-affected vegetation on the spot brings about a high degree of local persistence of the present vegetation pattern. One has to accept, that fire even brings many positive effects to the ecosystems under natural conditions.

These optimistic statements should not be regarded as an encouragement for careless handling with fire or even as an excuse for pyromania, however. On the limited space of the Canarian archipelago and in face of a rapid demographic and economic growth, fire and man came too close in contact. Fire as a menace to human property and lives requires effective measures of fire-fighting and fire-management. Namely the recent escalation in the number of fires caused by arson ("terrorismo ecologico") is alarming. Frequent fires in short time intervals may bring about accumulated damaging effects. A high fire frequency (< 6–8 years) can prevent the complete regeneration of the forest and shrubland ecosystems, will promote a progressive degradation of vegetation and soils, and may result in gradual nutrient depletion and accelerated soil erosion.

The future concept of fire management should not be confined to the passive-reactive practice of fire-fighting alone, but should be extended to active-preventative measures to control and to improve the fire regime, e.g. by reduction of the fire-prone biomass and of the fire frequency. This will not be done by technical improvements only; it rather needs a better understanding of the specific Canarian situation and the special fire-ecological conditions here, which are largely different from the experiences transferred from the Iberian Peninsula (see e.g. MAY 1995) or from other Mediterranean countries (e.g. GOLDAMMER a. JENKINS 1990; NAVEH 1990). An interdisciplinary, long-term research project would be very helpful for a deeper understanding of the specific role of fire in Canarian ecosystems and would facilitate further decisions about fire management on a sound scientific base. This can open a serious and unbiased discussion free of hysteria and misleading generalizations. Furthermore, it needs a better understanding of the socio-economic situation and requirements of the native Canarian people, which should be better included in the discussions about the future aims of fire management and protection of natural environments. An absolute fire exclusion is not attainable even by extreme efforts; and it is not even desirable. Fire was and can be a natural ecological control factor as well as a useful tool in landscape management, while on the other hand the frequent abuse of fire finally turns out to be detrimental to the forest and shrubland ecosystems. To conclude: the major ecological problem is not the occurrence and impact of fire in ecosystems in general, but the abuse of fire by man and the growing human impact and stress on the natural environments of the Canary Islands.

References

BAÑARES BAUDET, A. (1990): Programa de Recuperación de la Flora Amenazada del Parque. In: PÉREZ DE PAZ, P. (Ed.): Parque Nacional de Garajonay, ICONA, Excmo. Cab. Ins. de La Gomera, 255–261.

DEL ARCO AGUILAR, M. J. et al. (1992): Incendios. In: Atlas Cartográfico de los Pinares Canarios II. Tenerife, S/C de Tenerife, 71–74.

DORTA, P.; MARZOL, M. V. a. SANCHEZ, J. L. (1991): Los Incendios en el Archipiélago Canario y su Relación con la Situación Atmosférica. Causas y Effectos. In: XII Congr. Nacional de Geogr., Valencia, 151–158.

GOLDAMMER, J. G. a. JENKINS, N. J. (Eds.) (1990): Fire in Ecosystem Dynamics. Mediterranean and Northern Perspectives. The Hague, 191 p.

HÖLLERMANN, P. (1993): Fire ecology in the Canary Islands and Central California – a comparative outline. In: Erdkunde 47, 177–184.

– (1995): Wald- und Buschbrände auf den westlichen Kanarischen Inseln. Ihre geoökologischen und geomorphologischen Auswirkungen. In: Abhandl. d. Akad. der Wissensch. Göttingen, Mathem.-Physikal.Klasse 3, 46, 184 p. (with Summary in English and Spanish language).

– 1996: Feuer als geoökodynamischer Faktor in subtropischen Winterregen-Gebieten. Das Beispiel der jüngsten Wald- und Buschbrände auf den Kanarischen Inseln. In: Geoökodynamik 17, 1–24 (with English Summary).

– (1996): Los Incendios Forestales en las Islas Canarias y sus Consecuencias. In: Diario de Las Palmas, Fin de Semana, 7. September 1996, I–III.

KÄMMER, F. (1974): Klima und Vegetation auf Tenerife, besonders im Hinblick auf den Nebelniederschlag. Scripta Geobotanica 7, Göttingen, 78 p.

MAY, T. (1995): Wald- und Buschbrände in Spanien. In: Geograph. Rundschau 47, 298–304.

NAVEH, Z. (1990): Fire in the Mediterranean Perspective. In: GOLDAMMER, J. G. a. JENKINS, N. J. (Eds.): Fire in Ecosystem Dynamics, 1–20.

SANTANA PÉREZ, L. (1990): La Importancia Hidrológica de las Nieblas en las Cumbres del Parque Nacional de Garajonay. In: PÉREZ DE PAZ, L. (Ed.): Parque Nacional de Garajonay, ICONA, Excmo. Cab. Ins. de La Gomera, 67–71.