Chapter IV

RAINFALL, FOG AND THROUGHFALL DYNAMICS IN A SUBTROPICAL RIDGE TOP CLOUD FOREST

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ABSTRACT

Mixed tree-heath/beech forest is a type of subtropical montane cloud forest found on wind- and fog-exposed ridges in the Canary Islands, including in the National Park of Garajonay on La Gomera. With a dry season of five months and an annual precipitation of 600-700 mm any extra water inputs to the forest system through fog interception assume particular importance. Measurements of rainfall, fog occurrence, wind speed and wind direction were made above the canopy of a ridge top cloud forest in the Jelima catchment in the centre of the Park. Measurements of incident rainfall were corrected for wind-induced losses around the gauge and for topographic effects, leading to a 39% increase in conventional gross precipitation. Amounts of fog water as collected by a 0.25 m^2 fog screen were corrected for changes in effective screen surface collection area depending on wind direction, yielding an extra input of 63% of gross fog water. No such corrections were taken into account in previous studies of rainfall and fog water inputs in the Canary Islands. Although potential fog deposition was double the amount of precipitation, only ca. 6% of the corrected fog collected above the canopy contributed to crown drip. Apparently, the fog capturing efficiency of the forest was much lower than that of the fog collector.

IV.1 INTRODUCTION

Laurisilva vegetation is a laurel-dominated subtropical forest formation which was widespread in the Mediterranean region during the Tertiary era. Today it only survives on the Macaronesian Islands (Canary Islands, Madeira, Cabo Verde and the Azores), at mountainous locations where humid conditions are guaranteed throughout the year. On exposed ridges, *Laurisilva* is replaced by an impoverished form, mixed tree-heath/beech forest, or *fayal-brezal* in Spanish. One of the largest expanses of *Laurisilva* is found in the National Park of Garajonay on La Gomera, in the Canaries.

Being located on the south-eastern edge of the Azores anticyclone where air masses are descending, and with their coastlines washed by cold Atlantic ocean currents and their mountains swept by north-easterly trade winds, the climate of the windward sides of the Canary Islands is heavily influenced by the formation of a thermal inversion leading in turn to a stratocumulus cloud deck known locally as the *sea of clouds* (Dorta, 1996). This atmospheric situation is observed during much of the year although the atmosphere tends to become less stable during winter when depressions come in from northerly directions and rain storms prevail over fog (Dorta, (1996); Figure IV.2). The temperature inversion is more stable during the dry summer period and is believed to play a major role in sustaining evergreen forest types despite the scarce precipitation from May to September (Dorta, 1996). Some early studies conducted in cloud-exposed laurel forest in northern Tenerife (Ceballos and Ortuño, 1942; Kämmer, 1974) found that throughfall was 1.2 and even 3.2 times incident rainfall amounts, indicating the importance of fog as an extra input of water to at least some Canary forests. Whilst the general hydrogeological study of La Gomera Island (I.G.M.E., 1985) took such findings into account, it is clear that assessments of water inputs in complex mountainous terrain are subject to significant uncertainties (Mulligan et al., 2006a). These uncertainties relate to the fact that results are not only highly dependent on the method of rainfall and fog collection (Bruijnzeel et al., 2005; Holwerda et al., 2007; Sevruk, 1982) but also on the location of the measuring site in terms of windiness and topographic exposure (Mulligan et al., 2006a; Sharon, 1980; Sharon and Arazi, 1997). Knowledge of rainfall and fog water inputs and how these amounts are transformed into throughfall and stemflow is essential to better understand the hydrological fluxes in cloud forests. This paper presents the water inputs and related amounts of throughfall in an exposed ridge top cloud forest in central La Gomera over the period February 2003 – January 2005.

IV.2 METHODS

IV.2.1 Study area

The Jelima catchment is situated in the volcanic headwaters of the Vallehermoso basin in La Gomera, close to the central summit area of the Garajonay National Park (located between 28° 17' 41'' and 28° 17' 42'' N latitude and between 31° 08' 06'' and 31° 08' 28'' W longitude) (Figure IV.1).

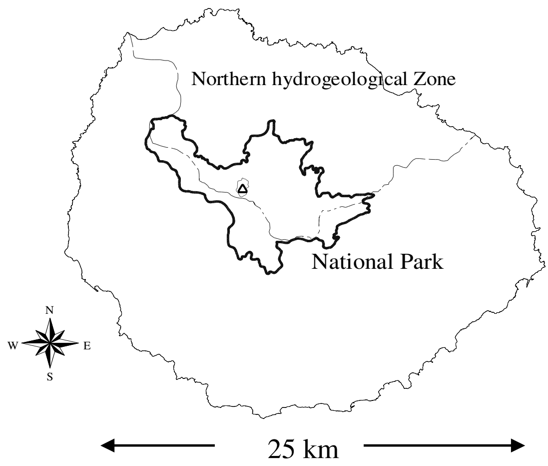

Figure IV.1. Location of the Jelima catchment in La Gomera and the Garajonay National Park. Ridge position indicated by △.

A scaffolding tower 9 m high with a final 3 m mast and equipped with various climatic instruments was erected at Laguna Grande on one of the upper ridges of the catchment at 1270 m altitude. The slope immediately below had a gradient of 25o and a NE orientation and was therefore well exposed to the trade winds and the regular 'sea of clouds'. The climate is classified as humid Mediterranean (Köppen Csb-type), with a mean annual precipitation around 660 ± 247 mm (Arévalo et al., 2002), high relative humidity and low insolation caused by the frequent presence of the clouds which also brings about mild temperatures throughout the year (minimum 5-7 ºC in winter vs. maximum 25 ºC in summer; source: National Park of Garajonay, undated). Figure IV.2 shows the seasonal variation in rainfall at Laguna Grande in relation to the height of the cloud deck.

Vegetation at the top of the ridge (1300 m) consists of stunted tree-heath forest of about 4 m high. Further down on the ridge (1270 m), the forest increases in size (6-9 m) due to the presence of vigorous individuals of *Erica arborea* (a dominant species on the ridge) with some admixtures of beech (*Myrica faya*). Therefore, the vegetation can be classified as mixed tree-heath/beech forest or "*bosque de fayal-breza"l* in Spanish. The forest had a leaf area index of 4.2 ±1 and was characterized by abundant epiphytes and bryophytes which covered almost all branches and trunks (Golubic, 2001).

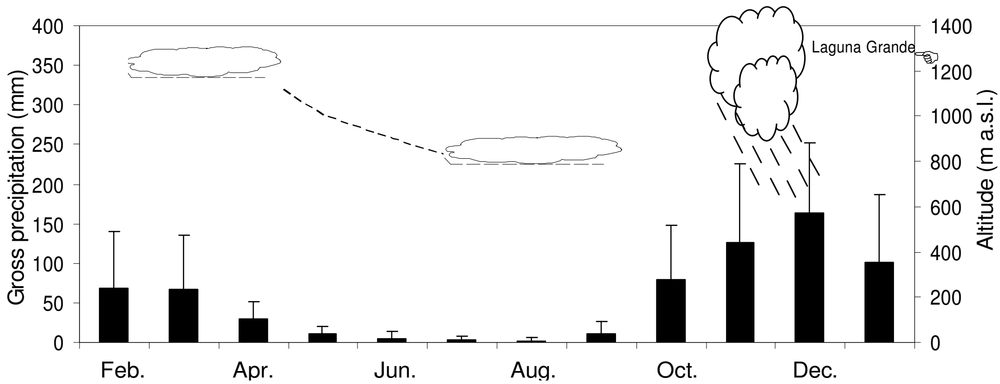

Figure IV.2. Seasonal variation of long-term rainfall (1987-2005) in relation to the location of the thermal inversion (-- inversion altitude, m) (Dorta, 1996) at the Laguna Grande site (☜), La Gomera. Vertical lines represent one standard deviation from the monthly mean. Source: National Park of Garajonay. Data from 2003 to 2005 are from this study.

IV.2.2 Rainfall input and correction for wind losses

Gross rainfall (P_g, mm) was measured above the canopy by a tipping-bucket rain gauge (Rain-o-Matic, 200 cm^2 orifice and 0.25 mm resolution) installed at the top of the tower (cf. Figure IV.3). Adjustments of the measurements for the systematic error caused by wind losses around the gauge were obtained according to Yang et al. (1998), assuming that trace, wetting and evaporation losses from the gauge were negligible under the prevailing climatic conditions:

$$P_a = kP_g \qquad \text{IV.1}$$

where P_a is the adjusted precipitation or meteorological rainfall (mm/d), P_g the measured (gross) precipitation (mm/d) and k the wind-loss coefficient calculated as k=1/R, with:

$$R = \exp(4.605 - 0.062u^{0.58}) \qquad \text{IV.2}$$

where R is the daily catch ratio in percent and u wind speed in m/s. Wind speed was measured with an A100R (Vector Instruments) anemometer at ca. 2 m above the canopy, i.e. at about the same height as the rain gauge. Data used in this study were collected on a 15-min basis and summed to hourly values instead of daily values as used by Yang et al., (1998) to allow for better evaluation of the effect of changes in wind speeds during the day. Tests revealed no significant differences in overall results whether using daily or 15-min data.

Under windy conditions in sloping terrain rainfall tends to impact against the vegetation at an angle, thereby decreasing the apparent intensity of the rain (Sharon, 1980). In order to estimate the "true" amount of rainfall incident to the forest canopy, also called hydrological rainfall (P_a^*, mm), the wind-loss corrected rainfall P_a was multiplied by the correction factor f_c obtained in turn from the following trigonometric model (Sharon, 1980):

$$f_c = 1 + \tan(a)\tan(b)\cos(\Omega_a - \Omega_b) \qquad \text{IV.3}$$

where a is the inclination of the canopy (assumed to be the same as the ground slope), b the angle of rainfall from the vertical, Ωa the slope aspect (site orientation) and Ωb the average direction of the wind (Figure IV.3). The median rainfall inclination angle was calculated using relations between rainfall intensity, raindrop size, the terminal velocity of the raindrops and wind speed on a 15-min basis as described in detail by Holwerda et al. (2006a).

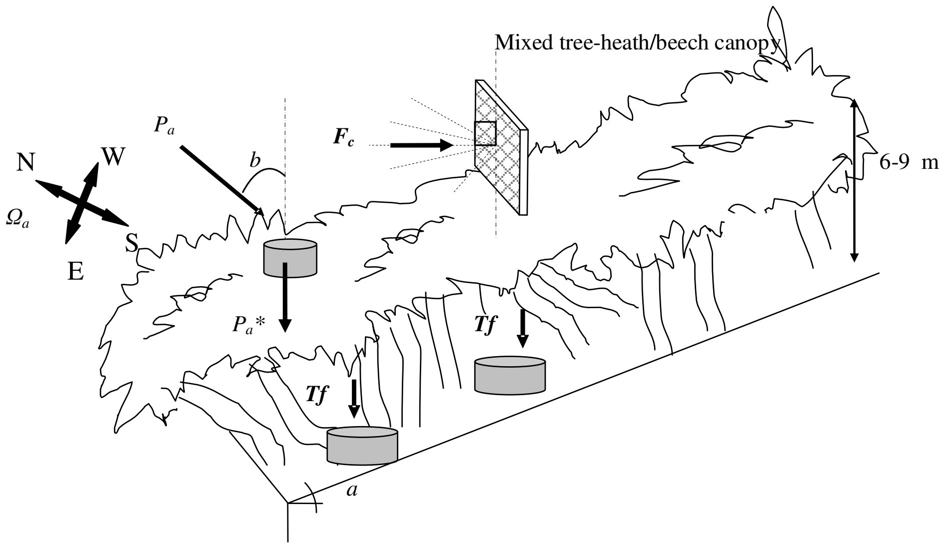

Figure IV.3. Measurement of water inputs at canopy and soil surface levels in a hillcrest tree-heath forest oriented towards the NE (Ω_a) on a 25% slope (a). Pa: meteorological rainfall (corrected for wind loss around the gauge); P_a*: rainfall corrected for topographic and wind effects (hydrological rainfall); b: angle of the rainfall; F_c: wind-direction corrected fog water volume; Tf: throughfall.

IV.2.3 Fog water inputs

Fog water was collected by a screen with a surface area of 0.25 m^2 (0.5 x 0.5 m) placed at the top of the tower with a fixed orientation facing NE (45º) (see Figure IV.3). This type of passive screen is called a 'quarter' fog collector (QFC) and consists of a mesh made of polypropylene (Raschel-type), placed in a single layer and having a shade coefficient of 65% (Marzol, 2002). The fog collector was connected with a tipping bucket rain gauge (Rain-o-Matic, bucket capacity 5 ml or 0.02 mm). To express fog water volumes in mm, volumes (L) were divided by the cross-sectional area of the screen (Walmsley and Schemenauer, 1996). The resulting amounts are referred to henceforth as gross fog (F_g, mm). However, the use of a flat collection screen of fixed orientation poses a major limitation when wind directions are variable (Figure IV.4) and is likely to lead to an underestimation of fog inputs as the effective collection surface becomes reduced when the direction of the impaction is not perpendicular to the screen (Juvik and Nullet, 1995).

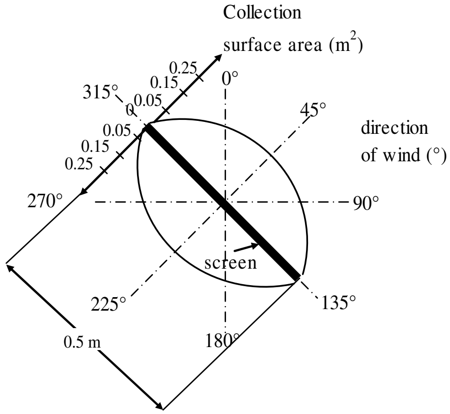

Figure IV.4. 2-D screen fog collector (0.5 x 0.5 m) oriented to NE (45º) and the theoretical relationship between effective collection surface area (from 0 to its maximum 0.25 m^2) and wind direction (º).

To correct collected gross fog amounts for the effects of wind direction (corrected fog, F_c), it is proposed to estimate the effective cross-sectional screen area as a function of wind direction using simple trigonometry (Figure IV.4). Wind direction was measured with a Vector Instruments W200P potentiometer wind vane. Thus, F_c was obtained from:

$$F_c = \frac{n \cdot v}{A_{ce}} \qquad \text{IV.4}$$

where n is the number of tips registered by the recording gauge, v is the spoon capacity (5 ml) of the tipping bucket, and A_{ce} the estimated effective cross-sectional area (m^2) as a function of wind direction (Figure IV.4). Naturally, the effective cross-sectional screen area may vary from its maximum (0.25 m^2) when fog comes perpendicular (45º or 225º) to its minimum (ca. 0 m^2) when fog comes almost parallel to the surface (135 º or 315 º), and this well resulted in unrealistically high F_c values. Such cases should not be too numerous, however, because of the constancy of the trade winds (cf. Figure IV.8 below). A prudent approach (though admittedly arbitrary but based on a possible variation of ±10° in the mean registered by the instrument) was adopted in which a minimum value for effective screen area of 0.04 m^2 (1/6 of the QFC's area) was assumed constant when wind drove fog from 135±10° and 315±10° (Figure IV.5).

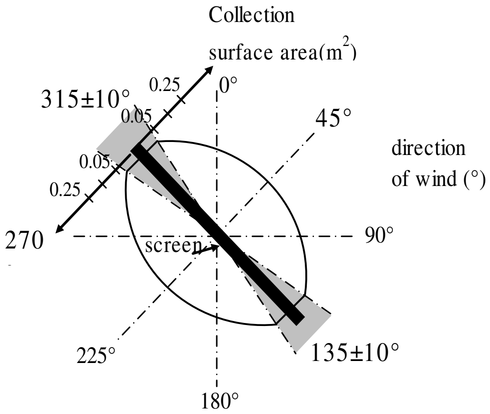

Figure IV.5. 2-D screen fog collector (0.5 x 0.5 m) oriented to NE (45º), the theoretical relationship between effective collection surface area and wind direction (º) and the adopted spectra (135±10° and 315±10°) in which the effective screen area is assumed to be constant (0.04 m^2).

Next, potential fog water incidence (D_{Fc}) was estimated by dividing F_c by the screen's collection efficiency (different from the shade coefficient). Differences in mesh efficiency in relation to wind direction are unknown, but a mean overall collection efficiency of 50% was derived for this type of polypropylene mesh as used in 1 m^2 screens (so-called Standard Fog Collectors or SFC; Schemenauer and Cereceda (1994)). In addition, in comparative tests conducted in nearby Tenerife by Marzol (2002), the catch efficiency of the QFC (used in this study) was 10% higher than that of an SFC of 1 m^2. Incorporating the later efficiency into the former results in a mean overall collection efficiency value of 60%.

The performance of SFC- and QFC-type collectors during rainfall is poorly documented (Holwerda et al., 2007). Although cumulative annual totals of gross fog input (F_g) did not differ much, regardless whether there was rainfall during the previous 1 or 2 hours (11 ± 5.1% of F_g), it was nevertheless decided to only consider recorded inputs as fog water if no rainfall was recorded by the rain gauge during the preceding hour.

IV.2.4 Throughfall

Throughfall was measured with two automatic pluviometers with a collecting surface of 0.2 m^2 each, installed 1 m above the ground. Although the total collecting surface area of the two gauges was equivalent to that of 40 standard gauges of 0.01 m^2 each, it is recognized that the spatial variability in *Tf* is not represented well by the use of only two gauges. The gauges were periodically cleaned to prevent blockage of the orifices by the fine tree-heath needles and other organic debris.

IV.3 RESULTS AND DISCUSSION

IV.3.1 Annual rainfall inputs

Annual gross rainfall totals (P_g) were 670 mm and 1185 mm for the first (February 2003 - January 2004) and second (February 2004 – January 2005) year, respectively. Time period was decided so caused of a logistic constrain. As such, the first year experienced more or less average amounts of rain for this altitude (long term mean at Laguna Grande 660 ± 247 mm), but the second year was very wet, mostly because of unusually high winter rainfall, especially in January 2005 (cf. Figure IV.9 below). Adjustment for wind losses around the gauge (Yang et al., 1998) gave an overall extra inputs for both years in the order of 20% of P_g, illustrating the importance of wind effects on rainfall collection on exposed ridges. The annual adjusted rainfall totals (P_a) amounted to 760 mm and 1493 mm for the first and second year, respectively (Figure IV.6). Corrections to account for rainfall underestimation due to topographic and rain-angle effects (Sharon, 1980) were even higher at 18% and 13% of P_a in the respective years. Mean annual wind speeds were 2.9 ±1.9 m/s in 2003 and 3.1 ±1.9 m/s in 2004, which induced an overall theoretical mean droplet angle of incidence of 31 ±15°. Thus, corrected incident rainfall totals (P_a^*) were raised to 900 and 1693 mm for the respective years (Figure IV.6), implying a correction by measured rainfall (P_g) of ca. 39% (underestimation of 28% P_a^*). The uncertainty (annual maximum random relative error) in P_a^* was estimated at ca. ±7.4%. This is based on the error in the measurement of rainfall itself (i.e. without wind effects) estimated from the standard deviation between gross rainfall measured at the site and at the nearest station within the study catchment during rainfall events not affected by wind effects (ca. 1.9%) whereas the errors associated with the application of Yang's equation was assumed to be ca. 5.5% (according to the method used in Frumau et al. (2006)).

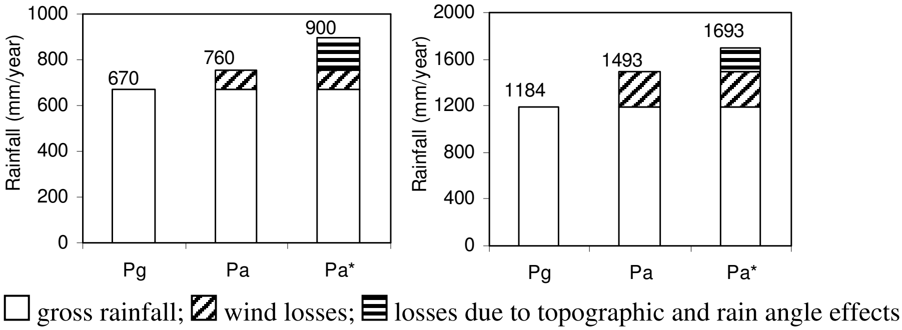

Figure IV.6. Annual rainfall and effect of various wind-induced losses (all in mm) at the Laguna Grande ridge top site, Garajonay National Park, La Gomera. Left: February 2003 - January 2004, right: February 2004 - January 2005. P_g: gross rainfall; P_a: adjusted for wind losses around the gauge; P_a^*: corrected for rainfall and terrain inclination effects.

The frequency distribution of daily amounts of adjusted rainfall (P_a^*) during the two years is shown in Figure IV.7. The total number of days with a measurable rainfall input (> 0.25 mm) was 459 (224 in the first year and 235 in the second), half of which consisted of rainfalls ≤2 mm/d whereas 38% of the days registered rainfalls ≤1 mm/d. Maximum daily rainfalls were 53 mm in 2003/04 and 215 mm in 2004/05 as recorded in November 2003 and January 2005, respectively.

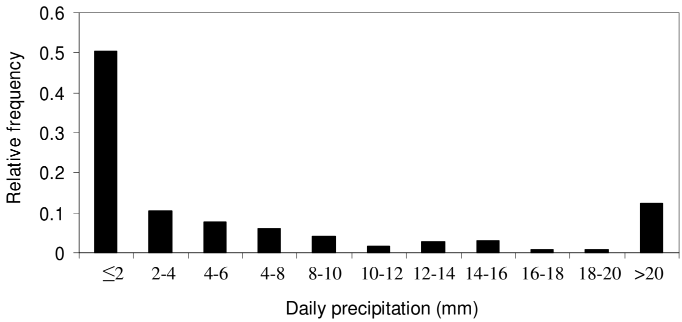

Figure IV.7. Relative frequency distribution of adjusted daily precipitation totals during two years at the Laguna Grande ridge top site at 1270 m, Garajonay National Park, La Gomera.

IV.3.2 Annual fog water inputs

The prevailing wind direction when fog was registered was NNE, with northerly and north-easterly winds occurring less frequently (Figure IV.8). Therefore, the orientation of the fog collector deviated by 22.5º from the dominant wind direction. Gross amounts of fog water (F_g) were 594 and 468 mm for the first and second year, respectively. Corrected for variations in effective collection surface as a function of wind direction (F_c) these figures were raised to

882 mm (+48%) and 834 mm (+78%) for the respective years (Figure IV.8), implying a mean correction of 63% of F_g. The limitation of using screen collectors with a fixed orientation is evident. However, because F_c was derived by trigonometry, these results should be considered with caution until they can be compared with the results obtained with a cylindrical fog collector under the same conditions (Frumau et al., 2007b; Holwerda et al., 2007; Juvik and Nullet, 1995).

Annual totals of potential fog incidence (D_{Fc}) may be derived by dividing F_c by the mesh efficiency of the screen, essentially almost doubling (ca. 1.7 the values to 1500 mm and 1420 mm for the two years, respectively. The standard deviation of D_{Fc} was estimated at ca. 14.3% based on an assumed variation of ±5% in mesh efficiency (55-65%).

The average F_c value of 2.35 mm/day falls in the upper part of the published spectrum obtained with various types of passive fog gauges in subtropical and tropical cloud forest environments (Bruijnzeel et al., 2005; Bruijnzeel and Proctor, 1995). Using similar fog screens in Tenerife, Marzol (2005) observed maximum F_g values of 6.24 mm/day.

Based on visual and general climatic evidence, the Laguna Grande site is located within one of the foggiest parts of La Gomera. Similarly exposed ridges within the National Park area occupy ca. 7.5% of the total Park area (300 ha). Taking the average of the two annual F_c values as a first approximation would imply an associated potential extra water input from fog of as much as 2.35 mm/d (even 1.7 times this value based on D_{Fc} values). However, because actual fog deposition onto a live canopy is strongly dependent on tree architecture and ecosystem structure (Lovett, 1986; Mulligan et al., 2006b), the actual amounts stripped by the trees will be much smaller (see also below).

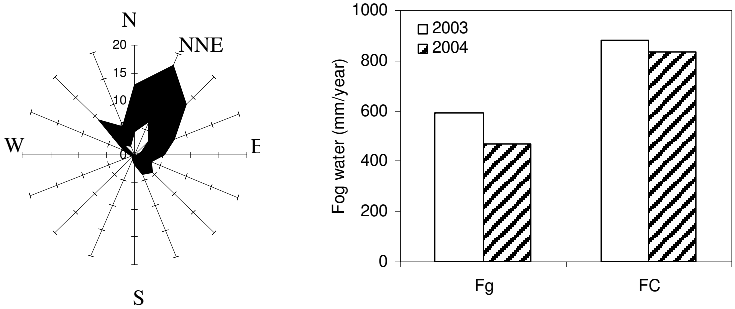

Figure IV.8. Left: Overall distribution of wind direction frequency (black shapes) expressed as % of hours at the Laguna Grande ridge top site, Garajonay National Park, La Gomera between February 2003 and January 2004. White shape represents wind direction frequencies during times of fog. Right: Annual gross fog water (F_g) and fog corrected for effective collecting surface area (F_c) for periods when precipitation was <0.02 mm/h. White bars represent the period February 2003 until January 2004, and hatched bars the period February 2004 until January 2005.

IV.3.3 Seasonal variability of water inputs

The seasonal distribution of rainfall (P_a^*), fog (F_c) and potential fog incidence (D_{Fc}) during the two-year study period at the Laguna Grande forest is shown in Figure IV.9. The rainfall total for 2003 was heavily dominated by rainfall occurrence in two months, October and November with 176 and 291 mm, respectively, followed by February with 245 mm. In the second year, most of the rainfall was received in four months, viz. February, November, and December 2004 and January 2005 with 120, 333, 350, and 335 mm, respectively. December 2003 and January 2004 were unusually dry, coinciding with a Saharan wind invasion, whereas January 2005 was extremely wet due to depressional activity. The respective totals obtained in the two January months illustrate the variable nature of the rainfall climate of La Gomera and the need for long-term observations in these uplands.

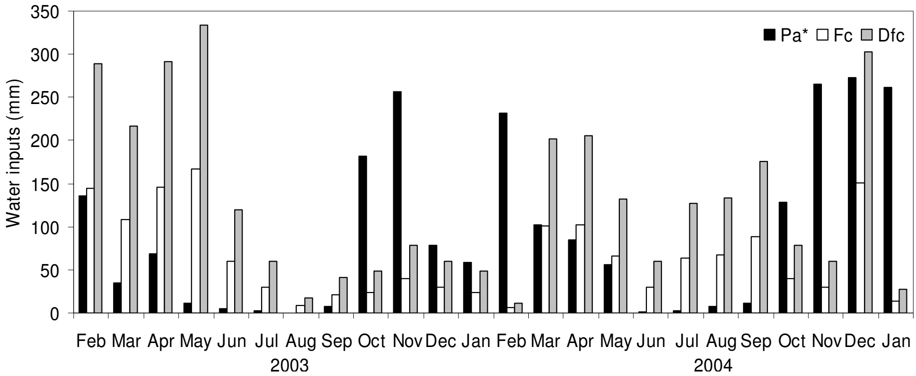

Figure IV.9. Monthly rainfall (corrected for wind speed, ■ Pa*, mm), fog (corrected for wind direction, □ Fc, mm) and potential fog incidence (corrected for wind direction and screen efficiency, ■ DFc, mm) from February 2003 until January 2005 at the Laguna Grande ridge site, Garajonay National Park, La Gomera.

Fog occurred during the whole year, but the highest amounts were generally recorded during spring time (February–May) when the site is enshrouded in the sea of clouds (cf. Figure IV.2). Maximum monthly fog totals were 185 mm (D_{Fc}= 315 mm) in May 2003, and ca. 160 mm (D_{Fc}= 270 mm) in February and April 2003 and December 2004.

Despite the stable occurrence of stratocumulus clouds during the summer (cf. Figure IV.2), observed fog amounts during the May to September period were relatively low, especially in the first year, with an absolute minimum of 10 mm (D_{Fc} = 17 mm) in August 2003 (Figure IV.9). This can be explained by the fact that at 1270 m elevation the Laguna Grande site is sometimes situated above the base of the thermal inversion during this time of year and therefore hardly influenced by the stratocumulus at such times (Figure IV.2). Therefore, measured fog occurrence followed the expected seasonal variation as a function of the elevation of the sea of clouds.

The seasonal distribution of the days on which the canopy received rainfall, fog or rain plus fog is shown in Figure IV.10. During the two years of observation, some form of water input was recorded on 459 days (62% of the two years), but only 81 days (18%, relative frequency) had an input by rain-only (F_c<0.1P_a*). Such days mainly occurred in autumn and winter, which were the rainiest periods (see above). Days with inputs from fog-only were the most numerous (223 days or 49%, relative frequency). Whilst such days occurred throughout the year, the highest intensities were observed in spring. The fog screen collected a maximum total of 96 mm in 37 hours between 22.00 h on the 3rd of April and 10.00 h on the 5th of April 2003 (mean F_c rate of 2.59 mm/ h). At the observed mean wind speed of 6.3 m/s for that period one would require a sustained fog liquid water content (*LWC*) of 113 mg/m^3 to attain such a high flux. Holwerda et al. (2006a) reported directly measured maximum *LWC* values of ca. 100 mg/m^3 in dense fog in Puerto Rico. However, their spectrometer applied a cut-off point at 50 μm and it cannot be excluded therefore that the actual *LWC* value was higher. Higher values between 100 and 500 mg/m^3 has been observed in Quebec at 850 m altitude and between 100 and 200 mg/m^3 in El Tofo (Chile). Nevertheless, direct measurements of *LWC* and associated fog deposition rates in the Canaries are needed. Although the highest fog incidence was recorded in spring, fog water inputs assume their greatest ecological importance in the dry summer months when fog is the only source of water input to the forest ecosystem (Figure IV.9). Days with mixed precipitation (P_m) were quite frequent too (34%), mainly during spring and winter. Summer rainfall (very light showers) was invariably combined with some fog.

IV.3.4 Seasonal variation in throughfall

Throughfall (*Tf*) amounts were only available until September 2004 and did not include the wet winter season of the second year. Therefore, comparisons with annual totals of rainfall and fog incidence were only possible for the first year of near-average rainfall. The seasonal distribution of monthly totals of P_a*, F_c and *Tf* during the period February 2003 until September 2004 is shown in Figure IV.11. Total *Tf* over this period was 1400 mm or 95.6% of the 1450 mm of P_a*. However, uncertainty in daily *Tf* estimates was large: ±30% for events with rain-only and ±70% for events with fog-only. The number of gauges required to remain within ±10% error from the mean at 95% confidence level (using the method of Kimmins (1973) and Snedecor (1956) for events with rain-only) was estimated at 22 ± 17 gauges whereas eight gauges would be sufficient to given an overall error of ±15%.

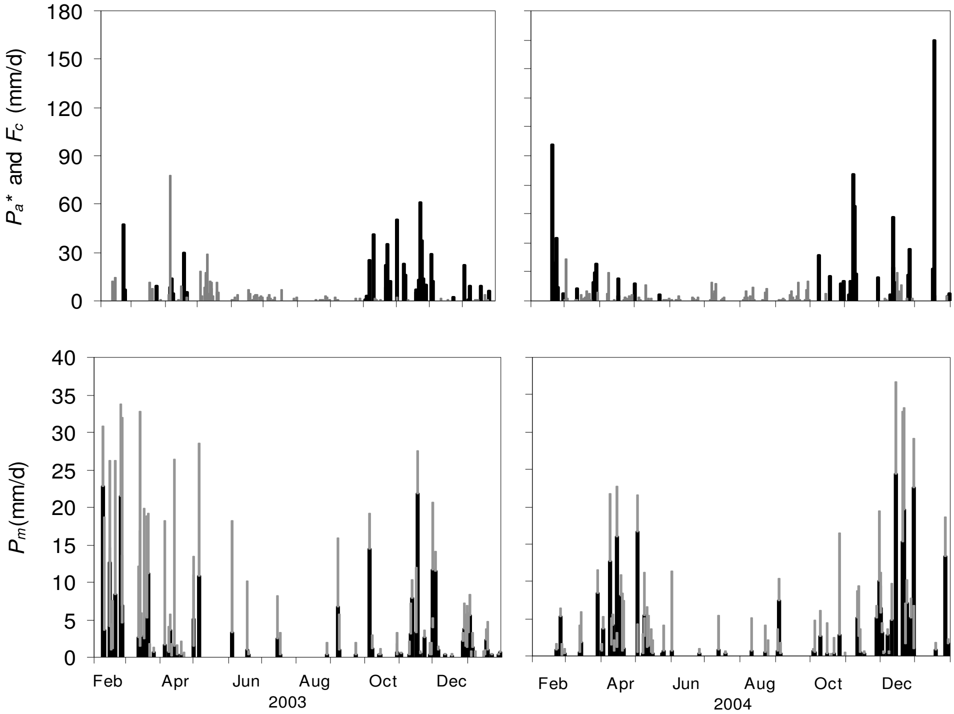

Figure IV.10. Seasonal distribution of (top panels) daily wind- and topography-corrected rainfall (P_a*, mm) (black bar) and fog (F_c) (grey bar), and (bottom panels) mixed precipitation (P_m) from February 2003 until January 2005 at the Laguna Grande ridge top site, Garajonay National Park, La Gomera.

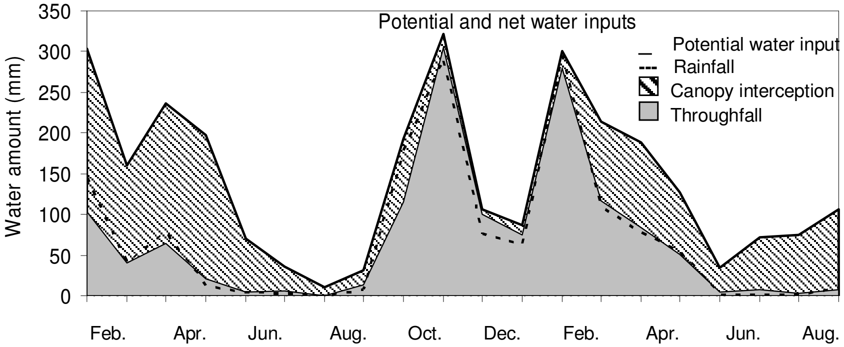

Figure IV.11 Seasonal distribution of monthly rainfall and fog (corrected fog) water inputs (potential water input), along with throughfall and derived potential canopy interception (all values in mm) in the Laguna Grande ridge top forest from February 2003 until September 2004.

On average, monthly amounts of *Tf* matched those of P_a* suggesting that net fog-derived contributions to *Tf* were roughly balanced by wet canopy evaporation. Days with rainfall-only or fog-only were studied separately (Figure IV.12) and different *Tf* proportions were obtained. During days with rainfall-only, average *Tf* equalled 0.87P_a*, but on days with mixed precipitation, a much higher ratio of 1.1P_a* was found. This observation may be explained tentatively by the fact that once the canopy (including bryophytes) is saturated by rainfall, a much larger proportion of the fog may finds its way to the forest floor. Conversely, on days with fog-only, only a very small proportion (5.9% of F_c) reached the forest floor as *Tf* on average. This suggests that the fog screen was much more efficient at trapping the fog than the forest canopy.

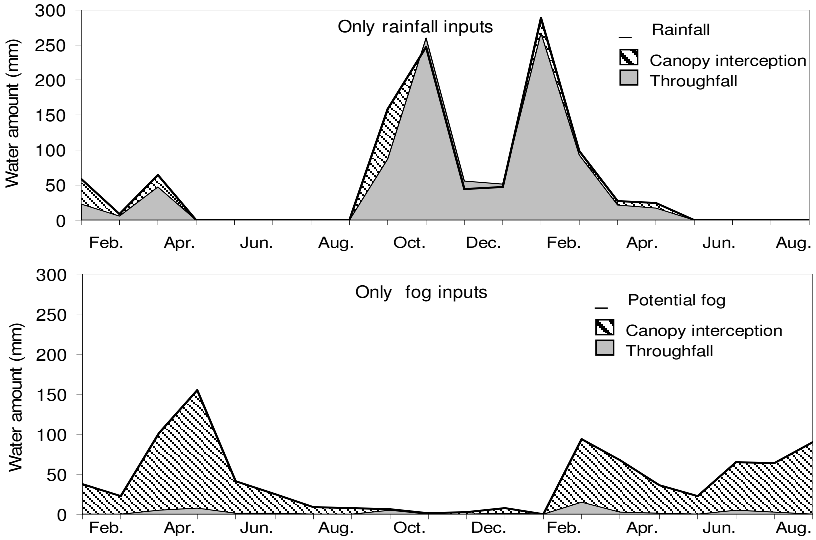

Figure IV.12 Above: Seasonal distribution of monthly water inputs, throughfall and derived potential interception totals on days with rainfall-only at the Laguna Grande ridge top site between February 2003 and September 2004. Below: Idem for potential fog inputs (corrected fog collected above the canopy) and throughfall on days with fog-only.

IV.4 CONCLUSIONS

The ridges of the Jelima catchment in the north-central part of the Garajonay National Park in La Gomera at ca. 1270 m altitude represent a good example of mixed tree heath-beech cloud forest. Water inputs (rainfall and fog) were measured above the canopy from February 2003 to January 2005.

Corrections to rainfall were applied to account for wind losses around the gauge (13%) and for topographic effects during times of inclined rainfall (a further 26%). Rainfall was very seasonal and was insignificant from May to September. Most of the rain fell in small events (50% had <2mm). Fog screens with a fixed orientation towards the dominant wind direction (NE) underestimated fog incidence on average by 63% due to variations in wind direction. Throughfall fractions differed between events with rain-only (87% of wind-corrected rainfall), fog-only (c.a. 6% of corrected fog), and mixed precipitation (110%). It is concluded that the fog screens were more efficient at capturing fog water than the forest canopy.