

## The relict forests of Northwest Peru and Southwest Ecuador

### Los bosque relictos del noroeste de Perú y del suroeste de Ecuador

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#### Resumen

Los bosques relictos o fragmentos de bosque en las vertientes andinas Noroccidentales del Perú y Suroccidentales de Ecuador, son frágiles ecosistemas, que en el pasado fue un todo continuo. La importancia y singularidad de los bosques como «refugios» y hábitats con poca dinámica radica en su compleja diversidad florística y endemismos, consecuencia de su complicada topografía y ecología de sus hábitats. En este artículo introductorio se analizan 12 trabajos de investigación expuestos en el Taller sobre Bosques Relictos de la Vertiente Occidental Andina del Norte del Perú y Sur del Ecuador en mayo del 2004 en el X CONABOT, Trujillo-Perú. Aquí, los conocimientos sobre el tema son consolidados y actualizados, es así que los fragmentos de bosque suman más de 20 en el norte del Perú, enfatizando a dos de gran importancia: Bosque La Oscurana (Cajamarca) y Kañaris (Lambayeque). Así mismo, se determinan las relaciones entre los bosques relictos, analiza su dinámica, caracterización y como puede lograrse su conservación inmediata. Se plantean los aspectos cruciales para alcanzar la conservación de estos bosques remanentes: investigar y mostrar urgentemente su gran biodiversidad, subrayar el valor económico potencial de la fitodiversidad que poseen para la región y revalora su papel como áreas de captación de agua para los ríos que son fuente prioritaria para la agricultura y vida urbana en la costa.

**Palabras clave:** bosques montanos relictos, Andes, vertiente occidental andina, Perú, Ecuador

#### Abstract

The forest fragments or relict forests on the Western slopes of the Andes in northwest Peru and in south-west Ecuador are fragile ecosystems, which were largely continuous at some stage in the past. The importance and uniqueness of these forests as «refuges» and stable habitats roots partly in their complex diversity and their high levels of endemism. These in turn are the outcome of a complex topography and ecology. In this introductory chapter 12 studies are analysed, which were presented at the Taller sobre Bosques Relictos de la Vertiente Occidental Andina del Norte del Perú y Sur del Ecuador in May 2004 at the X CONABOT, Trujillo-Perú. This helps to consolidate and update our knowledge on these over 20 forests fragments in northern Peru and two previously unknown fragments are presented for the first time: Bosque La Oscurana (Cajamarca) and Kañaris (Lambayeque). Some ideas are exposed on the the relationships between the relict forests, how to analyse their dynamics, how to characterize their structure and how their conservation may be achieved. It is proposed that crucial elements in a conservation of these forests are a) urgently inventoring them to demonstrate their high diversity b) emphasizing their economic potential with respect to the abundance of phylogenetic resources c) evaluating their role as catchment areas for the rivers which are the primary source of water for agriculture and urban life on the coast.

**Keywords:** montane relict forest, Andes, Andean Western slopes, Peru, Ecuador

#### Introduction

Northwest Peru and Southwest Ecuador possess some unique relict forests. These have been repeatedly mentioned and discussed in the literature (e.g., Dillehay & Netherly, 1983; Dillon, 1993; 1994; Dillon & Cadle, 1991; Dillon et al., 1995; 2002; Ferreyra, 1977; Koepcke & Koepcke, 1958; Koepcke, 1961; Arana, 1994; Valencia, 1992; Weberbauer, 1945; Young & Reynel, 1997; Sagástegui & Dillon,

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1991; Sagástegui et al., 2003). There is general consensus, that these forests have outstanding importance for the conservation of biodiversity, but also as catchment areas for the rivers running down to the coast. The present volume wants to address a wide range of topics, providing better understanding of these forests, some ideas on their importance, research needs and aspects of conservation. These relict forests are concentrated in the so-called Amotape-Huancabamba Zone (Weigend, 2002; 2004), an area of outstanding biodiversity where the flora of the northern and central Andes overlap and additionally a stunning amount of endemic species and genera are found. In this transitional area between the northern and the central Andes the climate does not allow a complete forest cover of the western slope, as it does further north, but these forests are naturally restricted to those areas which receive high precipitation. It seems plausible to assume that under different climatic conditions these forests were at some stage more or less coherent, at least to the southern limit of the Amotape-Huancabamba Zone (where the deep and arid Río Santa valley probably always formed a natural barrier to forest taxa).

### Montane forests

About 2600 and 3200 m of altitude on the arid western slopes of the Central and Northern Andes, montane forests are localized (Weberbauer, 1945; Koepcke, 1954; Valencia, 1992). Although these forests can be considered parts of a near continuous strip in the past, however actually just some hundreds of relict forests are presented.

These relict forests present a strong gradient of their characteristics, with a increment in patch size, species richness, trees abundances and structural complexity toward north of distribution. These changes are consequence of the latitudinal gradient of the climatic conditions on the western slopes of the Andes with more humid and warm climate toward north.

In this volume we nearly exclusively consider the montane relict forests of the NW Peru and SW Ecuador, and leave the tropical dry forests of the lower regions and the mangrove forests largely aside (contributions by Linares-Palomino and Charcape & Moutarde). These montane forests are what has generally been referred to in the literature on these relict forests (Figs. 1—3). They are generally considered as the southernmost fragments of the montane forests of the western slopes of the Andes, which is (or was) largely continuous in Ecuador and Colombia, but is highly fragmented in the region under consideration. The small-scale climatic conditions responsible for the presence or absence of montane forests can not usually be measured by classical climatological means, but requires fine-scale methods, one of which is presented by Richter & Moreira-Múñoz (infra). The cloud forests are often found very locally where unusually strong condensation takes place (Figs. 4—5).

Each of these relict forests tends to have its own suite of endemic species in plant groups (Gentry, 1992; Cano & Valencia, 1992) such as the Solanaceae (e.g., Leiva, 1996; Leiva et al., 1998a; 1998b; 1998c; 1998d; 2003; Leiva & Mione, 1999; Leiva & Quipuscoa, 1998), Asteraceae (e.g., Dillon & Sagastegui, 1994; Sagastegui & Dillon, 2001; Sagastegui & Quipuscoa, 1998; Sánchez & Dillon, 2000) and Loasaceae (Dostert & Weigend, 1999; Rodríguez & Weigend, 1999; 2004; Weigend & Rodríguez, 2003; Weigend et al., 1998; 2004a; Weigend, 2000a; 2000b; 2004), and Alstoemeriaceae-*Bomarea* (Hofreiter & Rodríguez, infra) but also in many animal groups (Dillon & Cadle, 1991; Duellman, 1979; Duellman & Pramuk, 1999; Cadle & Chuna, 1994; Cadle & Mc Diarmid, 1990, Franke, 1992; Salinas et al., 2003). Flanagan et al. (infra) provide an overview over the avifauna of the relict forests of NW Peru and show the exceptional wealth of the forests of Ayavaca underscoring the importance of these forest fragments for bird life.

## The double nature of the relict forests

The relict forests of northwestern Peru are very rich in endemic species (see citations above, and Hensold, 1999) and the numerous endemic taxa in themselves are proof of the fact that some of these forest fragments must be natural fragments and that evolution of narrowly endemic taxa took place in them. However, some part of the fragmentation is undoubtedly man-made and there is good reason to believe that some natural forest fragments have vanished altogether and others were further fragmented into (man-made) relicts of (natural) relict forests. Very little is known about the natural extent of these forests or to what degree pre-colombian cultures already decimated their extent: There are some important sites with pre-incaic ruins in or very close to these forests, e.g., next to the bosque San Mateo (Contumazá), in the Río



**Figure 1.** Relict forest on steep west-facing slope south of Contumazá (Prov. Contumazá, Depto. Cajamarca).



**Figure 2.** Interior of *Podocarpus*-forest (Bosque San Mateo, Prov. Contumazá, Depto. Cajamarca)



**Figure 3.** Seedling of *Podocarpus oleifolius* (Bosque San Mateo, Prov. Contumazá, Depto. Cajamarca)



**Figure 4.** Condensation in the former cloud forest area of Guzmango (Prov. Contumazá, Depto. Cajamarca).



**Figure 5.** Spill-over of pacific cloud condensation at the Abra de Porculla (Depto. Piura), seen from the (dry) eastern side of the pass.





**Figure 6.** Formerly forested area between Bambamarca and Paccha, note the presence of isolated trees of *Alnus acuminata* (Prov. Bambamarca, Depto. Cajamarca).



**Figure 7.** Scattered forest fragments and isolated trees north of Agua Blanca looking towards San Miguel (Prov. San Miguel, Depto Cajamarca) – this area was formerly covered in one more or less coherent forest belt, of which larger fragments exist only on steep slopes (e.g., Cerro Quillón) and in narrow valleys.



**Figure 8.** Degraded forest fragments above Guzmango (Prov. Contumazá, Depto Cajamarca), more or less coherent forest left only in quebradas, area in the foreground converted into fields and pastures.



**Figure 9.** Area north of Llama (Prov. Cutervo, Prov. Cajamarca), isolated forest fragments in steep slopes, otherwise deforested and converted into fields and pastures.



**Figure 10.** Cerro Quillón (Prov. San Miguel, Depto Cajamarca), note the presence of complete forest cover on the steepest slopes only, all more or less flat surfaces deforested as are the lower parts of the slope.

Zaña valley (Dillehay & Netherly, 1983) and in Ayavaca (Vellinga et al., 2004).

However, there is general agreement that there has been a rapid process of deforestation, which has rather accelerated than stopped in recent years and more than 90% of the forests may already have been destroyed (Figs. 6—10).

Thus the current relict forests are the isolated remnants of isolated natural forest vegetation and require our urgent attention with respect to investigation and conservation. Table 1 summarizes the known forest fragments from the Peruvian part of the Amotape Huancabamba Zone and give their rough location and extent. In some cases the forest fragments are known from hearsay only and precise localities could not be obtained – localizing and investigating them should be a focus of our attention in the immediate fut

**Table 1.** List of the forest fragments on the western slope of the Andes in northern Peru. In some cases neither the precise locality, state of conservation nor altitudes are documented in the literature.

Dpto.	Prov.	nombre del bosque	altitudes (m)	localización	estado de conservación	extensión aproximada (ha)
Piura	Huancabamba	Canchaque	1800–2500	04° 30' S, 079° 05' W - 05° 22' S, 079° 36' W <sup>6</sup>	largely destroyed	1000
Piura	Morropón	Chalaco	?	?	unknown	unknown
Piura	Morropón	Mijal	2350–3350	--- --- ---	conserved	unknown
Piura	Ayabaca?	Huamba	ca. 2500	04° 43' S, 079° 31' W	unknown	unknown
Piura	Ayabaca	El Toldo1	2800–3100	04° 40' S, 079° 31' W	partly conserved	various fragments one of them ca. 400
Piura	Ayabaca	Aypate1(Ayabaca)	2800–3100	04° 42' S, 079° 35' W	conserved	600–800
Piura	Ayabaca	Los Molinos1(Ayabaca)	2200–3100	04° 36' S, 079° 44' W	conserved	400
Piura	Ayabaca	Bosque Cuyas1,2 (Ayabaca)	2200–3100	04° 36' S, 079° 44' W	partly conserved	600
Cajamarca	Contumazá	Bosque de San Mateo <sup>3,6</sup> (Cachil)	2400–2700	07° 24' S, 078° 47' W	conserved	ca. 100
Cajamarca	Santa Cruz/ San Miguel de Pallaques	Bosque de Montesecco <sup>3,6</sup> (La Florida Taulis)	1500–2800	06° 52' S, 079° 05' W	partly destroyed	2500
Cajamarca	Cutervo	Bosque de Cutervo <sup>3,6</sup>	2500–2500	06° 05' S, 078° 40'–53' W	partly destroyed	2500–3000
Cajamarca	Chota	Ucshahuilca <sup>3,6</sup> (Pagaitbamba)	2300–2800	06° 24' S, 079° 01' W <sup>6</sup>	partly conserved	1000 ca. 2100 <sup>6</sup>
Cajamarca	Chota	Las Palmas <sup>3</sup>	2400–2800	06° 24' S, 079° 01' W	highly fragmented & partly converted to field	500<100 <sup>6</sup>
Cajamarca	San Miguel de Pallaques	Tongod <sup>3,6</sup> -Quellahorco	2600–2700	06° 30' S, 078° 38' W - 06° 49' S, 078° 46' W <sup>6</sup>	highly fragmented	200
Cajamarca	San Miguel de Pallaques	Santa Rosa - El Palmo	?	?	unknown	unknown

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Dpto.	Prov.	nombre del bosque	altitudes (m)	localización	estado de conservación	extensión aproximada (ha)
Cajamarca	San Miguel de Pallaques	La Oscurana <sup>4</sup> (Niepos y Corral Viejo)	2000 – 2800	06° 90' S, 079° 08' W	conserved	Ca. 65
Cajamarca	San Miguel de Pallaques	Cerro Quillón	3320 – 3500	07° 01' S, 079° 4' W	conserved	Ca. 50
Cajamarca	Cutervo	Querocotillo-Granadillo-Shinshin Sur - Río Chotano	?	?	unknown	unknown
Cajamarca	San Miguel de Pallaques/ Santa Cruz	Los Cedros y Cascarilla	2500 – 2800	-----	conserved	2500
Lambayeque	Ferreñafe	Kañaris <sup>5</sup> (Upaipeta)	750 – 4000	06° 02' S, 079° 15' W	conserved	13800
Lambayeque	Ferreñafe	Bosques de Yatrapa	?	?	conserved	unknown
Lambayeque	Ferreñafe	Bosques Chillama-Mamahua-Bosque del Cerro Pluto (Santa Lucía Kañaris)	?	?	conserved	unknown
La Libertad	Gran Chimú	Bosque de Lucma (Callanquitas)	2200 – 2600	-----	largely destroyed fragmented	ca. 200

<sup>1</sup> Vellinga et al. 2004<sup>2</sup> Vellinga et al. give one grid reference for Cuyas and Los Molinos, but separate sizes.<sup>3</sup> Dillon 1994<sup>4</sup> Juárez et al. *infra*.<sup>5</sup> Llatas Quiroz, *infra*<sup>6</sup> Sagástegui et al., 2003

Particularly tenacious elements of the montane forest flora such as many members of Solanaceae (Leiva, 1996; Leiva et al., 1998a; 1998b; 1998c; 1998d; 2003; Leiva & Mione, 1999; Leiva & Quipuscoa, 1998), Urticaceae and *Ribes* (Weigend et al., *infra*) persist long after the forests have been replaced by fields and hedges. Their distribution can thus be indicative of former forest cover of a region and the data on *Urtica* and Solanaceae indicate that there used to be very extensive forests in Prov. Otuzco (La Libertad) where no well preserved forests are now left at all.

### How many forest fragments are there and what do we know about them?

The literature (e.g., Dillehay & Netherly 1983, Dillon 1993, 1994, Dillon & Cadle 1991, Dillon, et al. 1995, 2002, Ferreyra 1977, Koepcke & Koepcke 1958, Koepcke 1961, Weberbauer 1945; Valencia, 1992; Sagástegui et al., 2003) deals principally with a few well-known forest fragments, typically those of San Mateo, Monte Seco, Canchaque and Cutervo. This covers only a fraction of the total of over 20 forest fragments currently known and in this volume first data are given on two new, well-preserved and hitherto completely ignored forest fragments, the bosque de Oscurana and - most importantly - the forests of Kañaris (Llatas & López, *infra*). The latter are by far the single largest forest fragment and alone make up possibly more than a 1/3<sup>rd</sup> of the entire preserved area of montane forests in NW Perú. Investigating this little-known fragments should be first priority in the future.

Two studies on Podocarpaceae (Vicuña) and Orchids (Calatayud) document the enormous floristic wealth of these forest fragments in a species level and also show that the actual diversity far exceeds what has been previously documented in the literature. The herbaria of the region house a considerable wealth of specimens, and so do some herbaria overseas, but the conclusion from revisionary studies (Weigend et al., *infra*) is that a very considerable part of the forests is still largely or completely unknown: common

elements such as *Ribes* or *Urtica* are not, or incompletely documented from the majority of forest fragments. Even some well-known forests, such as the forest of Cutervo, are certainly incompletely inventoried. Collection effort have to be intensified and spread evenly over the year to complete our inventories and to provide material for the systematical studies: Phenology in the forest fragments is complex, and many taxa are incompletely documented because they can not be found throughout the year (*Bomarea*: Hofreiter, *Ribes*: Weigend).

We expect that numerous new species from these forest relics still await their discovery, either in herbarium collections, where they are mis-filed under names of common and wide-spread congeners, or in the field, where many collection gaps still exist.

### What are the relationships between these forests and are some of them particularly diverse?

Investigations on the relationships between the floras of these forests and to the montane forests of Ecuador and the western slope in Peru have been carried out at genus level (e.g., Dillon et al., 1995). This approach can give valuable clues on a larger scale, but the crucial patterns on disjunction are probably reflected only in the the relationships at species level in genera with narrowly endemic taxa such as *Larnax* (e.g., Leiva, 1996; Leiva et al., 1998b; 1998d), *Jaltomata* (e.g., Leiva & Mione, 1999; Leiva et al., 1998a), *Iochroma* (e.g., Leiva & Quipuscoa, 1998; Leiva et al., 1998c; 2003), *Nasa* (e.g., Dostert & Weigend, 1999), *Ribes* or *Urtica* (Weigend et al., *infra*) or the *Passiflora lobbii* group (Skrabal et al., 2002) with few exceptions the subgenus *Bomarea* s.str. and without exceptions subgenus *Sphaerine* (both Alstroemeriaceae) have in the relict forest their southern most distribution limit in the Cordillera Occidental (Hofreiter & Rodríguez, *infra*).

However, more or less comprehensive collections will be required before this can be sensibly undertaken. The present data very tentatively suggest, that there is some degree



of closer relationship between the relict forests of Otuzco and Contumazá on the one hand, and the relict forests of San Miguel, Santa Cruz and Cutervo on the other. The relict forests of Ayavaca seem to be fairly closely related to those of Huancabamba and San Ignacio, which are more or less the westernmost outliers of the eastern slope forests (Rodríguez et al., 2002; Calatayud, *infra*), but they also appear to have close ties to the north (e.g., *Sessea*, Beltran & Galan, 2001). Also, the diversity of these last forests is related to the good conserved forests of the South of Ecuador (Loja and Zamora-Chinchi), which indicates that in the past these were an all continuous one (Bussmann, 2003; Lozano et al., 2003; Rodríguez et al., 2005, *en prep.*)

The crucial forests of Kañaris are at present virtually unknown and will play a central role in an understanding of the relationships between the relict forests of NW Peru in the future.

In spite of various efforts to classify the forests according to different levels of diversity, our data on the taxa actually present are probably too scanty to allow us to safely judge relative levels of diversity. It is not surprising that the particularly well-known forests of Monte Seco and Contumazá have a high number of taxa reported, but it seems unlikely that the huge forests of Kañaris will stay far behind and taxa previously considered as endemics of Monte Seco are only now being reported from other places, which had not been explored previously (*Nasa insignis*, *N. humbolditana* subsp. *obliqua*, Juárez et al., *infra*).

### **What are the dynamics of these forests and how can it be characterized?**

The term relict forests implies that they are more or less «refugia» and stable habitats with little dynamicity. Strangely enough, however, the plant taxa with the highest incidences of endemism and the most narrow endemics (some Asteraceae, Solanaceae, Loasaceae) are nearly exclusively plants of disturbed sites and regular habitat disturbance in the form of, e.g., land slides may play a crucial role in

generating and preserving the high diversity. Lozano & Bussmann (*infra*) explore the effect of land slides on the dynamics of the forests in S Ecuador and we can safely assume that similar mechanisms are at work in the relict forests in NW Peru. An attempt for a phytosociological classification of the forests is provided by Bussmann (*infra*) and this should be seen as a guide line for a more scientific classification of the relict forests in NW Peru in the mid-term, that goes beyond the rather bland classification as «montane forest».

### **How can their conservation be achieved?**

The ecological and economical role of these forests and their extraordinary wealth in endemic taxa of both plants and animals very strongly argues for measures for their preservation. Charcape et al. (*infra*) explain how a wide range of activities involving large parts of the population can generate public awareness and prepare the ground for conservation measures. Clearly this approach is especially suited to relatively small forest fragments belonging to an individual municipality. Other measures, higher up in state authority, will be required to protect thus huge tracts of forest as the forest of Kañaris. Each region has its very particular problems and land-ownership and unclear responsibilities – as in the case of the forests of Montesecco which span three administrative units – abound. One of the important aspects of these forests is the presence of potential agricultural and pharmaceutical resources (Sagástegui 1996, Sagástegui & Dillon 1998) which are not at present at all appreciated.

The crucial aspects for achieving the conservation of these remnants of forest are evidently

- a) investigating and showcasing their enormous biodiversity,
- b) underscoring the potential economical worth of the phytodiversity of the region
- c) emphasizing their role as catchment areas for the rivers which drive agriculture and urban life on the coast.



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