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A Campaign for Cloud Forests:

Unique and Valuable Ecosystems at Risk

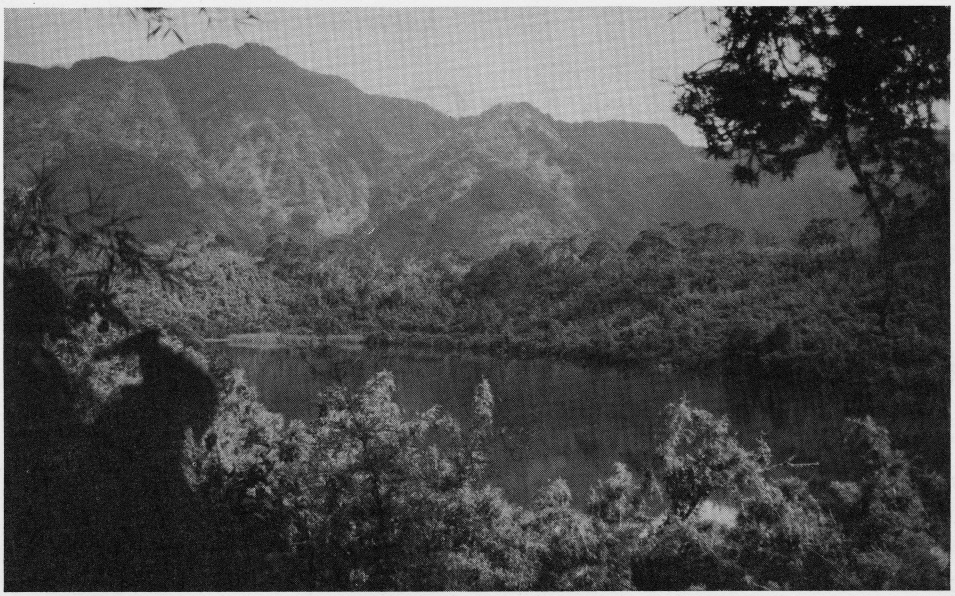
What and Where Are Cloud Forests?

Cloud forests are unique vegetation complexes that occur where there are persistent or frequent wind-driven clouds. From this moving cloud (or fog) they "strip" or harvest atmospheric moisture, this harvest being above and beyond the normal rainfall precipitation. This is "horizontal" precipitation (often called "occult" precipitation), and, in the absence of these intercepting surfaces of trees, shrubs, epiphytes, mosses and lichens, it is not harvested, and thus is a lost water resource. This situation is most common on mountains in the tropics and sub-tropics that are subject to oceanic influences. It occurs also where there are frequent coastal fogs (e.g., the coastal redwoods of California) or even with horizontal winter snow clouds on mountain tops in the temperate zone. It is the mountain cloud forests with which this article is concerned, for their biological, hydrological and heritage values are very high, and the rate of disappearance or degradation is most alarming. (See Hamilton *et al.* 1994.)

These mountain cloud forests are designated as special vegetation units in many languages, by such names as "nebelwald," "forêt néphéliphile," "bosque de ceja montaña," "elfin forest," "mossy forest," "matinha nebular," "unmu-rin," and many others (Stadtmüller 1987).

In comparison with lower-elevation moist forests, these forests usually exhibit reduced tree stature (hence another name, "dwarf cloud forest") and increased stem density. Canopy trees usually have gnarled trunks and branches, dense compact crowns, and small, thick, and hard (sclerophyll) leaves. A high proportion of the biomass may occur as lichens, mosses, briophytes, and filmy ferns. Tree ferns are commonly found in many cloud forests. Soils are wet, frequently waterlogged, and highly organic. The unusual physiognomic features have not been convincingly explained, but in many high-elevation forests, rapid fluctuations in radiation (including ultraviolet-B radiation), concentrations of polyphenols in foliage and fresh litter, excess water affecting root systems, and high winds seem to be part of the complex awaiting further study (Bruijnzeel and Proctor 1994).

Cloud forests occupy a relatively narrow altitudinal belt, but the position of the belt varies widely. For large inland mountain systems in the tropics (e.g., Andes, Ruwenzoris) they may typically be found between 2,000 and 3,500 m; whereas in



Africa's Ruwenzori Mountains contain biologically unique cloud forests. *IUCN photo by J. Thorsell.*

coastal and island mountains this zone may descend to 1,000 m (e.g. Hawai`i). On steep, small islands in very humid, equatorial conditions, a cloud forest may develop as low as 500 m, or in rare cases 350 m (Gau in Fiji). Cloud forests occur within a wide range of annual rainfall regimes (500–10,000 mm/year) and from year-round moisture to very seasonal. It is in these low- and seasonal-rainfall regimes that cloud forest stripping can provide the bulk of the water additions to the water budget of the area.

Maps showing the approximate locations of tropical montane rain forests (where the bulk of the cloud forests are found), as identified by the World Conservation Monitoring Centre, appear as Figures 1, 2, and 3. The original extent of cloud forests in the early 1970s was thought to be 50 million hectares. Much less than this remains today, even though they are not very hospitable environments for human occupation, and they are about as remote as forests can be.

The Value of These Mountain Eyebrows

Hydrological importance. Mountain forests in general because of their location in the headwaters of streams and rivers have a high value as watershed protection. Conversion of these forests to other uses almost invariably adversely affects water quality, and may cause undesirable changes in flow regime. Mountain cloud forests have value above and beyond this because of their function in capturing

Fig 1

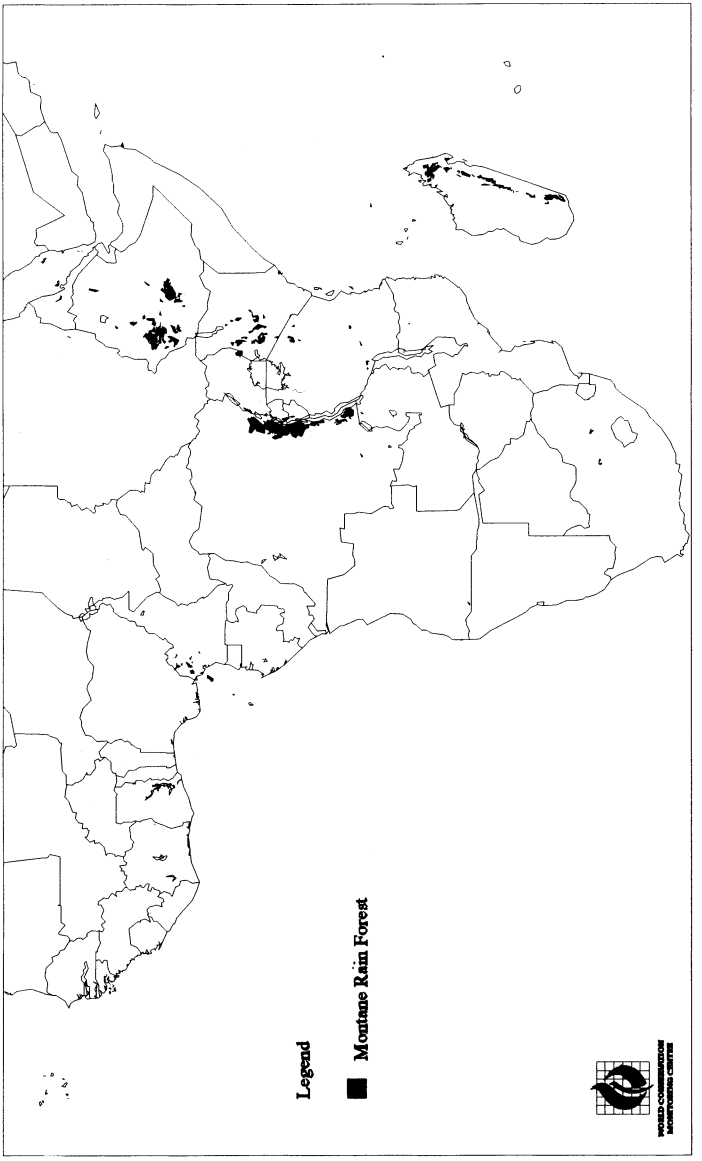


Figure 1. Tropical montane rain forest in Sub-Saharan Africa.

Fig 2

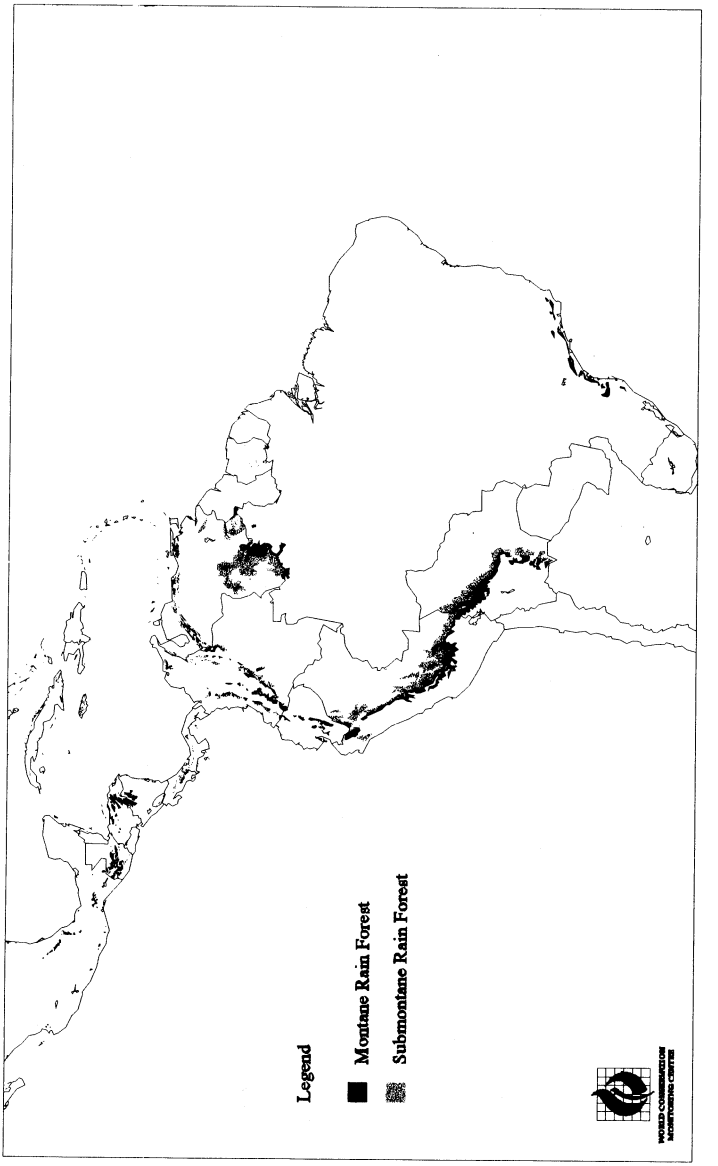


Figure 2. Tropical montane and submontane rain forest in Latin America.

Fig 3

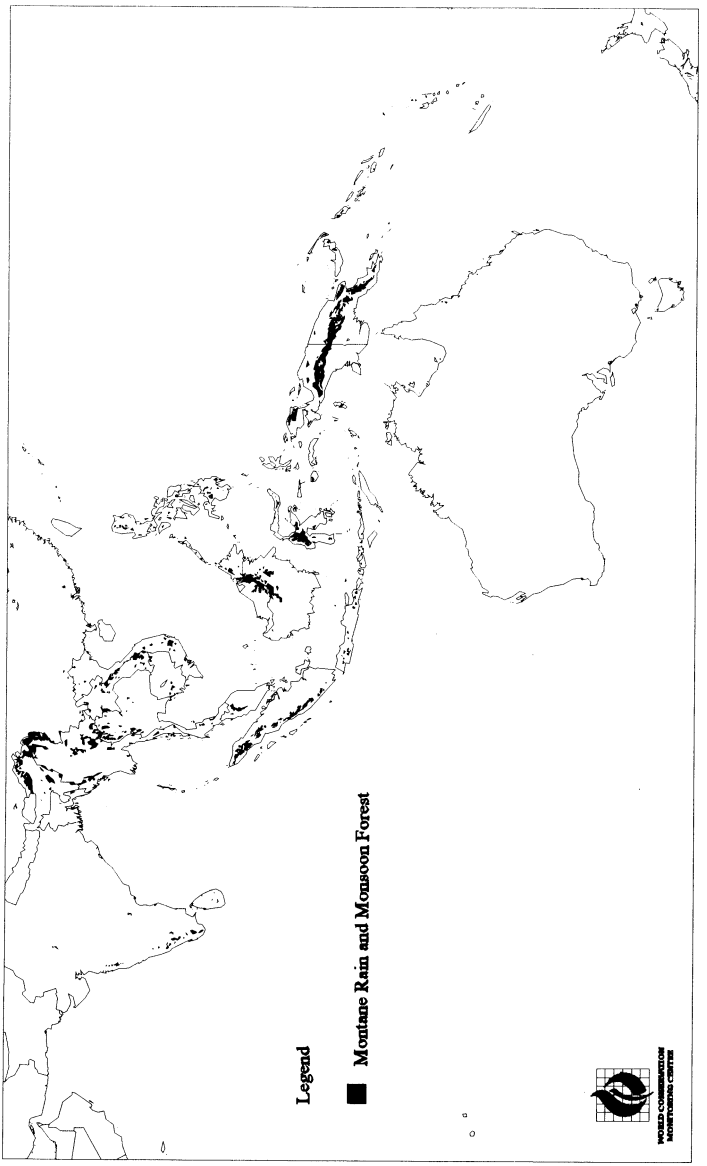


Figure 3. Tropical montane rain and monsoon forest in Southeast Asia.

atmospheric moisture beyond normal rainfall. Horizontal precipitation capture may reach hundreds of millimeters per year. Typical values range between 5 and 20 percent of ordinary rainfall, but might be much higher if there is a rainfall dry season, but one which still has cloud moving through vegetation (for example where there are afternoon inversion layers in trade wind belts). Moreover, these usually stunted forests with thick leaves have low rates of water use, even during periods of bright sunshine. When cloud forests are removed, the mass of moisture-intercepting leaf surfaces and abundant epiphyte biomass on branches and stems are lost. Thus, occult precipitation is consequently also lost or at least greatly reduced. Moreover, if the forest is cleared for grazing (one of the most common impactors) a deterioration of infiltration characteristics can further degrade the flow regime from the ecosystem. In areas of low rainfall but intercepted cloud, even single trees can be important sources of water for wildlife, domestic stock or people. One such tree in the Canary Islands had such value and veneration to the residents of El Hierro that this "fountain tree" appears on a coat of arms (Gioda et al. 1994). In the arid coastal areas of Perú and Chile where there are few or no trees, artificial towers of screens are constructed on high terrain where clouds may be intercepted. These collectors supply substantial communities with their domestic water requirements. Where trees will grow, reforestation can restore this valuable hydrologic function in cloud areas.

Biodiversity importance. It is generally assumed that mountain cloud forests are not as species-rich as their tropical or temperate rain forest counterparts. There is a generally accepted relationship that the number of tree species and lianas decreases with increasing altitude in the tropics. However, there is substantial evidence that the number of species of epiphytes, shrubs, herbs, and ferns increases with altitude in the humid tropics, so that total flora diversity does not compare unfavorably with lowland tropical rain forest. For cloud forests in strongly seasonal to even semi-arid environments, the biodiversity is surely greater than in the adjacent ecosystems. Moreover, many of these "eyebrow forests" (cejas de montaña) are given this name because they are the last remnant of native vegetation on heavily-used and often abused mountains. Biodiversity values in terms of native species, gene pools, and ecosystems are in these cases supremely high. But whether isolated or simply an altitudinal ecosystem belt abutting other forest, there is no denying the relatively high number of plant and animal *endemics*, sometimes confined to one cloud forest on a single "island" mountain. A recent BirdLife Biodiversity Project report on tropical montane cloud forests shows their great importance to restricted-range and threatened bird species, especially in the Andes (Long 1994). The resplendent quetzal *(Pharomachrus*

mocinno) of Central American is now virtually restricted to a few cloud forest "islands" of separate mountains. Charismatic megafauna of some fame, such as the mountain gorilla *(Gorilla gorilla beringei)* of Central East Africa and the spectacled bear *(Tremarctos ornatus)* of the Andes, are specific to cloud forest environments. The former is a major national income earner through nature tourism, in at least one country (Rwanda).

Losses and Erosion of Values

It is widely reported that these valuable mountain forests are being cleared or degraded at an unprecedented rate. Bad news about losses came from Central America and the Caribbean as long ago as the late 1970s (LaBastille and Pool 1978), and a system of cloud forest parks or reserves was called for. Today the news is even more serious. It is thought that they are being destroyed at a rate exceeding that of their more well-publicized cousins the tropical lowland rain forests. The latest data from the UN Food and Agriculture Organization study indicates that, whereas the tropical forest biome as a whole disappeared between 1981 and 1990 at a rate of 0.8 percent per year, loss of tropical mountain and upland forest was 1.1 percent per year (FAO 1993). Land hunger is pushing agriculture and occupation higher up Africa's mountains. The growing of temperate vegetables in tropical uplands, and the siting of resorts and golf courses in the cool uplands, are new threats to many of Southeast Asia's cloud forests. There are estimates from neotropical botanists that almost 90 percent of the cloud forests have been lost from the northern Andes, largely due to the extension of grazing into these high forests from both above and below. Worldwide, many are being degraded of their biodiversity and endemism by unsustainable fuelwood and charcoal wood cutting, and by uncontrolled extraction of the unusual plant and animal life of the cloud forests. High-value commercial trade has developed for orchids, bromeliads, birds, amphibians, and medicinals, including rare or endangered species.

These forests, because they are "washed" in frequent cloud, are particularly susceptible to damage from atmospheric pollution. The temperate cloud forests of the industrialized world have well illustrated this great threat through the widespread decline and death of these forests due to acid precipitation. Someone has given the name "Metallic Mountain" to Mount Mitchell, the tallest peak in the Eastern United States (elevation 2,037 m), due to the build-up of aluminum, cadmium, lead, zinc, and mercury in its cloud-washed spruce-fir forest. Cloud forests of the tropics, though not yet so dramatically affected, are nonetheless not immune to cloud-borne pollutants from their increasing urban and industrial concentrations of atmospheric emissions. Cloud forests also are particularly vulnerable to climate change since

these relatively narrow altitudinal belts of unusual vegetation are so specifically climate-determined. Moreover, clearing of forests in the lowlands may raise the cloud condensation elevation, and so deprive cloud forests of some of their occult precipitation.

Suggestions for Damage Control

The underlying causes of the adverse impacts on cloud forests relate to such basic, pervasive pressures as rapid population increase, inequity in access to the earth's resources, demand for increasing per capita levels of consumption, uncertainty of land tenure, greed, political expediency, and transboundary air pollution. These pressures are very complex and difficult to deflate, whether by a land manager, administering agency, or national government wishing to protect or manage better a cloud forest area or set of areas. Moreover, there is the distinct possibility of climate warming due to increasing atmospheric greenhouse gases and ozone-depleting emissions. Reducing greenhouse gas and ozone-depleting emissions requires international action, which seems to be coming into effect but at a snail's pace. A single country or a land management unit is unable to cope with this mega-problem.

What actions can be taken at an operational level by a nation, a resource management agency or at a local cloud forest management level?

First and foremost is the *raising of awareness of the values of cloud forests*. This needs to be carried out not only at all levels from local to international, but with the many actors who directly impact them or who derive benefit from them. Of particular import here are water-dependent communities as well as the local graziers, fuelwood cutters, and plant and animal collectors. Development aid donors have rarely heard of cloud forests and have their sights focused on biodiversity conservation in the lowland rain forests. An international "Cloud Forest Campaign" might do much to educate this latter community. Local, national, or international non-governmental organizations (NGOs) may be effective in awareness-raising at all levels, if given reliable information by the scientific community. Cloud forests will not be conserved until people know what values are being lost, and this requires education.

In the second place, the high hydrological and biological values of these ecosystems warrant that most, if not all, of those remaining be given some type of *protected area status*. Several options are available under the categories system recognized by IUCN-The World Conservation Union, such as: national park, strict nature reserve, habitat management area, managed resource protected area, or protected landscape. While formal designation of a protected area does not guarantee protection, it is the first step. There is considerable urgency in this action for all countries having cloud forests. The World Conservation Monitoring Centre is

seeking funds to prepare a Cloud Forest Atlas that would greatly help us to see the status of these ecosystems, and it would indicate where are the gaps in a protected area system.

Whatever the land ownership (state, communal or private), the most important part of a protected area designation is the *control over use* so that there is no serious nor irreversible degradation. This, after all, is what protection or sustainable use means. Controls over extraction, conversion, intensity of use (as in tourism), roads and trails, and introduction of alien species, are all necessary elements. *Management plans*, made with local community input and support, and then effectively implemented, are important elements of control in meeting the threats. Educational programs with local communities must precede the planning and adoption of management policies. Much valuable knowledge may be obtained from traditional resource users in this process. Surveys and inventories need to extend beyond the boundaries of the cloud forest and include not only biophysical information about land use, but tenurial and demographic data.

Provisions for *monitoring the state of the ecosystem* need to be incorporated, for these are "stressed," slow-to-recover systems. Measures of change should be made not only for local impactors, but cloud forests are good "miners' canaries" for monitoring global changes in weather, air quality, ozone levels, and ultraviolet radiation.

Mountain cloud forests have experienced little research and even less *long- term research* when compared with almost all other major forest ecosystems. Perhaps this is due to their relative inaccessibility and their rather inhospitable environment for research. There has been absolutely no integrated research involving scientists from different disciplines working on the principal ecosystem processes and elements. At the very least, integrated studies involving hydrology, meteorology, soils, vegetation, fauna, and nutrient cycling need to be commenced as soon as possible. Probably the Monteverde Cloud Forest Reserve in Costa Rica, Bwindi Impenetrable National Park in Uganda, the Blue Mountains in Jamaica and the Luquillo National Forest in Puerto Rico come the closest to having research which approaches this criterion. Sites where benchmark data are being collected on many elements offer exceptional opportunities for a global monitoring network with respect to the close-to-surface atmospheric changes.

But there is also a need for *applied research* to answer pressing management needs. This includes determining sustainable levels (if any) of resource harvesting (especially for nonwood products). It should cover the socio-economic factors that increase the chance of buffer zones protecting these increasingly rare fragments, and the putting of a price tag on the water harvest of these forests or on the water loss when they are destroyed.

A worldwide *inventory and mapping* of these forests, and the development of a data base for them is a matter of high priority. The World Conservation Monitoring Centre working with IUCN, could well carry out this task, given financial support.

Irreversibility

Donor assistance for this research agenda, and for all of the other measures for damage control, is an urgent need. In many ecosystems, the consequences of many land-use decisions are somewhat reversible, given sufficient time and inputs of energy. While much more research is needed to increase our knowledge about mountain cloud forests, the current consensus is that consequences of activities which remove cloud forest cover are usually irreversible. This is because of the high endemism, unique gene pools, small size of the areas ("eyebrows" of the higher mountains or "caps" on the lower mountain summits), and slow recovery of these "stressed" systems. It is true that one of the important values—namely, the occult water capture function—can be restored without great difficulty. Reforestation, or even erecting large screen structures (as is done for water supply in the arid fog belt of Perú and Chile) can provide the necessary surfaces for cloud stripping. But restoration of the complex mix of life forms, including the amazing epiphyte community and the unusual fauna, of the recreation value, of the authenticity, of the scientific and genetic information, is beyond our capability.

How much better to protect these ecosystems from destruction, since the uses that replace cloud forests are economically marginal at best. Perhaps only the use of these sites (where they are at the summit), for communication facilities can claim a higher economic use. Even in these cases, it is surely often possible to find alternative locations for this infrastructure. An awareness-raising about mountain cloud forests is a matter of some urgency. IUCN could be uniquely well placed, using the strength and support of its membership, to provide leadership in a campaign to maintain cloud forests, given the necessary resources to do the job.

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