Tropical montane cloud forests: a challenge for conservation

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Many challenges need to be overcome to ensure the sustainable management and conservation of cloud forests. However, various successful conservation and sustainable use projects illustrate the potential of a range of approaches to conserve these forests. Furthermore, networks and initiatives promote their conservation. Much hope is placed in the International Year of the Mountain and Rio +10 to conserve the cloud forests that still remain.

Photo 2.
Henri Pittier National Park, Venezuela.
Photo T. Hartmann.

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RÉSUMÉ

FORÊTS TROPICALES NÉPHÉLIPHILES DE MONTAGNE : UN DÉFI POUR LA CONSERVATION

Les forêts tropicales néphéliphiles de montagne ont été identifiées sur 736 sites, dans 59 pays. Leur importance est reconnue pour la survie des populations locales, en termes de protection des bassins-versants et d'alimentation en eau. Ces forêts sont une source majeure de produits forestiers non ligneux et un habitat vital pour de nombreuses espèces endémiques. Toutefois, depuis vingt ans, on constate un déclin rapide de ces forêts. Localement, elles sont gravement menacées par le déboisement et le mitage consécutifs à la pression démographique, à l'exploitation non viable et aux pratiques de gestion inadaptées. Des pressions externes comme l'extraction minière, la construction de routes, la pollution atmosphérique et le réchauffement climatique exacerbent ces problèmes. La conversion vers d'autres usages affecte la qualité des eaux, et peut fortement réduire en aval la disponibilité en eau. La conservation et la gestion durable de ces forêts se heurtent à la pression démographique, la méconnaissance de leur valeur et au manque de données fiables, d'aides financières et de volonté politique. Cependant, le succès de projets de conservation et d'exploitation durable illustre la pertinence d'un éventail d'approches. Par ailleurs, des réseaux et des initiatives à diverses échelles favorisent la conservation de ces forêts. On espère que l'année internationale de la montagne et le sommet Rio + 10 vont inciter les bailleurs de fonds, les gouvernements, les entreprises, les ONG et les communautés locales à conserver les forêts néphéliphiles qui n'ont pas disparu.

Mots-clés : forêt tropicale néphéliphile de montagne, eau, diversité biologique, gestion, conservation.

ABSTRACT

TROPICAL MONTANE CLOUD FORESTS: A CHALLENGE FOR CONSERVATION

Tropical montane cloud forests (TMCF) have been identified in 736 sites in 59 countries. The important role of TMCF in sustaining the livelihoods of local populations by protecting watersheds and sustaining unpolluted freshwater sources has been generally recognised. Cloud forests are important sources of non-timber forest products and are an essential habitat for many endemic and threatened plant and animal species. During the past 20 years, cloud forests worldwide have been disappearing rapidly. They are facing considerable localised threats from clearance and further fragmentation, as a result of population pressure, unsustainable harvesting and poor management practices. External pressures such as mining, road building, air pollution and global warming further exacerbate the problem. Converting TMCF to other uses almost invariably affects water quality, and may significantly reduce water availability further downstream. Sustainable management and conservation of cloud forests faces many challenges including population pressure, poor awareness of their value and the lack of reliable information, political will and donor assistance. However, various successful conservation and sustainable use projects illustrate the potential of a range of approaches to cloud forest conservation. Furthermore, networks and initiatives are promoting cloud forest conservation at local, national, regional and global levels. Much hope is being placed in the International Year of the Mountain and Rio +10 to raise awareness and encourage donors, governments, businesses, NGO's and local communities to conserve the cloud forests that still remain.

Keywords: cloud forest, mountain, water, biodiversity, management, conservation.

RESUMEN

BOSQUES NUBLADOS TROPICALES DE MONTAÑA: UN RETO PARA LA CONSERVACIÓN

Se identificaron bosques nublados tropicales de montaña en 736 zonas de 59 países. Es sabida la importancia que tienen para la supervivencia de las poblaciones locales, en cuanto a la protección de las cuencas hidrográficas y de alimentación de agua. Estos bosques constituyen una fuente principal de productos forestales no leñosos y un hábitat vital para numerosas especies endémicas. No obstante, desde hace veinte años se observa una decadencia rápida de estos bosques. Localmente, están amenazados seriamente por la deforestación y la parcelación que son consecuencia de la presión demográfica, la explotación no viable y prácticas de manejo inadaptadas. Las presiones externas como la extracción minera, la construcción de carreteras, la contaminación atmosférica y el recalentamiento climático incrementan estos problemas. La conversión hacia otros usos afecta la calidad de las aguas y puede reducir mucho la disponibilidad hídrica aguas abajo. La conservación y el manejo sostenible de estos bosques chocan con la presión demográfica, el desconocimiento de su valor y con la falta de datos fiables, ayudas financieras y voluntad política. Sin embargo, el éxito de proyectos de conservación y explotación sostenible ponen de manifiesto la adecuación de una serie de enfoques. Por otra parte, redes e iniciativas a distintas escalas favorecen la conservación de estos bosques. Se ha puesto mucha esperanza en el año internacional de la montaña y la cumbre Río + 10 para concientizar y motivar a los donantes, gobiernos, empresas, ONGs y las comunidades locales a conservar los bosques nublados que aún existen.

Palabras clave: bosque nublado tropical de montaña, agua, diversidad biológica, manejo, conservación.

Introduction

The important role of tropical montane cloud forests (TMCF) in sustaining the livelihoods of local populations by protecting watersheds and sustaining unpolluted freshwater sources has been generally recognised. Whilst all mountain forests help regulate the flow of rivers from their headwaters, cloud forests are unique as they intercept wind-driven cloud moisture on leaves, branches and epiphytes, which then drips to the ground. This "cloud stripping" phenomenon is generally equivalent to 15-20 percent of ordinary rainfall, but can reach 50-60 percent in more exposed conditions. Tropical montane cloud forests are known in many languages as unique vegetation systems through names such as cloud forests, mist forests, elfin forests, moss forests, *Nebelwald*, *forêt néphéliphile*, *matinha nebular*, *unmu-rin* and many others. In Africa, cloud forests form part of the Afromontane forest type, although the term "cloud forest" is rarely used. In the Gulf of Aden, low-elevation cloud forest is described as mist forest. In South East Asia, cloud forests are commonly equivalent to the term "upper montane rain forest", although in Malaysia and the Philippines they are also described as moss forest (ALDRICH *et al.*, 2001).

"Hach Akyum, dios de todos los dioses, creó el cielo y la selva.
En el cielo sembró estrellas y en la selva sembró árboles,
son una sola las raíces de los árboles y las raíces de las estrellas...
Por eso, cuando cae un árbol cae una estrella."
Chan K'in viejo (1900-1996), traditional leader of the Hach Winik, Chiapas, Mexico.

TMCFs have been disappearing rapidly in recent decades because the use of forest resources is increasingly driven by the immediate benefits to be derived from them. The growing interest in tropical montane cloud forests today is largely due to the untiring efforts of Professor Lawrence S. Hamilton, Vice Chair of the World Commission on Protected Areas for Mountains of IUCN – The World Conservation Union. Prof. Hamilton has stressed the hydrological and ecological importance of cloud forests for many years. This paper explains the role of cloud forests in watershed management and the conservation of biological diversity. It discusses some of the socio-economic issues at stake in cloud forest management. A few examples of cloud forest conservation and sustainable use projects are given, together with an overview of major initiatives aimed at cloud forest conservation.

Photo 1.
View of a tepui ringed with cloud forest, Venezuela.
Photo T. Hartmann.

Defining cloud forests

Cloud forests typically occur between 1 500 m and 3 000 m above sea level, usually within an altitude range of about 300 m. Cloud forests have been broadly defined as "*forests that are frequently covered in cloud or mist*" (HAMILTON, 1995) (photo 1). However, the definition of cloud forests is controversial, as it is difficult to make a useful distinction between true "cloud forest" and more general montane rain forest. The main reasons are the scarcity of accurate data on the duration of cloud cover and the actual inputs of moisture from interception of horizontal cloud precipitation, and the tendency to use the term "cloud forest" to describe any montane forests that are sometimes observed to have cloud cover.

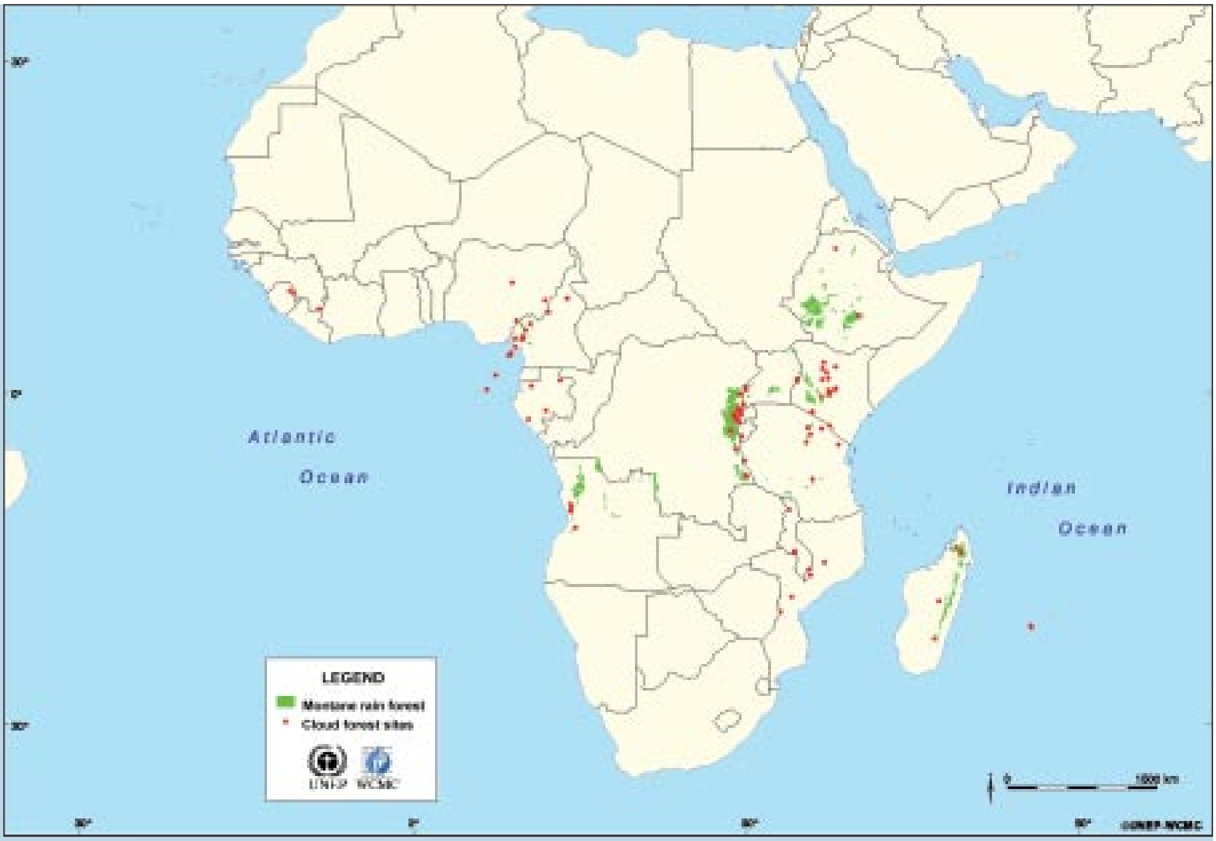
During the first international "Tropical Cloud Forest Symposium" in Puerto Rico in 1993, organised by Prof. Hamilton, the following working definition was developed by scientists and conservation professionals: The tropical montane cloud forest is composed of forest ecosystems of distinctive floristic and structured form. It typically occurs as a relatively narrow altitudinal zone where the atmospheric environment is characterised by persistent, frequent or seasonal cloud cover at the vegetation level. Enveloping cloud or wind-driven clouds influence atmospheric interaction through reduced solar radiation and vapour deficit, canopy wetting, and general suppression of evapotranspiration. The net precipitation (throughfall) is significantly enhanced (beyond rainfall contribution) through direct canopy interception of cloud water (horizontal precipitation or cloud stripping) and low water use by the vegetation. In comparison with

Table I.
Occurrence of cloud forests.
Total number of tropical montane cloud forest (TMCF) sites per region, with the number of sites protected.

Region	Total number of countries	Total number of TMCF sites	Total number of TMCF sites with protection
Asia	15	230	115
Africa	21	97	38
Mesoamerica / Caribbean	13	218	98
South America	6	160	76
Pacific/Oceania	4	31	n.a.
World Total	**59**	**736**	**> 327**

Source: Aldrich *et al.*, 1997; Chaverri, 2001; Hamilton, 1993

lower latitude tropical moist forest, the stand characteristics generally include reduced tree stature and increased stem density. Canopy trees usually exhibit gnarled trunks and branches, dense compact crowns and small, thick, hard (sclerophyllous) leaves. TMCF is also characterised by having a high proportion of biomass as epiphytes (bryophytes, lichens and filmy ferns) and a correspondingly lower proportion of woody climbers. Soils are wet and frequently waterlogged, with a high organic content in the form of humus and peat (histosols). Biodiversity in terms of tree species, herbs, shrubs and epiphytes can be relatively high (considering the small extent of each area) when compared with lowland rain forests that are rich in tree species. Endemism is often very high. TMCF occurs on a global scale within a wide range of annual and seasonal rainfall regimes (i.e. 500-10 000 mm/year). There is also significant variation in the altitudinal position of this mountain vegetation belt. For large, inland mountain systems, TMCF may typically be found between 2 000-3 500 m (Andes, Ruwenzori), whereas in coastal and insular mountains this zone may descend to 1 000 m (Hawaii). Under exceptionally humid marine equatorial conditions, a TMCF zone may develop on small, steep island mountains at elevations as low as 500 m or even lower (Micronesia and Gau in Fiji) (Hamilton *et al.*, 1993).



Map 1.
Cloud forest sites and montane forest in Africa.
Data source: UNEP-WCMC. Reproduction authorized by UNEP-WCMC.

Map 2.
Cloud forest sites and montane forest in Latin America and the Pacific.
Data source: UNEP-WCMC. Reproduction authorized by UNEP-WCMC.

Occurrence of cloud forests

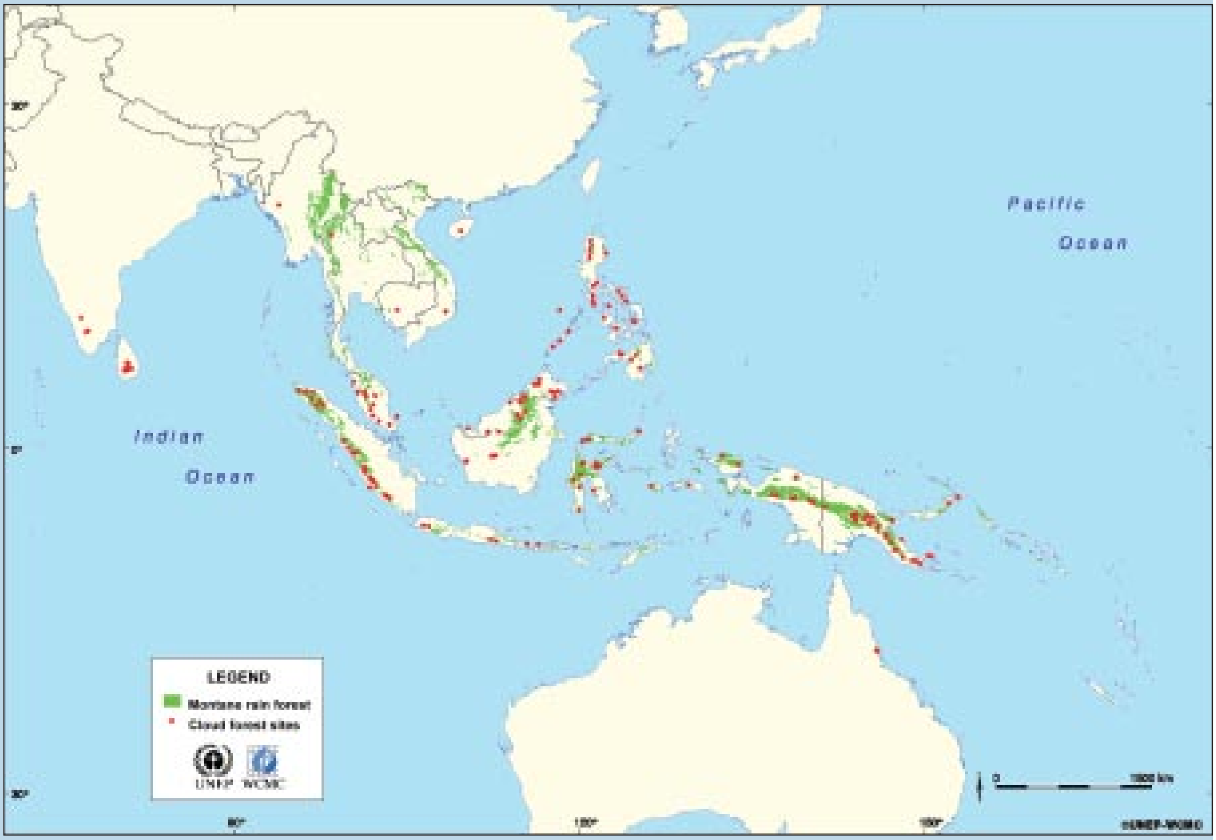
Worldwide, a total of 736 cloud forest sites have been identified in 59 countries by the World Conservation Monitoring Centre (WCMC, 1997), Hamilton *et al.* (1993) and Chaverri (2001) (table I, map 1-3). 378 sites are found in Latin America and the Caribbean, mainly in Venezuela (photo 2), Mexico, Ecuador and Colombia. In South East Asia and the Pacific-Oceania region, 261 sites have been identified, principally in Indonesia and Malaysia. In Africa, 97 sites have been recorded in 21 countries. In the 1970s, it was estimated that cloud forests covered 500 000 km², a fourth of the montane and submontane forest or 11 percent of all tropical forests. The area covered by the remaining cloud forests today is unknown (Bruijnzeel, 2000).

Importance of cloud forests

Hydrological value

While the importance of the additional water input from cloud forests is undisputed, it has been very difficult to quantify. In reality, little is known about the effect on down-stream water yield of cloud forest conversion to cattle pasture or other land uses. However, research results indicate that water yields for a given amount of rainfall from cloud forested headwater areas tend to be higher than streamflow emanating from montane forests not affected by fog and low cloud. In addition, flows from cloud forest areas seem to be more stable during periods of low rainfall. Therefore, there is good reason to believe that converting cloud forests to other land uses could result in significant declines in overall and dry season flows. (Brown *et al.*, 1996; Bruijnzeel, 2000; Bruijnzeel, Proctor, 1993; Stadtmueller, 1987). In 2001, the Forestry Research Programme of the Department for International Development in the United Kingdom decided to fund a long-term study of the effects on water flows and quality of land-use changes in water catchment basins with significant cloud forest cover. In parallel, socio-economic research has been initiated to identify mechanisms for downstream users to compensate upstream land-managers for sustainable watershed management.

In many parts of the world, people and industries depend on the freshwater flowing from the cloud forests (photo 3). For example, the cloud forests in La Tigra National Park in Honduras sustain high-quality



Map 3.
Cloud forest sites and montane forest in South East Asia.
Data source: UNEP-WCMC. Reproduction authorized by UNEP-WCMC.

water flow throughout the year, providing over 40% of their water supply to the 850 000 people in the capital city, Tegucigalpa. In Africa, the 2.5 million people in the Tanzanian capital of Dar es Salaam rely on drinking water from the Ulugura mountains and for hydroelectric power from the cloud forests of the Udzungwa mountains. Other capitals supplied by cloud forest water include Quito and Panama City (Aldrich *et al.*, 2001). In the Sierra de las Minas Biosphere Reserve, 63 permanent rivers drain the area, making it Guatemala's biggest single water resource and providing water to the 37 industries in the semi-arid Motagua valley (Brown *et al.*, 1996).

Photo 3.
Water from Henri Pittier National Park (Venezuela) supplies the villages of Uraca, Puerto Colombia and numerous smaller communities with freshwater.
Photo T. Hartmann.

Mist forests in arid and semi-arid regions

Interception of moisture from clouds is especially important in arid and semi-arid regions, where water sources are few and unreliable (photo 4). However, their contribution to water availability for urban and rural people, livestock and crops remains unrecognised in most cases and needs to be further investigated. There are few practical experiences of the conservation of cloud forests and their management for water supplies, especially in semi-arid areas in Africa.

In the arid coastal areas of Peru, Chile, Ecuador, Cap Verde and Oman with few or no trees, artificial fog collectors have been constructed where clouds may be intercepted. Fog collectors are built in the form of vertical mesh panels. The largest project to date has provided up to 11 000 litres of water per day to a village of 330 people in the arid coastal desert of northern Chile. In some areas, collected fog water has been used to reforest such areas to restore this valuable hydrological function (Schemenauer, Cereceda, 1994).

Cloud forest biodiversity

Cloud forests make up an essential habitat for many endemic and threatened plant and animal species. They provide a wide range of goods and services for local communities and strong cultural values are attached to them. TMCF provide a unique habitat for species such as tree ferns, bromeliads and many rare and endemic orchids, as well as several important tree species. Economically valuable plants from cloud forest habitats include wild relatives of strawberries, raspberries, blueberries and some bean species. Quinine is extracted from the bark of the cinchona tree, an Ecuadorian cloud forest tree species. Much of the knowledge on cloud forest species and their uses resides in the indigenous communities that have lived for many years in or adjacent to cloud forests. Cloud forest plant species are used for instance for medicines, cosmetics, birth control, stimulants and ornaments. (Aldrich *et al.*, 2001). Researchers in the Monteverde Cloud Forest Reserve are presently investigating cloud forest plants that may yield useful medical or commercial chemicals for the future.

A biodiversity project report by BirdLife International showed that 400 of the world's 1 200 threatened bird species are associated with tropical montane forests. Similarly, the WWF Global 200 Priority Ecoregions for conservation action include 90 percent of the TMCF sites known to date. The resplendent quetzal (*Pharomachrus mocinno*) of Central America is now virtually restricted to a few cloud forest "islands" on separate mountains. Species such as the mountain gorilla (*Gorilla gorilla beringei*) in Central/East Africa and the spectacled bear (*Tremarctos ornatus*) in the Andes are specific to cloud forest environments. They are flagship species for cloud forest conservation and sustain many ecotourism ventures (Aldrich *et al.*, 2001).

Photo 4.
In arid and semi-arid areas, patches of cloud forest are even more crucial for water supply to surrounding communities, especially during the dry season.
Mount Kenya National Park.
Photo T. Kohler.

Threats

Cattle and crops are encroaching on cloud forests

Over the past 20 years, cloud forests worldwide have been disappearing at nearly twice the rate of average global deforestation. This trend has been recognised by the UN Intergovernmental Forum on Forests, which stated that "*cloud forests are of particular concern*" in soil and watershed protection and in the conservation of biological diversity in environmentally critical areas (Aldrich *et al.*, 2001). There are many causes of cloud forest disappearance and degradation. Worldwide, the greatest losses come from their conversion to grazing land. When cloud forests are cleared for timber, cattle or crops, the loss of their "cloud stripping" capacity diminishes the water yields available for domestic use and irrigation. At the same time, erosion of topsoil causes sedimentation in rivers, blocking up lakes and reservoirs. Despite this, cloud forests continue to be cleared for new farming land as population pressure grows and existing farmland becomes impoverished. Other regionally important causes for cloud forest loss include: conversion to temperate vegetable cropping in the tropics, gathering wood for charcoal production, timber harvesting, mining, unsustainable extraction of non-timber forest products (e.g. orchids and bromeliads), introduction of alien species and the construction of telecommunications installations in cloud forests on mountain tops.

The impacts of climate change

There is increasing evidence that cloud forests are also threatened by global warming and air pollution (photo 5). Global warming causes clouds to form at higher altitudes, resulting not only in the forest losing this water input but in the extinction of many plant and animal species in cloud forests that are finely adapted to the prevailing climatic and soil conditions. The disappearance of 20 species of frogs and toads from the Monteverde Cloud Forest Preserve,

Photo 5.
Small-scale mining and air pollution in the northern Andes of Colombia.
Photo S. Hostettler.

Photo 6.
View at 1 700 m a.s.l. of cloud forest on the cliff face of tepui Roraima, Venezuela.
Photo T. Hartmann.

including the endemic golden toad (*Bufo periglenes*), is closely correlated with the years when there is low mist frequency in the forest (Pounds *et al.*, 1999). Cloud formation patterns can also be altered by deforestation in lowland areas, further adding to the stresses on these fragile ecosystems. It is very likely that climate change will affect the species composition and distribution of potential cloud forest locations and it may force those situated near mountain tops out of existence (Still *et al.*, 1999). Because epiphytes, amphibians and other cloud forest species are highly vulnerable to changes in radiation, temperature and humidity, these forests make ideal "canaries in the coal-mine" to detect ecological responses to climate change (photo 6), as has been recognised by Hamilton (1995) and others.

The Challenges

Cloud forest conservation and sustainable use face many challenges.

Awareness of the value of cloud forests needs to be raised at all levels, from local to international. In 1997, the WCMC produced a global directory of TMCFs. Whilst this database provides the best available information on the location and status of TMCFs, considerable work is required to develop the level of detail on a site by site basis. In particular, detail is required on protection status, biological importance, socio-economic conditions and current threats. Although detailed information exists in some cases for specific sites, it is widely scattered and often not generally available (Aldrich *et al.*, 1997). Few development aid donors have heard of cloud forests and therefore tend to focus on biodiversity conservation in lowland rain forests.

Rural poverty is still common in many developing countries, especially in the highlands, leading to great pressure in terms of forest clearing or unsustainable harvesting of a wide range of forest products.

Photo 7.
Participatory planning workshop in Ecuador.
Photo S. Hostettler.

Photo 8.
Preparation of material for oil drilling near Limoncocha Biological Reserve (lowland rain forest) in Ecuador.
Photo S. Hostettler.

The absence of economically viable alternatives often forces local communities to exploit cloud forest ecosystems for short-term gain and discourages long-term stewardship. Securing livelihoods for local communities by providing alternatives to the conversion of cloud forest areas to grazing or agricultural land use is essential for the conservation and sustainable management of cloud forest. For sustainable land uses to be acceptable, they need to be developed in partnership with the local communities who are meant to apply them (photo 7).

A review of the degree of recognition of TMCFs in National Biodiversity Strategies and Action Plans (NBSAPs) was conducted in July 2000 by UNEP-WCMC. Among the 59 countries where TMCFs have been identified, only 8 countries recognised montane forests as a conservation priority or of high importance for biodiversity (Cameroon, Kenya, Rwanda, Uganda, Bolivia, Peru, Costa Rica and the Philippines). However, lack of political will is not the only reason for this low degree of recognition. Governments in developing countries have limited capacity and resources to produce NBSAPs and reports, and the situation is exacerbated by the lack of awareness and available information on the distribution and importance of montane forests.

National Park management needs to be improved and legal protection implemented. Numerous National Parks containing cloud forests suffer from degradation and encroachment due to a lack of resources and commitment from governments to ensure legal implementation. In many countries, even where mining is specifically prohibited, mining both on a small scale and by multinational corporations has been continuing for years. Protected areas are also under constant threat from oil production (photo 8). In Ecuador, the government is planning to build a new pipeline for heavy crude oil. This highly controversial project would bisect the Mindo Nambillo Cloud Forest Reserve and surrounding intact forests.

A key challenge to achieving sustainable management is the creation of mechanisms to pay for environmental services. Mechanisms need to be developed and implemented that reward communities for maintaining the environmental services provided by intact cloud forests, such as clean water and erosion control. Both the public and private sector benefit from these environmental services and must therefore be involved in cloud forest conservation. In order for that to happen, a supportive policy environment with appropriate laws, institutional arrangements, market frameworks and information is needed.

Conservation of cloud forests today

According to Chaverri (2001), there are at least 40 ongoing conservation and sustainable use projects in cloud forest areas in Mesoamerica. Since cloud forest conservation is most advanced in Mesoamerica, there are probably between 60 and 80 projects running at this moment in the world. In addition, assuming that there is at least one ongoing project in each country where cloud forest occurs, and many more in countries such as Costa Rica, at least the same number of research projects are in progress. However, these are very rough estimates.

At least four cloud forest networks have been formed during the past 5 years. At international level, a Tropical Montane Cloud Forest Initiative was formed in 1999 to strengthen recognition and resources for cloud forest conservation around the world, with an emphasis on their role in providing freshwater (table II). These networks potentially strengthen conservation and management efforts by increasing knowledge and exchanges, raising awareness and promoting cooperation on specific projects. Progress has, however, been severely impeded by funding constraints.

There are several ways of approaching the conservation of cloud forests (table III).

Awareness and environmental education

At regional level, the *Cloudforest Alive* website is raising awareness about cloud forests in Mesoamerica. In Honduras, *Friends of Celaque National Park* launched a web site to help conserve Celaque Mountain and its cloud forest. It attracts attention to illegal clearing for coffee plantations, cattle ranching, and logging within the park and is meant to initiate a process which will involve local communities in restoring degraded buffer-zones and linking the park to nearby natural areas through green corridors (www.generation.net/~derekp/celaque.html). Many local environmental education programmes on cloud forests already exist in Latin America: Volcan Mombacho Nature Reserve in Nicaragua, Montecristo National Park in El Salvador, and Guandera Reserve in Ecuador are some examples.

Photo 9.
Henri Pittier National Park, Venezuela.
Photo T. Hartmann.

Table II.
Tropical montane cloud forest networks.

Name	Objectives / approach
Tropical Montane Cloud Forest Initiative	The TMCF Initiative was established in 1999 by IUCN, WWF, UNEP-WCMC and the UNESCO International Hydrological Programme. It includes the hydrological expertise of the Free University of Amsterdam. The TMCF Initiative is currently developing a project proposal for the Global Environmental Facility (GEF). (www.unep-wcmc.org/forest/cloudforest/english/homepage.htm)
Mexican Cloud Forest Network	In 1999, PRONATURA a Mexican NGO, whose mission is to protect and conserve Mexico's biodiversity, initiated the Mexican Cloud Forest Network to establish a national network and action plan. Membership of this network includes over 50 members from NGOs, government agencies and the scientific community. (www.pronatura.org.mx)
African Cloud Forest Network	The Albertine Rift Conservation Society (ARCOS) in Central Africa includes member organisations from five countries. After a priority-setting workshop in Uganda in 1999, ARCOS is presently developing a project proposal for conservation of montane forests in the Albertine Rift Valley. (www.wcmc.org.uk/arcos/projectstop.html)
Cloud Forest Alive	The Cloud Forest Alive web site aims to enhance global understanding of the cloud forests of Central America. The website provides information on the impact of cloud forests on water and soil quality, climate patterns, and numerous plant and animal species. Cloud Forest Alive was implemented through assistance by the Central American Commission for Environment and Development under the auspices of the Mesoamerican Biological Corridor initiative. (www.cloudforestalive.com)

Protected areas

Over 327 legally protected areas with cloud forest have been established (Aldrich *et al.*, 1997; Chaverri, 2001) (photo 9). However, some of these protected areas are small remnants of once extensive areas of habitat. Others are not big enough to contribute substantially to conservation, many exist only on paper and relatively few are sufficiently well managed to achieve their conservation objectives. According to the recent survey by Chaverri (2001), the only well managed protected cloud forest areas in Central America are Monteverde Cloud Forest Reserve (Costa Rica), El Triunfo Biosphere Reserve (Mexico), Sierra de las Minas Biosphere Reserve (Guatemala), La Tigra National Park (Honduras), Volcán Mombacho Natural Reserve (Nicaragua) and Volcán Barú National Park (Panama). A number of the national parks and other areas included in the Mesoamerican Biological Corridor (MBC), such as La Amistad Reserve on the Costa Rica/Panama border, already contain cloud forest. The inclusion of further cloud forest sites into the MBC is being promoted by IUCN and WWF offices in Mesoamerica.

Table III.
Cloud forest conservation and sustainable use projects.

Name	Approach
The Tropical Rainforest Programme of the Netherlands Committee for IUCN	The funds of the Netherlands Committee for the IUCN/Tropical Rainforest Programme support projects in the field of conservation and sustainable management of tropical rainforests. Worldwide, 45 projects aimed at cloud forest conservation or sustainable management have been funded by providing small grants to local NGOs. (www.nciucn.nl)
The DGIS-WWF Tropical Forest Portfolio	The DGIS-WWF Tropical Forest Portfolio provides support to two integrated conservation and development projects in Sangay National Park in Ecuador and on Mount Guiting Guiting in the Philippines, both containing important cloud forest areas. (www.panda.org/resources/publications/forest/dgis1)
Kilum-Ijim forest project, Cameroon	Birdlife International is supporting this project focusing on sustainable farming systems, securing land tenure and ecological monitoring. (www.birdlife.org/people/kilum-ijim.cfm)
Sierra de Manantlán Biosphere Reserve, Mexico	The Manantlán Institute of Ecology and Conservation of Biodiversity (IMECBIO) is doing research in restoration with native cloud forest species and has implemented various integrated conservation and development projects in the Sierra de Manantlán. (www.cucsur.udg.mx)
Conservation of the Andean bear in Ecuador	This project, led by EcoCiencia, an Ecuadorian NGO, is focusing on surveys, sustainable management, education and communication to conserve the Andean bear and its cloud forest habitat. (www.ecociencia.org)
Makiling Forest Reserve, Philippines	This project is led by the University of the Philippines, Los Baños. Downstream users pay upper catchment owners to maintain and improve hydrological conditions in the catchment area by protecting the cloud forest ecosystem. Due to its success, it will be replicated in two other sites in the Philippines. (www.eepsea.org)

Eco-tourism

There are many examples where (eco)-tourism is used as a tool for the sustainable management of cloud forest. Best known are the National Parks, but there are many smaller projects, primarily in Central and South America, that are lesser known but very promising. These range from extremely basic accommodation and interpretative trails through the Sierra de la Botija cloud forest in Honduras to the very exclusive private cloud forest reserve at Bosque de Paz in Costa Rica. There is much potential for ecotourism to support cloud forest conservation, especially in Africa where the concept still has to be fully explored. The main problems with eco-tourism are the large number of visitors needed to provide local communities and park management with enough revenue to conserve the area and leakage of the revenue back to urban areas and to developed nations : relatively little is actually spent on conservation (Ceballos-Lascurain, 1996).

Payment for environmental services

Payment for environmental services preserves cloud forest ecosystems by compensating cloud forest managers for the environmental services they provide, such as a steady water supply and attractive tourist locations. Such mechanisms exist in the Philippines, Ecuador, Colombia, Costa Rica and El Salvador (Aldrich *et al.*, 2001; Campos, Calvo, 2000; Chaverri, 2001). However, more work is needed to link successful local compensation schemes with national policy making, to achieve a fair distribution of costs and benefits and to implement effective and efficient mechanisms to transfer benefits from downstream to upstream stakeholders.

Sustainable agricultural systems

There is increasing interest in organic coffee growing to help conserve biodiversity at the same time. This is an opportunity to increasingly associate organic coffee cultivation with cloud forest conservation, as has

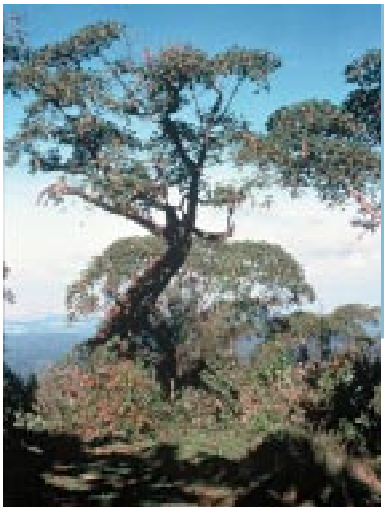


Photo 10.
Mount Kenya National Park.
Photo T. Kohler.

been successfully done in Selva Negra cloud forest (Nicaragua), Sierra de Manantlán Biosphere Reserve (Mexico) and a recent project on "*Conservation through Market Mechanisms*" promoting organic coffee growing in the cloud forest in El Triunfo Biosphere Reserve in Mexico (www.gefweb.org).

A successful combination of approaches

In Ecuador, cloud forest and paramo forest is being cleared by farmers to open new fields for potato cultivation. In the past, hundreds of hectares have been cut annually. Because soil nutrients are quickly depleted, new fields have been opened continuously to produce more cash income. In 1995, the "Eco-Papas" project in the Guandera Reserve began an environmental education and alternative agricultural programme. It fosters an appreciation of the value of the forest while working towards developing economic activities that do not involve clear-cutting, such as planting fruit trees. The environmental education programme stresses how the intact forest contributes to everyday life by providing a clean freshwater supply and a variety of useful plants, birds and insects. Results have been positive, and additional income has been generated through eco-tourism and research activities (www.bchip.com/equafor).

Conclusion

The importance of cloud forests for local communities and downstream freshwater supplies has been not been adequately addressed in conservation strategies. Given the ecological and socio-economic factors affecting cloud forest conservation, there are no easy solutions to the problem of over-utilisation of cloud forests and the corresponding problems of securing sustainable livelihoods. However, expertise, networks and project experience exist and constitute an initial knowledge base for the sustainable management and conservation of cloud forests.

Commitments from governments and the donor community have been inadequate so far. The key challenge is to raise awareness of the importance of cloud forests for water supplies and the conservation of biological diversity, prompting donors, governments, businesses, NGOs and local communities to take action before the world's remaining cloud forests disappear. Cloud forests merit special conservation action (photo 10). Much hope is placed in Rio +10 and the International Year of the Mountain 2002 as unique opportunities to increase political, institutional, and financial commitments for concrete action on sustainable cloud forest management. The second International Symposium on Tropical Montane Cloud Forests – planned to take place in Hawaii in 2004 – will help in finding out how much has been achieved in the past 10 years or, which is more likely, how much still remains to be done.

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LES INVERTÉBRÉS DANS L'ÉCOSYSTÈME FORESTIER. COLL. DOSSIERS FORESTIERS N° 9, MNHN-ONF, 224 P.

ISBN 2-84207-210-3

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Diversité des formes des structures des peuplements, des adaptations, des niches occupées, du trophisme et surtout des fonctions accomplies sont autant de facettes de la diversité biologique des invertébrés saprophages développées dans cet ouvrage. Il s'agit d'une étude synthétique, analytique et critique des interrelations complexes entre les invertébrés et le milieu forestier.
Chaque chapitre analyse une situation voire une étape évolutive de l'écosystème forestier, où transparaît une conception novatrice de l'écologie. Les invertébrés sont considérés comme des facteurs actifs de l'évolution des milieux et comme d'excellents indicateurs écologiques. L'analyse des insectes saproxylophages et leurs actions principales dans la transformation des bois morts ainsi que l'étude des ravageurs de la canopée montrent une biodiversité élevée, organisée en guildes spécialisées, avec des conséquences importantes sur le fonctionnement de l'écosystème. La fragmentation des massifs, l'effet de lisière, le rôle de réservoir de faune que jouent les haies et corridors sont étudiés avec un esprit de gestion de la forêt et de conservation de la diversité. L'ouvrage se termine par la place de l'écologiste dans une politique de la biodiversité. Un glossaire détaillé et une bibliographie étendue complètent l'ouvrage.
Résumé adapté d'après l'annonce de l'éditeur.

OAB, 2001.
LES DEUX ENSEMBLES DE PRINCIPES, CRITÈRES ET INDICATEURS (PCI) DE L'ORGANISATION AFRICAINE DU BOIS (OAB) POUR LA GESTION DURABLE DES FORÊTS TROPICALES AFRICAINES.
OAB, 28 P.

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Cette publication contient l'un des principaux résultats d'un projet sur la gestion durable des forêts tropicales africaines. Elle présente deux ensembles de principes, critères et indicateurs (PCI) de l'Organisation africaine du bois (OAB), dont un est à utiliser au niveau national et l'autre à celui de l'unité forestière d'aménagement (UFA).
Ces ensembles de PCI sont issus de résultats de tests de terrains réalisés dans cinq pays membres de l'OAB : la Côte d'Ivoire, le Cameroun, le Gabon, la Centrafrique et le Ghana. Ils sont le fruit d'une étroite collaboration entre l'OAB et le Centre pour la recherche forestière internationale (Cifor), sous la direction du Dr Robert Nasi. Les subdivisions de ces ensembles couvrent les sous-indicateurs (SI), qui peuvent servir de modèle ou donner des orientations lors de l'élaboration des vérificateurs ou des standards à l'échelle nationale ou de l'UFA.
Ces ensembles ont été mis en cohérence avec les ensembles de PCI internationaux du Forest Stewardship Council (FSC) et de l'Organisation internationale des bois tropicaux (OIBT). Ils ont été validés lors de réunions internationales sur les PCI tenues en 2000 et 2001.
Les pays membres de l'OAB disposent ainsi d'outils pour mettre en œuvre la gestion durable de leurs forêts. L'OAB, en collaboration avec les autres partenaires du développement, les assistera dans le processus d'internationalisation de ces outils qui sont indispensables pour l'avenir des forêts tropicales africaines.
Résumé adapté d'après l'annonce de l'éditeur.