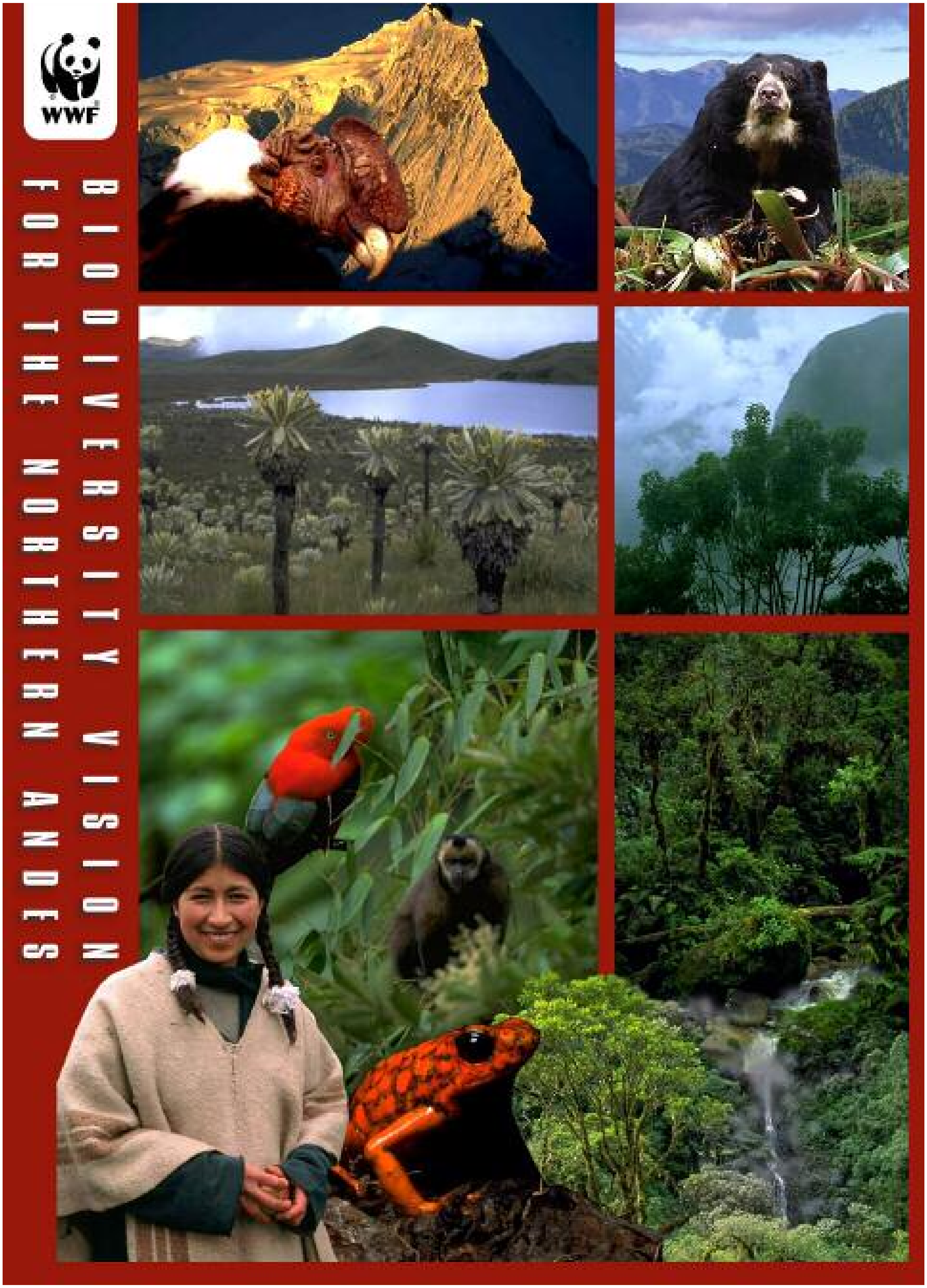
WWF
BIODIVERSITY VISION
FOR THE NORTHERN ANDES

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BIODIVERSITY VISION FOR THE NORTHERN ANDES

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INTRODUCTION TO THE NORTHERN ANDES ECOREGIONAL COMPLEX AND TO ECOREGIONAL CONSERVATION

The tropical Andes support almost half of the biological diversity of angiosperms (Gentry, 1982), birds (Fjeldså, 1994) frogs (Lynch et al. 1997), and butterflies (Andrade & Amat, 1996) in the Neotropics. Despite being less than one-fourteenth the size of the Amazonian watershed (490,000 vs. 6,869,000 km^2), the Northern Andes boasts about the same number of species as the vast Amazonian lowlands, including 45,000 species of plants (Gentry, 1982), more than 1,400 species of birds (15% of the world's total), and more than 500 species of frogs (Duellman, 1999; Lynch et al., 1997). A large portion of the flora and fauna consists of unique taxa with restricted geographic ranges.

The biological diversity of the Northern Andes has long been considered both globally outstanding and significantly at risk by a wide range of scientists and conservation organizations. WWF has placed the Northern Andes ecoregions among the top 200 biogeographic conservation priorities, and it has subsequently been ranked as 1 of the 17 most important conservation priorities for Latin America based on the uniqueness and threatened status of its biodiversity. Conservation International (CI) has identified the northern Andes as one of the world's 25 biodiversity "hotspots" (Myers et al., 1999). Bird Life International also classifies virtually the entire ecoregional complex as an endemic bird area (EBA) of global importance (Stattersfield et al. 1998; Wege and Long, 1995), while the International Union for the Conservation of Nature (IUCN) jointly with WWF recognize the uniqueness of the flora of this region, identifying at least nine Centers of Plant Diversity (Davis et al., 1997) in the tropical Andes.

In recognition of the globally outstanding stature of the Northern Andes, collaborators from four countries- Colombia, Ecuador, Peru and Venezuela - joined forces with WWF to analyze the patterns of biodiversity in the region and establish minimum spatial and distributional requirements for its long-term conservation. The analytical conservation planning process is a procedure that aims to establish conservation priorities based on sound scientific information, and principles of conservation biology and landscape ecology (among others) on a spatial scale that will conserve the ecological and evolutionary processes and dynamics (e.g. population dynamics) that have created and sustain the natural patterns of biodiversity. This scale is the ecoregion, and effective and lasting conservation can only be achieved by planning and working at such a spatial and temporal scale.

Conservation at the Ecoregional Level

An ecoregion is a relatively large ecological unit of classification that contains a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions (Dinerstein et al. 2000). The ecoregion comprises a grouping of natural ecosystems that are closely related geographically, physically, and biologically and thus have been subject to similar evolutionary processes.

ERC has four major goals (modified from Noss 1992):

1. **Assure representation** of at least 10%, but optimally 20-30% of all distinct **natural communities**, or habitat types, within conservation landscapes.
2. Maintain **viable populations** of **focal** native species.

3. Conserve **blocks of natural habitat large enough to be resilient** to large-scale stochastic and deterministic disturbances and long-term changes.
4. Ensure **connectivity among blocks of natural habitat** while considering land uses that are compatible with conservation goals.

In situations where groups of ecoregions have particularly strong ecological interconnections or interdependencies, they can be grouped into ecoregional complexes. The Northern Andes Ecoregional Complex (NAEC) is an example. It consists of 11 distinct yet interrelated ecoregions that encapsulate the complex mountain massif that runs some 2,000 km from northern Venezuela and Colombia south through Ecuador into northern Peru.

The biodiversity vision

A key component of ERC is the "**biodiversity vision**", a statement, based on biotic and abiotic information, of the biologically and ecologically important features of the ecoregion, their distribution, and the conservation landscape that will be needed to maintain them over the long term. The aim of the biodiversity vision is to determine, from a conservation perspective, what the ecoregion should look like in the long term (>50 years) to conserve its biodiversity and ecological processes in perpetuity**.**

The promotion of sites for protection, restoration, low-impact resource extraction, ecotourism, and other conservation-oriented activities can then be determined by each site's role in the biodiversity vision, in a purposeful rather than a haphazard fashion. A biodiversity vision "provides a useful framework for interpreting threats to the integrity of the entire ecoregion as well as to individual sites. Without a vision, we lose sight of the overarching conservation targets, we have difficulty establishing priorities, and we waste scarce resources." (Dinerstein et al., 2000.)

DESCRIPTION OF THE NORTHERN ANDES ECOREGIONAL COMPLEX

The Northern Andes Ecoregional Complex (NAEC) and associated adjacent dry forests comprise an area of approximately 490,000 km^2, which constitutes the tropical Andean highlands and intermontane valleys of western Venezuela, Colombia, Ecuador, and northern Peru. The 11 ecoregions that make up the NAEC consist of seven moist montane forest classifications and four páramo classifications. The montane forests occur on both slopes of three adjacent Andean ranges, and make up the bulk of the area of the complex. Within the 7 forest montane ER, moist evergreen (cloud) forests are the most abundant formation in the NAEC, covering over 31% of the total area. The alpine páramo habitat exists as relatively small discrete zones in a matrix of tropical premontane and montane forest (Fjeldså and Krabbe, 1990). Paramos extend across 4 countries and cover about 6% of the NAEC.

Three dry forest ecoregions occur in the intermountain valleys that lie between the three cordilleras that make up the NAEC. While the dry forests are not technically part of the NAEC, there is extensive interaction between them and the higher montane forests that surround them. The dry forest regions were thus considered areas of influence on NAEC and have been included in the ecoregional maps and analyses described in this document.

The least abundant vegetative types are the montane scrublands, the southern dry montane shrubland, and the montane moist shrubland of the Amazonian piedmont, all located only in Ecuador. The wetlands of the high plains (Altiplano) are another scarce vegetative formation, covering only 0.034 % of the total area of the NAEC and occurring only in the Northern Andes páramo in Colombia (Kattan et al., 2000).

Geographic location

Located in the highlands of the tropical Andes, this complex extends from 11 ° North latitude at the Sierra Nevada de Santa Marta in northern Colombia, 2,000 kilomenters southward to the Abra de Porculla mountain pass in the Huancabamba depression in northern Peru, at approximately 6° South latitude.

The recognized northeastern limits of the Northern Andes ecoregional complex are the Sierra de Perijá (Colombia, Venezuela) and the Mérida Cordillera (Vene zuela). The northwestern limit is the Sierra Nevada de Santa Marta (Colombia). The southern limit of the complex is the Huancabamba depression (Peru), which serves as a biogeographic barrier to species movement, separating the northern and southern Andes (Duellman, 1979).

The geographic boundaries of the NAEC are based primarily on vegetation types and barriers to the movement of species, and physical (water, soil, materials) elements, which were determined in large part by altitudinal limits. The outsi de limits of the complex as a whole are based primarily on lower elevations that differentiate the Andes ecosystems from the coastal and Amazonian/Orinoquian lowlands. The lower limit in the northwestern (Caribbean) slopes is 500m, 200-300 m on the Pacific slopes, and 500-800 m in elevation on the eastern (Amazonian and Orinoquian) slopes.

Climate

The geographic location and topographical complexity of the Northern Andean region gives rise to a great variety of physical environments and ecosystems. We sterly winds from the coast bringing humid air from the Pacific Ocean and northeasterly trade winds bringing humid air from the Atlantic maintain a consistently wet climate on both exterior slopes of the Northern Andes. Interior slopes of the intermountain valleys have more variable weather conditions: the higher portions of these slopes intercept moisture -laden clouds and receive extensive condensation, while the middle and lower elevations of the valleys experience more frequent and extended dry periods due to rain shadow effects. Dry periods are longest in the InterAndean valleys and the extreme north and south of the complex. The most extreme case is the SW corner where <60mm of rain may fall during 10 months of the year. While less drastic, the Venez uelan Andes also experience dry conditions for periods of up to six months (created from CIAT).

Heterogeneity stemming from changes from Atlantic to Pacific -facing slopes and significant altitudinal gradients on both slopes generate a wide ranges in temp erature, from the fairly hot climates near the edges of the Amazon and Orinoco lowlands to sub -arctic conditions that support permanent snow and ice in the highest elevations.

Habitat heterogeneity

The variation in climate resulting from altitudinally -induced temperature changes and topographically induced orographic rainfall and rain shadows has a dramatic effect on vegetation. Lower-elevation tropical wet forests grade into premontane and montane forests, which in turn give way to páramos and ultimat ely permanent snow and ice at the highest elevations.

While major vegetation types tend to vary with altitude, several of the unique environments occurring in the NAEC are due to additional factors. Even within the generally moist northern Andes there are several dry or subxerophytic zones that contain a variety of unique taxa, particularly plants (e.g. Dagua and Patia Valley). Changes in local topography, soil types, and climatic conditions allow the occurrence of multiple habitat types - including many types of montane forests, shrublands, wetlands, and páramos - in relatively small areas.

Several extremely wet regions are found, which probably served as humid refuges during the climatic fluctuations of the Pleistocene, contain a high diversity of species of both plants and animals. Many of these areas are centers of endemism for a variety of taxa.

Fauna and flora

As a result of the above-described geographic climatic and habitat heterogeneity, on a per area basis, the Northern Andes is among the most diverse region of the world. In an area 1/14 the size of the Amazon basin, the Northern Andes harbor almost 30% of the palms found in the Neotropics and 11% of the world's palm species (Kattan et al., 2000). The 1,450 bird species, which by far exceeds the 1,000 species found in the Amazon, constitutes 15% of the world's birds. From a sample of 8,117 species, representative of Neotropical flora, compiled by Gentry (1982), 23% had Amazonian distributions, versus 17% with Andean distributions, des pite the large difference in surface area. In Colombia, 80% of the frog species are from the Andes, an area equivalent to that of the Colombian Amazon (Lynch et al. 1997).

The large number of habitats in a relatively small area implies an equially large number of ecotones, or zones of transitional habitats. The biota of these sites mixes elements of two adjacent habitats, and the variety of niches permits the development of unique species. These features produce dramatic and relatively small scale, uni que ecosystems with unique taxa, and high numbers of species with ranges that are restricted to particular elevations or other biogeographic units (Fjeldså and Krabbe, 1990; Kattan et al., 2000).

These factors further contribute to the notable turnover of species along environmental gradients such as altitude and latitude, known as beta -diversity. For example, Croat (1992) found major differences in species composition among Araceae communities located only several kilometers apart.

Ecological and evolutionary processes

The diverse South American biota is a result of four great historic processes. First, the separation of South America from Gondwanaland, allowed for the isolated evolution of the region's biota during several million years. Second, the rise of the Andes in the Mesozoic period produced a diverse number of new environments, with the great variety of temperature and precipitation regimes and other physical factors seen. Third, the establishment of a connection with North America permitted floristic and faunistic interchange that complemented the endemic biota. Finally, the climatic variations during the Pleistocene period caused contractions and expansions of the geographic ranges of many species, resulting in the isolation of populations, diversification, and eventually speciation, followed by the subsequent expansion of ranges of these new taxa.

After the separation of the South American continent from Gondwanaland, its species began evolving independently from those of other land -masses. The subsequent diversification resulted in a number of endemic plant families, some of which are extremely diverse. For example, two of these families - Bromeliaceae and Cactaceae – have assumed major roles in their dominant habitats, Bromeliaceae in montane habitats and Cactaceae in xerophytic habitats and are represented by more than 2000 species each (Gentry, 1982).

The rise of the Andes chain in the Mesozoic period only increased this diversification. This rise was a response to a complicated series of tectonic movements during the Tertiary period that ended in the Quaternary (from Pliocene into Pleistocene epochs, some 2 -2.5 millon years ago), when the northern Andes reached their current height (Bürgl, 1961; Hernández Camacho et al, 1992). In the Miocene, several peaks reached 2,000m in elevation, bringing about a separation of the Amazonian and western biotas (Hernández Camacho et al, 1992). This process also gave rise to the divergence of the biota of the humid forest belt of the Colombian -Ecuadorian Pacific slope, which today supports high levels of endemism (Brumfield and Capparella, 1996; Gentry, 1982, 1982b; Lynch, 1979). Some of the peaks in the Andes show no evidence of glaciation, which suggests that the completion of this rise is relatively recent, after the last major glaciation in the Pleistocene.

Many of the ecological and evolutionary processes that began during these events, such as speciation, and genetic interchange with North American and Central American biota, continue today. Fjeldså (1994, cited in Kattan et al., 2000) has called the northern Andes, a geologically relatively young range, an "active speciation factory" that itself serves as a center of endemism. Certain regions within the NAEC, including the moist hills of the Pacific slope, the middle slopes of the Cauca valley, the central region of the Central Cordillera in Colombia, and the Perijá and Santa Marta highlands, have particularly high concentrations of endemic species (Kattan et al., 2000).

In addition to species diversification, watershed regulation, wetland maintenance, and Nearctic and intraregional seasonal migrations and their corresponding impacts on pollination and seed dispersal are essential processes that support and maintain patterns of biodiversity in the region. Some 53 species of birds overwinter in this ecoregional complex (Roca et al. 1996), and many resident species migrate seasonally up and down the slopes on both sides of the Andes. The headwaters of over 70 rivers and over 300 streams occur in the NAEC (WWF GIS calculations), including 3 of the largest and most important rivers in South America (Amazon, Orinoco and Magdalena Rivers).

Species diversification

The diversity produced by the separation of South America from the rest of Gondwanaland and the rise of the Andes continues today, particularly in isolated highland systems. These isolated zones include the Cordillera del Cóndor, Macarena Mountains, Sierra Nevada de Santa Marta, as well as the series of discrete páramo systems. These isolated highland areas have provided opportunities for the development of a distinctive biota, including unique species and sub-species.

The biota of the páramos represents a unique evolutionary phenomenon of the Northern Andes. These grasslands extend from tree line to the upper limits of vegetation and are isolated from one another in a matrix of montane humid forests. The outstanding, commonly occurring genus in the páramos is *Espeletia*; it radiated from its center of origin around the páramos of the northern portion of the Central Andes south to the páramos of Ecuador. Animal species unique to the páramo includes marsupials of the Coenolestidae family and the tiny deer *Pudu mephistopheles*.

Regulation of watersheds

The montane forests are essential for the maintenance of water quality and flow. These highlands contain the sources of the continent's major rivers. The alto Marañón area is the source of the Amazon River, and the Colombian Massif is the source of the Cauca, Magdalena, and Caquetá rivers. The alto San Juan and Atrato and the watersheds of the Patía, Mira, Esmeraldas, Napo, Pastaza, Santiago, Puyango, Yaupi, Jubones, Catamayo, and Chinchipe rivers occur on the Pacific slope, while the headwaters of numerous rivers of the Llanos that flow into the Orinoco river in Venezuela, occur on the eastern slope.

Maintenance of wetland refuges

The forests and processes that maintain water quality and flow in this region are also essential for the creation and persistence of montane wetlands. There are few lakes in the northern Andes, so these wetlands, and in particular the systems of high Andean glacial lagoons, are important refuges for migratory water birds, including endemic subspecies of water birds. Such lagoons occur in the Bogotá plateau of the Eastern Andes and the central region of the Central Andes in Colombia (the Los Nevados-Las Hermosas-Puracé range), the páramos of Ecuador (at El Cajas), and the wetlands and oxbow lakes of the Cauca Valley. Few wetlands occur on the Andean slopes, so highland and lowland populations of water birds are often well isolated, which may explain a certain differentiation into subspecies or species pairs (Fjeldså and Krabbe, 1990).

Nearctic and seasonal (intraregional) migration

The Northern Andes are a principal stop over for migratory passerines and waterbirds that breed in North America and winter in the Neotropics. While most of the migrant passerines overwinter in the lowlands, some cross the northern Andes, others wander through them, and still others stay and establish winter territories there (Fjeldså and Krabbe, 1990).

A large number of permanent tropical resident birds - including forest birds, such as hummingbirds and parrots, and savanna and wading birds, such as storks, ibises, herons, and ducks- as well as the Andean Spectacled Bear, migrate seasonally to follow available food supplies (Hilty and Brown, 1986). Some high-elevation birds, such as hummingbirds, finches, and seed-eaters, move downslope seasonally or during inclement weather (Fjeldså and Krabbe, 1990). Preserving these seasonal migrations requires the maintenance of connectivity along altitudinal gradients and other migration routes.

Conservation context in the NAEC

The Northern Andes has been a center of human development for over 10,000 years and is considered one of the world's 12 major centers of origin of plants cultivated for food, medicine, and industry (Saavedra & Freese, 1986). The long presence of human cultures has caused variable impacts on the region's biodiversity, which is now considered one of the most threatened in the world. Original vegetation has been eliminated from more than 50% of the region.

Currently, the NAEC supports a human population of over 28,000,000 inhabitants (Corrales, 2000). Some of the region's principal population centers such as Mérida in Venezuela, Bogotá, Cali, Medellín, and Bucaramanga in Colombia and Quito in Ecuador, which support over 2/3 of the citizens of those 2 countries (CIAT, WWF, 1999), are located in this ecoregional complex.

Despite the long occupation of this land by humans, most of the extensive alteration of natural habitat in the Andes has taken place since the beginning of the 20th century, and particularly over the last 50 years (Corrales, 2000). While the dry valleys were the first zones to be cultivated, expansion of large landholdings in the lowlands over the past 1-2 centuries has pushed indigenous groups and poorer campesinos to cultivate the hills and highlands, including páramo zones. The displacement of peasants to smaller properties has encouraged them to farm their lands more intensively. Intensive use of land and natural resources continues today, resulting in continued habitat loss, fragmentation and degradation.

DEVELOPMENT OF THE BIODIVERSITY VISION

Conservation status of the 14 ecoregions of the NAEC

The NAEC contains a wide range of protected areas of different management categories, according to the International Union for the Conservation of Nature (IUCN), including National Parks, Natural Monuments, Unique Natural Areas, and Wildlife Sanctuaries. A number of these reserve areas cross international boundaries.

Three categories of protected area were recognized for the NAEC analysis and development of the vision:

- **Category 1**: Protected areas that allow only indirect use of resources (such as national parks, IUCN categories 1-2).
- **Category 2**: Protected areas that allow limited direct resource use (the National Reserve in Peru, IUCN categories 3, 4, 5, etc).
- **Category 3**: Indigenous territories that are not protected areas, but may serve as areas of biodiversity protection due to limited resource use.

Strict protection of natural habitat is distributed unevenly among the different ecoregions (see table below). Over five million hectares (around 11%) of the NAEC are under strict (Category 1) protection, concentrated in the higher elevation forests and páramos.

The Venezuelan Andes páramo (ER152) is the most protected ecoregion, with 87% of its area under protection, followed by the Northern Andean páramo, with 32% protection, and the Venezuela Andean montane forest, with 21% protection.

The three dry forest valleys have no protection and have suffered severe habitat alteration, while the corresponding montane forests of the Magdalena and Cauca valleys (ER 28 and ER 29) have only 1.5 and 2.8% of the area under protection, respectively.

Table 1. Characteristics of the ecoregions of the NAEC and areas of influence.

Number	Name	Area (ha)	No. LU's	Remaining veg (%)	Protected area (%)*
19	Santa Marta montane forest	476,800	17	71.5	3.0
20	Eastern Range montane forest	7,292,300	86	64.9	16.1
22	Venezuelan Andes montane forest	2,938,900	66	52.0	20.8
26	Northwestern Andes montane forest	9,195,100	156	50.1	10.3
28	Cauca Valley montane forest	3,184,700	48	19.0	2.8

29	Magdalena Valley montane forest	10,012,700	67	39.1	1.5
34	E. Cordillera Real montane forest	9,356,700	94	75.7	12.4
151	Santa Marta páramo	123,200	5	99.8	0.0
152	Venezuelan Andes páramo	281,200	11	89.3	86.7
153	Northern Andes páramo	2,988,400	73	87.7	32.0
154	Central Range páramo	102,500	12	75.3	12.6
90	Magdalena Valley dry forest	1,939,900	10	30.9	0.0
91	Cauca Valley dry forest	676,600	12	12.4	0.0
109	Patia Valley dry forest	269,900	5	29.2	0.0
	Totals	**48,838,900**	**662**	**54.6**	**11.0**

* Protected areas percentages include only those areas that are under strict protection (IUCN's Category 1); for instance, the Santa Marta massif only have 3% in the table when most of the area belongs to a National Park, because this protected area overlaps with an indigenous territory.

Ecoregions of the NAEC

Significant altitudinal and climatic gradients distinguish the 11 ecoregions that make up the NAEC. The variety of habitats is reflected in the diversity of montane forests, dry forests, and páramos in the Northern Andes complex.

Montane forests

The Sierra Nevada de Santa Marta is an isolated pyramid -shaped massif supporting a wide range of habitats, including premontane, montane, páramos, and permanent ice and snow. The isolation of the **Santa Marta montane forests (ER19)** from other montane forests has produced a relatively lower floristic and faunal diversity in absolute numbers but on a per unit basis, is among the most diverse ecoregion within the complex with high concentrations of endemics. Biotic zones and elements are found at lower elevations here than in the main Andean range (Hernández et al., 1992a; Lozano, 1994, cited in Carbono, 2000a), and Santa Marta shares elements with other regions (Panama, Chocó, Amazon piedmont).

The **Eastern Cordillera montane forests (ER20)** is one of the three largest ER and extends in the north from the Serranía de Perijá and south to the Tamá Massif and the Serranía de La Macarena. The northern part of this ER, the Serrania de Perijá displays similarity with the Santa Marta montane forests while the eastern slopes are influenced by the dry forests of the piedmont and the Llanos grasslands. In the southern portion, the Amazon lowlands influence climatic patterns and lead to the presence of moist piedmont forests. Species richness in this ecoregion is outstanding both at a regional and global level, due to high turnover rates in species composition. Current inventories for this ecoregion include 878 species of birds (18 endemic taxa), 169 species of frogs (32 endemic; Ruiz et al. 1996), and 63 species of palms (5 endemic) (Kattan, 2000).

The location of the **Venezuela Andean montane forests (ER 22)** between the Orinocan (Amazonian) lowlands and the Caribbean coast makes it an important physical barrier to winds, rains, and associated climatic elements. This location has also permitted the merging of biological elements from the Andes, Amazonian basin, coast range, and the Llanos. These highlands also share animal species with the coast range and the Guianese highlands (Yerena, 1994).

The **Northwestern Andes montane forests (ER 26)** run the full extent of the western slope of the Western Cordillera in Colombia and Ecuador, stretching some 11 degrees of latitude. This ecoregion also includes the eastern slope of the Western Cordillera in Ecuador, as well as the north-central inter-Andean valleys in southern Ecuador. This ecoregion reaches its lower limit at 200 m above sea level on the Pacific slope. Species richness varies between the different slopes of the ecoregion. For instance, the Pacific slope has more species of birds and bats than the eastern slope and the inter-Andean valleys in both its bird and bat compositions, while the eastern slope tends to have a higher diversity and more unique set of frog species (Kattan et al., 2000).

The **Cauca Valley montane forests (ER 28)** occur on the middle elevations (from 1,000-1,500m to approximately 3,000m elevation) of the internal slopes of the Cauca Valley, between the Western and Central cordilleras in Colombia and are distinct from both the drier valley lowlands and from the highland headwaters of the Cauca River. This region contains one of the Endemic Bird Areas determined by BirdLife International, with 12 restricted-range species (4 of which occur nowhere else) in an area of 19,000 km^2 (EBA B12; Bibby et al. 1992). More remarkable is the case of frogs, of which 60 species are endemic to the region (Lynch et al. 1997). The biological dynamics of this ecoregion and that of the Magdalena Valley montane forests (ER29) are closely linked both to each other and to adjacent ecoregions, including the Cauca and Magdalena valley lowlands and the outer slopes of the the main Andean chain.

The Magdalena Valley montane forests ecoregion (ER29) comprises the upper internal slopes (from approximately 1,000 m to 3,000-3,500 m elevation) of the Magdalena Valley in Colombia, an inter-Andean valley between the Central and Eastern Cordilleras. There are several areas of endemism within the ecoregion.

The **montane forests of the eastern slope of the Cordillera Real (ER 34)** extend from the Colombian Massif south some 7^{o} of latitude into northern Peru and include the Cóndor and Cucutú ranges. The Amazonian slope of the cordillera supports the greatest number of species exclusive to the ER complex and also the highest species richness for most groups assessed.

Páramos

In general, species diversity for most groups is considerable reduced in the páramo ecoregions than the surrounding montane forests. However, given the isolated "island habitat" nature of most páramos, it is here where the most complex phenomena and patterns of speciation and endemism have taken place.

The **Santa Marta Páramo (ER 151)**, the northernmost páramos of South America extend from approximately 3,300 m to around 4,500 m, where they are replaced by permanent ice and snow (Rangel, 1991 and Cleef and Rangel, 1984, both cited in Rangel and Garzón, 1997). The occurrence of 61 endemic species of angiosperms, as well as endemic mammals and birds, make this páramo ecoregion distinct from both the montane forest and other páramos.

The **Venezuelan Andes Páramos (ER 152)** extend from the Zumbador Páramo to the Cendé cluster of paramos, all along the Mérida Cordillera, between 2800-3000 m, up to 5000 m above sea level. This ecoregion is characterized by the presence of many endemic, and as a center of origin and major center of diversification of the Espeletiinae tribe (Asteraceae), genus *Espeletia* or frailejon as it is commonly known, the emblem of paramos in Venezuela and Colombia.

The **Northern Andes Páramo (ER 153)** is the largest páramo ecoregion and extends through the whole of Colombia and Ecuador anywhere from 2900 to 3650 m above sea level. Plant and animal community composition in the páramos varies latitudinally and as a function of abiotic factors, especially moisture.

The Central Range Páramo (ER 154) ecoregion is restricted to the northern Andes of Peru and their lower altitudinal limit ranges between 1500 and 3600 msnm. The relatively low elevation, dry climate and plant community composit ion differentiates these alpine formations from both páramos and to the puna of the southern Andes. Several species of animals of amazonian origin occur in this ecoregion, as well as some elements from the northern end of the Peruvian desert. The uniquenes s of the ecoregion is evidenced by the location of several centers of bird endemism within it.

Areas of Influence

In the **dry forests of the Magdalena Valley (ER 90)**, **Cauca Valley (ER91)**, and **Patía Valley (ER109)**, rainfall reaches no more than 1,000 mm p er year, most of which falls in two separate rainy seasons. The alluvial or sedimentary soils with volcanic ash on the valley floors make them preferred agricultural regions, thus most of the original vegetation has been removed or seriously degrades.

The **Magdalena Valley dry forests** are located in an inter-Andean valley between the Eastern and Central cordilleras of the Northern Andes in Colombia, dissected by the Magdalena River, the largest Colombian western river. There are several plants species end emic to this area*.*

The **Cauca Valley dry forests** are also located in an inter-Andean valley between the Central and Western cordilleras in southwestern Colombia, parallel to the Cauca River. The ecosystems in this region are highly disturbed and very few a nd small remnants of natural habitat still found, however, these pockets still support populations of some endemic taxa *.*

The **Patía Valley** is a dry valley dissected by the Patia River and surrounded by the cloud forests of the Western Cordillera and the An dean massif. Although no endemism has been found at the species level, there are several sub -species of birds, butterflies and plants that are endemic to this valley.

Identifying sub-ecoregions: a tool for ensuring representation

Given that spatial vari ation is so high within most of the 14 individual ecoregions that comprise the complex, to analyse and achieve the objective of full representation of all distinct natural communities, the ER's were subdivided into subER units as a proxy to help capture th e large-scale ecological variations that are thought to occur over changes in latitude, elevation, slope, and other factors, previously described. A total of 36 subER were identified; 25 within the montane forest ER's, 8 with the 4 paramo ER's and the dry valley ER's were considered relatively homogenous and without need for subdivision.

Country-Wide Analyses of Biological and Physical Features

Initial biological and socioeconomic assessments were carried out individually in each of the four participating countries. An interdisciplinary team of professionals from WWF Colombia and Peru, and WWF associates, FUDENA and Fundación Natura from Venezuela and Ecuador, respectively, convened to develop technical criteria for country -level studies of biodiversity patterns and the socio-economic context in which they occur.

The countrywide analyses identified and compiled pertinent secondary literature and its associated data in order to describe the essential ecological features, including the alpha and beta diversity, endemism, ecological and evolutionary processes, and areas of particular biological interest- for each ecoregion. In particular, comparative analyses were carried out among some of the larger ecoregions and subecoregions, using inventories of bats, birds, butterflies, frogs, orchids, and palms. The information was used to construct a preliminary database containing species lists for these taxonomic groups in each ecoregion of the NAEC, as well as specialists groups working in the region and important sources of more detailed information.

Identification of Areas of Taxonomic Importance

A workshop was carried out with experts from diverse biological and social disciplines and specialities to complement the second data collection process for the definition of areas of high biological importance. About 65 professionals from different disciplines related to conservation of the northern Andean biodiversity, including specialists on different taxa and ecosystems, and experts from the social sciences, were asked to identify and locate important areas for biodiversity, describe the current status of the biological elements that make the areas outstanding, and list significant threats to biological diversity in those areas.

The areas nominated for their biological importance to particular taxa were consolidated into a single series of areas of taxonomic importance, which was based on zones identified for multiple taxa and zones considered of highest importance for one or more taxa.

The five working groups, separated by taxonomic specialty, identified a total of 210 areas of importance to the five taxonomic groups and to general biodiversity conservation in particular regions (Baptiste, 2000; WWF GIS calculations). Of these, 82 were considered of high importance for a particular group, 57 were considered of higher importance, and 33 were considered of highest importance for at least one taxonomic group. The areas nominated as conservation priorities by this group of experts were synthesized into a single series of 80 areas. This combined set of nominated areas served as one of three biological variables used to delineate the priority areas for the NAEC.

Setting Block Size Objectives Based on Focal Species Habitat Use

Information on the distribution or area requirements of the vast majority of resident species in most ecoregions of the NAEC is limited or largely nonexistent. In the absence of knowing what each and every species requires for long-term survival, one strategy is to select a small number of species, **focal species,** and use the spatial requirements of those species as a proxy for the habitat requirements of all the others.

Due to certain life-history traits such as specialized diets or breeding requirements, focal species are generally area sensitive and require large, interconnected areas to maintain viable populations (Lambeck, 1997). These species are selected on the assumption that establishing sufficiently large and interconnected areas to fulfill their habitat requirements will be likely to fulfill the requirements of most (ideally all) other species native to the region.

Two focal species proxies were chosen, the Andean Spectacled Bear (*Tremarctos ornatus*), which is considered to be the most sensitive species in the Andes to size restrictions or loss of particular habitats. The conservation target for spectacled bears was defined to be a habitat block, or complex of blocks, that would be large enough to sustain a viable sub-population of the species.

In addition to maintaining habitat blocks large enough to support populations of bears, it was recognized that smaller intact habitat blocks exist that can support a wide range of medium-sized seed dispersers, pollinators, and predators. Thus, a secondary focal species with medium-sized habitat demands, the mountain tapir (*Tapirus pinchaque*), endemic to the northern Andes, was defined. Tapirs have a substantially smaller home range, about 1 individual per 500-600 hectares (Lizano and Cavalier, 2000), than that of the Spectacled Bear but still probably large enough to serve as an umbrella for most resident species.

Locating areas of importance for focal species

The presence of an extant Spectacled Bear population was used as one of three principal factors in delineating the priority areas for conservation. Spectacled Bears were considered indicators of a relatively intact ecosystem, so areas where these bears are currently present were considered particularly important.

Current literature and a workshop on the conservation of the Spectacled Bear, held in Riobamba, Ecuador, in November, 2000, provided information used in the development of a map of distribution of populations of the species throughout the tropical Andes.

Establishing minimum area requirements for viable populations

In addition to using current Spectacled Bear population areas to help indicate **where** conservation action must take place, the vision process for the NAEC incorporated the habitat use and spatial needs of this area-sensitive focal species, in order to estimate **how large** conservation areas must be to support minimum viable populations of all resident species and relevant ecological processes.

A long-term minimum viable population was considered by Shaffer (1987) to be at least 500 breeding units and, in the NAEC, would require periodic genetic interchange within a large single population or among the sub-populations of a meta-population (a population of distinct subpopulations). Given that the breeding individuals make up the *effective (breeding) population*, which is usually about 10 to 20 percent of the entire population, approximately 2,500 - 5,000 individuals are necessary for a population to persist with its full complement of genetic variability over the long term (Shaffer, 1987; Soulé, 1987; Dinerstein et al., 2000).

Assuming that female Spectacled Bears have non-overlapping home ranges of approximately 3,000 ha, the area required to maintain a viable sub-population of 50 breeding Spectacled Bear females -- at least 150,000 ha -- served as a basis for measuring the size and connectivity potential of habitat blocks, one of three parameters used for ranking priority areas for conservation.

The NAEC is a highly fragmented region, and the principal hope for the survival of the Spectacled Bear over the long term is through the maintenance of connectivity (corridors) among the habitat blocks supporting sub-populations. Assuming the need to maintain at a minimum 500 breeding females to ensure the survival of a meta-population (a population of distinct sub-populations), some 1,500,000 ha in relatively large, interconnected blocks of appropriate habitat must be maintained within the NAEC.

IDENTIFYING PRIORITY AREAS FOR CONSERVATION ACTION

Vegetation Analysis

In the absence of a standardized map of currently existing vegetation in the Northern Andes WWF, working in cooperation with the Instituto Latinoamericano de Investigaciones Geoestratégicas (ILIG), created a new map based on 36 Landsat TM satellite images, dating from 1996 to 2000. This map, delineated at a 240 square meter resolution, identified ten major native habitat types plus four types of anthropogenic origin.

Identifying Conservation Gaps

While beta diversity is known to be high, detailed information on the distribution of most species and vegetative communities in the northern Andes is not available. As a proxy for habitat heterogeneity, a model of spatial heterogeneity was developed, based on abiotic characteristics considered to be important determinants of biodiversity in the Northern Andes.

To develop the landscape units' map, country-level maps of elevation, precipitation, and number of dry months (one in which less than 60 mm of rain fell) were combined in a GIS to create regional-level maps of these factors (Figure 1). The three regional maps were then overlaid in the GIS along with a map of biogeographical barriers that had been used as part of the basis for defining the sub-ecoregions. Each of the 662 resulting unique combinations of these three climatic factors and the biogeographical information became a distinct landscape unit (LU). The 662 landscape units served as the fundamental units of the representation analysis.

The size and distribution of the landscape units (LU's) varied from 100 ha to almost 1,900,000 ha. The number of landscape units in each sub-ecoregion ranged from 3 in the north Pacific slope of the Western Cordillera between the San Juan River and the Patía Valley (subecoregion 26b) to 47 in the north eastern slope of the Eastern Cordillera montane forest (subecoregion 20b).

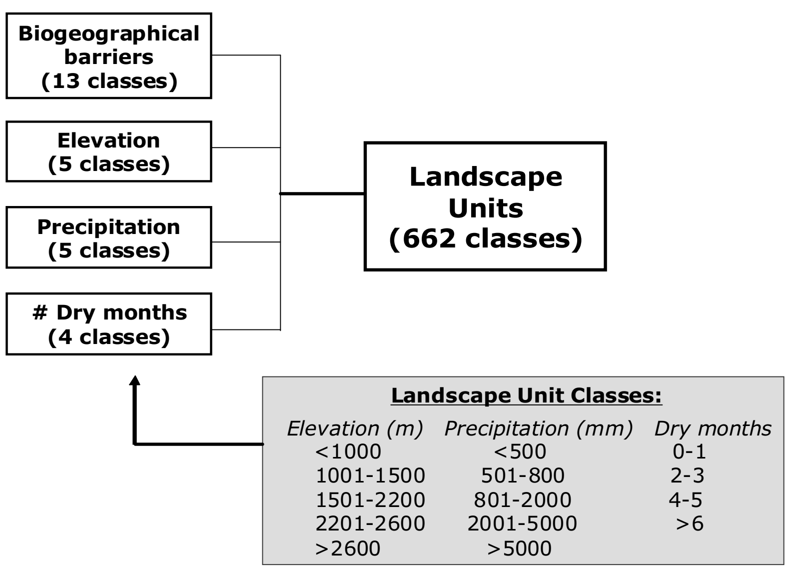


Figure 1. Inputs used to create the map of landscape units

Applying a gap analysis

To assess how well all distinct native habitats and their species are represented within the system of protected areas in the NAEC, the map of the LU's was overlaid with maps of the existing protected areas in the four countries. As earlier noted, the analysis was limited to areas that pertain to management category levels 1 and 2 of the International Union for the Conservation of Nature (IUCN); thus, in the case of Colombia, those portions of Category 1 and 2 protected areas that overlap with indigenous reserves were considered as unprotected.

With the establishment of the landscape unit and protected areas maps, the next step was to establish the **quantity** (area) required to adequately represent each unique LU in a conservation landscape that includes protected areas and other conservation efforts.

Scientists still do not agree on what level of representation is adequate to guarantee the viability of all species and natural communities in an area over the long term. Because of this, the analysis of representation in the NAEC used three levels of protection to gauge the adequacy of representation in conservation landscapes. The 10% level of representation of each habitat's distribution was considered a minimum representation target, 20% the recommended representation level, and 30% an ideal goal for maintaining native species, communities, and ecological and evolutionary processes over the long term.

The gap analysis of the landscape units determined that representation of the region's different habitat types, as represented by the LU, in the existing protected area systems is extremely variable. Only 103, or 14.5% of the LU have at least 30% of their area represented in strict protected areas, 162 LU (39.2%) have less than 30% of their area under strict protection, and 397 (46.3%) are not included in the system of protected areas.

Setting Habitat Priorities

Comparing the complex-wide map of remaining natural vegetation to the results of the gap analysis of the landscape units made it possible to identify remaining blocks of natural habitat situated in landscape units that had less than the optimal level of representation. Patches of **intact but unprotected vegetation** located in underrepresented landscape units were considered of top conservation priority.

These unprotected forest blocks were overlaid with maps of the presence of watershed headwaters and human accessibility (Figure 2). Vegetation in headwater zones was considered of particular importance for its role in providing quality water to human and natural communities. All vegetated areas occurring in the highest 20% of the total elevational profile of each watershed were considered headwater areas.

Regions of low human accessibility, as determined by the time required to reach a given area from major human settlements, were assumed to have more intact habitats due to the likelihood of lower pressure from human populations. Accessibility was determined using a time-distance model constructed in a GIS from data layers of populated places, terrain (slope, vegetation cover), and transportation routes (presence of roads, navigable rivers, railroads, and other pathways that enable humans to enter natural habitat) (CIAT, 1999). The accessibility values ranged from 0 to over 400.

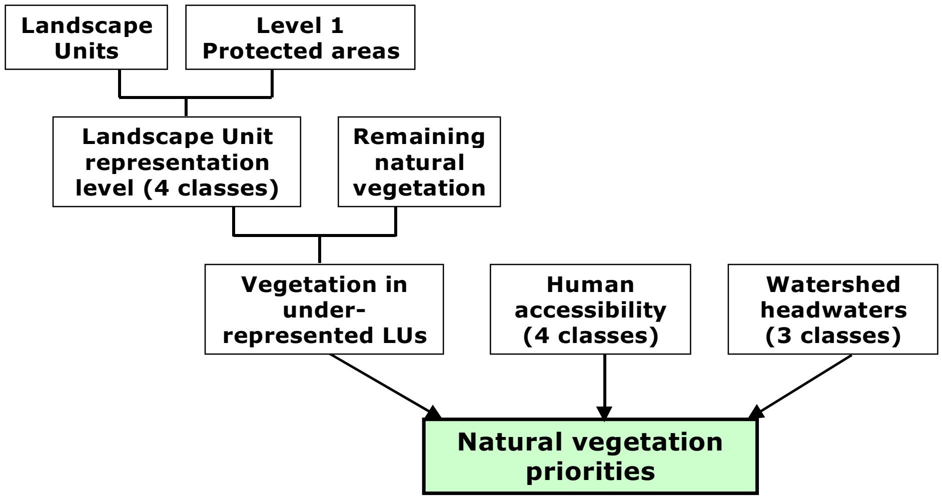


Figure 2. Modelling natural vegetation priorities from landscape units, protected areas, remaining vegetation, accessibility, and headwaters.

Overlap of key biological factors

The zones of overlap for the maps of areas of taxonomic importance, areas with known Spectacled Bear populations, and areas with high priority habitats were consolidated into a series of 65 priority areas for conservation (Figure 3).

To ensure that all landscape units with native vegetation were incorporated in either protected areas or the priority areas, the latter were added to the protected areas for a second iteration of the representation analysis. Zones with remaining unprotected vegetation in landscape units that were not sufficiently represented in protected areas or draft priority areas were added to the series of priority areas to achieve the representation goals to complete the coarse-level conservation design for the NAEC.

From these analyses and adjustments, a draft biodiversity vision, or coarse-level conservation design for the northern Andes, was developed. The average size of the proposed series of 65 priority areas is just under 150,000 ha, though they range from 10,400 ha to over 715,000 ha. The percentage of natural vegetation found in the proposed priority areas varies from 6 to 100% of each area's surface, with an average of 86% still in natural vegetation. High value is given to areas with remaining vegetation.

The priority areas contain an average of 11 landscape units each, though several contain 30 or more. Together with the protected areas, the 65 proposed priority areas, if implemented, would encompass at least 30% of the 662 different landscape units in the NAEC.

Some priority areas occur in a single sub-ecoregion, while others cross the borders of up to 5 or 6 sub-ecoregions. Only one subecoregion, the Macarena (subecoregion 20d), did not contain a priority area.

Fifty-seven priority areas contain known Spectacled Bear habitat, while at least 37 occur in highlands that are considered to be important watershed headwaters.

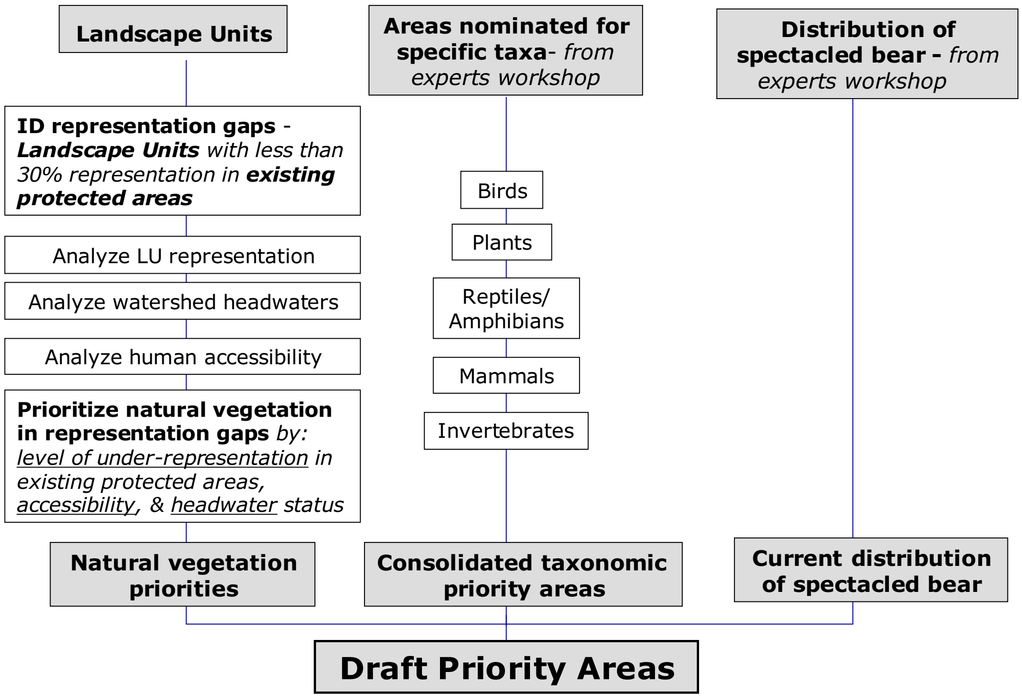


Figure 3. Flow chart of inputs and processes followed to delineate priority areas for conservation.

To prevent any priority area, even one that is relatively large and intact, from becoming isolated and thus unfavorable to wide-ranging or patchily-distributed species, the ER process analyzed the connectivity potential among priority areas. The map of connectivity among priority areas was generated from the combination of several factors, including presence of natural vegetation, distance from protected areas, and low human accessibility.

RANKING OF PRIORITY AREAS BASED ON BIOLOGICAL IMPORTANCE, ECOLOGICAL PROCESSES, AND INTACTNESS

Each of the 65 priority areas identified was considered essential for the maintenance of biodiversity in the NAEC. It would be impossible to work immediately or address conservation needs in all 65 areas at once, thus the areas were ranked w ith respect to where the greatest contribution to the biodiversity vision would be made. These factors included importance for biodiversity intactness and ecological processes, as well as on the basis of their intactness (Figure 4).

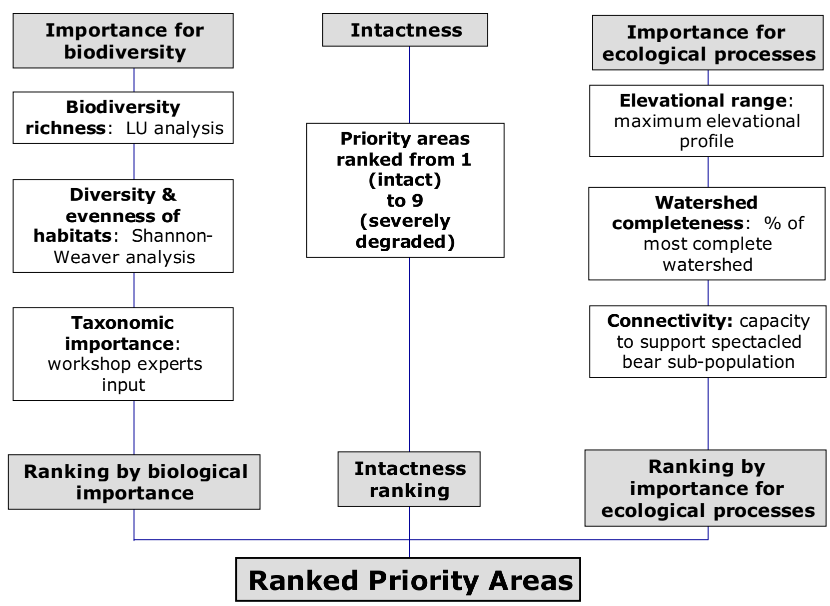


Figure 4. Inputs and processes completed in the priority area ranking process.

Ranking Priority Areas by Contribution to Biodiversity Conservation

The analysis of biological contribution of each priority area to the conservation of the northern Andes consisted of three measures: its number of landscape units, the dive rsity of landscape units within it, and its importance to taxonomic groups. The **number of landscape units** per priority area was calculated by overlaying the map of priority areas with the map of landscape units. The number of landscape units in a single p riority area ranged from 1 to 31 with the exception of one priority area, which contained 50 LUs.

The **diversity score** was calculated as the Shannon -Weaver index of diversity and evenness (Shannon and Weaver, 1949), to reflect the distribution of the lan dscape units in each priority area. The scores for the Shannon -Weaver analyses ranged from 0 to 4.06.

The areas of taxonomic importance identified by the experts attending the Bogotá workshop served as one of the three major factors in delineating the final set of priority areas for biodiversity conservation. Since the boundaries of the areas of taxonomic importance did not necessarily match those of the final priority areas (which also considered Spectacled Bear habitat and habitat representation), an **average taxonomic score** was calculated for each priority area. This average ranged from less than 1 to 12.81 (out of a possible total of 15).

Generating rankings for biological importance

The values of these three factors (number and diversity of land scape units and the average taxonomic scores) were reclassified to values between 0 -1.0 for each priority area to standardize their contribution to the biological evaluation. This standardized range assured that the three scores of each priority area would all have the same weight and could therefore be summed.

Figure 5. Number of priority areas in each biological importance category, with the rankings inside and the score ranges at the bottom of each category.

The combined rankings for biological importance, the Bio Scores, reflect the sum of the landscape unit number, landscape unit diversity, and average taxonomic score of each priority area. The scores ranged from 0.33 to 2.34. These scores were reclassified into five categories of biological importance. Only eight priority areas had biological importance scores in the top fifth of the total scores, and another seven had scores in the lower fifth (Figure 5).

Ranking priority areas by contribution to conservation of ecological processes

The ranking of the contribution that each priority area makes to conserving ecological processes was based on an analysis of three of the most essential ecological and evolutionary processes in the region: **altitudinal migrations**, **habitat connectivity**, and the integrity of **watersheds**.

Seasonal species migrations through altitudinal gradients

Seasonal altitudinal migrations are essential parts of the annual cycles of many animals, particularly birds and butterflies, in tropical montane environments (Hilty and Brown, 1986; Fjeldså and Krabbe, 1990; DeVries, 1987; Stiles and Skutch, 1989). These species include valuable seed dispersers, pollinators, prey, and predators that help to maintain the tropical Andes' high vegetative diversity.

To assess the relative capacity of priority areas to support altitudinal migrations, the NAEC was divided into five altitudinal classes, based on the divisions used in the development of the landscape units' map. Most of the 65 priority areas contained over 1,500 m of elevational change, enhancing their potential importance for altitudinal migrants and for narrow-range endemic species that might inhabit only certain elevational bands. If the average altitudinal band for key endemic species varies between 500 – 1,000 m of elevation, then the conservation of natural habitat in all but a few of the priority areas should protect such species.

Water catchment and release through conservation of complete watersheds

Maintenance of water quality and quantity, for plant, animal, and human communities, is a second essential ecological process provided by certain priority areas. Priority areas were thus ranked on their capacity to protect functional watersheds by identifying those watersheds that would be most protected by each priority area and determined the percent of that watershed that would fall within the priority area. Few priority areas capture large sections of watersheds, which are essential for the protection of river courses, aquatic flora and fauna, topsoil, and certain narrow-range endemic species (Table 2).

Table 2. Percent scores categories for watershed completeness.

Percentage range	Rank	No. areas
Less than 30% of watershed included in priority area	Low	51
30 – 60% of watershed within priority area	Medium	10
More than 60% of watershed within priority area	High	4

Habitat connectivity for large-ranging species and overall ecological continuity

Finally, priority areas were ranked according to their potential contribution to the maintenance of connectivity based on their ability, alone or together with adjacent areas of natural habitat, to provide sufficient biological connectivity to maintain sub-populations and a meta-population of Spectacled Bears. Each priority area received one of five possible rankings (0-4), based on the amount and degree of connectivity it provided to the habitat landscape in around each priority area (Table 3).

This analysis of potential connectivity complemented the habitat intactness analysis for priority areas that was based on habitat requirements for the medium sized focal species. That analysis highlighted priority areas that, based on the focal species analysis, were large enough to support most resident species, but not necessarily maintain source populations of Spectacled Bears or withstand large-scale environmental perturbations.

Table 3. Connectivity potential of priority areas based on habitat block size and connectivity with adjacent habitat blocks.

Connectivity potential	Size (ha) of natural habitat	Rank	No. areas
Limited connectivity potential	<150,000 ha & isolated	0	10
Contributes to sub-population area	<150,000 ha but part of an area that is >150,000 ha	1	3
Includes sub-population area*	>150,000 ha & isolated	2	20
Contributes to meta-population area	>150,000 ha; part of an area that is >1,500,000 ha	3	32
Includes meta-population area*	>1,500,000 ha	4	0

* Alone or in conjunction with adjacent protected area.

None of the priority areas by itself or with a protected area is large enough to support a meta-population of Spectacled Bears (at least 1,500,000 ha). Nevertheless, when combined with other contiguous habitat, almost half of the priority areas form complexes that would be large enough to maintain such a meta-population.

Combining the analyses of ecological processes

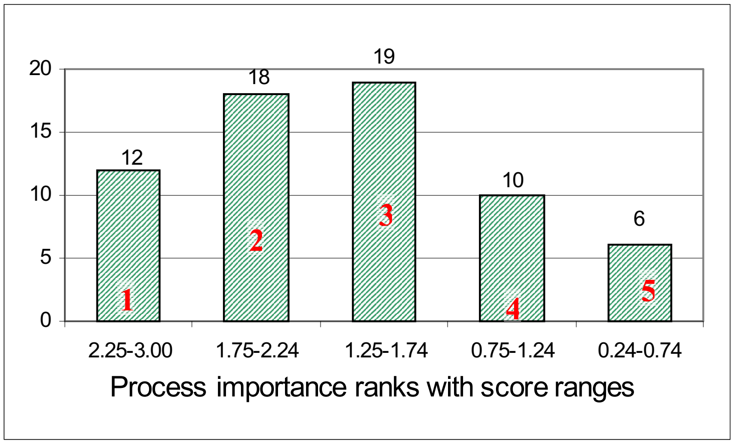


Figure 6. Number of priority areas in each process importance category, with the rankings in red and the score ranges at the bottom of each ranking category.

The values for altitudinal gradients, watershed coverage, and habitat connectivity were normalized for each priority area and summed to give a combined process score. These scores, which ranged from 0.24 to 3.00 for the 65 priority areas (a value of 3 would be the maximum score), were reclassified into five categories of biological importance (Figure 6). Forty-nine of the 65 areas received combined process rankings of 1, 2, or 3- a higher proportion than that receiving these ranks for biological importance.

Analysis of Habitat Intactness

To consider the importance of long-term survival probability, as well as biological importance, **habitat intactness**, or integrity, was assessed for each priority area using the vegetation map generated from satellite imagery. The intactness ranking served as a proxy for predicting the long-term survival probability of the biodiversity within a given priority area. More disturbed areas were considered to have less likelihood of supporting the full complement of biodiversity over the long term.

"**Natural habitat**" was considered to be those areas covered by habitats that were non-anthropogenic in origin. These included: forest, scrub, páramo, native grasslands, snow and sparse high Andean vegetation, xerophytic communities, or wetlands. These habitats may have been degraded, but according to the satellite analysis, natural vegetation was still in place.

The block size criteria used to define intactness was 25,000 ha, a value that was derived from an analysis of habitat requirements of the second level of focal species. Priority areas with habitat blocks of over 25,000 ha were considered "intact". Those with smaller habitat blocks, but contiguous with protected intact habitat were also given an "intact" rating if the combined size of the existing protected area plus the priority area was greater than 25,000 hectares. This adjustment was based on the assumption that the adjacent protected block provides the same, if not greater, connectivity and ecological services as adjacent unprotected habitat within the actual priority area.

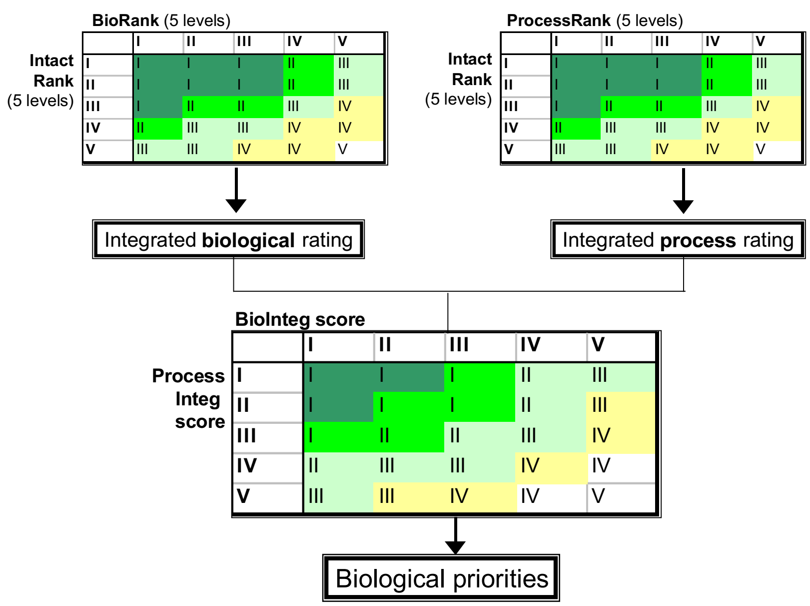
Each priority area was assigned a value from 1-9 according to its degree of intactness. Priority areas with forest blocks greater than 25,000 ha were given a value of 1. Priority areas that were somewhat degraded, but still contained habitat blocks of 25,000 ha or more received an intactness value of 2, while those even more degraded, but still with relatively well-connected large habitat blocks of up to 25,000 ha received intactness values of 3.

Priority areas with habitat blocks ranging between 10,000 ha – 15,000 ha or with intermediate or low levels of connectivity received values of 4 -6. These areas contained mosaics of "altered" habitat, where clearing for agriculture or grazing has likely modified the dominant distribution patterns of plant species. Values of 7 -9 were assigned to priority areas with one or more poorly connected and degraded forest b locks that together totaled less than approximately 10,000 ha.

The intactness scores were regrouped into 5 rankings. Since most priority areas were relatively intact and therefore received rankings of 1, 2, or 3, the few with more degraded landscapes were grouped into categories 4 and 5.

Integrating the biological, ecological processes and intactness analyses

To integrate the results of the three analyses - biological richness, conservation of ecological processes and habitat intactness - two matrices were created that covered the entire ecoregion complex (Figure 7). The first integrated the scores for biological richness and intactness of the 65 priority areas, and the second integrated the scores for ecological processes and intactness. The results of these two matrices were combined in the third matrix of Figure 7, and the final combined rank for each priority area was produced.



Intact Rank \ BioRank	I	II	III	IV	V
I	I	I	I	II	III
II	I	I	I	II	III
III	I	II	II	III	IV
IV	II	III	III	IV	IV
V	III	III	IV	IV	V

Intact Rank \ ProcessRank	I	II	III	IV	V
I	I	I	I	II	III
II	I	I	I	II	III
III	I	II	II	III	IV
IV	II	III	III	IV	IV
V	III	III	IV	IV	V

Process Integ score \ BioInteg score	I	II	III	IV	V
I	I	I	I	II	III
II	I	I	I	II	III
III	I	II	II	III	IV
IV	II	III	III	IV	IV
V	III	III	IV	IV	V

Figure 7. Matrices used to integrate biological and ecological process importance with intactness v alues in prioritizing priority areas.

Through the use of these matrices, each priority area was subjected to the same set of criteria and assigned a priority ranking of 1 to 5, with Level 1 having the highest combination of biological and process ranking and intactness. For example, an area containing a large enough block of intact habitat for a sub -population of the focal species that als o harbors outstanding levels of endemism and richness for a range of taxa and/or several altitudinal zones would be deemed highest priority. A degraded area with medium levels of richness for a single taxon or habitat connectivity would rank lower. Small, highly degraded areas that contain examples of biodiversity commonly occurring throughout the ecoregion or few elevational bands might rank lowest of all.

Over half of the priority areas achieved an integrated score in the top fifth of the range of possible scores (Figure 8), which indicates that the majority of priority areas identified through the selection process are highly important to achieving the objectives of the vision. This result is in large part due to the methodology used in ranking the pri ority areas which places a heavy emphasis on vegetative intactness at all stages of the process.

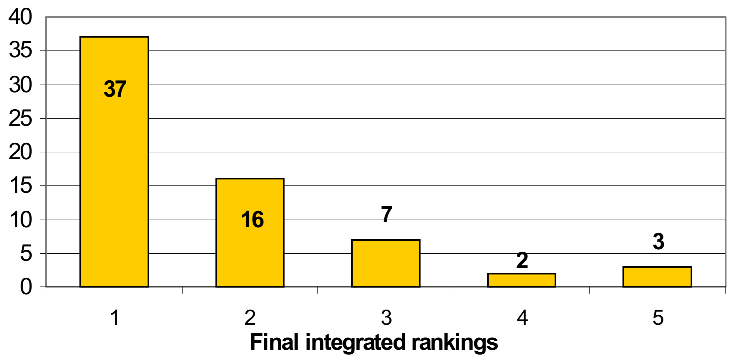


Figure 8. Final rankings of priority areas based on biological, process, and intactness criteria

The final set of refined priority areas consisted of those with the highest integrated rankings of biological importance, ecological process importance, an d intactness. These priority areas indicate the general location of habitat blocks that are vital components of a conservation strategy for the Northern Andes that are located throughout the whole ecoregional complex. Each of these priority areas will nee d to be analyzed at a finer scale (about 1:10,000) in order to design a conservation landscape that achieves the objectives of protecting the biological and ecological aspects of that priority area that made it a top priority.

Comparison of Analysis Results Using Protected Areas

The previous series of analyses were repeated on the existing protected areas, to see how well they contribute to the conservation of biodiversity and ecological and evolutionary processes in the NAEC.

The 56 protected areas ana lyzed consisted of Category 1 (strict protection) designations, including national parks, national monuments, ecological reserves, wildlife sanctuaries, and other country-specific types in the highest protection category.

Biological importance analyses

The average number of landscape units in the protected areas was 9.96, due to several very rich protected areas. The maximum score for the Shannon -Weaver index of diversity and evenness was 3.82. These scores are actuallly less than those for the highest -ranking priorty area but again were influenced by the four highest -ranking priority areas.

Average taxonomic scores were significantly higher in the protected areas, with a maximum of 12.82. The average final biological score for protected areas, which re presented the sums of the previous three analyses, was 1.52, out of a possible total score of 3.00. These scores were higher than those generated for the proposed priority areas. The maximum score for biological importance was 2.87.

Protected area ecological and evolutionary process importance analyses

The watershed coverage scores for protected areas were similar to those of the priority areas. The average percent coverage of a single watershed by protected areas was 12%, while the median coverage score was only 5.5%. Only one protected area, Perijá National Park, with 61% coverage of a watershed, would have qualified for the highest level of coverage in the priority areas analysis.

In comparing the number of altitudinal classes encompassed by each protected area, the average score (from a range of 1 – 5 altitudinal classes) was 3.32 classes

The average score for connectivity potential, in terms of the amount of remaining natural vegetation found in large blocks suitable for sub-populations or a meta-population of Spectacled Bears, was 1.89, out of a total of 4. No protected area is large enough to support a meta-population of bears on its own, but 19 of the 56 protected areas could support such a meta-population in conjunction with adjacent remaining vegetation.

The average final process importance score for protected areas, which represented the sums of the watershed, altitudinal class, and connectivity analyses, was 2.24, out of a possible total score of 3.00. These scores are substantially higher than those for the priority areas. The maximum score for process importance, achieved by six protected areas, was 3.00.

Protected area intactness analysis

For the intactness analysis, the average score was 3.82, on a scale of 1 (intact) to 9 (severely degraded). Eleven protected areas were smaller (less than 25,000 ha) than the minimum required. Many of these areas contained intact vegetation, but could not be analyzed because their small size and potential isolation will theoretically not support minimum viable populations of even medium-sized focal species.

Final biological scores for protected areas

Of the 56 protected areas, 35 generated combined biological analysis scores of 1 (the highest score). This high proportion of the protected areas with highest-level scores indicates that, despite their relatively smaller size than the proposed priority areas, they harbor high levels of biodiversity and support ecological processes that maintain biodiversity.

INCORPORATING SOCIO-ECONOMIC DATA: A SITUATION ANALYSIS STUDY FOR THE TOP-RANKED PRIORITY AREAS

Application of Socio-Economic Data and Analyses - Overview

Once biological criteria had been established and applied to the selection and ranking of specific priority conservation areas for the biological vision, these areas were evaluated in terms of conservation opportunities, feasibility, and urgency of implementation in order to help identify where actions would be most effectively taken in the short and medium versus the long term. The determination of such needs and opportunities also helps to develop the overall strategy for conservation actions that address ecoregion-wide and regional issues (Figure 9).

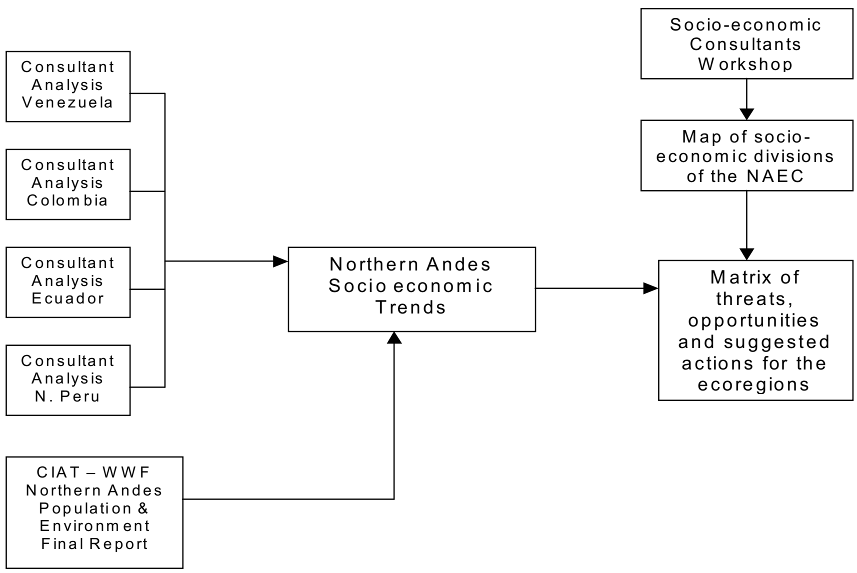


Figure 9. Flow chart for socio-economic process

It is important to note that priority areas were evaluated and ranked in terms of their contribution to the biological and ecological process-related objectives of the vision. The socioeconomic data and expertise were then used to classify the highest ranked priority areas in terms of where conservation activities can and should be focused in the short and medium term and what kinds of actions will be necessary.

Summary Socio-Economic Data for the NAEC and Subdivisions

A summary of social and economic data for the NAEC (Corrales, 2000) was prepared to identify the principal socio-economic trends, including human population and productive activities, principal threats and conservation opportunities that may affect, both positively and negatively, biological diversity.

This summary document synthesized the data from the country-level studies carried out for the Andean regions of Venezuela, Colombia, Ecuador, and northern Peru, a report by the Centro Internacional de Agricultura Tropical (CIAT) and WWF on Population and the Environment for the Northern Andes Ecoregional Complex, and information presented at the I Northern Andean

Congress on Environmental Law, Policies, and Institutions held October 20 -21, 2000 at the Universidad Simón Bolívar in Venezuela (Corrales, 2000).

The socio-economic experts delineated an independent map of socio-economic subdivisions, which represented large areas with distinct combinations and degrees of threats from human activities. The information in this matrix is outlined by Corrales (2000) and is based on supporting data from Grimaldo et al, (1999); Vega-Centeno (1999); Corrales et al. (2000); and Ospina (1999). Most of the information was generated at the scale of administrative regions (countries, departments, or municipalities) and was not consistent over the four countries, so its application to ecoregions and subregions was necessarily incomplete. Therefore, the matrix focuses on socio-economic subdivisions which cross political boundaries, and some conclusions were necessarily made for countries or other political regions instead of ecoregions.

Threats for biodiversity conservation

Hyman and Strand (1999) describe the NAEC as a densely populated region with climatic and edaphic conditions that have favored human occupation (CIAT -WWF, 1999), and the most densely populated and degraded ecoregion of the complex is the Cauca Valley montane forest ecoregion (ER 28) and the least densely populated are the two largest ecoregions, the Eastern Cordillera montane forest (ER 20) and the Cordillera Real montane forest (ER 34) ecoregions.

The country-level studies identified some 24 threats from human activity to the biological diversity of the NAEC, the most significant of which are:

- Expansion and intensification of unsustainable agriculture.
- Immigration & colonization of new lands, and the migration of poorer farmers to remaining forests, often on higher and steeper slopes.
- Ranching and over-grazing of foothills and páramos.
- Illegal crops (opium poppy, marijuana), and associated fumigation and armed conflicts.
- Proposed and current infrastructure projects.
- Timber extraction & deforestation.
- Tourism
- Oil drilling & mining
- Urban expansion
- Contamination
- Exotic species
- Fire

Many of these direct threats are related to the unequal distribution of land and the movement of the landless to increasingly remote, and less productive, regions of the northern Andes. The country-level studies also identified the increasing technification of agriculture which has allowed more intensive cultivation, ranching, and infrastructure development in previously less-productive regions (Corrales, 2000). Extensive livestock grazing has replaced in many places other land uses with less severe impacts on local biodiversity. The negative effects of extensive livestock grazing on steep slopes are manyfold, including deforestation, erosion, siltation and contamination of water courses, reduction of habitat heterogeneity and increase of pesticida use (Murgueitio, 1998).

Because of the concentration of headwaters of important hydrographic systems within the northern Andes, most of the complex has an enormous value for energy generation through hydroelectric development. However, many public works projects pose serious threats to the conservation of intact river basins and sub-watersheds both through direct damages to the ecosystems and as a result of an increase of colonization rates after a project is implemented.

Over the last two decades, the expansion of illicit crops in Colombia, mainly opium poppy and marijuana has resulted in a number of new threats to mountai n ecosystems. Besides forest clearing for these cultivations, contamination of watersheds with chemicals used for processing the crops undoubtedly have negative effects on local biotas. The problem might be compounded by the aerial fumigation of the illega l crops with herbicides done by the Colombian government to control drug production in the country.

Habitat intactness and alteration

Native vegetation still covers about 55% of the NAEC, although between different ecoregions, this is highly variable (Figure 10). In some ecoregions, particularly the páramos, heavy livestock grazing has degraded much of the habitat. Habitat loss has varied considerably among the different ecoregions and sub-ecoregions. The highest levels have occurred in the Cauca Valley dry forest ecoregion (ER91) and the Cauca valley montane forest ecoregion (ER28). The montane forests in the higher elevations of these two valleys are also seriously degraded and fragmented: the Cauca valley and Magdalena valley montane forest ecoregions have each lost approximately 75% of their original forest, and the expansion of agriculture, both legal and illegal, and urbanization continue to threaten the remaining fragments.

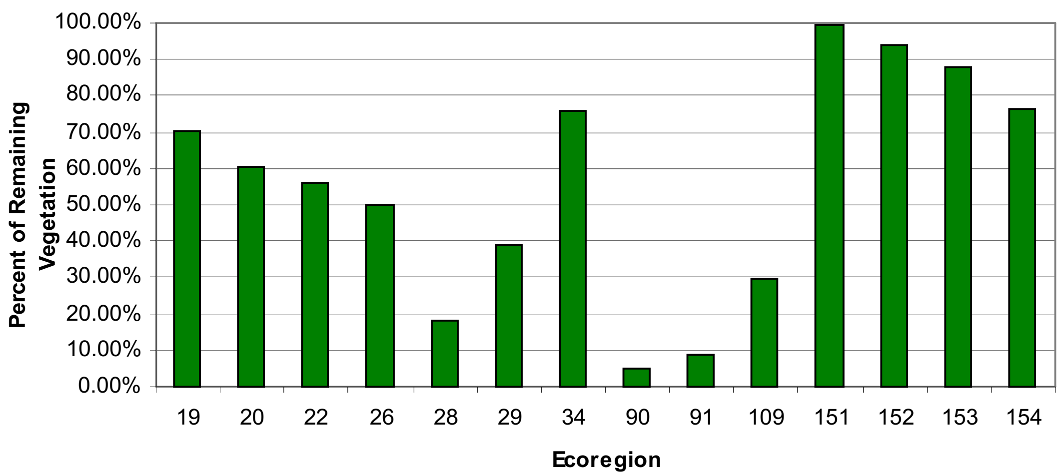


Figure 10. Remaining natural vegetation in the different ecoregions of the NAEC.

Certain sub-ecoregions, such as the inter-Andean valleys sub-ecoregion (sub-ecoregion 26h) of the Northwestern Andean montane forest ecoregion (ER26), have also lost the majority of their native habitat, despite the intact condition of the rest of the ecoregion.

The most intact of the 14 ecoregion s of this analysis are the páramo ecoregions: the Santa Marta páramo (ER151) is almost entirely intact while the other three páramo ecoregions (ERs 152, 153, and 154) all retain at least 75% of their native vegetation. While páramos throughout the northern Andes are experiencing degradation due to livestock grazing, their original flora still exists and has not (yet) been replaced by exotic vegetation. The most intact montane forests are those of the Eastern Cordillera Real montane forest ecoregion (ER34).

Opportunities for conservation

One positive outcome of the long history of human occupation of the northern Andes and the concentration of large urban areas within the ecoregional complex is the existence of important Universities, research centers and both governmental and non governmental conservation organizations. The growth of many of these institutions over the past decade has been significant, and the number of conservation projects has increased throughout the region.

WWF's program offices in Colombia and Peru and WWF's associate organizations FUDENA in Venezuela and Fundación Natura in Ecuador have played important roles developing projects, promoting and facilitating conservation processes, and contributing to build the capacities of many other stakeholders in the northern Andes.

Other opportunities identified by the country teams varied by sub-ecoregion but focused on the presence of existing parks and reserves and indigenous groups that manage large tracts of land, often with low human densities. These groups could be an opportunity for conservation, since in the Northern Andes most of the remaining natural vegetation is in private or collective territories hands. Clear examples of this potential for conservation is the development of networks of private reserves in Colombia and Ecuador, formal legal recognition of these reserves in Colombia, and the recently initiated process of establishing private reserves in the Venezuelan Andes.

Situation Analyses of Top Priority Areas for Conservation

The identification of threats and conservation opportunities at the level of the socio-economic subdivisions was helpful for determining general trends within the NAEC. Nevertheless, these areas are large and the threats identified were generalized over the entire area of each subdivision.

The socio-economic subdivisions were intersected with the biological priority areas, which permitted the technical team to establish the presence and absence of specific threats in each priority area. Even though the data did not quantify the amount of threat, the presence/absence information served as an indicator of the types of threats occurring in each priority area.

Based on these analyses, a group of regional experts selected one or two areas per sub-ecoregion from the highest ranked priority areas that they believed showed the greatest conservation potential, in terms of their threats, opportunities, active conservation efforts, and political-social-economic situation. This high-potential subset of the top biologically ranked areas was considered for both their urgency and opportunity and was therefore considered the highest priority for conservation action.

The expert group selected 18 priority areas, in 15 sub-ecoregions. Top-ranking areas with high conservation potential were not identified for the páramo ecoregions (ERs 151-154), or in the dry forest ecoregions (ERs 90, 91). The list was revised and expanded to include a total of 25 priority areas belonging to 19 sub-ecoregions. Again, the dry forest ecoregions were not represented in the list, but one priority area is located in one of the páramo ecoregions (ER 154).

Towards an Action Plan: Initial Steps in the Implementation of the Vision

A conservation action plan emerges first from the identification of the priority areas and strategically directing conservation investments to target those areas where needs are most urgent and opportunities assure a greater level of success. Ecoregional conservation goes beyond the identification of priority sites to consider larger more macro-level pressures and processes that can affect conservation on a site specific level.

As a first step in this process, technical staff working on environmental policy, environmental education and communications from WWF Colombia, WWF Peru, FUDENA and Fundación Natura met in Quito in July 2001 to draft a joint agenda around the goals of the biodiversity vision, focusing on the 25 priority areas identified above.

The main goals of the resulting agenda were:

- Raise the profile and understanding of the biological importance of NAEC on an international level, including the WWF network;
- Promote strategic alliances with potential partners and both governmental and non governmental organizations working throughout the ecoregional complex.
- Promote policy reform and incentives on key cross-cutting issues affecting natural vegetation and ecosystems in the Northern Andes especially related to energy policies and potential hydrological infrastructure development, the importance linkage between conservation of forest resources, paramos and water, and globalization affecting agricultural systems.

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