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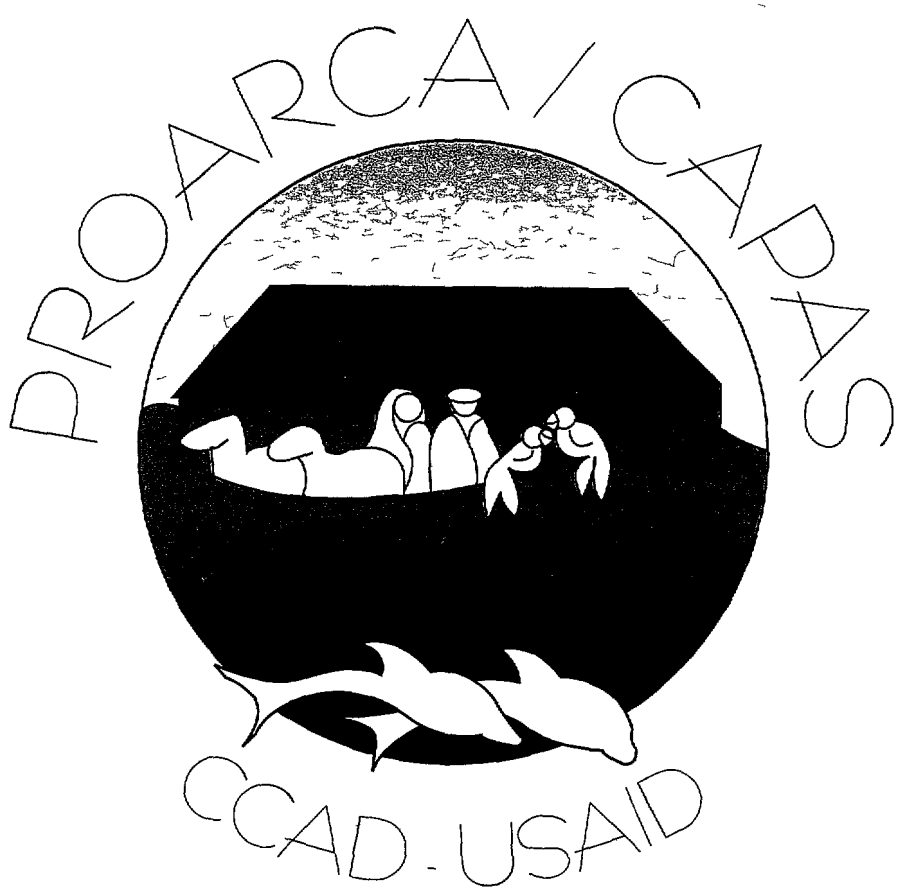

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A CONSERVATION ASSESSMENT OF CENTRAL AMERICAN VEGETATION AND ECOREGIONS

GAP ANALYSIS APPROACH

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ACERCA DE ESTA PUBLICACIÓN

Este trabajo representa los compromisos de los Estados Unidos y Centroamerica bajo CONCAUSA la declaracion Conjunta Centroamerica – Estados Unidos (Miami, octubre de 1994) sobre la conservacion del ambiente en Centroamerica

Esta publicacion y el trabajo descrito en ella fueron financiados por la Agencia de Estados Unidos para el Desarrollo Internacional (USAID) Sin embargo, las opiniones e ideas presentadas aqui no son necesariamente respaldadas por USAID ni representan sus politicas oficiales

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EXECUTIVE SUMMARY

The fundamental vision of the Paseo Pantera project, and its evolutionary successor, the Mesoamerican Biological Corridor (MBC) concept, has been the re-establishment of a natural bridge that includes a series of protected areas which would protect biodiversity and permit migration of wide-ranging animals and plants This concept has evolved to follow a more ecological approach where the human being plays an important role

The present report assesses the degree to which both existing and proposed protected areas and corridors protect/would protect landscape-level biodiversity, which we represent as vegetation types delineated from remotely-sensed imagery A comprehensive, standardized, and thematically appropriate map of Central American vegetation and landcover types was developed by classifying remotely sensed imagery (AVHRR - Advanced Very High Resolution Radiometer imagery -- 1 km2 resolution) using advanced digital image processing routines and expertise provided by the Central America Vegetation Working Group (a group of experts in vegetation cover analysis and ecology from the seven Central American countries that worked together to generate and review the map as well as played a primary role in the gap analysis) The map identifies 17 remaining natural vegetation types The classification accuracy of the map is estimated to exceed 80%

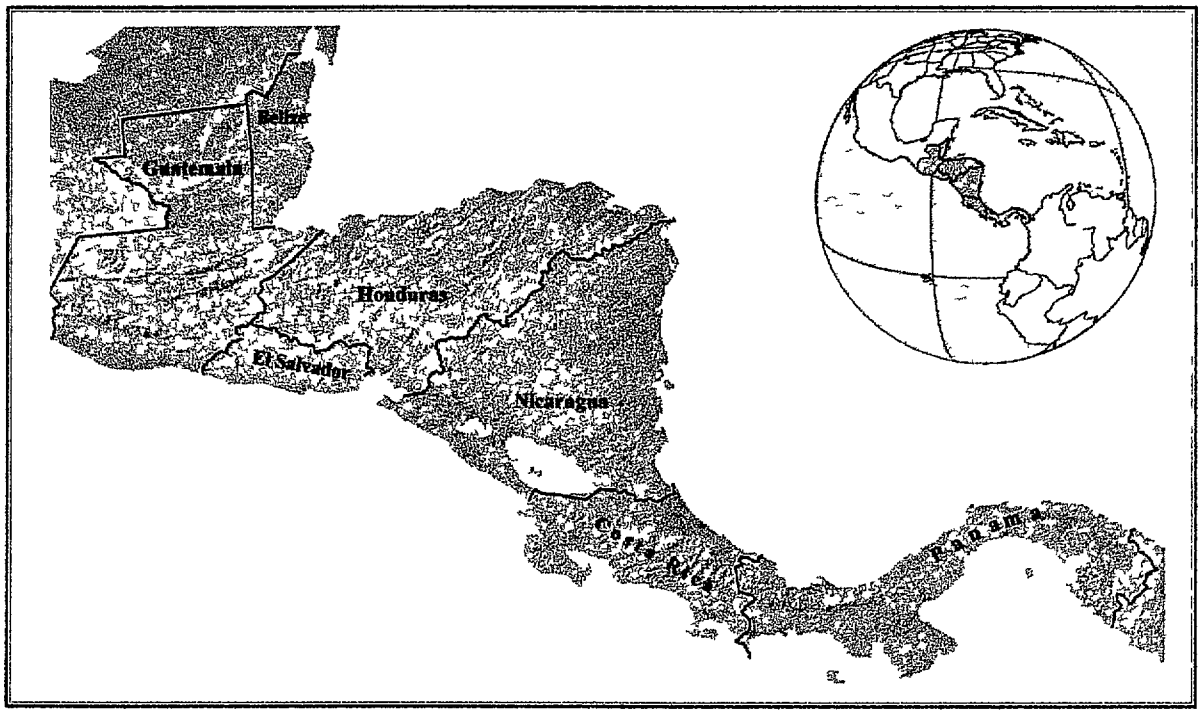
Using a gap analysis approach, a map of existing and proposed protected areas and corridors was overlaid on the vegetation map to analyze the protection status of vegetation types Eleven of the 17 natural vegetation types were found to be under-represented (<10% of their total area contained in parks) and of these, eight vegetation types were found to have less than 5% protection A similar analysis of the protection status of ecoregions revealed that eleven of the 16 ecoregions are under-represented Eight ecoregions have been extensively converted (<40% original forest remaining) from pre-colonization states The Vegetation Working Group and other Central American experts reviewed the results and incorporated a viability analysis to confirm the conservation gaps of Central America

It is recommended that the mapping of vegetation types as surrogates of species as well as gap analyses should be continued in order to maintain up-to-date information The Vegetation Working Group should be consolidated as a consultation body in the region In addition, future biological corridor or protected area network design initiatives, such as the PROARCA/CAPAS project, seek to establish representation of all unique vegetation types and ecoregions in protected areas as a fundamental conservation goal Appropriate minimum protection standards should be established for determining the necessary areas of vegetation types that should be contained in the network Future site selection should be determined with spatial models that allow considerations of both landscape and human ecology

1 INTRODUCTION

Central America encompasses approximately one half million km2 of land which extends from the Peten region of Guatemala and Belize to Serrania del Darien of Panama (Figure 1) Some three or four million years ago, an isthmus of land formed a bridge that connected North and South Americas This land connection allowed animal species to move freely in both directions, transforming the region into a biological bridge Central America is a complex biogeographic region, representing a unique melding of North American and South American biotic elements Together with the region's topographic and climatic heterogeneity, this mixture has contributed to the development of an unusually diverse assemblage of vegetation types and ecosystems (Janzen, 1983)

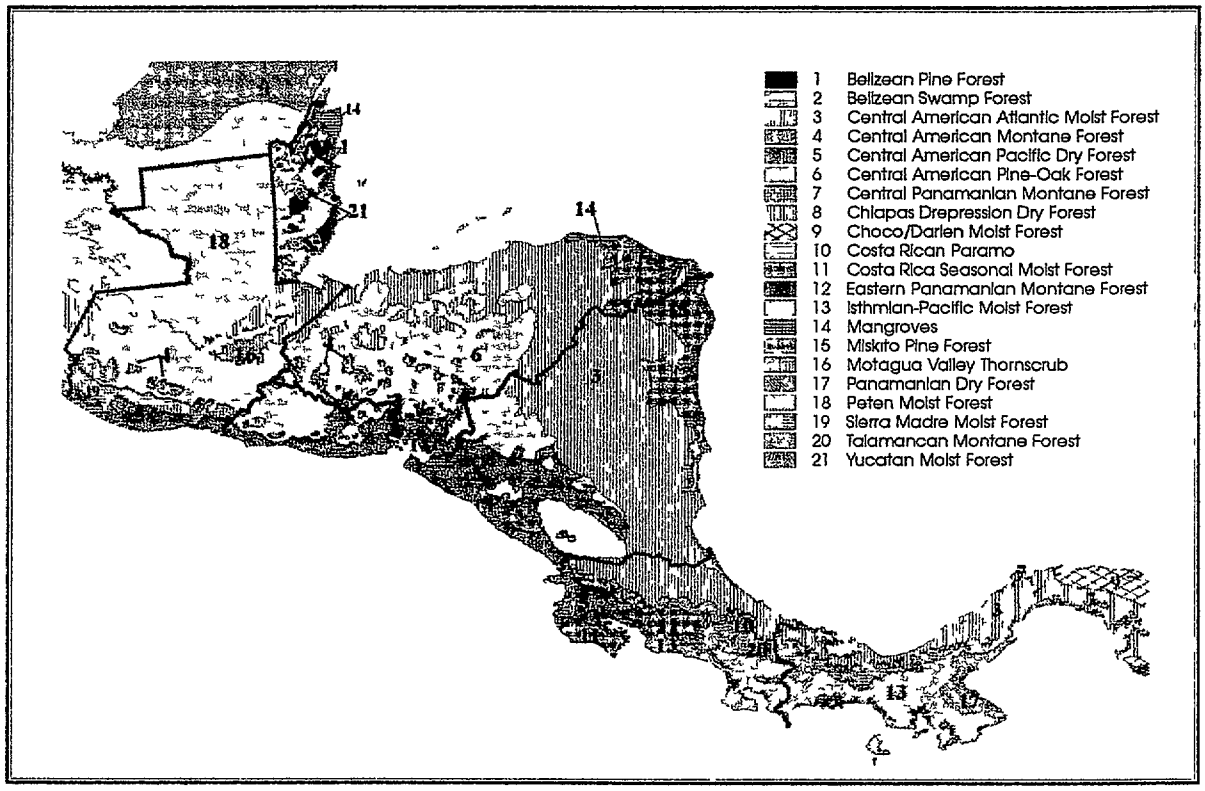
Figure 1 Countries of Central America



In order to conserve Central American biodiversity, it must first be characterized Landscape level biodiversity in Central America can be described at ecoregional scales or at finer spatial scales as vegetation types and/or cover types An ecoregion is defined as a geographically distinct assemblage of vegetation types that share a large majority of their species, ecological dynamics, and similar environmental conditions, and whose ecological interactions are critical for their long-term persistence (The Nature Conservancy, 1997) Ecoregions represent the original (estimated) extent of vegetation complexes, and thus are more reflective of potential vegetation, and do not describe current vegetation distributions A set of ecoregions for the Latin America and Caribbean region

were developed during two recent biodiversity priority setting initiatives commissioned by the World Bank (Dinerstein et al , 1995) and the United States Agency for International Development (BSP et al , 1995) The ecoregions of Latin America and the Caribbean GIS dataset developed by the World Bank and World Wildlife Fund (1995) was also used in the GAP analysis (Figure 2, Table 1)

Figura 2 Ecorregions of Central America



At finer scales, vegetation types and landcover classes are commonly used as conservation planning units because they can be delineated from remotely-sensed imagery (Anderson et al , 1976, Loveland et al , 1995) These landscape types are often considered as "coarse filter" representations of biodiversity The frequent lack of species-level and habitat-level (fine filter) information in Latin America and the Caribbean often establishes image-derived landscape types as the only available measure of/surrogate for biodiversity Coarse filter-based biodiversity assessment methodologies are increasingly utilized instead of traditional, exhaustive species and habitat inventory (Noss, 1987)

Table 1
Ecorregions of Central America

Ecoregion Name	Area (Km^2)
Central American Atlantic Moist Forest	157 499
Central American Pine-Oak Forest	105 122
Central American Pacific Dry Forest	46 588
Isthmian-Pacific Moist Forest	28 277
Miskito Pine Forest	18 688
Talamancan Montane Forest	16 312
Costa Rica Seasonal Moist Forest	10 547
Central American Montane Forest	7681
Sierra Madre Moist Forest	5762
Panamanian Dry Forest	4999
Belizean Swamp Forest	3399
Belizean Pine Forest	2672
Motagua Valley Thornscrub	2384
Eastern Panamanian Montane Forest	1777
Central Panamanian Montane Forest	404
Costa Rican Paramo	32
Ecoregions with Majority of Area outside Central American Region	**Area (Km^2)**
Peten Moist Forest	60837
Choco/Darien Moist Forest	13335
Yucatan Moist Forest	1986
Chiapas Drepression Dry Forest	1079
Mangroves	14121
Total Area	**503501**

In the early 1990s the Paseo Pantera (the Path of the Panther) project was conceptualized, with the goal of establishing a biological corridor from the Petén to Panama which would permit the unimpeded migration of wide-ranging animals, such as the panther The concept (and name of the project) evolved when Central American governments assumed the responsibility for establishing the Mesoamerican Biological Corridor This evolution occurred in 1995 when the Central American Commission on Environment and Development (CCAD) initiated the planning of a United Nations Development Program (UNDP) project, the Mesoamerican Regional System of Protected Areas, Buffer Zones, and Biological Corridors (Mesoamerican Biological Corridor) The seven countries of Central America pledged by treaty to support the project so that a continuous biological corridor would once again extend across the region

Both the Paseo Pantera project and the Mesoamerican Biological Corridor project established solid conceptual foundations for a regional efforts to conserve the biodiversity of Central America Interest in supporting this work resulted in the initiation of the PROARCA/CAPAS (Programa Ambiental Regional para Centro América/Central America Protected Area System) project in 1996

PROARCA/CAPAS is a partnership of the Central American Commission on Environment and Development (CCAD), the U S Agency for International Development (USAID), the International Resources Group, Ltd (IRG), The Nature Conservancy (TNC), and Winrock International The objective of PROARCA/CAPAS is to provide political, technical, and economic support for the management of protected areas in Central America In that regard, PROARCA/CAPAS is working towards regional coordination of biodiversity conservation, which supports the development of a Mesoamerican Ecological Corridor In the context of the PROARCA/CAPAS project, The Nature Conservancy has coordinated 1) the production of a map showing the distribution of remaining vegetation within Central America and 2) analysis of the protection status of these vegetation types and ecoregions under both existing and proposed protected areas (GAP analysis)

2 OBJECTIVES

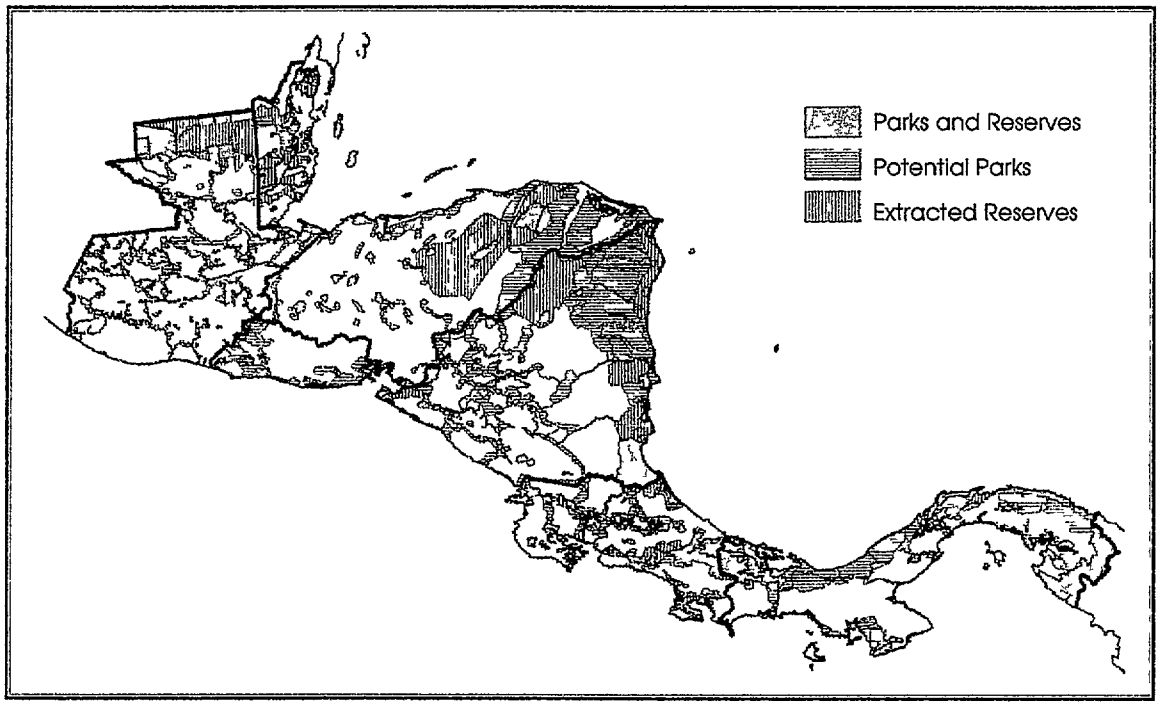
The goal of this GAP analysis was to improve our understanding of the distribution and protection status of landscape-level biodiversity in Central America Objectives of this analysis were as follows

- To characterize the distribution of Central American vegetation types, as interpreted from satellite imagery, throughout the region as a whole, using vegetation types and ecoregions as units of analysis
- To analyze the representation in the existing and proposed protected areas and corridors of the vegetation types and ecoregions
- To identify as conservation gaps those vegetation types and ecoregions not represented and under-represented in the existing and proposed protected areas and corridors of Central America
- To analyze the viability of the identified conservation gaps

3 METHODS

To assess the conservation status of the remaining vegetation in Central America, the Central American Protected Areas System was overlaid on the vegetation/landcover map in a geographic information system (GIS) and calculated the percentage protection of each vegetation at the regional and country scales The protected area types of the Central American Protected Areas were grouped into three major categories 1) Parks and Reserves, 2) Potential Parks, and 3) Extractive Reserves (Figure 3) The distribution of remaining vegetation in each ecoregion was analyzed by overlaying the ecoregions on the vegetation/landcover map, and the conservation status of each ecoregion was determined by overlaying the Mesoamerican Protected Areas on the WWF/WB's ecoregions

Figura 3 Protected areas of central america



3.1 Geospatial Data

The dataset used in this gap analysis comprised the most spatially detailed dataset on protected areas, vegetation, and ecoregion data ever assembled for the region as a whole The following digital geospatial data were compiled for the gap analysis

Country boundaries (Belize, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama) (1 1 Million, Digital Chart of the World, ESRI Inc 1993)

Vegetation and landcover map (1 2 Million, PROARCA/CAPAS, 1998)

Mesoamerican protected areas network systems (1 1 Million, WCS, 1996)

Digital Elevation Model (1 km2 grid, USGS EROS Data Center, 1996)

Ecoregions (1 15 Million, Dinerstein, et al , 1995)

3.2 Vegetation Classification and Mapping

A comprehensive, thematically appropriate and accurate map of the current location, extent and distribution of vegetation and landcover for Central America is needed to support biodiversity conservation and protected area system planning These landscape-level data can provide a template for the prioritization of protection strategies in a coarse-filter (landscape) approach The present effort is based on the first standard Vegetation/Landcover Map of Central America

A Central America Vegetation Working Group was formed from a host of regional, country and international experts (see Appendix B for a list of members and workshop participants) to provide ground-truth information and to contribute to the proposed vegetation classification system and maps The working Group convened in different workshops held in Central America

A standard classification system is essential if vegetation-mapping efforts in different countries of the region are to be directly comparable Without using a single, consistent, and standardized set of mapping units, vegetation maps in various countries cannot be placed in a regional context. For the PROARCA/CAPAS vegetation mapping work, the Federal Geographic Data Committee/ The Nature Conservancy (FGDC, 1997) system used in the United States was modified in both the hierarchy structure and vegetation classes to accurately represent the tropical vegetation types and their tropical environments This modified system was reviewed and refined by the Central American Vegetation Working Group during the workshops A subset of the vegetation classes was selected as the mapping units by the Working Group based on the characteristics of the AVHRR data and the relative abundance and importance of the vegetation types within the Central American region (Table 2) The primary remote sensing data used in this study to map Central American vegetation types was monthly-composited (1992-93) AVHRR-NDVI data Other high resolution satellite imagery traditionally used in natural resources assessment and monitoring such as SPOT and Landsat TM, was used for the delineation, description, and parameterization of "ground-truthing" sites Existing natural vegetation and anthropogenic community data were used in the project, especially vegetation data from a number of Rapid Ecological Assessments (REA) at several Central American sites (Iremonger and Sayre, 1994, Fundación Ecologista "Hector Rodrigo Pastor Fasquelle" and TNC, 1996, Maldonado et al , 1995, Anleu, 1993, APESA, 1993, ANCON, 1995) REA is an approach for rapidly inventorying the biodiversity of an area using an imagery-based characterization of landscape units, and field campaigns for verification of landscape types and species-level sampling (Sobrevila and Bath, 1993)

Table 2

Vegetation/Land Cover types of Central America

Vegetation Type N°	Vegetation/Land Cover Type Name	Area (Km²)	% Area
1	Tropical needleleaf evergreen forest	44588 62	8 7
2	Tropical broadleaf evergreen forest	185338 56	36 0
3	Tropical broadleaf/needleleaf evergreen forest	11539 60	2 2
4	Tropical broadleaf deciduous forest	10243 11	2 0
5	Tropical swamp forest	6935 94	1 3
6	Palm forest	2121 85	0 4
7	Mangroves	3710 07	0 7
8	Tropical needleleaf evergreen woodland	3513 00	0 7
9	Tropical broadleaf evergreen woodland	7744 52	1 5
10	Tropical broadleaf deciduous woodland	1717 90	0 3
11	Tropical broadleaf/needleleaf woodland	2465 21	0 5
12	Tropical broadleaf evergreen savanna	912 74	0 2
13	Tropical needleleaf evergreen savanna	6925 24	1 3
14	Tropical broadleaf evergreen scrub/shrub	5036 00	1 0
15	Tropical cactus/thorn scrub	3505 83	0 7
16	Tropical swamp scrub/shrub	8029 90	1 6
17	Tropical perennial graminoid grassland	18927 86	3 7
18	Tropical herbaceous wetland	5142 77	1 0
19	Barren rock, sand and soil	396 83	0 1
20	Inland water	14249 03	2 8
21	Forest-woodland agricultura complex	12752 56	2 5
22	Urban/vegetation complex	4216 74	0 8
23	Agriculture	152670 54	29 7
24	Urban/industrial	1496 00	0 3
	Total	**514180 45**	**100 0**

The preliminary vegetation map was developed by Boston University Center for Remote Sensing and Department of Geography in collaboration with The Nature Conservancy's Latin America and the Caribbean Region (LACR) and the Central American Vegetation Working Group Sophisticated processing algorithms (fuzzy-set and artificial neural network classifier routines) were employed to relate spectral clusters in the imagery to plot-based vegetation and environmental parameters (Muchoney et al , 1997) The final vegetation map was developed by revising and digitally recoding the classified preliminary map according to comments from Central American expert reviewers under the coordination of PROARCA/CAPAS

The best estimate for the overall accuracy of the draft map was above 70 percent The draft map was reviewed several times by a group of Central American experts, including the Central

America Regional Program of TNC before implementing the GAP analysis Based on experts' comments, corrections were made to the draft map by recoding the misclassified areas The accuracy of the final vegetation/landcover map was estimated to exceed 80% The distributions of remaining vegetation types and other landcover types of Central America were summarized directly from the AVHRR imagery derived vegetation/landcover map Total area (km2) and percentage of each vegetation type were calculated at the region, country, and ecoregion scales

3.3 Gap Analysis

A map showing how vegetation types are distributed with respect to categories of conservation management helps to identify which elements of biodiversity might be especially vulnerable to habitat conversion or degradation A gap analysis makes such an assessment by overlaying maps of existing protected areas and proposed new protected areas onto maps of the distribution of vegetation types (see Scott et al , 1993) Vegetation types and ecoregions whose distributions fall largely outside the protected areas are identified as "gaps" in biodiversity conservation

GAP analysis can be performed on any collection of biodiversity elements Ultimately, a comprehensive plan for the protection of biodiversity must include all elements of biodiversity from genes to landscape and is thus hierarchical both in spatial scales and biological levels of organization (Noss and Cooperrider, 1994) Caicco et al (1995) have utilized a habitat representation concept of GAP analysis, assessing the degree to which native vegetation types are represented in reserves Many conservation organizations now recognize the representation of all distinct natural communities in protected areas as a fundamental conservation goal (The Nature Conservancy, 1997, Dinerstein et al , 1995) It should be emphasized that GAP analysis is only the first stage of protecting biodiversity in the region It provides an overview of biodiversity conservation for the region and a direction to those areas that should be considered as high priority Once these initial priorities have been established, other conservation biology approaches can help determine reserve boundaries and management techniques necessary to maintain viable populations and ecosystem processes Detailed descriptions of the gap analysis approach and methods can be found in Scott et al , 1993, and Davis and Stoms, 1996, Keister et al , 1996

3.4 Maps and Gaps Workshop

The workshop was held in San José, Costa Rica, September 1-4, 1998 The participants to the workshop were the members of the Central American Vegetation Working Group (CAVWG), one representative of each national protected areas system from the seven Central American countries, and TNC staff

The main goals of the event were

1 To review the existing vegetation cover of each ecoregion In order to do this, the participants had blown-up maps of the ecoregions of Central America with the vegetation cover These maps included the existing and proposed protected areas as well as the proposed Mesoamerican Biological Corridor

2. To define which ecoregions and vegetation types were not (and under) represented in each ecoregion In order to accomplish this, the participants reviewed the presence of existing or proposed protected areas in the ecoregion as well as the coverage of all the vegetation types in those ecoregions The places that were identified as not represented were considered conservation gaps

3 To evaluate the viability of the gaps identified The viability was defined as the possibilities of protecting biodiversity in the gap The viability was evaluated using three levels (high, medium and low viability) based on the following criteria

3 1 Status of the vegetation coverage defined as the status of the existing vegetation cover according to the map and the expert opinion of the participants Good vegetation cover equaled high conservation viability

3 2 Biological diversity defined as the abundance and diversity of flora and fauna in the gap This point was estimated qualitatively using expert opinion of the participants High biological diversity equaled high conservation viability

3 3 Environmental services defined as the potential and existing services that the biodiversity may provide to society (hydroelectric power, carbon fixation, etc) Existance/potential of several environmental services meant high conservation viability

3 4 Land tenure defined as the status of the land inside the gap The predominance of land owned by local or national government equaled high conservation viability

3 5 Demographic pressure defined as the presence of human settlements Low demographic pressure equaled high conservation viability

3 6 Development projects defined as the existence of such projects in the gap The existence of few projects equaled high conservation viability

3 7 Government conservation policies defined as the existence of government policies that benefit conservation in the gap The existence of several policies equaled high conservation viability

3 8 Natural access limitations defined as the existence of natural features that limit the access of humans to the gap The presence of several limitations equaled high conservation viability

3 9 Potential use defined as the potential ways humans could use the gap That is, agriculture, cattle, fishing, charcoal, firewood, tourism, etc The less potential uses equaled high conservation viability

3 10 Private protected areas defined as the presence of private protected areas in the gap The presence of more private protected areas equaled high conservation viability

The participants evaluated the criteria in group discussions and assigned, by consensus, a value of high, medium or low viability for each criterion of each gap Those gaps with high viability were selected as the main conservation gaps of Central America

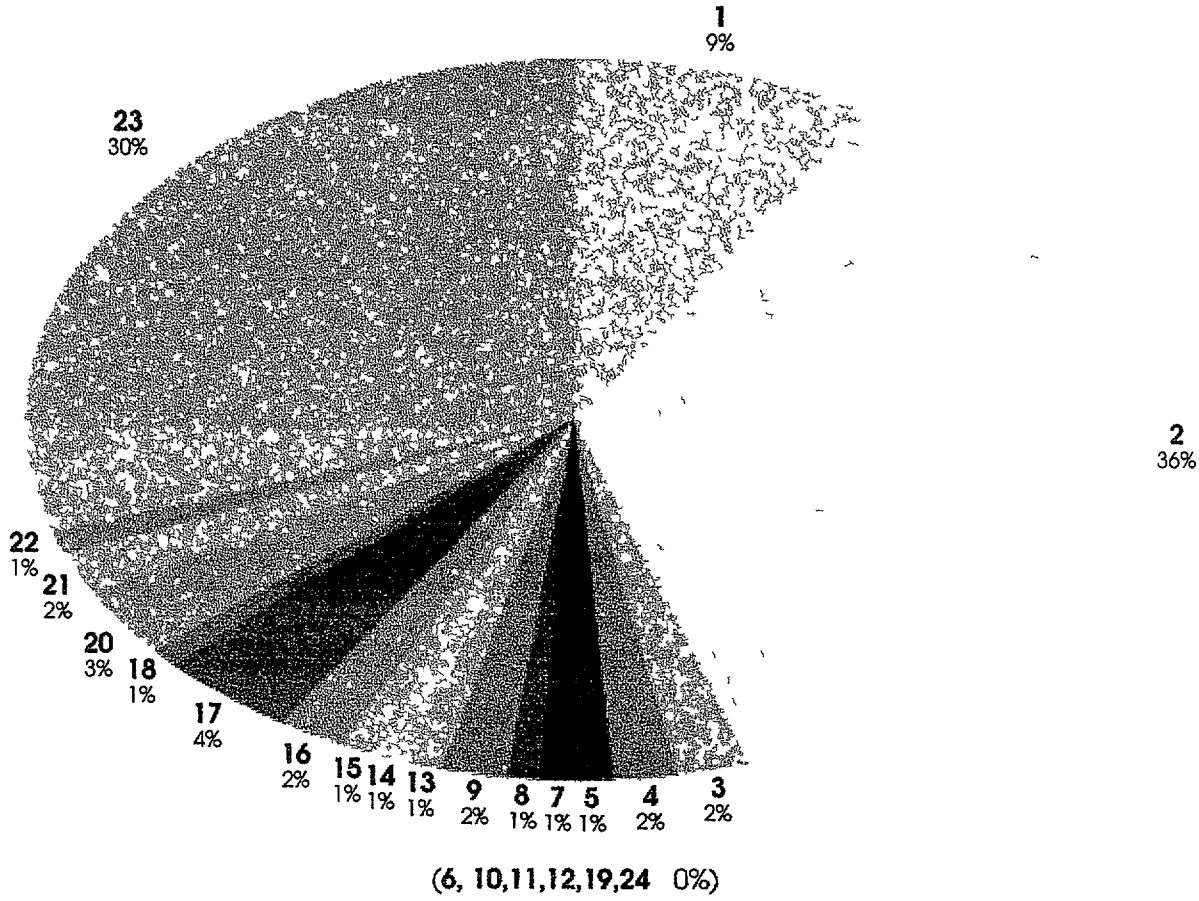
4 RESULTS

4.1 Remaining Vegetation and Their Distribution in Central America

The Central American Region was mapped over an area of 514,180 km2 A total of 24 vegetation and landcover types were mapped from the AVHRR imagery These vegetation and land cover units are represented in the map entitled Central American Vegetation and Landcover Map Area statistics of the distribution of the Central American Vegetation and Landcover classes are presented in Table 2, Figures 4 and 5 Spatial analysis showed that 95 5% of the Central American region was mapped as vegetated, including agriculture and agroforestry lands Non-vegetated areas include urban areas, lakes, reservoirs, rock outcrops, and sand beaches with little or no vascular plant cover Of the total non-vegetated area, 67% is inland water bodies

Agriculture lands cover about 32% of the total land in the region This percentage is substantially under-estimated as it did not include certain agriculture types, such as agroforestry (including shade cocoa and coffee plantations) Due to the lower spatial resolution of AVHRR imagery, these agroforestry types could not be separated from other forest types

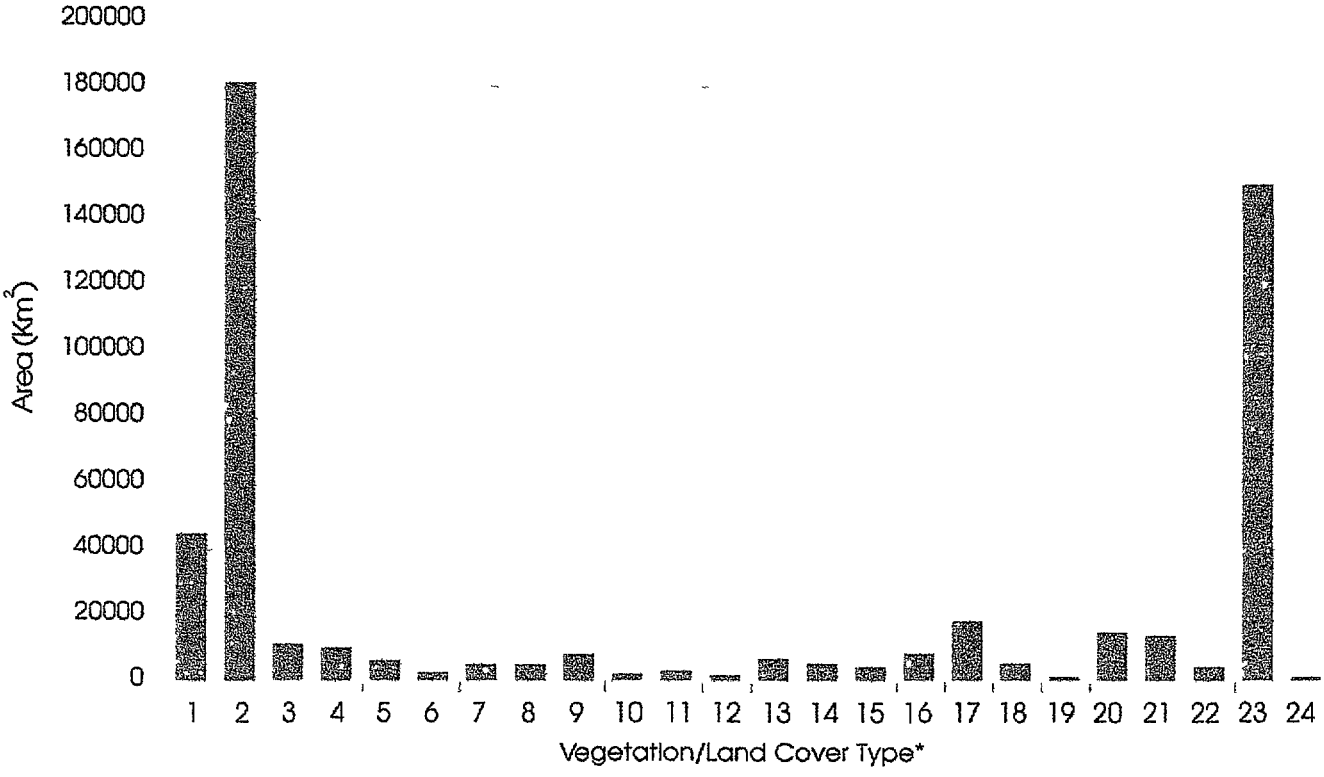
Figure 4 Vegetation/Land Cover of Central America*



*Note Numbers refer to vegetation types listed in Table 2
Percentages refer to percent land area occupied by that vegetation type

The most common vegetation in Central America is the tropical forest Six forest types contribute collectively about 48 7% of the region's total land Among them, Tropical Broadleaf Evergreen Forest is the most extensive vegetation type, covering 36% of the region's total area Tropical Needleleaf Evergreen Forest is the second most common vegetation in the region, covering about 9% of the region's total area (Table 2, Figure 4, and Figure 5) Savanna and grassland occupy 9% of the total area About 2% of the region's area is wetlands

Figure 5 Vegetation/Land Cover Distribution in Central America



*Note Numbers refer to vegetation types listed in Table 2

This study found that most vegetation types (11 of the 17 natural vegetation types) occupy relatively small areas, i e , less than 2 % of the region's total area The least abundant vegetation type in the region is the Tropical Broadleaf Evergreen Savanna It occupies only 910 km2, about 0 2% of the region's total land

Furthermore, the mapped vegetation types show distinct distribution patterns along the elevation range in Central America The spatial distributions of the Central American vegetation types were analyzed according to three elevation categories, i e , the lowland region (0 - 500 meters), the middle elevation region (501 - 2500 meters), and the high elevation region (> 2500 meters) (Table 5 and 6) About 80% of the Tropical Evergreen Needleleaf Forest is distributed in the middle elevation region and 19% occurs in the low land region A large portion (36 4%) of the Tropical Broadleaf Evergreen Forest is distributed in the middle elevation region About 2400 km2

(0-5%) of this kind of forest is found in the high elevation region, which is usually called the "Cloud Forest" locally Seven other vegetation types are also largely distributed in the middle elevation region (Table 3)

The distribution of vegetation types across large elevational gradients reflects the importance of vegetation structure as the primary classification discriminant in the image interpretation process Although structurally similar, a vegetation type with a large elevation range could exhibit considerable variation in composition (Holdridge, 1947)
Although not separable using AVHRR data, these differences may be discriminated using imagery with higher spatial and spectral resolution

Table 3 Vegetation/Land Cover Distribution by Elevation Range

Elevation		0m-500m		501m-2500m		mayor 2500m		Total
Vegetation Type N°		Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)
1	Tropical needleleaf evergreen forest	8556	19 2	35388	79 3	703	1 6	44647
2	Tropical broadleaf evergreen forest	115377	62 3	67512	36 4	2416	1 3	185305
3	Tropical broadleaf/needleleaf evergreen forest	8442	73 0	3110	26 9	5	0 0	11557
4	Tropical broadleaf deciduous forest	9090	87 5	1261	12 1	37	0 4	10387
5	Tropical swamp forest	7195	100 0	0	0 0	0	0 0	7195
6	Palm forest	2088	97 0	50	2 4	0	0 0	2138
7	Mangroves	4076	100 0	0	0 0	0	0 0	4076
8	Tropical needleleaf evergreen woodland	2464	69 0	1062	30 1	0	0 0	3526
9	Tropical broadleaf evergreen woodland	7678	98 9	87	1 1	0	0 0	7765
10	Tropical broadleaf deciduous woodland	1199	70 0	503	29 3	12	0 7	1713
11	Tropical broadleaf/needleleaf woodland	1839	75 2	607	24 8	1	0 0	2446
12	Tropical broadleaf evergreen savanna	904	100 0	0	0 0	0	0 0	904
13	Tropical needleleaf evergreen savanna	6866	100 0	0	0 0	0	0 0	6866
14	Tropical broadleaf evergreen scrub/shrub	1778	35 5	3216	64 2	14	0 3	5007
15	Tropical cactus/thorn scrub	3154	91 1	310	8 9	0	0 0	3464
16	Tropical swamp scrub/shrub	7387	92 2	624	7 8	0	0 0	8012
17	Tropical perennial graminoid grassland	10049	53 3	8674	46 0	115	0 6	18838
18	Tropical herbaceous wetland	5172	100 0	0	0 0	0	0 0	5172
19	Barren rock, sand and soil	65	22 0	216	73 2	14	4 8	295
20	Inland water	14202	97 1	429	2 9	0	0 0	14631
21	Forest-woodland-agricultura complex	6613	51 8	5207	40 8	952	7 5	12772
22	Urban/vegetation complex	1606	38 0	1674	39 6	951	22 5	4231
23	Agriculture	116494	76 3	36011	23 6	246	0 2	152751
24	Urban/industrial	559	37 6	918	61 7	11	0 7	1488

Table 4 Vegetation/Land Cover within seven Central American Countries

Elevation	Belize		Costa Rica		El Salvador		Guatemala		Honduras		Nicaragua		Panama	
Vegetation Type N°	Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)	% Area	Area (Km²)	% Area
Tropical needleleaf evergreen forest	298 0	0 67	1096 2	2 46	1158 9	2 60	11490 4	25 77	25562 9	57 33	4955 2	11 11	27 0	0 06
Tropical broadleaf evergreen forest	8096 6	4 37	20227 4	10 94	2024,7	1 09	50792,2	27 41	37579 3	20 28	39362 3	21 24	27206,0	14 68
Tropical broadleaf/needleleaf evergreen forest	15 6	0 14	479 7	4 16	473 1	4 10	280 4	2 43	4253 7	36 86	2986 9	25 88	3050 2	26 43
Tropical broadleaf deciduous forest	421 3	4 11	3062 1	29 89	57 5	0,56	1276 5	12,46	221,0	2 16	390 2	3 81	4814 5	47 00
Tropical swamp forest	335 5	4 84	955 8	13 78	5 0	0 07	1059 7	15 28	600 7	8 66	2499 2	36 03	1480 1	21 34
Palm forest	34 0	1,60	1449 2	68 30	0 0	0 00	111 0	5 23	5 0	0 24	129,9	6 12	392 7	18 51
Mangroves	558 8	15 06	192 1	5 18	84 9	2 29	217 1	5 85	649 0	17 49	1366 5	36 83	641 7	17 29
Tropical needleleaf evergreen woodland	392 0	11 16	78 0	2,22	59 0	1 68	154 0	4 38	2006 0	57 10	708 0	20 15	116 0	3 30
Tropical broadleaf evergreen woodland	0 0	0 00	24 0	0 31	21 0	0 27	23 0	0 30	57 5	0 74	7607 0	98 22	12 0	0 15
Tropical broadleaf deciduous woodland	0 0	0 00	315 7	18 38	16,0	0,93	590 2	34 36	60 0	3 49	51 0	2,97	685 0	39 87
Tropical broadleaf/needleleaf woodland	67 0	2 72	101 6	4 12	3 0	0 12	258 1	10 47	302 0	12 25	1634 5	66 30	99 0	4 01
Tropical broadleaf evergreen savanna	30 0	3,29	0,0	0 00	27 0	2 96	0 0	0 00	447 2	48 99	68 8	7,54	339,8	37 22
Tropical needleleaf evergreen savanna	155 0	2 24	240 8	3 48	0 0	0 00	59 5	0 86	3309 8	47 79	3080 7	44 49	79 4	1 15
Tropical broadleaf evergreen scrub/shrub	2 0	0,04	179,0	3 55	470,8	9,35	333 0	6 61	2067 1	41 05	1933,1	38 39	51 0	1,01
Tropical cactus/thorn scrub	0 0	0 00	0 0	0 00	1511 9	43 12	264 0	7 53	689 8	19 68	862 2	24 59	178 0	5 08
Tropical swamp scrub/shrub	3125 4	38 92	246 6	3 07	23 0	0 29	1906 2	23 74	1149 0	14 31	600 7	7 48	979 0	12 19
Tropical perennial graminoid grassland	205 6	1 09	101 3	0 54	5650 0	29 85	4109 8	21 71	3910 7	20 66	3318 9	17 53	1631 5	8 62
Tropical herbaceous wetland	28 8	0 56	479 7	9 33	0 0	0 00	1199 4	23 32	745 2	14 49	2476 6	48 16	213 0	4 14
Barren rock, sand and soil	3 0	0 74	32 8	8 27	0 0	0 00	0 0	0 00	27 0	6 80	7 1	1 79	327 0	82 40
Inland water	165 0	1,16	107 4	0 75	299 6	2 10	1240 4	8 71	1206 3	8,47	10315 7	72 40	914 7	6 42
Forest woodland-agricultura complex	0 0	0 00	886 2	6 95	0 0	0 00	6138 0	48 13	1381 1	10 83	592 0	4 64	3755 3	29 45
Urban/vegetation complex	0 0	0 00	226 8	5 38	77 4	1 84	2546 7	60 40	26 0	0,62	1273 0	30 19	66,8	1 58
Agriculture	7227 1	4 73	19449 5	12 74	8125 5	5 32	24703 3	16 18	25466 8	16 68	42122 4	27 59	25576 0	16 75
Urban/industrial	0 0	0 00	382 0	25 53	24 0	1 60	336 0	22 46	281 0	18 78	311 0	20 79	162 0	10 83

The map clearly indicates that most of the Central American Pacific coastal and lowland areas have been converted into agricultural land Furthermore, little forest exists in El Salvador

4.2. Protection Status of the Remaining Vegetation

The assessment of protection status is based on the 10% protection parameter In "The III World Congress on National Parks and Protected Areas", all attending countries agreed that a minimum of 10% for representation within protected areas is an appropriate and practical target for near-term protection Recent work suggests that a 10% minimum may not be appropriate (Soule and Sanjayan, 1998), that figure was used here more for the sake of comparison and not to describe adequate protection levels

The seven categories of protection of terrestrial areas used in the Mesoamerican Regional System of Protected Areas were logically grouped into three categories to allow easy visual interpretation and analysis in a chart form Three categories of protection were employed Parks and Reserves - Absolute Protection Status (IUCN I - III), and Parks without Legal Limits (El Salvador, Honduras and Nicaragua),

Extractive Reserves - Extractive Reserves (IUCN IV - VI), and Extractive Reserves Proposed for Upgrade,

Potential Parks - Proposed Connection Zones and Potential New Reserves

The results indicate that under existing protected areas, more than half of the vegetation types (11 of 17 vegetation types) are under- represented, i e , have less than 10% of their total areas designated as Parks and Reserves (Table 5, Figure 6) Eight of these vegetation types have less than 5% of their total areas represented in the existing Parks and Reserves (Table 5) They are Tropical Needleleaf Evergreen Forest, Tropical Needleleaf Evergreen Woodland, Tropical Broadleaf Deciduous Woodland, Tropical Broadleaf/Needleleaf Woodland, Tropical Needleleaf Evergreen Savanna, Tropical Shrublands, and Tropical Grassland The least protected vegetation type in Central America is Tropical Needleleaf Evergreen Savanna, only 0 32% of its land is represented in the parks and reserves The analysis revealed that a large portion (5,176 km2) of the land designated as parks and reserve areas has been converted to agricultural land (Table 5, Figure 6) Moreover, it was found that about one third (>30,000 km2) of the proposed potential parks is on agricultural land On the other hand, five vegetation types would have over 50% of their total distribution protected in this system (Table 5, Figure 6)

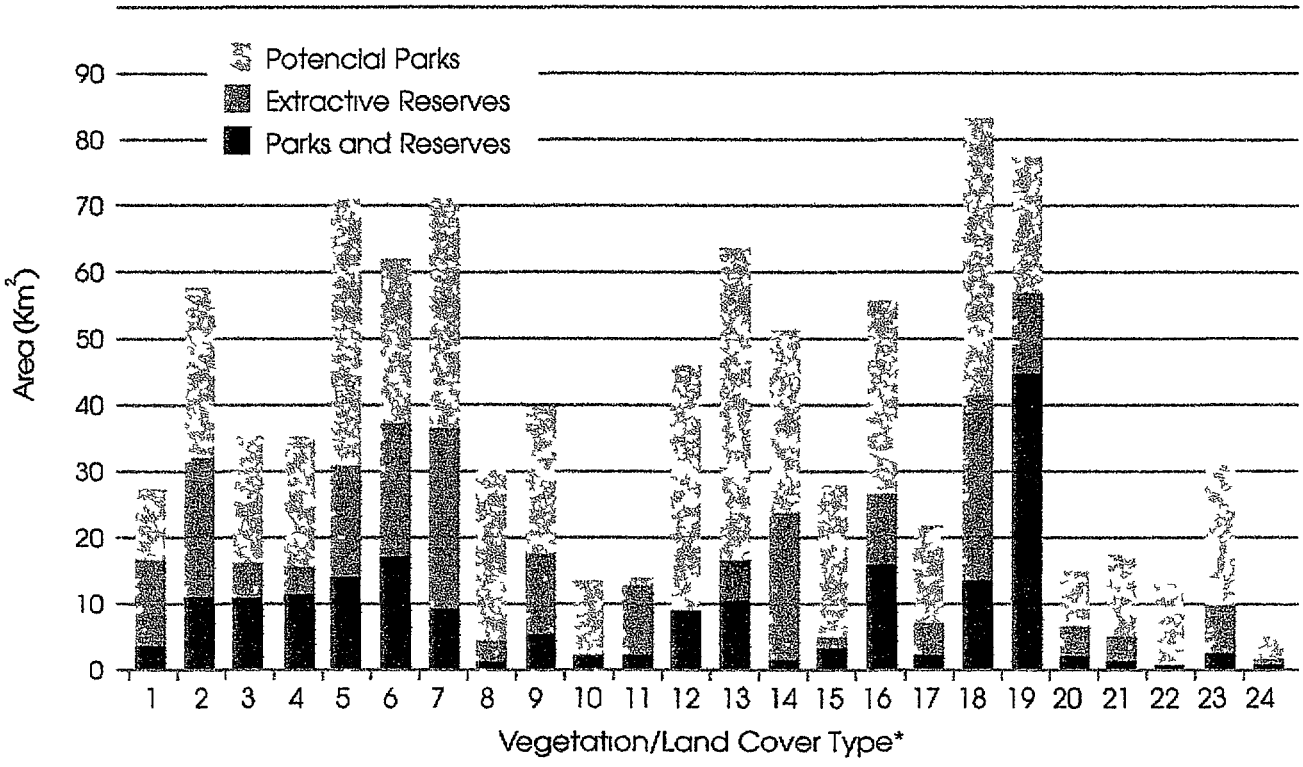
The protection status of vegetation also varies from country to country (Appendix A) El Salvador has the smallest protected areas, and all vegetation types in the country are under-represented Even though Costa Rica and Panama have relatively large protected area systems, half the vegetation types found in the two countries are under- represented

Additional analysis of the spatial relationship between remaining vegetation and protected areas can provide critical information for selecting new protected areas to fill the conservation gaps Future corridor design initiatives should target under-represented vegetation types

Table 5 Protection Status of Vegetation/Land Cover in Central America

	Parks and Reserves		Potential Parks		Extractive Reserves	
Vegetation Type	Size (Km^2)	% Area	Size (Km^2)	% Area	Size (Km^2)	% Area
Tropical needleleaf evergreen forest	1054 29	2 36	4595 93	10 31	6620 53	14 85
Tropical broadleaf evergreen forest	27383 47	14 77	49789 07	26 86	31456 31	16 97
Tropical broadleaf/needleleaf evergreen forest	1218 56	10/56	2131 93	18 47	804 56	6 97
Tropical broadleaf deciduous forest	1202 17	11 74	1955 66	19 09	547 06	5 34
Tropical swamp forest	963 50	13 89	2785 41	40 16	1158 71	16 71
Palm forest	358 08	16 88	535 87	25 25	430 89	20 31
Mangroves	347 22	9 36	1284 06	34 61	1000 10	26 96
Tropical needleleaf evergreen woodland	48 52	1 38	912 17	25 97	97 14	2 77
Tropical broadleaf evergreen woodland	391 87	5 06	1686 64	21 78	1018 53	13 15
Tropical broadleaf deciduous woodland	39 01	2 27	195 60	11 39	2.00	0 12
Tropical broadleaf/needleleaf woodland	77 00	3 12	37 55	1 52	244 68	9 93
Tropical broadleaf evergreen savanna	84 00	9 20	2 69	0 29	338 86	37 13
Tropical needleleaf evergreen savanna	22 42	0 32	3655 59	52 79	721 09	10 41
Tropical broadleaf evergreen scrub/shrub	81 20	1 61	893 43	17 74	1126 16	22 36
Tropical cactus/thorn scrub	108 80	3 10	827 41	23 60	50 84	1 45
Tropical swamp scrub/shrub	1305 06	16 25	1560 94	19 44	844 69	10 52
Tropical perennial graminoid grassland	388.01	2 05	2799 89	14 79	964 38	5 10
Tropical herbaceous wetland	723 25	14 06	2169 89	42 19	1380 23	26 84
Barren rock, sand and soil	179 37	45 20	84 83	21 38	45 97	11 58
Inland water	284 33	2 00	1220 06	8 56	645 18	4 53
Forest-woodland-agricultura complex	156 94	1 23	1718 55	13 48	418 94	3 29
Urban/vegetation complex	24 43	0 58	536 10	12 71	8 35	0 20
Agriculture	5176 40	3 39	32526 01	21 30	9754 40	6 39
Urban/industrial	11 11	0 74	55 23	3 69	19 12	1 28

Figure 6 Protection status of Central American Vegetation/Land Cover



4.3. Central American Ecoregions and Their Protection Status

Central American Ecoregions

There are 21 ecoregions in the Central American region (Figure 2) Of these, 14 have more than 80% of their total areas within the region, and two have more than 60% in the region (Table 1) Two very large ecoregions cover most of the region The first is the Central American Atlantic Moist Forests Ecoregion, which spans five of the seven countries and covers approximately 31% of the region The second is the Central American Pine-Oak Forests Ecoregion, which spans four of the seven countries and covers approximately 21% of the region's total land The third, fourth, fifth and sixth largest ecoregions found within the region are the Central American Pacific Dry Forests Ecoregion, the Isthmian-Pacific Moist Forests Ecoregion, the Miskito Pine Forests Ecoregion, and the Talamancan Montane Forests Ecoregion Combined, these ecoregions occupy approximately 21% of the region The rest of the ecoregions contained within Central America are small and cover less than 8%

Two ecoregions are not found largely within Central America the Peten Moist Forests found in Guatemala, Belize, and Mexico, and the Choco/Darien Moist Forests found in Panama and Colombia These two ecoregions are very large (with the majority of their extents occurring outside

the region) Mangroves also occur in Central America Mangroves are considered globally important and are under substantial threat They are particularly sensitive to changes in hydrography (draining or changes in tidal of river patterns) and pollution – a constant problem in coastal areas, which can occur due to changes in inland areas

The Distribution of Vegetation and Land Cover within Ecoregions

The 24 vegetation and land cover types have been grouped into eight broad habitat categories to allow easy visual interpretation and analysis in a chart form The groupings are as follows

Forest - comprises a grouping of all of the forest types, including Tropical Needleleaf Evergreen Forest, Tropical Broadleaf Evergreen Forest, Tropical Broadleaf/Needleleaf Evergreen Forest, Tropical Broadleaf Deciduous Forest, Tropical Swamp Forest, and Palm Forest,

Woodland - comprises all of the following Woodland Types Tropical Needleleaf Evergreen Woodland, Tropical Broadleaf Evergreen Woodland, Tropical Broadleaf Deciduous Woodland, and Tropical Broadleaf/Needleleaf Woodland,

Mangroves - an individual type,

Savanna - comprises the following savanna and scrub/shrub types Tropical Broadleaf Evergreen Savanna, Tropical Needleleaf Evergreen Savanna, Tropical Broadleaf Evergreen Scrub/Shrub, Tropical Cactus/Thorn Shrub, and Tropical Swamp Scrub/Shrub,

Grassland - only one class Tropical Perennial Gramminoid Grassland,

Wetland - one class Tropical Herbaceous Wetland,

Agriculture/Urban - comprises the following land cover types Forest-Woodland-Agriculture Complex, Urban-Vegetation Complex, Agriculture, and Urban-Industrial,

Non Vegetated - comprises the remaining land cover types Barren Rock, Sand, Soil, Unclassified, and Inland Water

As ecoregions represent potential (pre-colonization) vegetation, the amount of conversion of each ecoregion from its original (100% natural vegetation assumed) to its present state (a combination of natural and ag/urban classes) was analyzed This estimate provided an indication of the amount of deforestation that has occurred in each ecoregion

When comparing converted and non-converted vegetation within the ecoregions, it was found that eight ecoregions have been heavily converted (less than 40% original forest remaining) from forest lands to agriculture/urban (Table 6, Figure 7) Of these, Panamanian Dry Forests Ecoregion has had the most forest loss with over 84% having been converted to agriculture/urban (8 3% forest left) Other largely converted ecoregions include the Belizean Swamp Forests Ecoregion (14% forest remaining), Central American Pacific Dry Forests Ecoregion (17% forest remaining), Miskito

Pine Forests Ecoregion (21% forest remaining), Motagua Valley Thornscrub Ecoregion (23% forest remaining), and Isthmian-Pacific Moist Forests Ecoregion (39% remaining) The large amount of the savanna class occurring in some of the ecoregions, especially the Miskito Pine Forests (28%) and the Belizean Swamp Forest (20%), could be an indication of a thinning of the forest which might be a result of limited logging or clearing for pasture (used for cattle ranching) instead of total clearing for agriculture

Six ecoregions, however, have a large percentage (75%) of forest remaining (Table 6, Figure 7) Of particular interest are the Central Panamanian Montane Ecoregion, Eastern Panamanian Montane Ecoregion, and Talamancan Montane Forests Ecoregion, which all have over 80% forest remaining

Figure 7 Distribution of Vegetation/Land Cover within Ecoregions

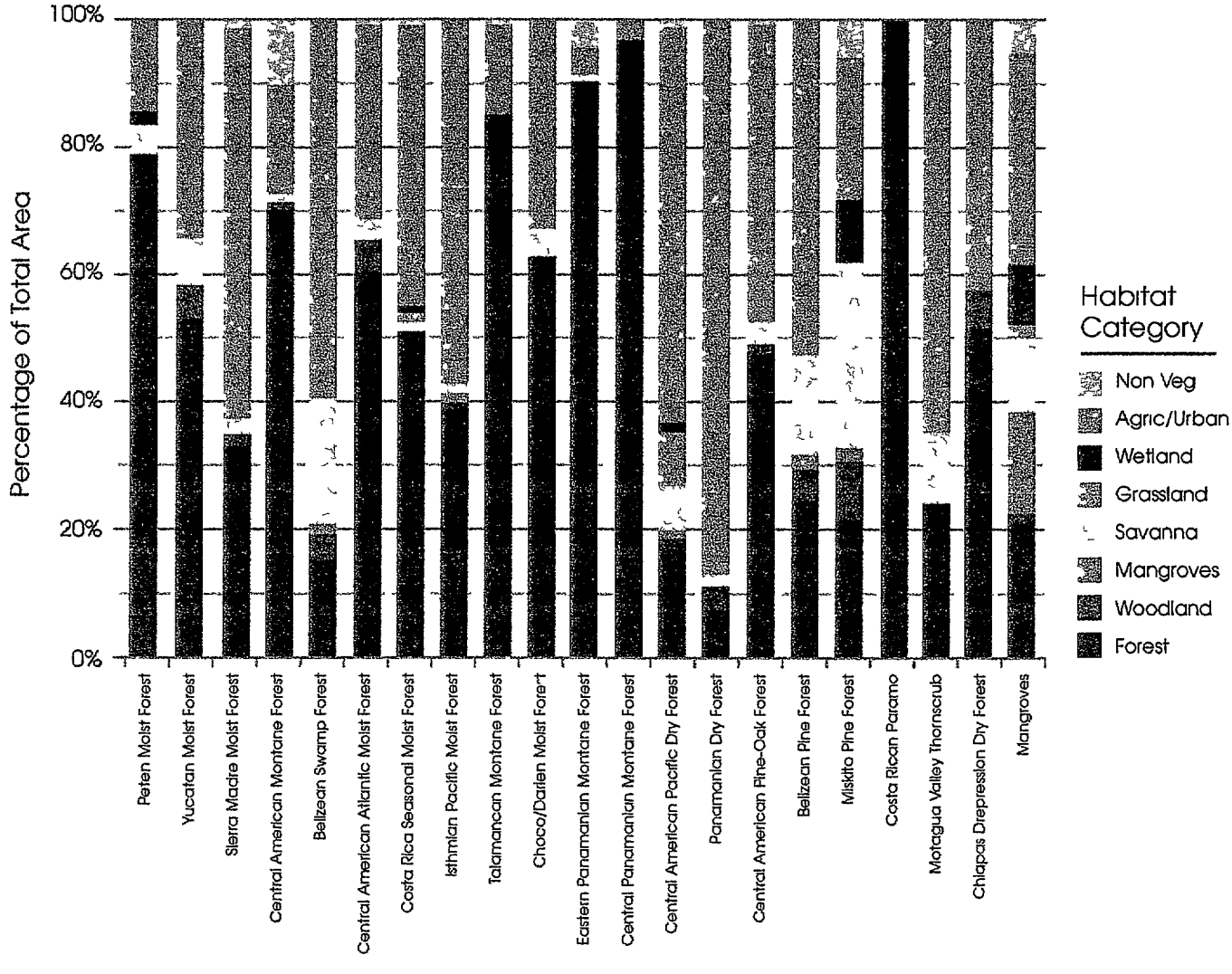


Table 6 Distribution of Vegetation/Land Cover within Central American Ecoregions

Ecoregion	Forest Size (Km^2)	Woodland Size (Km^2)	Mangroves Size (Km^2)	Savanna Size (Km^2)	Grassland Size (Km^2)	Wetland Size (Km^2)	Agric/Urban Size (Km^2)	Non Veg. Size (Km^2)
Peten Moist Forest	47985	282	24	2144	34	1164	8931	268
Yucatan Moist Forest	1059	85	7	149	31	4	648	2
Sierra Madre Moist Forest	1923	104	2	127	248	18	3340	5832
Central American Montane Forest	5423	101	0	84	91	0	1226	754
Belizean Swamp Forest	504	162	47	670	76	0	1940	0
Central American Atlantic Moist Forest	95399	8831	165	4845	1004	577	45439	1241
Costa Rica Seasonal Moist Forest	5390	72	0	165	139	59	4640	77
Isthmian-Pacific Moist Forest	110113	347	421	477	948	5	15006	57
Talamancan Montane Forest	13884	0	0	0	13	0	2298	118
Choco/Darien Moist Forest	8301	45	33	582	179	0	4150	44
Eastern Panamanian Montane Forest	1622	1	0	17	21	0	55	61
Central Panamanian Montane Forest	395	0	0	0	0	0	9	0
Central American Pacific Dry Forest	7918	1057	269	3278	4244	289	29297	493
Panamanian Dry Forest	415	191	12	75	85	0	4219	1
Central American Pine-Oak Forest	50448	1909	0	3846	11098	0	37246	576
Belizean Pine Forest	657	153	50	437	21	0	1352	0
Miskito Pine Forest	4000	1879	410	5366	69	1802	4134	1028
Costa Rican Paramo	32	0	0	0	0	0	0	0
Motagua Valley Thornscrub	566	0	0	268	166	0	1385	0
Chiapas Drepression Dry Forest	559	58	0	1	203	0	257	0
Mangroves	2962	159	2218	1843	250	1184	4882	622

Protection Status of Central American Ecoregions

The analysis of the representation status of ecoregions was methodologically identical to the analysis of the representation status of vegetation types Ten percent protection of an ecoregion area was considered adequate representation

Of the 16 ecoregions in the area (those that have a majority of their area within the region), seven have adequate representation (Table 7, Figure 8) Two small ecoregions have excellent representation They are the Costa Rican Paramo Ecoregion (32 km2 and 100% protection in the Chirripó National Park) and the Eastern Panamanian Montane Forest Ecoregion having 87% protected The Central Panamanian Montane Forests (404 km2) is another very small ecoregion that is well-represented (35%) The only medium to large ecoregion that is well represented is the Talamancan Montane Forests It is a moderately large ecoregion (16,312 km2) and for its size is very well represented (41% in parks and reserves) The Peten and Choco/Darien Moist Forests have adequate representation for the areas that are located within the Central America region

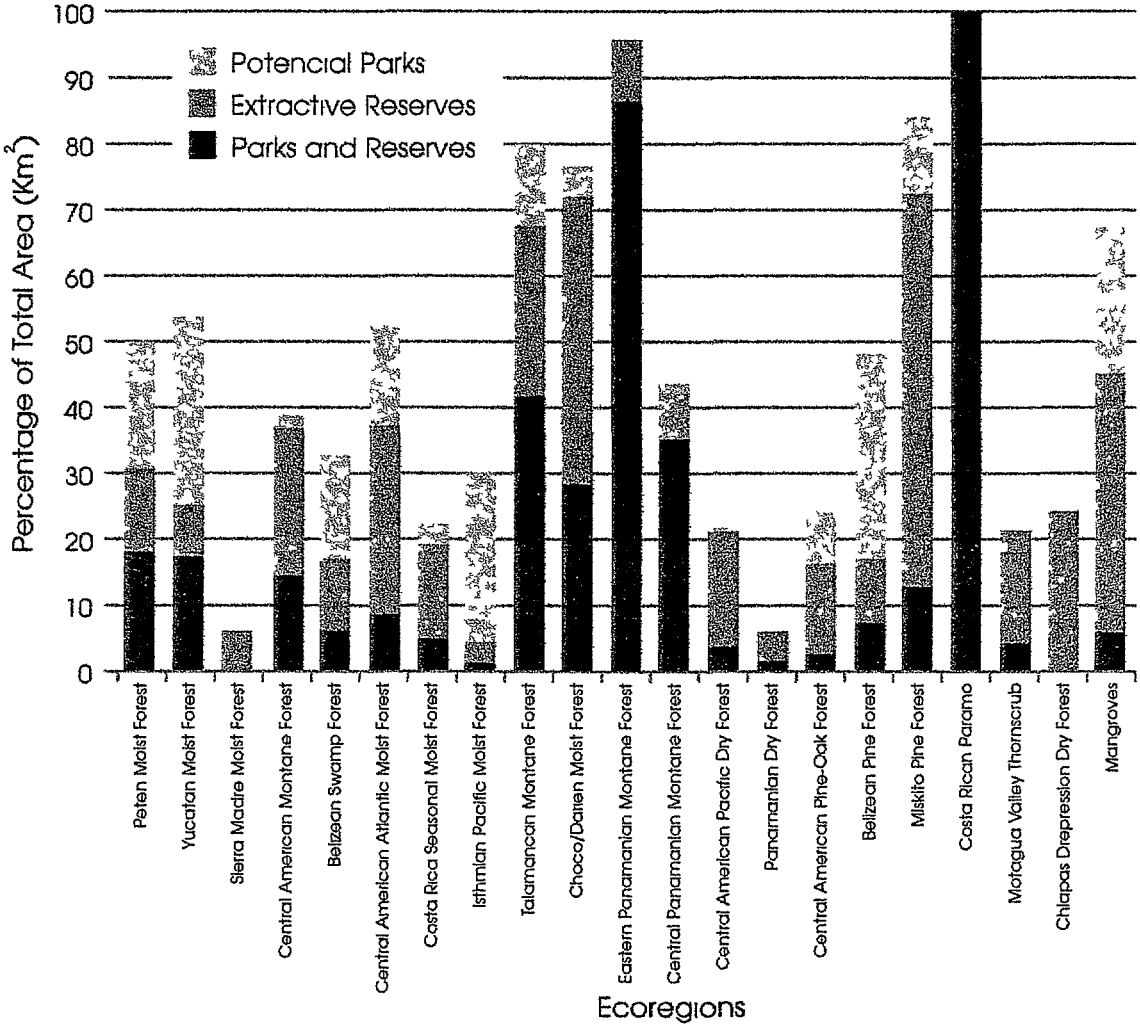
Eleven ecoregions (excluding Mangroves) should be considered inadequately represented in the protected areas of Central America (Table 7 and Figure 8)

Table 7 Protection Status of Central American Ecoregions

Ecoregion	Parks and Reserves		Potential Parks		Extractive Reserves	
	Area (Km^2)	% Area	Area (Km^2)	% Area	Area (Km^2)	% Area
Peten Moist Forest	11029	18 1	7552	12 4	11719	19 3
Yucatan Moist Forest	353	17 8	149	7 5	557	28 1
Sierra Madre Moist Forest	1	0 0	360	6 2	0	0 0
Central American Montane Forest	1140	14 8	1760	22.9	116	1 5
Belizean Swamp Forest	206	6 0	415	12 2	511	15 0
Central American Atlantic Moist Forest	14234	9 0	45452	28 9	22034	14 0
Costa Rica Seasonal Moist Forest	522	5 0	2399	22 7	392	3 7
Isthmian-Pacific Moist Forest	1681	5 9	3799	13 4	832	2 9
Talamancan Montane Forest	6816	41 8	4247	26 0	1984	12 2
Choco/Darien Moist Forest	3849	28 9	5792	43 4	634	4 8
Eastern Panamanian Montane Forest	1550	87 2	148	8 3	0	0 0
Central Panamanian Montane Forest	141	35 0	31	7 8	3	0 8
Central American Pacific Dry Forest	1735	3 7	8273	17 8	187	0 4
Panamanian Dry Forest	72	1 4	217	4 3	0	0 0
Central American Pine-Oak Forest	2836	2 7	14693	14 0	8099	7 7
Belizean Pine Forest	182	6 8	300	11 2	808	30 2
Miskito Pine Forest	2419	12 9	11154	69 7	2110	11 3
Costa Rican Paramo	32	100 0	0	0 0	0	0 0
Motagua Valley Thornscrub	87	3 7	415	17 4	0	0 0
Chiapas Drepression Dry Forest	0	0 0	261	24 2	0	0 0
Mangroves	892	6 3	5499	38 9	3016	22 0

Of these ecoregions, three are very poorly represented (less than 3%) These include the Sierra Madre Moist Forests Ecoregion with virtually no representation (although a large portion of the ecoregion occurs within Central America), Panamanian Dry Forests Ecoregion with only 1 4% representation, and most importantly, considering its large size, the Central American Pine-Oak Forests Ecoregion with only 2 7% representation Two other ecoregions are substantially under-represented as well The first is the Central American Pacific Dry Forests Ecoregion, which is a large ecoregion (46,588 km2) and has only 3 7% of its area represented The second is the Motagua Valley Thornscrub Ecoregion (a relatively small ecoregion of 2,384 km2) which also has only 3 7% representation The Central American Atlantic Moist Forests Ecoregion, the largest ecoregion in Central America, is inadequately represented at 9% of its total area For this ecoregion, however, the large areas of extractive reserves and potential new reserves help offset the small amount of representation The Chiapas Depression Dry Forests Ecoregion, although poorly represented (and highly ranked), has only a very small area inside the region The vast majority (over 94%) of this ecoregion is found in Mexico

Figure 8 Protection Status of Central American Ecoregions



The viability analysis identified the conservation gaps with highest possibilities for conservation strategies The Motagua Valley as an ecoregion is under-represented in the protected areas system In addition, Motagua presents significant attributes of endemism and uniqueness for Central America that make it the most important ecoregional gap identified in the analysis

Furthermore, the conservation gaps identified at the level of vegetation types are presented in Table # 8 Although none of these gaps is regional in coverage (i e is not a gap in all Central America) but national, it is important to take steps to assure they are included in the national protected area systems that correspond Guatemala, Honduras and Nicaragua are the countries with more vegetation type gaps The tropical broadleaf deciduous forest is the most common vegetation type gap since it is present in Guatemala, Belize and Honduras The fact that most of the vegetation types gaps are represented in protected areas of other Central American countries does not assure that all the species and/or ecosystems of importance are represented

Table 8 Vegetation types identified by the experts with high viability gaps and their distribution per country

Vegetation types with high viability gaps	COUNTRIES WITH REPRESENTATION
Tropical broadleaf deciduous forest	Guatemala, Honduras, Belize
Tropical broadleaf deciduous woodland	Guatemala
Tropical herbaceous wetlands	Guatemala, Costa Rica
Tropical broadleaf /needleleaf evergreen forest	Honduras
Tropical needleleaf evergreen woodland	Honduras, Nicaragua
Tropical broadleaf evergreen scrub/shrub	Honduras, Nicaragua
Tropical broadleaf evergreen savanna	Honduras, Nicaragua
Tropical perennial gramminoid grasslands	Honduras, Nicaragua

4.4 Summary of Results

The Central American region spans nearly 800 km from northwest to southeast, rises in places to over 4,000 m in elevation, and encompasses a wide range of environmental and vegetation/land use patterns Central America is rich in biodiversity, serving as an evolutionary land-bridge for the North and South America Adequate biodiversity protection in Central America should be undertaken with an efficient design, and in full consideration of potential benefit to local communities This analysis, based on the best regional-scale data available, provides a valid region-wide assessment of conservation status for both the remaining vegetation and ecoregions This analysis leads to the following major products and findings

Using monthly-composited AVHRR imagery as the primary data source, a standard vegetation/landcover map for Central America was produced which is over 80% accurate The current distributions of the twenty-four major vegetation and land cover types have been mapped at a scale of 1 2,000,000 The most common/abundant vegetation types in Central America are the Tropical Broadleaf Evergreen Forest and Tropical Needleleaf Evergreen Forest, which cover 45% of the region's total land Many other vegetation types also occur, but occupy relatively small areas GAP analysis results indicate that 11 of the 17 major vegetation types found in Central America are inadequately represented in existing absolute protected areas, i e , less than 10% protection Four of these vegetation types remain under-represented when extractive reserves are included as "protected" areas Proposed new protected areas and ecological corridors could fill these conservation "gaps " It was found, however, that the Mesoamerican Protected Areas Network, as currently conceptualized, is not adequately designed because 1) one third of the proposed protected areas occur on agricultural land, and 2) at least five vegetation types would be over protected (>50% protection) while several other types would receive less than 10% protection

It was found that eight of the twenty-one ecoregions have small amounts of forest remaining (<40%) The five least forested ecoregions are the Panamanian Dry Forests Ecoregion, the Belizean Swamp Forests Ecoregion, the Central American Pacific Dry Forests Ecoregion, the Miskito Pine Forests Ecoregion, and the Belizean Pine Forests Ecoregion The Panamanian Dry Forests Ecoregion has only about 8% of its original area remaining

Twelve ecoregions are inadequately represented, that is, they have less than 10% of their area in parks and reserves Of these, the Central American Pine-Oak Forests Ecoregion, Panamanian Dry Forests Ecoregion, Central American Pine-Oak Forests Ecoregion, and especially the Motagua Valley Thornscrub have less than 5% of their lands protected in the existing protected areas The least protected ecoregions are the Sierra Madre Moist Forests Ecoregion and Chiapas Depression Dry Forests Ecoregion, with no protection in their Central American extensions However, the fact that the Motagua Valley Thornscrub presents high endemism and uniqueness for the region, makes it the most important ecoregional gap for Central America In addition, within the proposed Mesoamerican Protected Area Systems, two ecoregions, the Sierra Madre Moist Forests Ecoregion and Panamanian Dry Forests, would remain under-represented

The most important gaps identified at the vegetation type level are Tropical broadleaf deciduous forest, tropical herbaceous wetlands, tropical broadleaf /needleleaf evergreen forest and tropical needleleaf evergreen woodland Although most of the vegetation types do not represent gaps at the regional level, some of them remain gaps at the national level Furthermore, the representation of a vegetation type in the protected areas of one or two countries does not mean that all the potential species associated to that vegetation type for Central America are represented It is important to keep in mind that the vegetation types are surrogates of species

5 MAJOR RECOMMENDATIONS

Developing a sound, long-term conservation strategy based on a biological corridor and protected area system for the Central American region in the face of clashing economic, social, and political issues is a challenge The following recommendations emerge from the gap analysis results of the present study The mere interest of such recommendations is to improve biodiversity protection on a regional scale The recommendations are directed to the Dirección General Ambiental de SICA, the national protected areas institutions, conservation NGOs and donors

- To consolidate and continue working with the Central America Vegetation Working Group established by the present study The group comprises experts from each Central American country in a wide variety of fields Their dedication and commitment as a team to Central America is remarkable and exemplary Future analyses are going to benefit significantly from the participation of this group

- To fill the gaps The gaps at the ecoregional and vegetation types level identified in the present study must be filled In order to assure protection of representative samples of all the different ecosystems of Central America it is critical to fill the existing conservation gaps The Dirección General Ambiental of SICA (DGA/SICA), should lead the effort to get to fill the gaps at the regional level Regional projects such as PROARCA/CAPAS play a lead role that should be taken into account

- To design and establish an appropriate protected areas system in the Central American region that seeks to adequately protect all unique vegetation types Particular attention should be given to those vegetation types that are inadequately represented under the existing protected areas Redesign some existing protected areas, provide institutional presence in paper parks and establish new protected areas where needed, are a few of the steps that could be followed to address this recommendation Perhaps this is an activity that the Mesoamerican Biological

Corridor project could assume for the regional level The establishment of strategic biological corridors in places where gaps exist is critical At the national level, government institutions, NGOs and donors could work closely to address this situation

• To extend the present study by adding information to the database of the different polygons described to generate the vegetation/landcover map This could be accomplish by Using satellite images with better resolution (TM, LANDSAT), ground-truthing the different polygons used to generate the map, adding new polygons to the database with up-to-date information and incorporating species-level information The Dirección General Ambiental of SICA (DGA/SICA) should lead this effort since it is the regional entity with the mandate Presently, there are different national and regional efforts involved in vegetation and forest cover mapping in Central America Coordination, standardization when possible and continuity of such efforts is highly needed PROARCA/CAPAS map and analysis provide the best structure and framework presently available for Central America Continuity of such effort should be high priority

• To establish and implement a long-term regional conservation goal to protect a minimum percent (e g at least 10%), of all major vegetation types found within each ecoregion This minimum percent should be reviewed at both regional and national levels Supervision of the regional level should be carried out by the DGA/SICA At the national level, the country protected area institution should be responsible for overseeing the standard

• To analyze the spatial relationships among existing vegetation, population density, land use, infrastructure, protected areas, biological corridors, and others In order to achieve this, it is critical to have the information in regional datasets readily available for analysis At the present time most of the information does not exist in digital format DGA/SICA should lead an effort to make information available in digital format New initiatives (e g agreement DGA with NASA), represent opportunities to make significant progress towards this goal

• To include representative freshwater as well as coastal and marine systems in future mapping efforts and gap analyses Freshwater biodiversity is the most threatened biodiversity in the U S (Richter et al , 1997) and it is reasonable to expect that the freshwater biodiversity of Central America is also highly threatened and underrepresented In the case of coastal and marine systems is also reasonable to expect that they are under constant pressure and change In Central America there is a good cadre of experts in the freshwater, coastal and marine fields that should be invited to participate in further analyses

6. REFERENCES

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APPENDICES

A Distribution and Protection Status of Remaining Vegetation Types within Each of the Seven Central American Countries

Figure A1a Current Vegetation/Land Cover of Panama

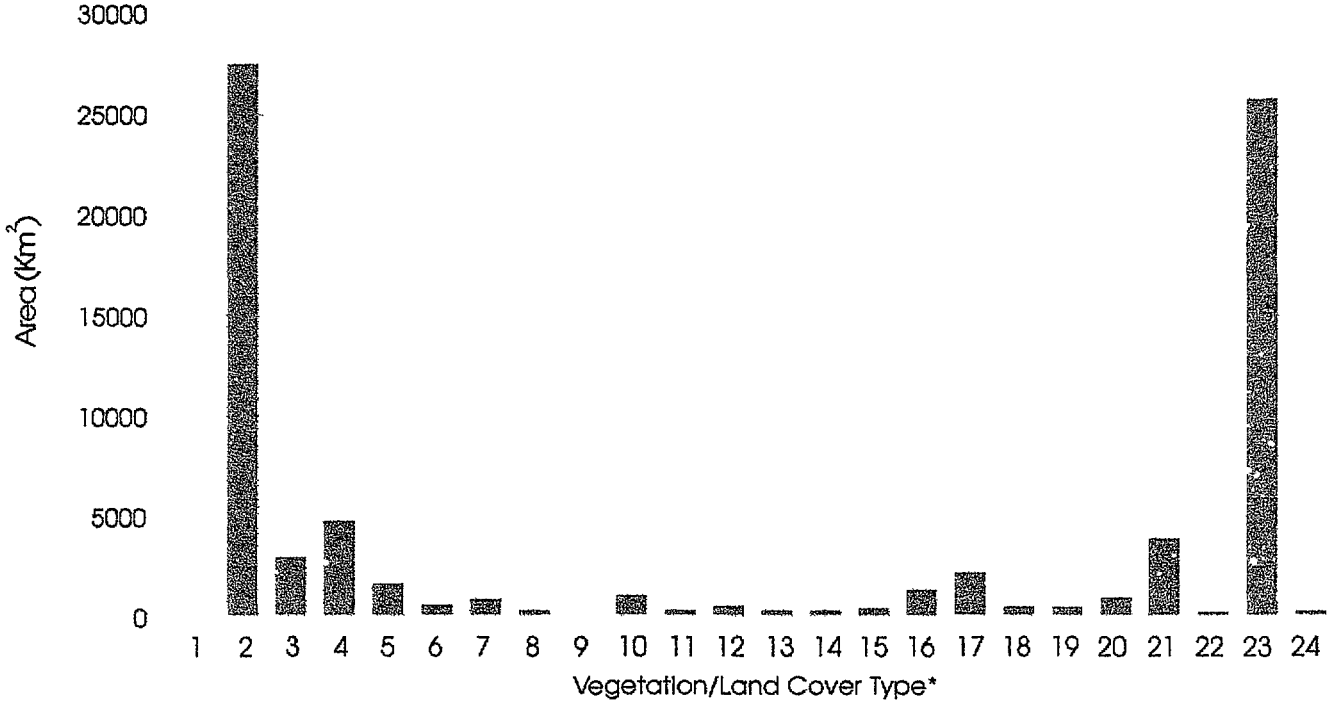
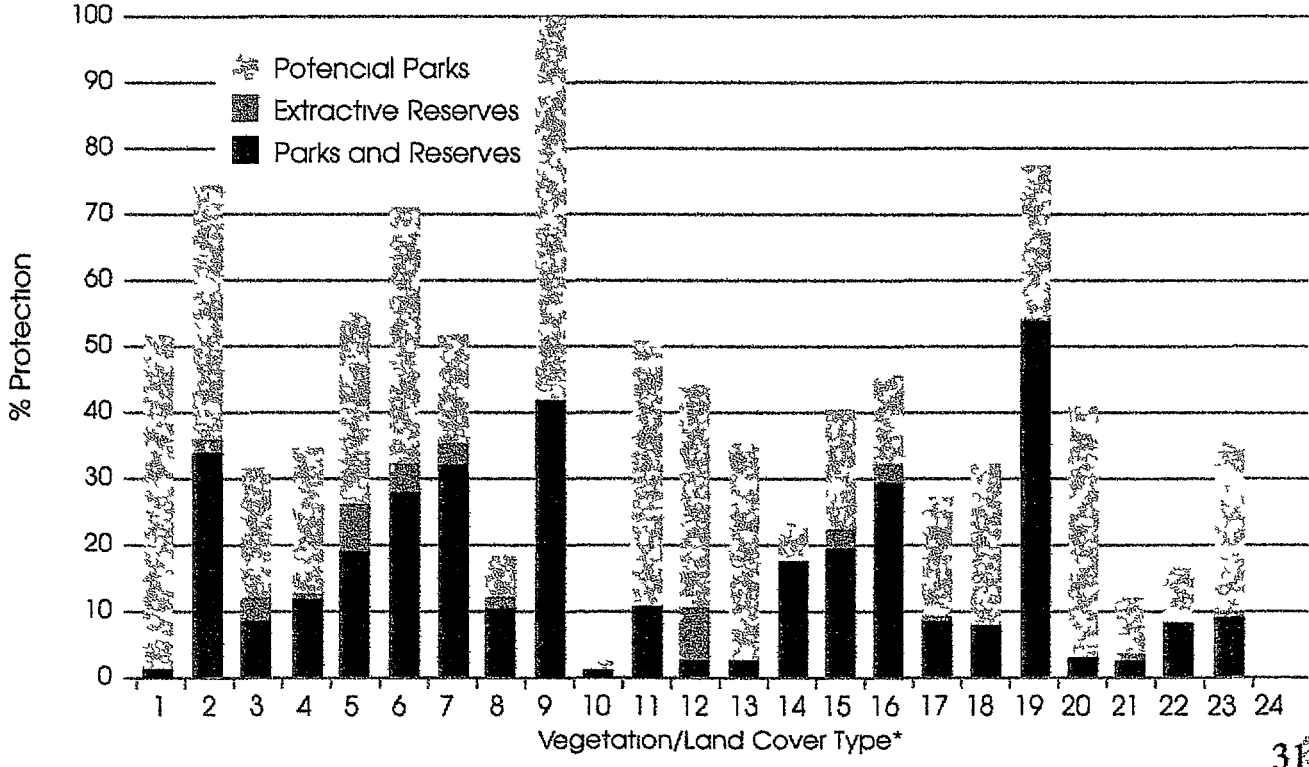


Figure A1b Protection status of Vegetation/Land Cover in Panama



*Note Numbers refer to vegetation types listed in Table 2

Figure A2a Current Vegetation/Land Cover of Nicaragua

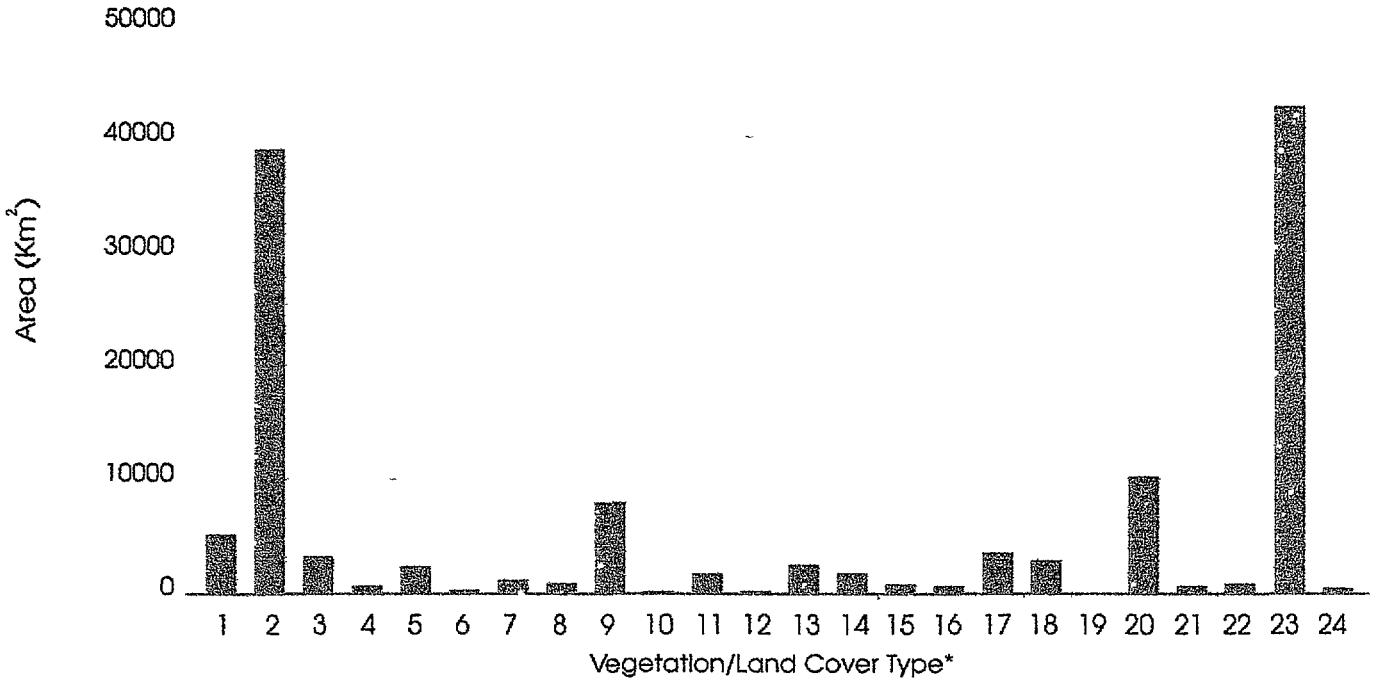
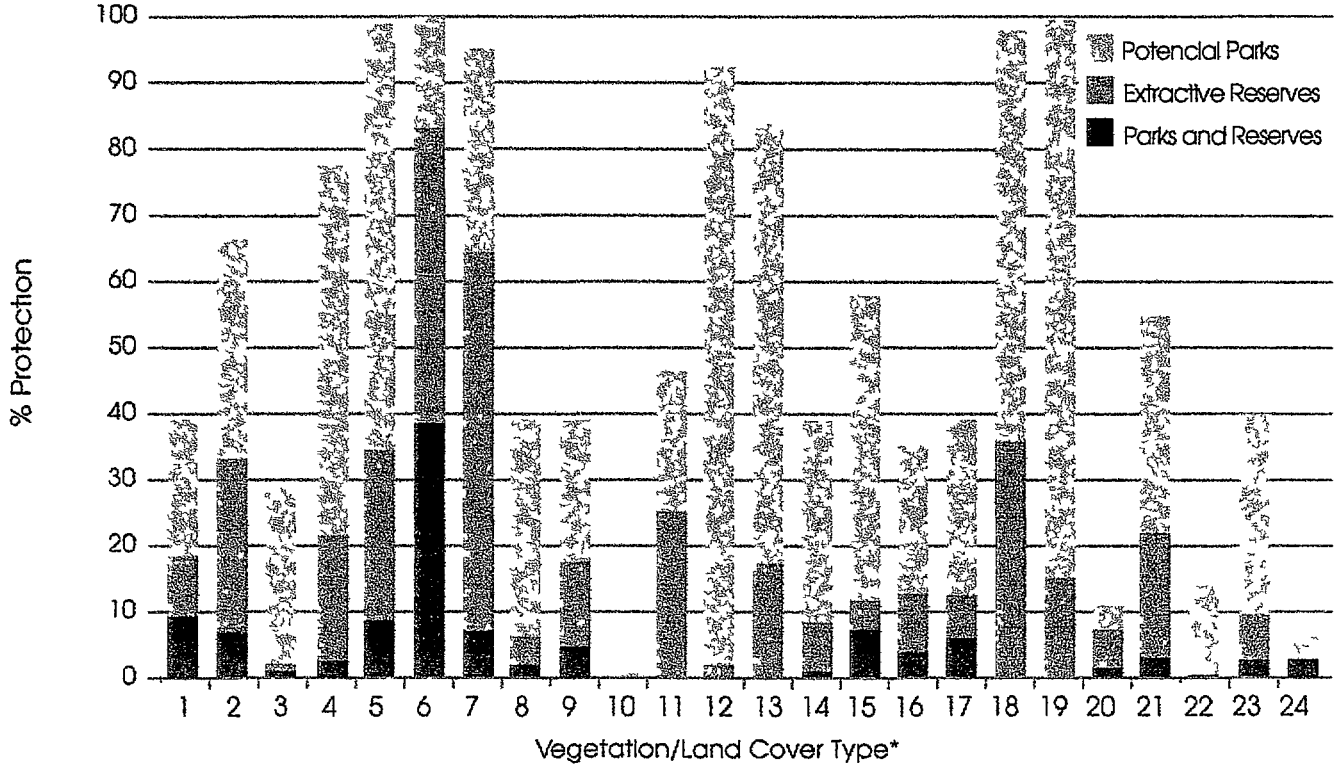


Figure A2b Protection status of Vegetation/Land Cover in Nicaragua



*Note Numbers refer to vegetation types listed in Table 2

Figure A3a Current Vegetation/Land Cover of Honduras

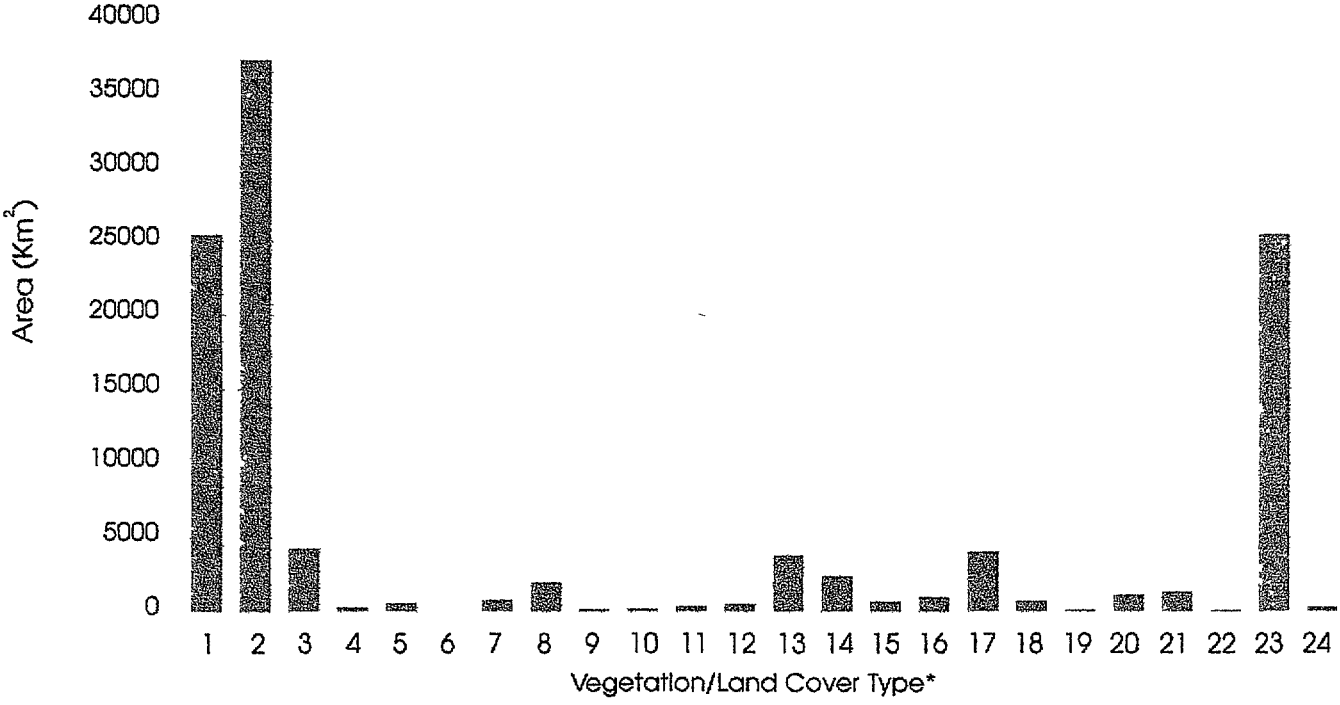
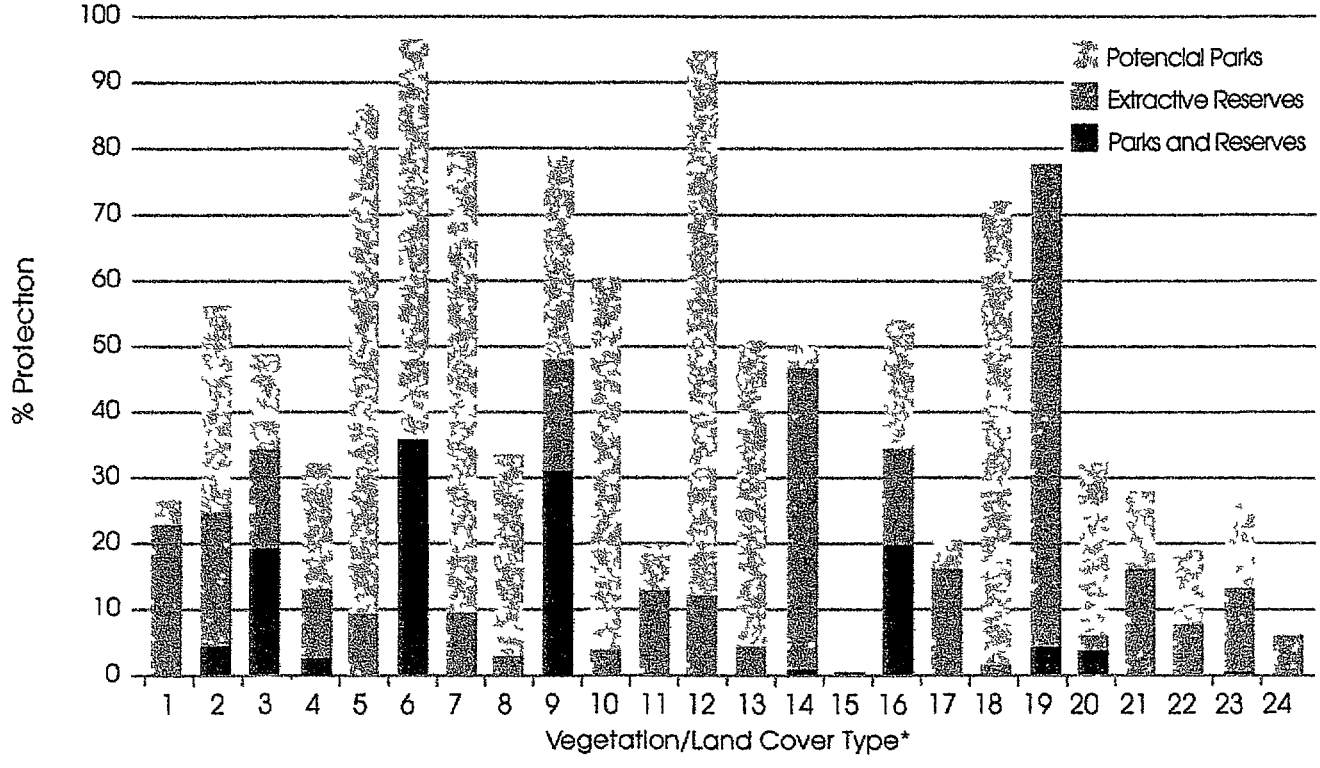


Figure A3b Protection status of Vegetation/Land Cover in Honduras



*Note Numbers refer to vegetation types listed in Table 2

Figure A4a Current Vegetation/Land Cover of Guatemala

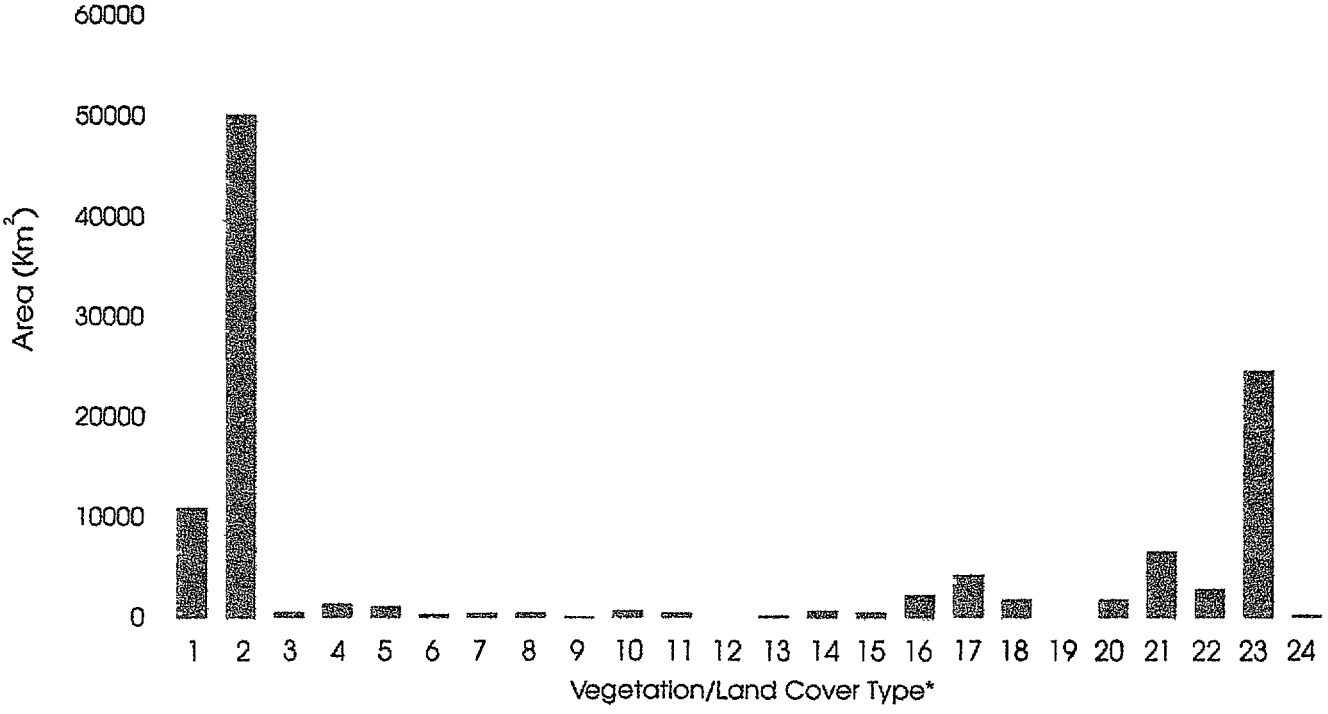
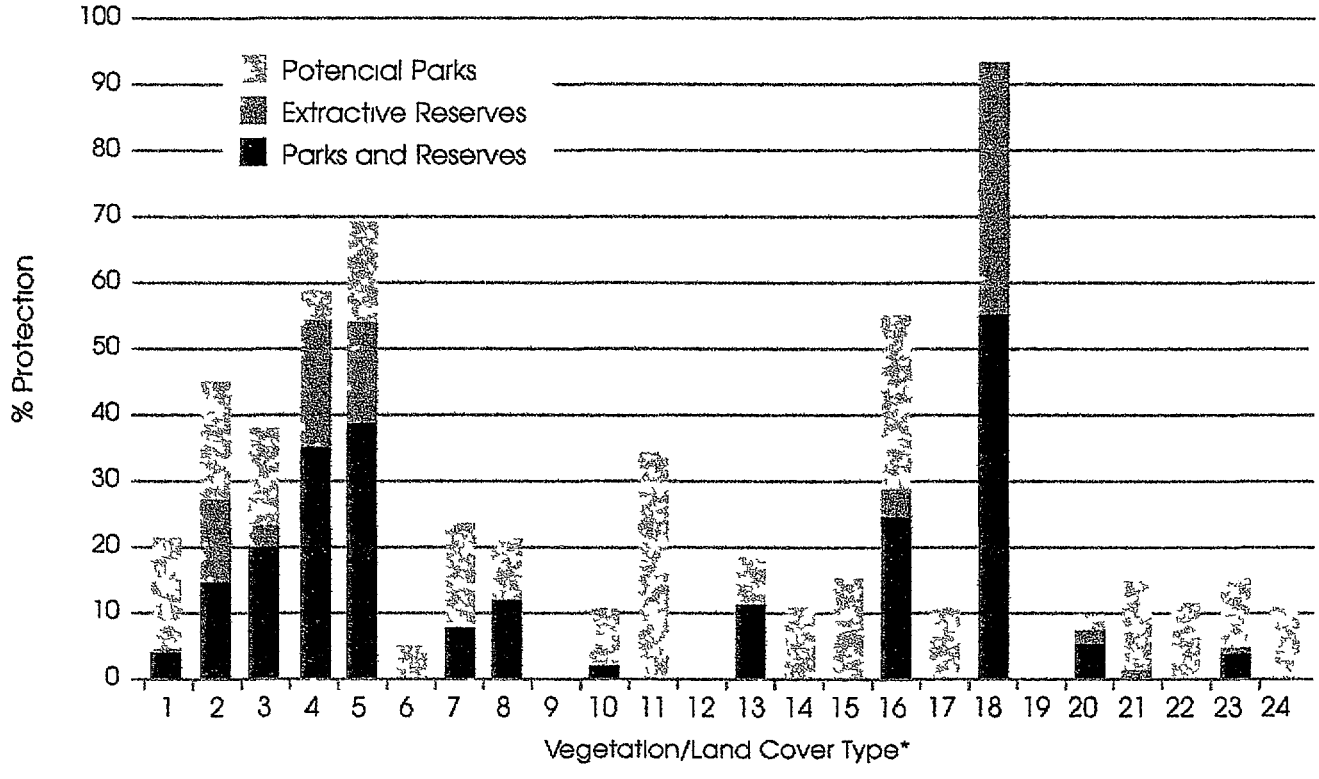


Figure A4b Protection status of Vegetation/Land Cover in Guatemala



*Note Numbers refer to vegetation types listed in Table 2

Figure A5a Current Vegetation/Land Cover of Costa Rica

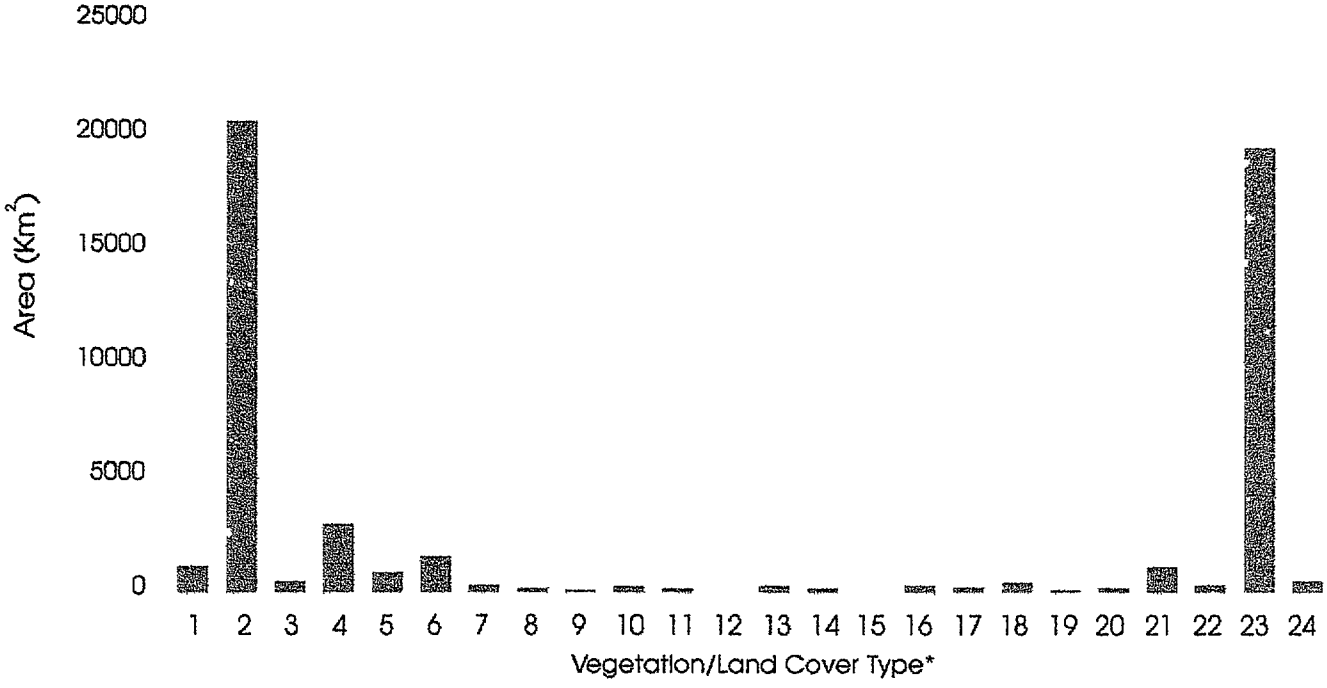
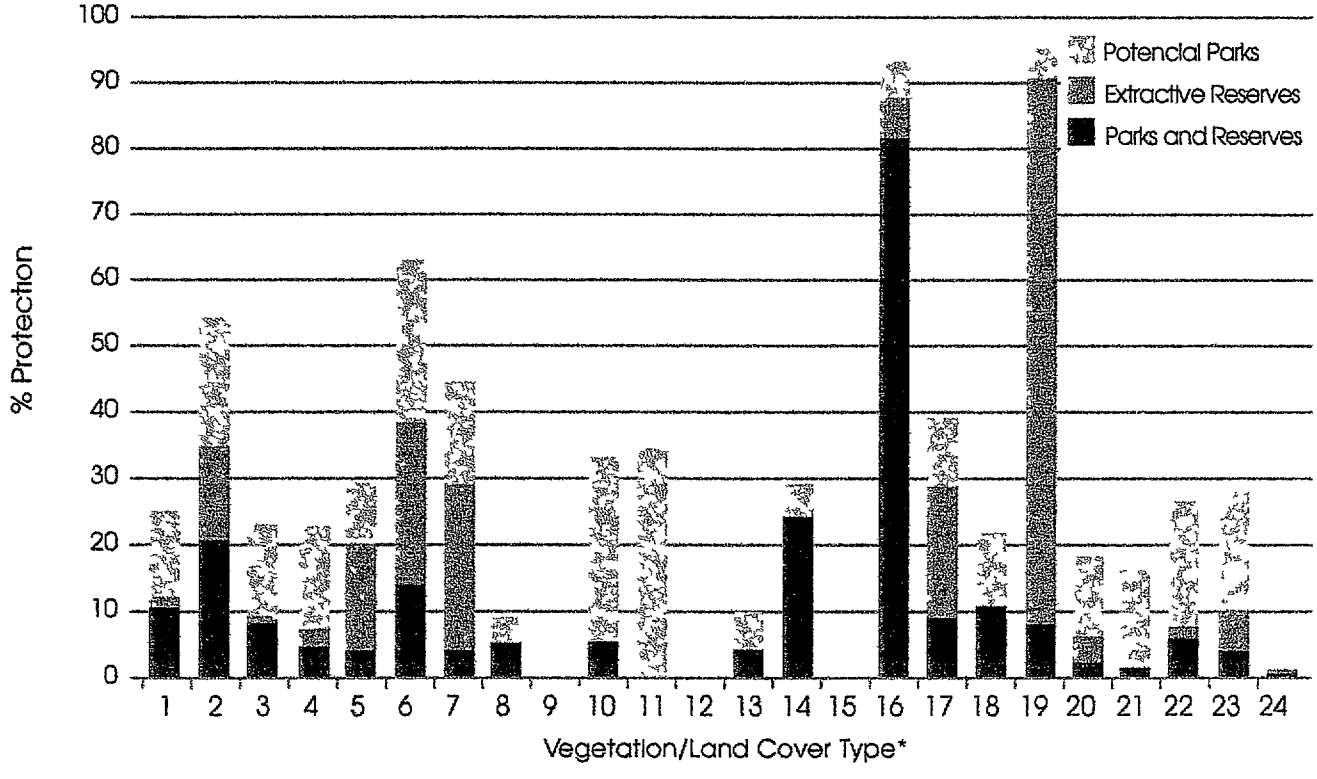


Figure A5b Protection status of Vegetation/Land Cover in Costa Rica



*Note Numbers refer to vegetation types listed in Table 2

Figure A6a Current Vegetation/Land Cover of El Salvador

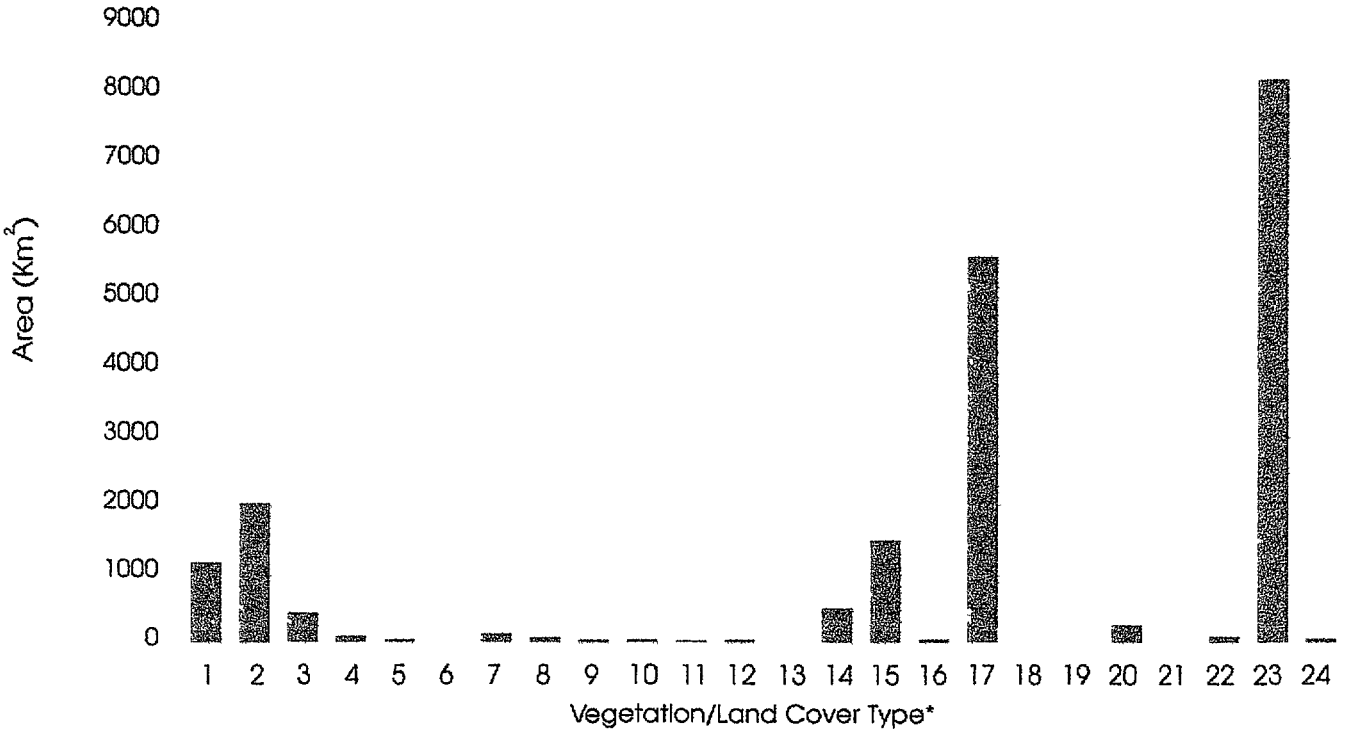
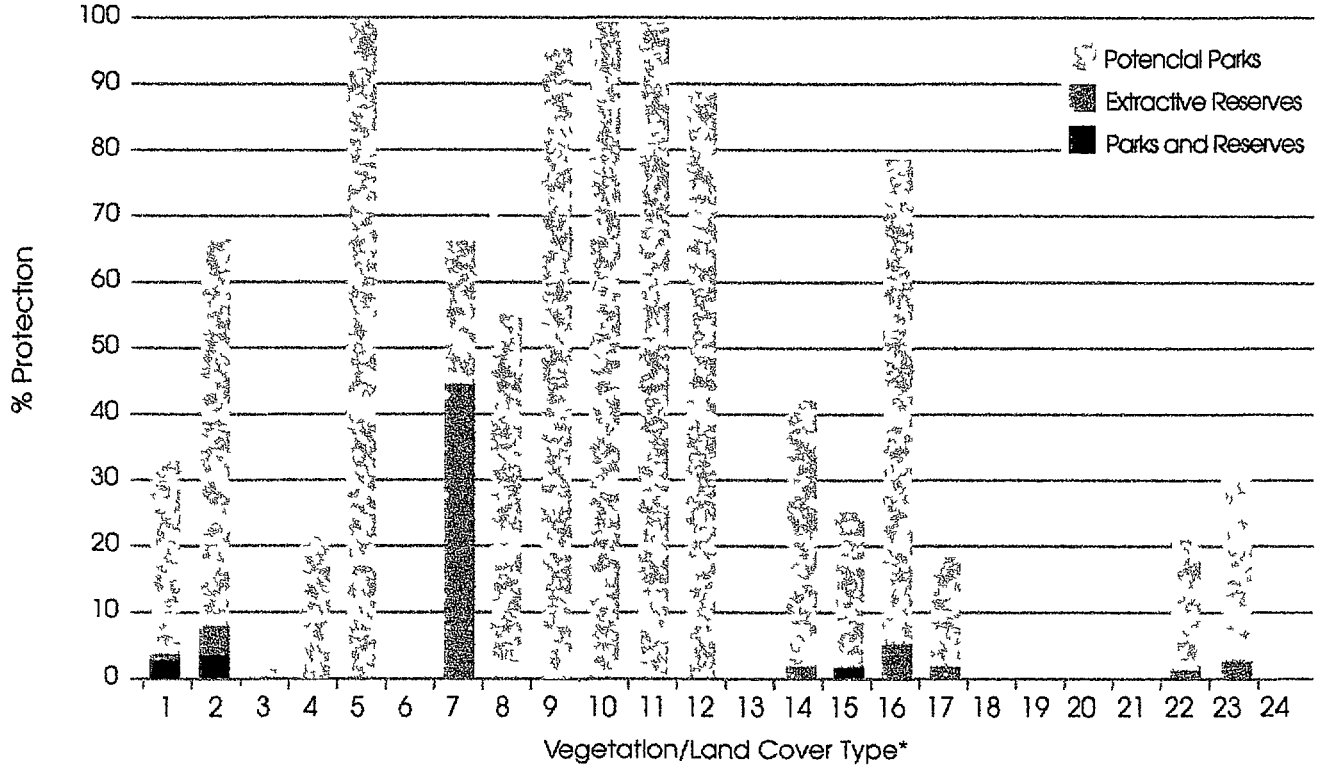


Figure A6b Protection status of Vegetation/Land Cover in El Salvador



*Note Numbers refer to vegetation types listed in Table 2

Figure A7a Current Vegetation/Land Cover of Belize

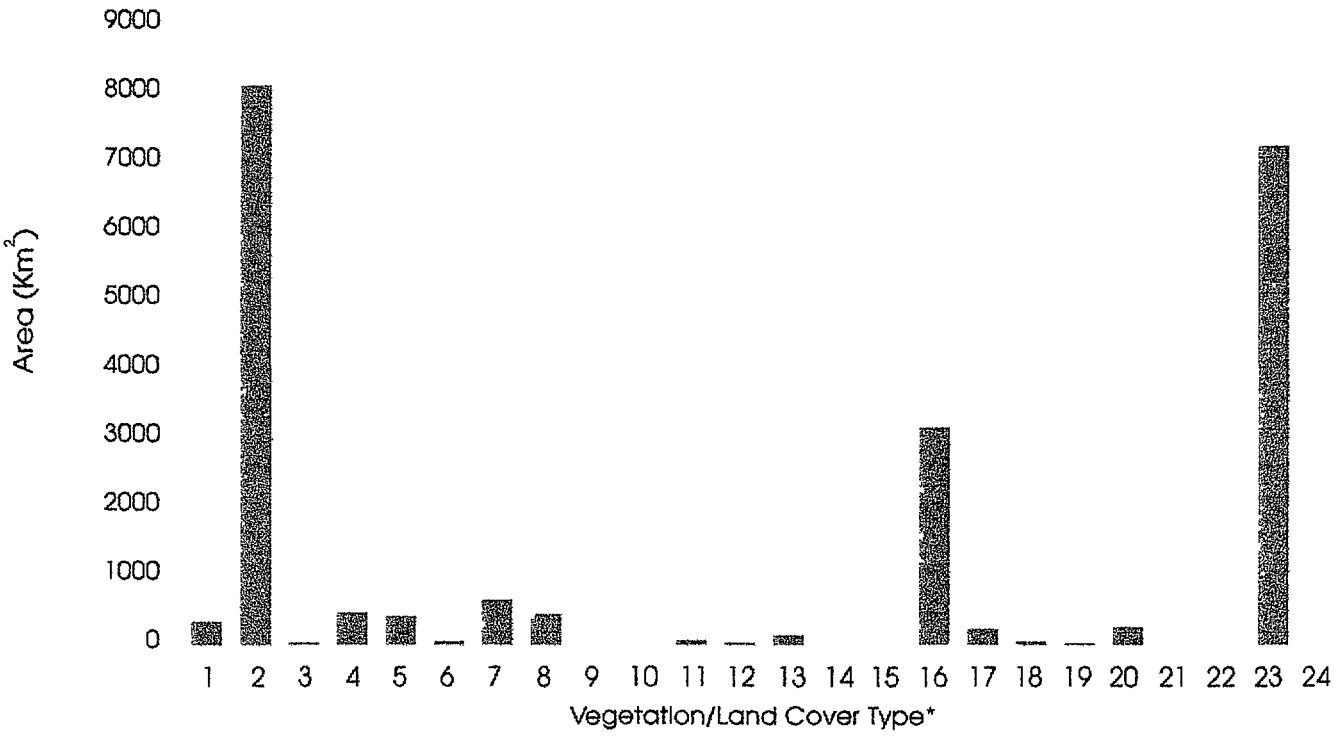
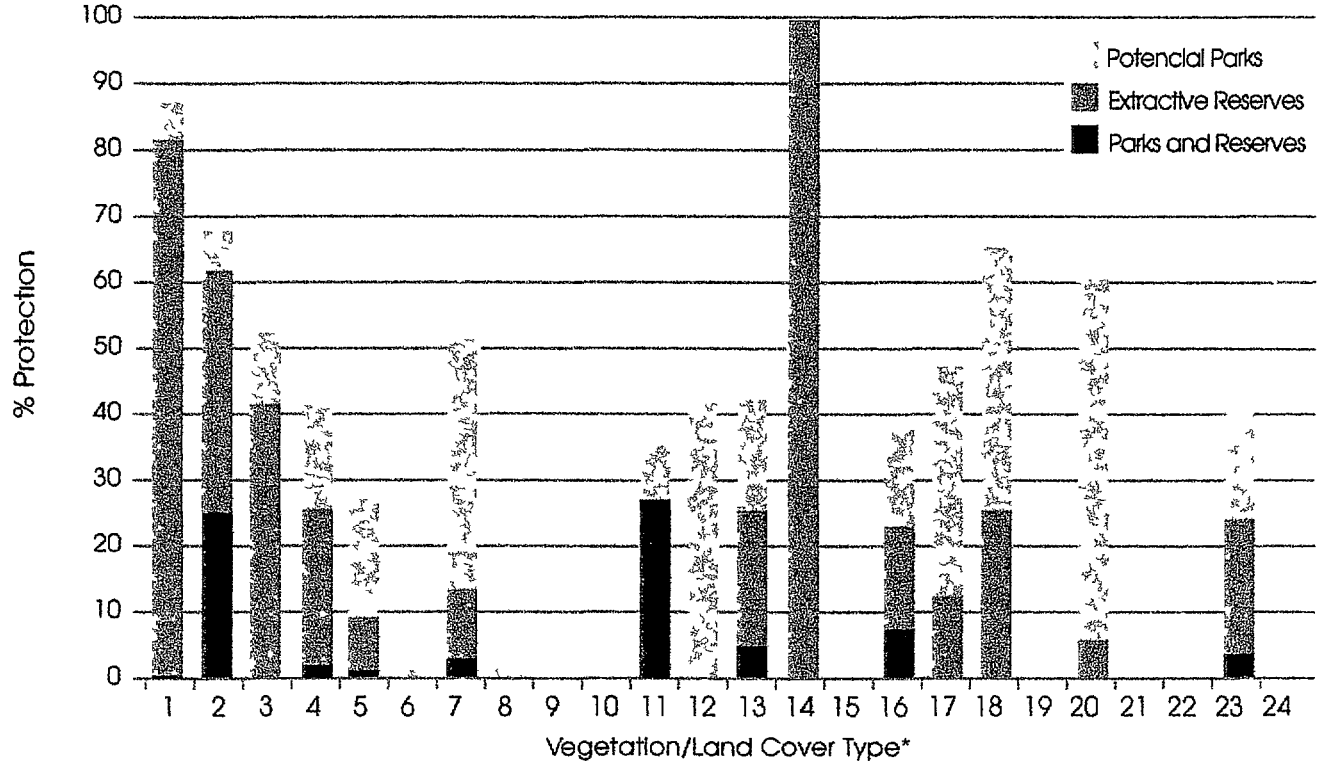


Figure A7b Protection status of Vegetation/Land Cover in Belize



*Note Numbers refer to vegetation types listed in Table 2

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C Glossary

AVHRR The Advanced Very High Resolution Radiometer (AVHRR) is a broad-band, four or five channel (depending on the model) scanner, sensing in the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum This sensor is carried on NOAA's Polar Orbiting Environmental Satellites (POES), beginning with TIROS-N in 1978

GAP A species or community under represented in the existing protected area network A missing component in a strategy to conserve biodiversity

GAP analysis The generalized technique of creating GIS data sets of various biological factors, and overlaying them to identify critical components and important areas under represented in the current network of protected areas

GIS Geographic Information System (GIS) A digital system of geographically referenced spatially explicit data The system is designed for collecting, storing, retrieving, and analyzing spatial data

APPENDICES

Forest Woody vegetation at least 6 m tall (usually much taller) with a fairly continuous and complete (two-thirds or greater) canopy closure

Herbaceous wetland Vegetated areas characterized by emergent herbaceous aquatic plants, excluding mosses and lichens, e g , freshwater march

Woodland Open stands of trees at least 6 m tall, with crowns often not interlocking, tree canopy discontinuous (often clumped), averaging between two-thirds and 40% overall cover, shrub layer often poorly developed or present only in gaps in the canopy

Savanna Mosaic of trees or shrubs and grassland, between 40% and 10% cover by trees and shrubs

Scrub/Shrub land Vegetated areas dominated by woody plants less than 6 m tall

Grassland Habitat dominated by non-woody plants known as herbs (including graminoids, forbs and ferns), trees and shrubs very widely scattered, if present

Deciduous vegetation Vegetation where the leaves drop in response to an annual unfavorable season

Evergreen vegetation Vegetation with 75% or more of the plants having leaves all year