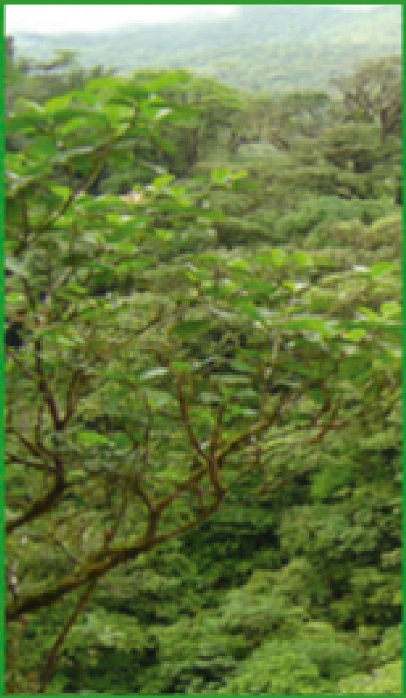
setting biodiversity conservation priorities in Central America



October 2004

Action site selection for the development of a first portfolio

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The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

Meso-American and Caribbean Region
Regional Conservation Science Program

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Executive Summary

Since biodiversity is increasingly threatened in the Neotropics, the need for site-based, high-leverage conservation strategies oriented towards threat abatement and mitigation has become more and more urgent over the last decade. The development of a network of conservation action sites is a prerequisite for the formulation and implementation of such high-yield strategies. Therefore, an interdisciplinary team of scientific experts addressed the need for a network-based portfolio of biodiversity conservation action sites covering a total of 27 terrestrial and 5 marine ecoregions in Central America. During a first-iteration exercise action sites were identified, prioritized and mapped to establish a network-based portfolio applying the *Ecoregional Planning* (ERP) method. First, terrestrial, freshwater and coastal-marine conservation targets at multiple scales and levels of biological organization were selected, representing the whole range of biodiversity. This was done on basis of a gap analysis using existing topographic, geological and vegetation maps, digital elevation models (DEMs), and drainage system information. In combination with *Ecological Land Units* (ELUs), terrestrial targets (vegetation types) occurring along environmental gradients were used as surrogates for levels of biodiversity. Similarly, *Ecological Drainage Units* (EDUs) were applied to determine aquatic targets. Habitat types and ecological systems at the Pacific and/or Caribbean coast were selected as coastal-marine targets. A total of 403 terrestrial, 25 freshwater and 34 coastal-marine conservation targets were selected. GIS-based data analysis resulted in a series of thematic data layers and maps which were reviewed and validated by 46 experts on basis of target occurrences and viability. They identified a total of 143 areas of biodiversity significance including 78 terrestrial, 50 freshwater and 15 coastal-marine areas. To ensure adequate representation, a total of 10 occurrences per target were set as a minimum conservation goal. The final network-based portfolio captured 70% of the terrestrial, 56% of the freshwater and 84% of the coastal-marine goals and included 20 priority areas for immediate action: 3 in Belize, 4 in Guatemala, 3 in Honduras, 2 in Nicaragua, 3 in Costa Rica and 5 in Panama.

Introduction

Over the past decade it has become evident that there is only a limited amount of funds available for addressing the global biodiversity crisis (Groves et al. 2002). The recognition of this trend has had a strong influence on conservation planning methods and strategies worldwide. Facing this challenge The Nature Conservancy (TNC), for instance, has developed a framework for conservation planning in relatively large spatial areas inhabited by terrestrial, freshwater, and near-shore marine species and communities (Groves et al. 2000). This framework has been tested and revised through the preparation and implementation of over 45 ecoregional and regional conservation plans in the United States, Latin America, the Caribbean, Micronesia, and Yunnan, China (*e.g.,* Master et al. 1998; Groves et al. 2002). However, to date no such priority-setting exercise had been conducted for the Central American isthmus. Therefore, a practical yet science-based planning framework for the conservation of biodiversity within Central America was designed as a basis for developing and implementing conservation strategies for identified priority sites. This paper discusses the outcomes of a first-iteration exercise to develop a network-based portfolio of biodiversity conservation action sites along this biodiverse tropical land bridge.

Study Area

This conservation planning exercise was conducted for the terrestrial, freshwater and coastal-marine environments across the Central American land bridge, covering the countries of Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama. The off shore marine environment was not included in this study due to time constraints.

Today's extremely high biodiversity of Central America is the result of a long and complex history of evolutionary and ecological processes. A variety of factors led to the current levels of diversity at gene, species, community, ecosystem and landscape level. Main causes are the region's past history as an archipelago, multi-scale differences in seasonal rainfall patterns (average 500-7,500 mm/year), superimposed on discontinuous mountain chains (0-3820 m elevation; average annual temperature: 32.5 – 7.5 °C) which separate the Pacific from the Atlantic (Caribbean) basin, rich mineral volcanic soils, the influence of past glaciations, and the nearness of large, species-rich continental areas (Hooghiemstra et al. 1992, Kappelle et al. 1992). Especially the evolution of the Isthmus, connecting North and South America, allowed for what has been called the *Great American Biotic Interchange* (Stehli & Webb 1985). Central America's Inter-Oceanic Channel was closed some 3 to 5 million years ago, when the Panamanian Isthmus was formed (Donnelly 1989, Coates 1998). Since that era the immigration of taxa from both the north (today's Mexico) and the south (today's Colombia) has played a principal role in assembling the floristic and faunistic diversity of the neotropical land bridge (Raven & Axelrod 1974).

Due to its enormous biodiversity Meso-America (Central America, including southern Mexico) has been considered a global priority for conservation (Miller et al. 2001). Myers et al. (2000) classified it among 25 hotspots – areas of extreme biodiversity today significantly threatened by mankind. At present, though covering only 530,492 km2 (CCAD 2002), Central America maintains 8 World Heritage Sites, 8 Biosphere Reserves, and 26 RAMSAR Sites (PROARCA 2003), 10 Endemic Bird Areas (EBAs) (Stattersfield et al. 1998), 8 Centers of Plant Diversity (Davis et al. 1997), and 2 ecoregions (Talamancan-Isthmian Pacific Forests, Chocó-Darien Moist Forests) classified among WWF's Global 200 priority ecoregions for conservation (Olson & Dinerstein 1998). It is home to a disproportionate share of the planet's biodiversity, including 3 biomes, 32 terrestrial ecoregions (Olson et al. 2001; Fig. 1), over 300 landscape forms, 2 marine biogeographic provinces and 4 coastal-marine (3 Pacific, 1 Caribbean) ecoregions (Sullivan Sealy & Bustamante 1999), 8 mangrove forest types and 4 coral reef types (PROARCA 2003).

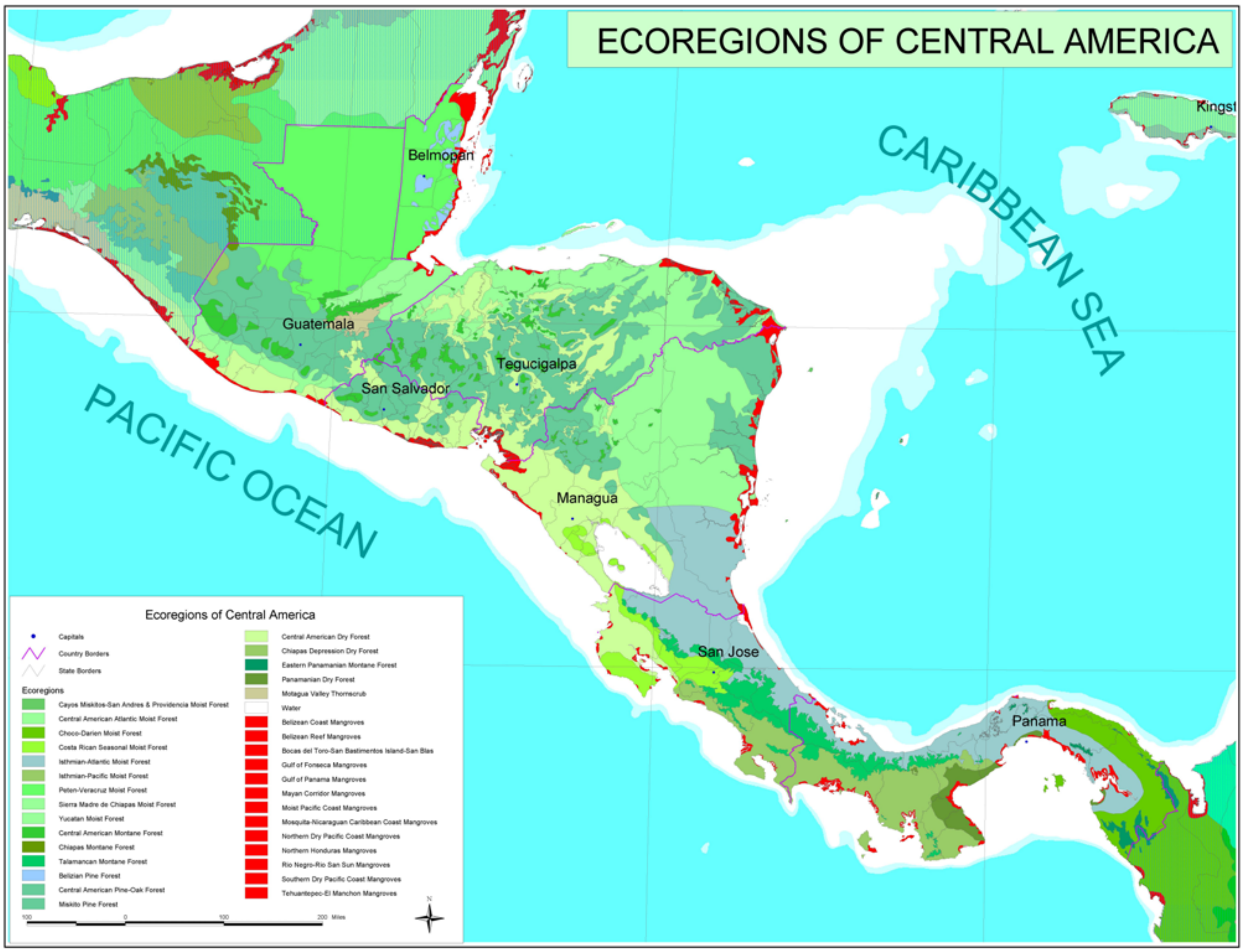


Fig 1. Terrestrial ecoregions of Central America (Olson et al. 2001).

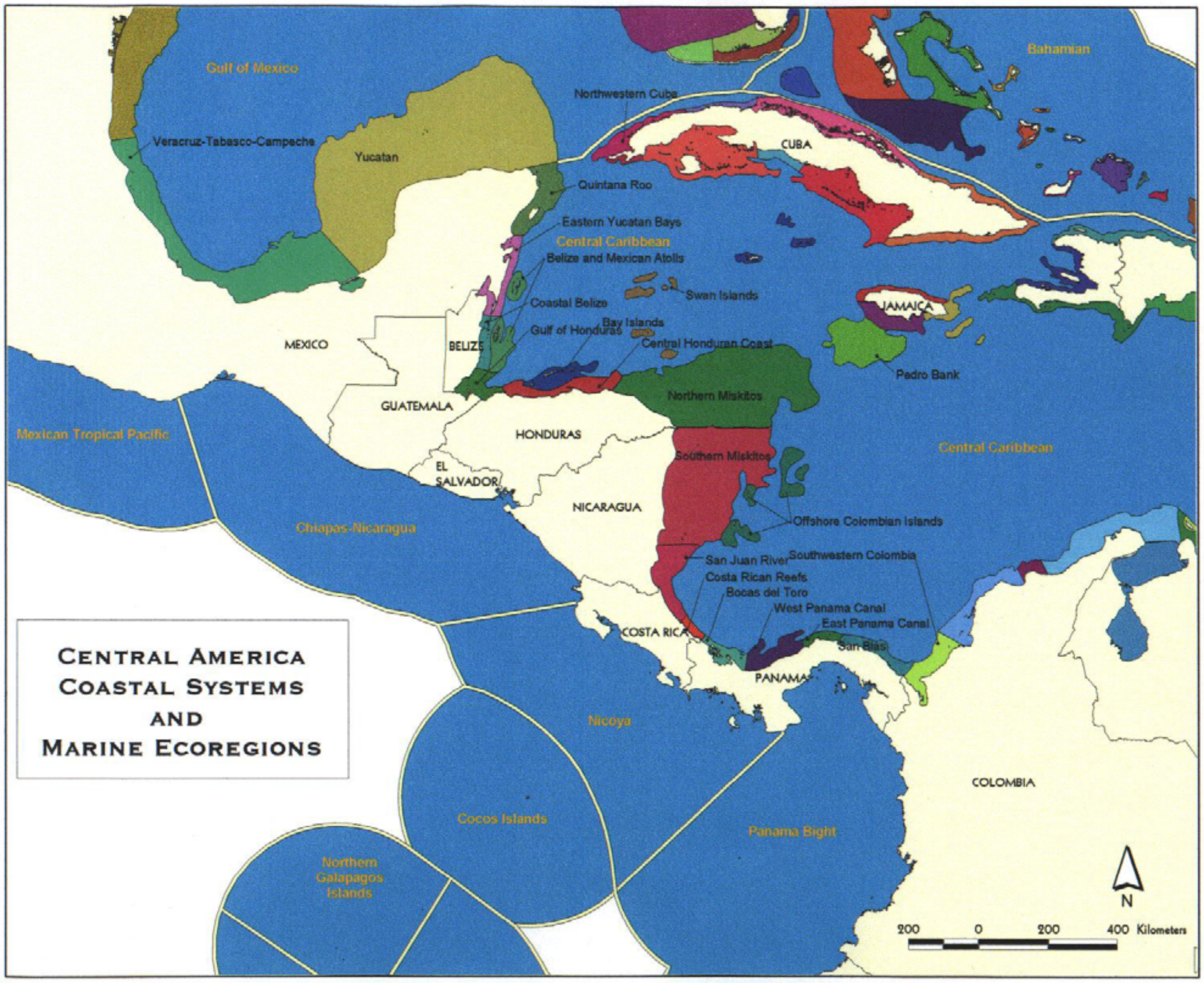


Fig 2. Marine ecoregions of Central America (Sullivan Sealy & Bustamante 1999).

The whole gamut of ecological communities is inhabited by more than 20,000 species of plants of which 20% are endemic to the region, and over 500 mammal (a third endemic) and over 1000 bird species (CCAD 2002). Central America and neighboring southern Mexico are also considered to be one of the world's most important centers of endemic wild species cultivated as agricultural crops, such as maize, squash, various beans, chili peppers, tomato, cacao and avocado (Miller et al. 2001, CCAD 2002).

According to PROARCA (2003) a total of 554 protected wildlife areas –excluding private reserves– has been established in Central America so far, covering 12,964,026 ha (i.e., 24.4% of the region's area, though CCAD [2002] provides a figure of 22.1%). However, it has been recognized at a regional level that the long-term maintenance of Central America's biodiversity is still far from secure as numerous processes driven by its ~34 million human inhabitants continue to pose threats on its natural richness (CCAD 1998). In order to address the biodiversity crisis and its socio-economic implications in Central America and five southern Mexican states (Campeche, Chiapas, Quintana Roo, Tabasco and Yucatan), the Meso-American Biological Corridor (MBC) initiative was created in 1997 (Miller et al. 2001). The CCAD (2002) estimated that about a third (30-35%) of Central America still had forest cover in 2000, while about 41% of the land was under some kind of agricultural regime at that time. The goal of the MBC – the most extensive regional platform of sustainable development in the world – is to offer a means to maximize conservation benefits while improving social and economic opportunities by applying a bioregional approach (Miller et al. 2001). TNC's coherent conservation planning effort to develop a portfolio of action sites in Central America contributes significantly to this wider conservation-oriented sustainable development goal.

Methods

The *Ecoregional Planning* (ERP) method was applied in order to conduct a first-iteration exercise to develop a network-based portfolio of conservation action sites as a planning framework for biodiversity conservation in Central America. This method is based on theories and principles from ecology and conservation biology, has been developed in consultations with scientists from research, natural resource management, and conservation institutions and organizations and has been described in detail in *Geography of Hope* (Groves et al. 2000). It is embedded in the *Conservation by Design* (CbD) approach, developed by TNC (Groves et. al. 2000), which includes four basic, interrelated, cyclic steps in biodiversity conservation: (a) setting conservation priorities, (b) developing conservation strategies, (c) taking conservation action, and (d) measuring conservation success (Groves 2003, The Nature Conservancy 2003).

ERP is considered a vital tool for conducting conservation priority-setting, the first step (a) of this iterative conservation cycle. It is a straightforward and proven approach to planning for conservation of landscape-scale priority areas as it helps select a representative sample of the biodiversity of the region under consideration and guides decision-making in investing in conservation actions on the ground for the years to come. At the same time, this approach is a prerequisite to successful conservation strategy development –*i.e.* step (b) in CbD- at finer scales (area or site level), for which the so-called *Enhanced Five-S* (E-5-S) approach is used (Low 2003). The E-5-S framework addresses the interrelations among: (1) Systems (or conservation targets); (2) Stresses (or threats); (3) Sources of stress (or sources of threats); (4) Strategies (or conservation actions); and (5) Successes (or conservation impact).

The ERP method consists of a series of steps: (i) identifying and selecting conservation targets; (ii) collecting and managing existing data and identifying information gaps; (iii) setting conservation goals; (iv) assessing viability of conservation targets; (v) selecting and designing a portfolio of conservation sites; (vi) taking conservation action; and (vii) completing the project and planning for the future (Groves et al. 2000, 2002). All steps are sequential, with exception of the information-collection-and-management step (ii), which is a continuous activity taking place during the whole process.

Due to the limited availability of data and information in Central America, especially on the precise presence, location and population size of species and community level conservation targets, it was necessary to make specific modifications to the ERP methodology. The two main changes concerned the collection and management of broad-scale data in stead of detailed information and the definition of coarse level conservation targets in lieu of fine level conservation systems.

The first step of the ERP process aimed at selecting representative terrestrial and freshwater conservation targets at multiple scales and multiple levels of biological organization. This was done in an attempt to ensure representation of the whole range of biodiversity. Coarse scale targets (ecological communities and systems) were preferred above fine-scale targets (species). Coastal-marine targets were selected from habitat types and ecological systems along the isthmian shores, assuming they serve as biodiversity surrogates (O. Salas, 2002, pers. com.). They were mapped in discrete quadrants for the Pacific and/or Caribbean coasts in accordance with the biogeographic provinces, marine ecoregions, and coastal systems described by Sullivan Sealy and Bustamante (1999). Then, identified targets were run through a presence/absence matrix for each quadrant in order to determine the location of the targets.

Off shore marine targets were not included in the analysis as the planning included only the Central American land bridge itself. Terrestrial and freshwater targets were selected on basis of a gap analysis, using existing topographic, geological and vegetation maps, *Digital Elevation Models* (DEMs), and drainage system information. The DEM used in this análisis was the1 km pixel resolution data from GTOPO30 (USGS, 1996) and showed the following distinct elevation classes: (a) Pacific slope: 0-1,200 m, 1,200-1,800 m, 1,800-2,500 m, and over 2,500 m; (b) Caribbean slope: 0-500 m, 500-1,200 m, 1,200-1,800 m, 1,800-2,500 m and over 2,500 m.

In combination with *Ecological Land Units* (ELUs; Anderson et al. 1998), terrestrial targets (*i.e.,* vegetation types according to USFS' National Vegetation Classification) occurring along environmental gradients (temperature [elevation], humidity [slope aspect], geology) were used as surrogates for levels of biodiversity.

Following Higgins et al. (2002), *Ecological Drainage Units* (EDUs) were developed on basis of GTOPO30 (USGS 1996) to stratify and prioritize freshwater ecosystem-level targets across the Central American region. Freshwater ecosystem targets, similar to the terrestrial targets, were developed as surrogates for biodiversity using the environmental variables of watershed slope, total river length (km), geologic origin of watershed, drainage direction (Pacific or Caribbean) and river mouth characteristics (e.g., draining into a lake, ocean, estuary, mangrove forest, etc.).

The availability of large-scale spatial data on Central America's vegetation and land cover (PROARCA's Gap Analysis: The Nature Conservancy 1996) in combination with recent satellite imagery catalyzed the interpretation of the unique landscape features present along the Isthmus. This, in turn, facilitated the selection of terrestrial, freshwater and coastal-marine course-scale targets (ecological systems).

Data were collected from multiple sources and managed in a consistent manner in tabular and geo-spatial (GIS) formats. A data gap analysis across the region identified the lack of consistent and comparable (field) data on fine-scale conservation targets (*e.g.,* species and communities). For this reason fine-scale targets were omitted from the ER planning process and only course-filter target information (*e.g.,* biophysical and vegetation data) was entered into the data base, as a surrogate for multiple-scale biodiversity. Map data layers (geology, elevation, topography, aspect, drainage and vegetation) from different sources were integrated in a GIS for analysis and resulted in a series of thematic, course-scale (1:500,000 -

1:1,000,000) data layers and maps. The most important spatial data layers consulted were: aspect (The Nature Conservancy 2000), biogeographic fish provinces (Bussing 1985), elevation (USGS 1996), gap analysis (The Nature Conservancy 1996), geology (Central American national geographic institutes), marine ecoregions (Sullivan Sealy & Bustamante 1999), protected areas and vegetation (The Nature Conservancy 1996), rivers and streams (ESRI 1993), terrestrial ecoregions (Dinerstein et al. 1996), topography (ESRI 1993), and watersheds (The Nature Conservancy 2000).

Since geological maps had different classifications for each country, geology map information was lumped into eight distinct types, chronologically ordered (from Quaternary to Cretaceous): (1) alluvial sediments, (2) other, non-alluvial sediments, (3) limestone rocks, (4) volcanic basaltic rocks, (5) extrusive rocks other than basalt, (6) intrusive rocks, (7) greenschist metamorphic rocks, and (8) serpentine metamorphic rocks.

The active participation of experts was crucial to bridge the existent gap in published field data. It was assumed that a wide variety of expert knowledge on biodiversity and physical aspects could considerably and adequately contribute to successful portfolio development. Therefore, a total of 46 experts (see Acknowledgements) from six Central American countries (El Salvador was not included) were convened and consulted at participatory workshops in Costa Rica (September 2000) and Belize (November 2001).

First, the experts assisted in validating conservation targets by reviewing the methods applied and the GIS-based thematic data layers and maps prepared during the process of target selection. They validated and complemented the preliminary results with more detailed information and were instrumental in developing conservation goals for each target, assessing target occurrence, viability and threats, mapping best occurrences of viable representations of biodiversity, and designing the final portfolio of action sites. A threat assessment was conducted for each potential portfolio area using the strategic concepts of stresses and sources of stress as key components of the *Enhanced Five-S* (E-5-S) framework (Low 2003, Groves 2003) and the concept of functional landscapes as presented by Poiani et al. (2000). Threat assessment based on expert knowledge included the identification of main stresses and sources of stress affecting the entire Central American isthmus. Therefore, they can be classified as multi-site or multi-area stresses and sources of stress.

Conservation goals were set with the aim to estimate the level of conservation effort necessary to sustain a target at viable numbers over a specified planning horizon (Groves et al. 2000; see also Soulé & Sanjayan 1998). Following Anderson et al. (1998) and Higgins et al. (2002), realistic conservation goals were established. Conservation target viability was assessed at the ecoregional level following Groves et al. (2000) and at the site or area level following Poiani et al. (2000). Target viability –the target's ability to persist– was evaluated on the basis of three main criteria: (1) size (a measure of area), (2) condition (a measure of the quality of biotic and a-biotic factors, structures and processes), and (3) landscape context (a measure of connectivity and intactness); (Morris et al. 1999). Experts then marked at least ten best (viable) occurrences per target on the printed maps. The marked occurrences of terrestrial targets were subsequently mapped in a more precise manner, on basis of landscape-scale topographic and vegetation boundaries and features. The same was done for occurrences of freshwater targets, though on basis of watershed limits, and for coastal-marine targets on basis of coarse bathymetric information, and borders of mangrove forests, and coastal lagoons and plains. As a next step, the marked occurrences were digitized in a GIS using the ESRI-developed *ArcView v. 3.2* software.

Selection of the best occurrences of each target, including at least ten viable occurrences per target, resulted in a final, expert-driven assembly of a portfolio of complementary conservation action sites (areas) covering coarse-scale terrestrial, freshwater and coastal-marine targets. Consequently, a network of conservation areas employing biogeographic principles was designed. This step was crucial for the following prioritization exercise which resulted in a total of twenty conservation action sites (areas) on the Central American isthmus.

Biophysical and socio-political criteria for prioritization were: (a) biophysical: watershed distribution, number of existing terrestrial, freshwater and coastal-marine targets, and total area (in ha) covered by terrestrial targets; (b) socio-political: protected areas, threats, feasibility, current and potential conservation partners, national/regional political will and interest, multi-site strategy platforms, leverage, local commitment, funding potential, accessibility, safety and security, current and potential social conflict, and high potential of added value through conservation action by TNC. Main non-biophysical criteria used for ranking important, potential conservation areas were presence of a potential partner, presence of a platform for multi-site strategies, potential for funding, potential of added value by TNC, threat level, and potential social conflict

The group of experts ranked the potential conservation areas according to these criteria, in a range from 1 to 3. This enabled the team to set priorities for action among the portfolios of potential conservation areas. This resulted in a set of conservation action areas for the final network-based portfolio assembly, integrating the terrestrial, freshwater and coastal-marine sub-portfolios, while maximizing the largest possible area (large-sized occurrence) of each viable target. The final portfolio was ultimately reviewed to analyze the ratio of success at meeting the conservation goals set at the start of the ERP process.

Results and Discussion

The ELU analysis resulted in the selection of a total of 403 terrestrial conservation targets (Fig. 3) occurring along environmental gradients and distributed over 27 terrestrial and 5 marine ecoregions across the entire isthmus.

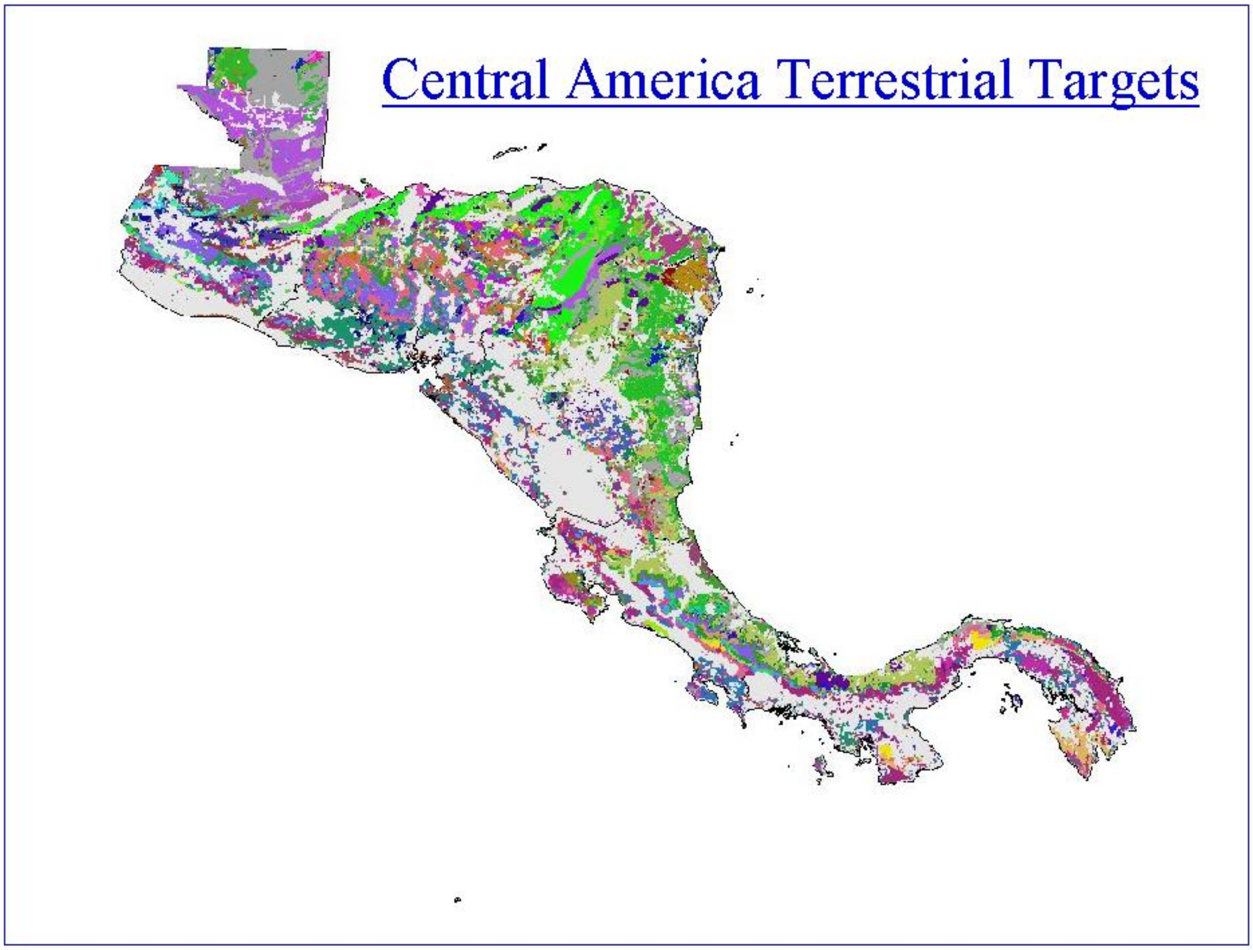


Fig. 3. Terrestrial targets for Central America representing vegetation types distributed and identified by drainage (aspect), geology and elevational gradients.

The parallel analysis provided 25 freshwater conservation targets (ecological systems, [sub]watersheds), distributed over four EDUs: the Tectonic South Pacific, the Volcanic Pacific, the San Juan and the Usumacinta (Fig. 4).

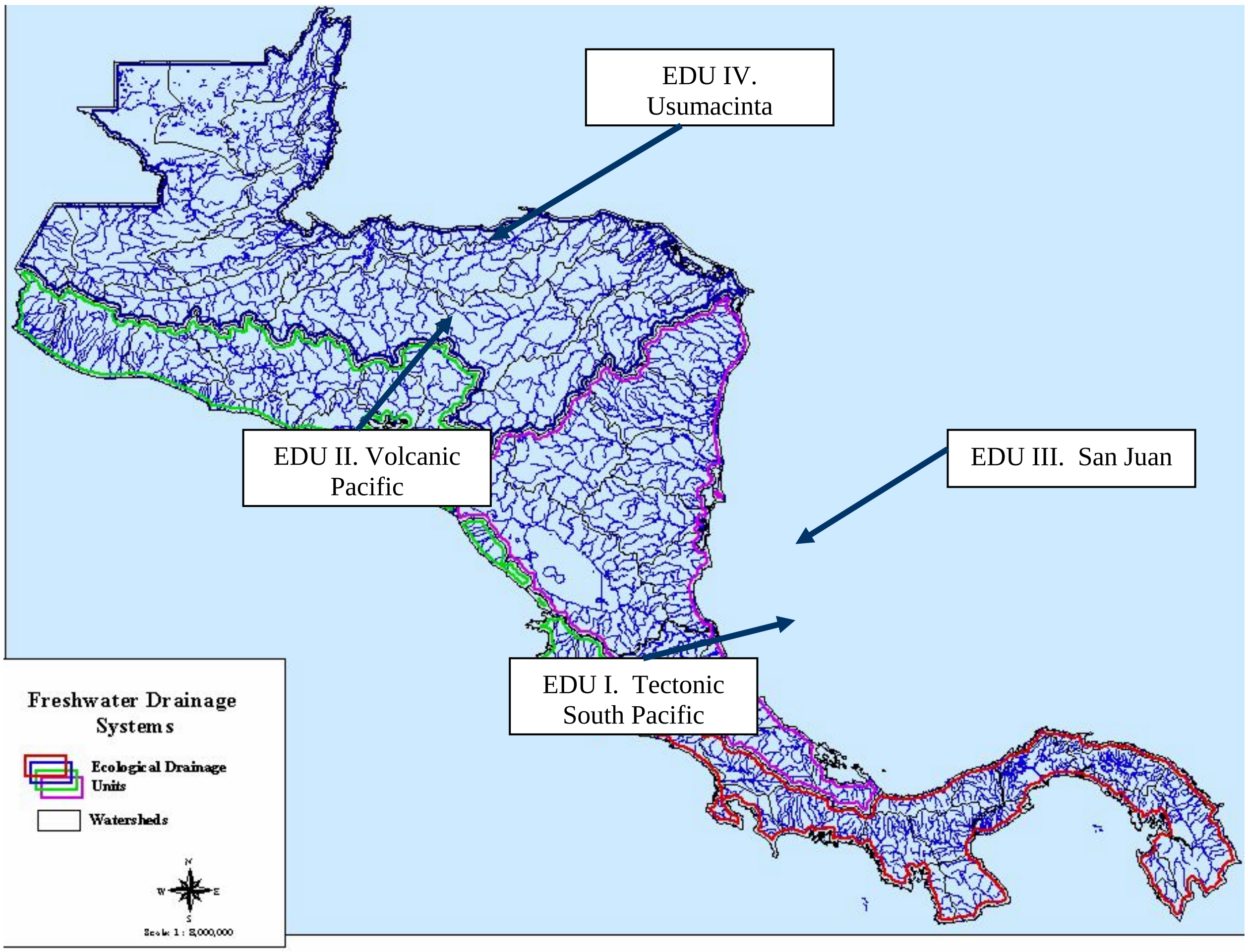


Fig. 4. Freshwater targets for Central America. Targets are depicted according to EDU, gradient, length, geological origin and influence (drainage orientation).

Additionally, a total of 34 coastal-marine conservation targets were selected (Fig. 5).

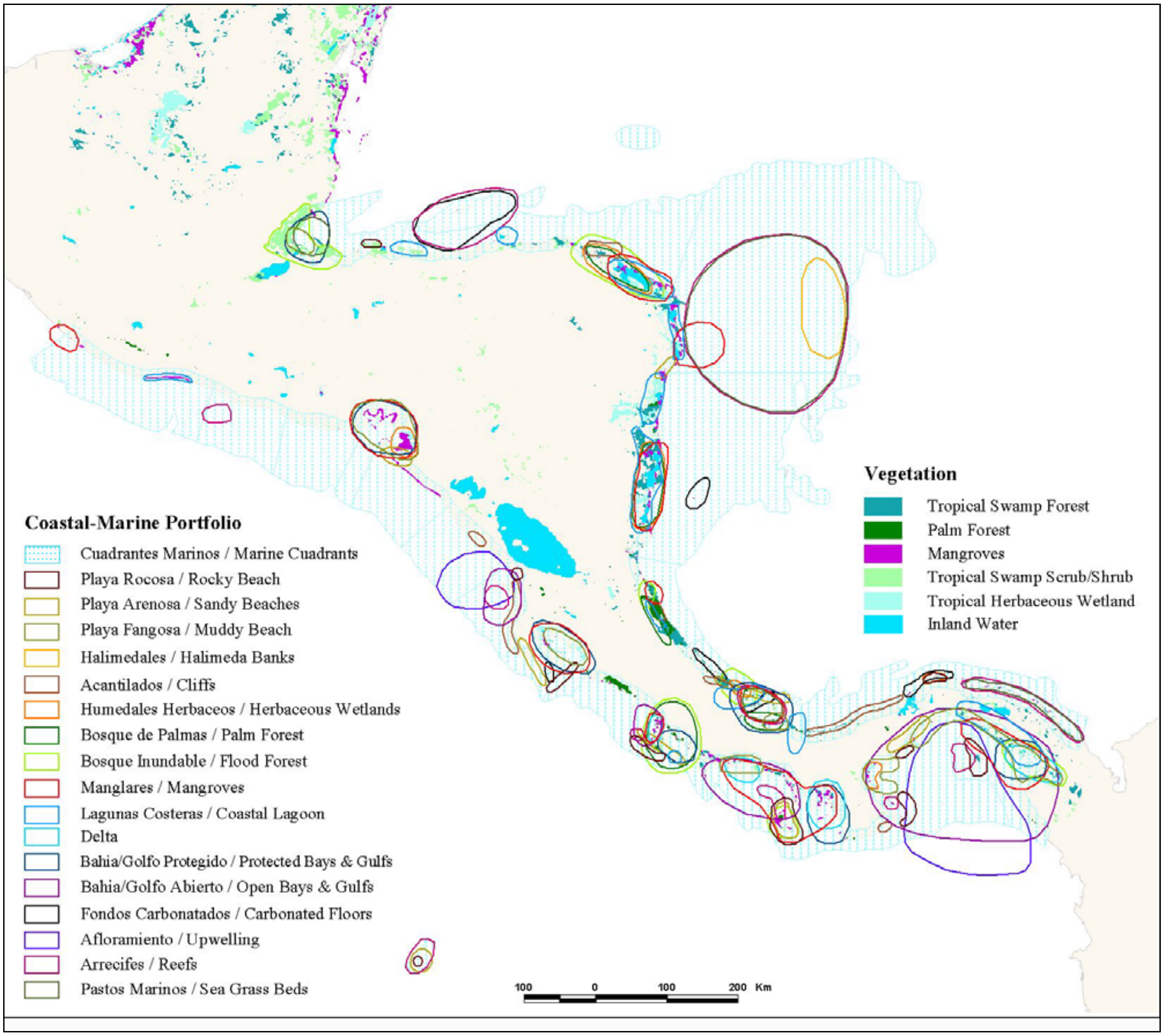


Fig. 5. Coastal-marine targets for Central America.

The latter were grouped by habitat type dominance (e.g., coral reefs, sandy beaches, sea grass beds, mangroves, upwelling sites, rocky platform or mixed types). Realistic conservation goals were developed by the experts for all or for groups of targets as two viable target occurrences per stratification unit. The target occurrence assessment resulted in the mapping of a minimum of ten wide-ranging, viable and best occurrences per target. This occurrence level was considered to represent long-term viability of that specific target. Figs. 6 and 7 show the results of the viability analysis for freshwater, terrestrial and coastal-marine components separately.

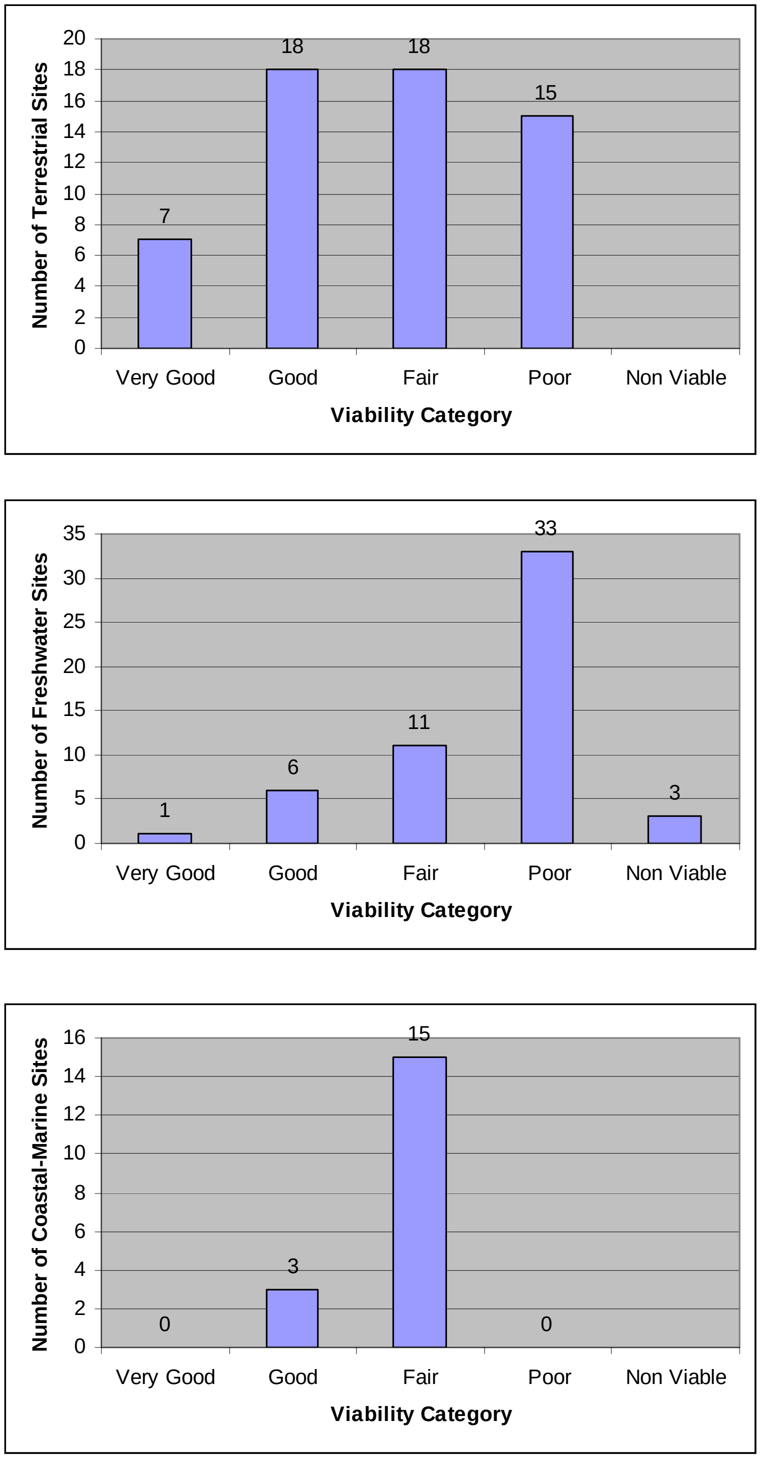
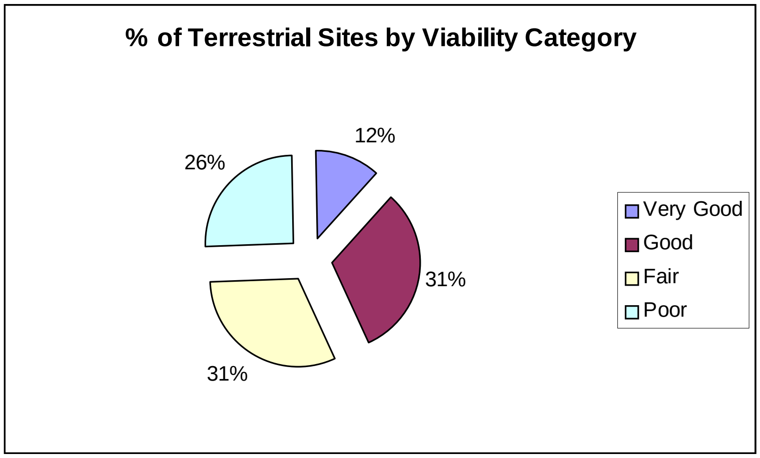
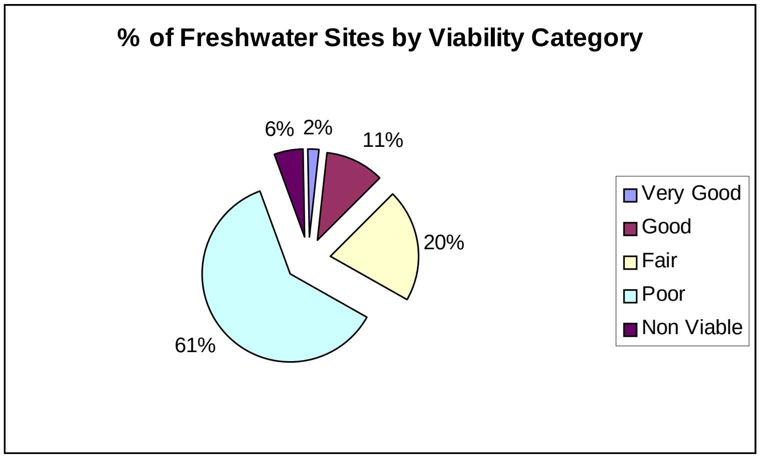


Fig. 6. Number of terrestrial (top), freshwater (center) and coastal-marine (bottom) conservation sites by viability category for the Central American portfolio.





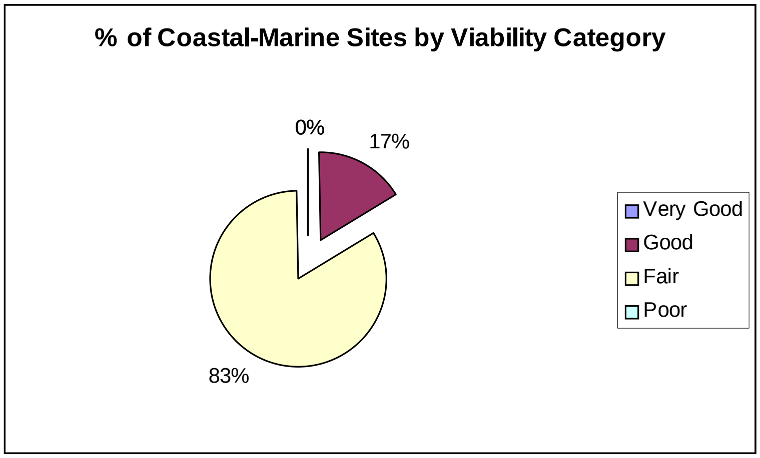


Fig. 7. Percentage of of terrestrial (top), freshwater (center) and coastal-marine (bottom) conservation areas by viability category for the Central American portfolio.

A high percentage present values for viability categories as "fair" and "poor", probably due to the fact that experts considered target restoration or "bringing them back" as feasible, because most environmental and biological processes were still present.

Main stresses and sources of stress occurring across the Central American region are listed in Table 1. Their possible impact on terrestrial, freshwater and coastal-marine targets is indicated. The four main stresses are: (1) disturbance, fragmentation, and conversion of habitats; (2) alteration of species composition and community structure of ecological systems; (3) alteration of hydrological regimes; and (4) alteration of erosion and sedimentation rates, and nutrient fluxes and cycles. The five most important sources of threats as identified by experts are: (a) intensification of (industrial) agricultural practices, (b) deforestation, (c) altered fire regimes, (d) unsustainable fishing practices, and (e) overgrazing.

Table 1. Major stresses (italic case) and sources of stress (plain case) for Conservation areas in Central America. Data based on expert knowledge. Environments: T = terrestrial areas; F = freshwater areas, M = coastal-marine areas.

Stress Source of stress	Affected Environment		
Habitat Fragmentation, Disturbance and Conversion			
Intensive/commercial agriculture	T	F	M
Land Tenure/Legal	T		
Overgrazing	T	F	M
Deforestation, Excessive Logging, Selective Logging	T	F	
Misuse of Fire	T	F	
Unsustainable Fisheries			M
Unsustainable Tourism	T		M
Altered Composition and Structure			
Land Tenure/Legal	T		
Overgrazing	T	F	M
Deforestation, Excessive Logging, Selective Logging	T		
Misuse of Fire	T		
Unsustainable Fisheries practices			M
Unsustainable Tourism	T		M
Water Pollution		F	M
Exotic/invasive species	T	F	
Hydrological Alteration/Sediment Regime			
Urban Sprawl/development		F	M
Dams/energy structures		F	M
Transportation/tourism development	T	F	M
Sedimentation/nutrient loading			
Animal husbandry/grazing	T	F	M
Urban Sprawl/developmentT		F	M
Dams/energy structures		F	M
Transportation/tourism development		F	M
Deforestation, Excessive Logging, Selective Logging		F	M
Overgrazing		F	M

Experts identified a first set of 143 areas of biodiversity significance, including 78 terrestrial, 50 freshwater and 15 coastal-marine areas (targets), distributed over seven Central American countries (Table 2). Targets are listed in Appendices 1 (78 terrestrial areas), 2 (50 freshwater areas) and 3 (15 coastal-marine areas). Next, the terrestrial, freshwater and coastal-marine targets were grouped into three separate portfolios which were subsequently mapped (Figs. 8, 9, 10).

Table 2. Conservation areas (targets) of biodiversity significance distributed per country and environment.

Country	Terrestrial Areas	Freshwater Areas	Coastal & Marine Areas	Total Areas
Belize	7	4	4	15
Costa Rica	13	7	3	23
El Salvador	3	3	1	7
Guatemala	21	9	1	31
Honduras	16	7	4	27
Nicaragua	13	11	2	26
Panama	14	13	4	31
Total Areas	78	50	15	143

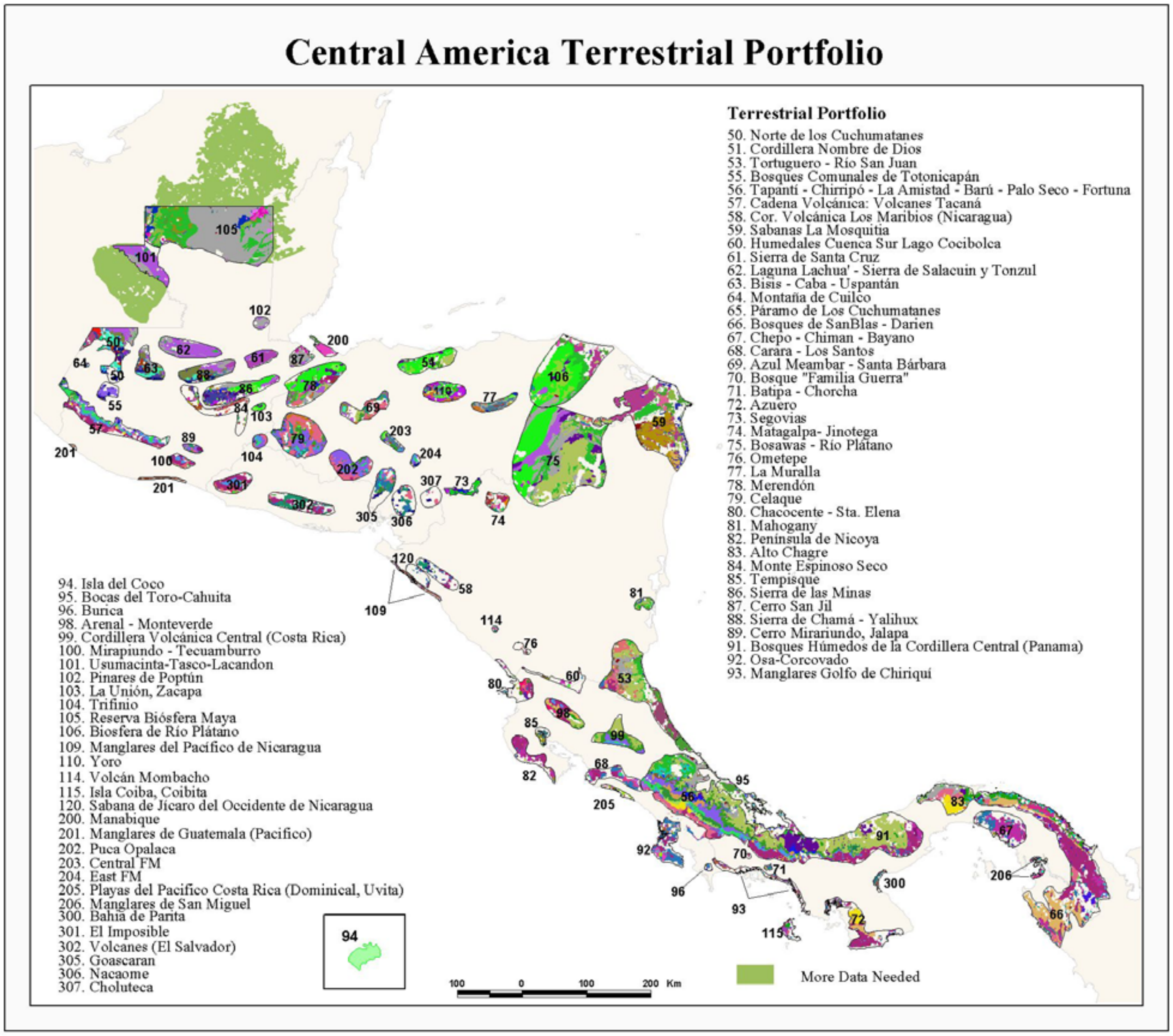


Fig. 8. Terrestrial conservation portfolio for Central America. Conservation areas are depicted by name and number.

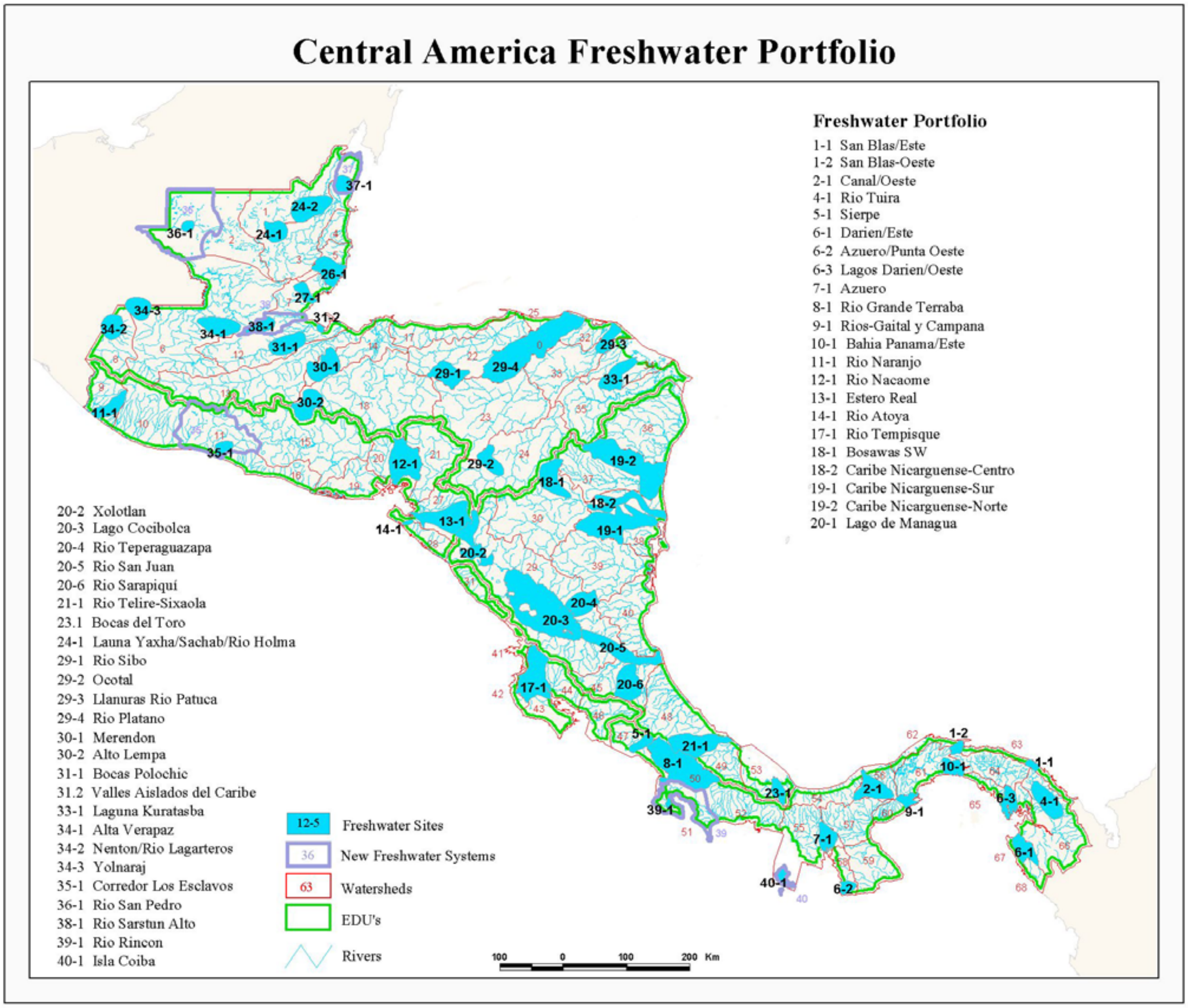


Fig. 9. Freshwater conservation portfolio for Central America. Conservation areas are depicted by name and number. The Belizean freshwater areas of New River (24-2), Eastern Maya Mountains (26-1) and Shipstern Reserve (37-1) are shown but do not appear in the map legend.

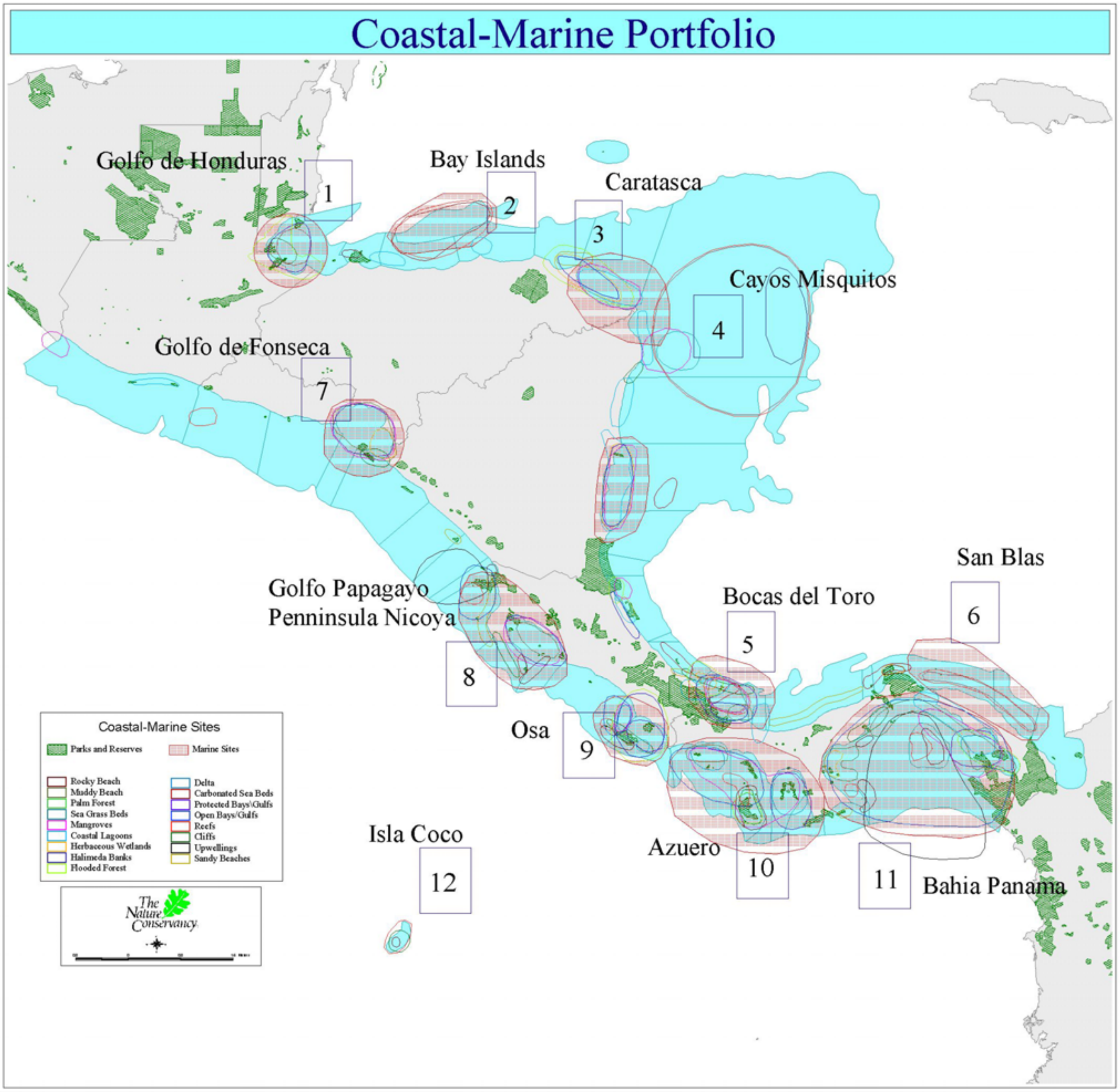


Fig. 10. Coastal-marine conservation portfolio for Central America. Conservation areas are depicted by name and number. The Belizean coastal-marine areas known as Central Barrier Reef Complex (13), Chetumal-Ambergis (14) and Oceanic Atolls (15) are not indicated in this map as they were identified during a separate workshop in Belize.

As a logical next step, experts ranked potential conservation areas in a range from 1 to 3 for each of the criteria mentioned. Table 3 shows the results of this exercise, which led to a portfolio assembly of 20 complementary conservation action sites (areas), covering coarse-scale terrestrial, freshwater and coastal-marine targets. These 20 priority areas selected for immediate conservation action included 3 sites in Belize, 4 in Guatemala, 3 in Honduras, 2 in Nicaragua, 3 in Costa Rica and 5 in Panama.

Table 3. Ranking of conservation areas on basis of selected non-biophysical criteria. Ranking was done by experts at workshops. Data for Belizean sites were not included as no Belizean experts participated in the workshop during which the ranking exercise was conducted. Only the twenty highest ranking conservation areas are listed and included in the final Central American conservation portfolio.

Nr	Name	Main Country	Criteria[1]						
			1	2	3	4	5	6	Average
1	Mesoamerican Reef	Belize	-	-	-	-	-	-	-
2	Maya Mountains	Belize	-	-	-	-	-	-	-
3	Río Bravo	Belize	-	-	-	-	-	-	-
4	Lacandón-Maya Forest	Guatemala	3	3	3	2	2	3	2.67
5	Gulf of Honduras	Guatemala	3	3	3	2	2	3	2.67
6	Cordillera Volcánica Occidental	Guatemala	2	3	3	2	2	3	2.50
7	Sistema Motagua – Polochic	Guatemala	3	3	3	2	2	3	2.67
8	Río Platano – Caratasca – Mosquitia	Honduras	3	3	2	3	2	3	2.67
9	Azul Meámbar – Santa Barbara	Honduras	3	3	2	3	3	3	2.83
10	Bay Islands	Honduras	3	3	3	3	3	3	3.00
11	Río San Juan - Lago de Nicaragua	Nicaragua	2	3	2	3	3	3	2.67
12	Bosawas	Nicaragua	3	3	2	3	2	2	2.50
13	Talamanca Pacífico	Costa Rica	3	3	3	3	3	3	3.00
14	Osa – Corcovado	Costa Rica	3	3	3	3	3	3	3.00
15	Talamanca Caribe	Costa Rica	3	3	3	3	3	3	3.00
16	Bocas del Toro	Panama	2	3	3	3	3	3	2.83
17	Darien – San Blas	Panama	2	2	2	2	3	1	2.00
18	Cordillera Central	Panama	2	3	2	3	2	3	2.50
19	Chiriquí – Azuero	Panama	2	3	3	3	2	3	2.67
20	Canal Watershed / Río Sucio	Panama	3	3	3	2	2	2	2.50

[1] Criteria: 1 = presence of a potential partner; 2 = platform for multi-site strategies; 3 = potential for funding; 4 = potential added value by TNC; 5 = threat level; 6 = potential social conflict.

Fig. 11 shows the final network-based portfolio of priority sites for conservation action in Central America.

Fig. 11. Final "first iteration" portfolio of conservation action areas for Central America, based on a ranking analysis of potential areas depicted in separate portfolio maps of terrestrial, freshwater and marine targets. Conservation areas are displayed by name and number.

To ensure adequate representation, a total of 10 occurrences per target were set as a minimum conservation goal. This final network-based portfolio captured 70% of the terrestrial, 56% of the freshwater and 84% of the coastal-marine goals (Figs. 12, 13).

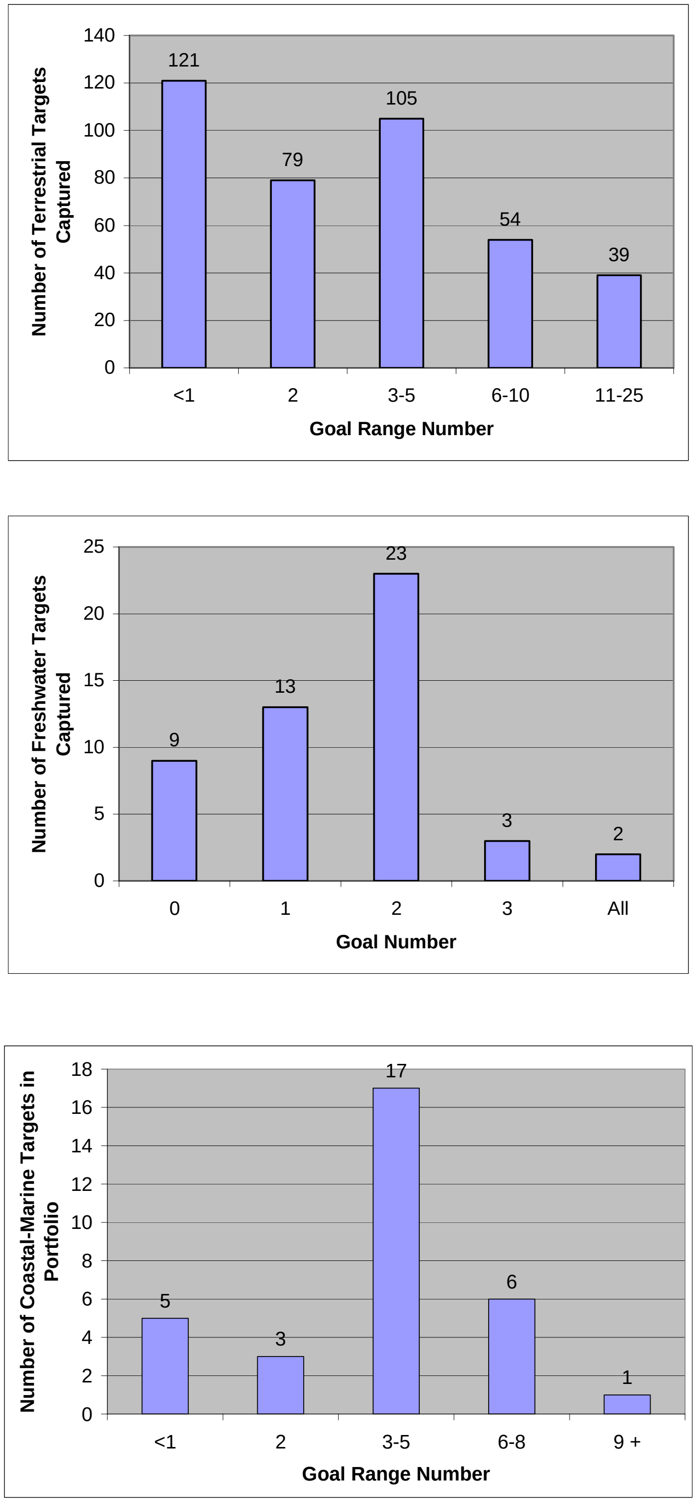


Fig. 12. Number of terrestrial (top), freshwater (center) and coastal-marine (bottom) conservation targets in the Central American portfolio presented by range of goal capture.

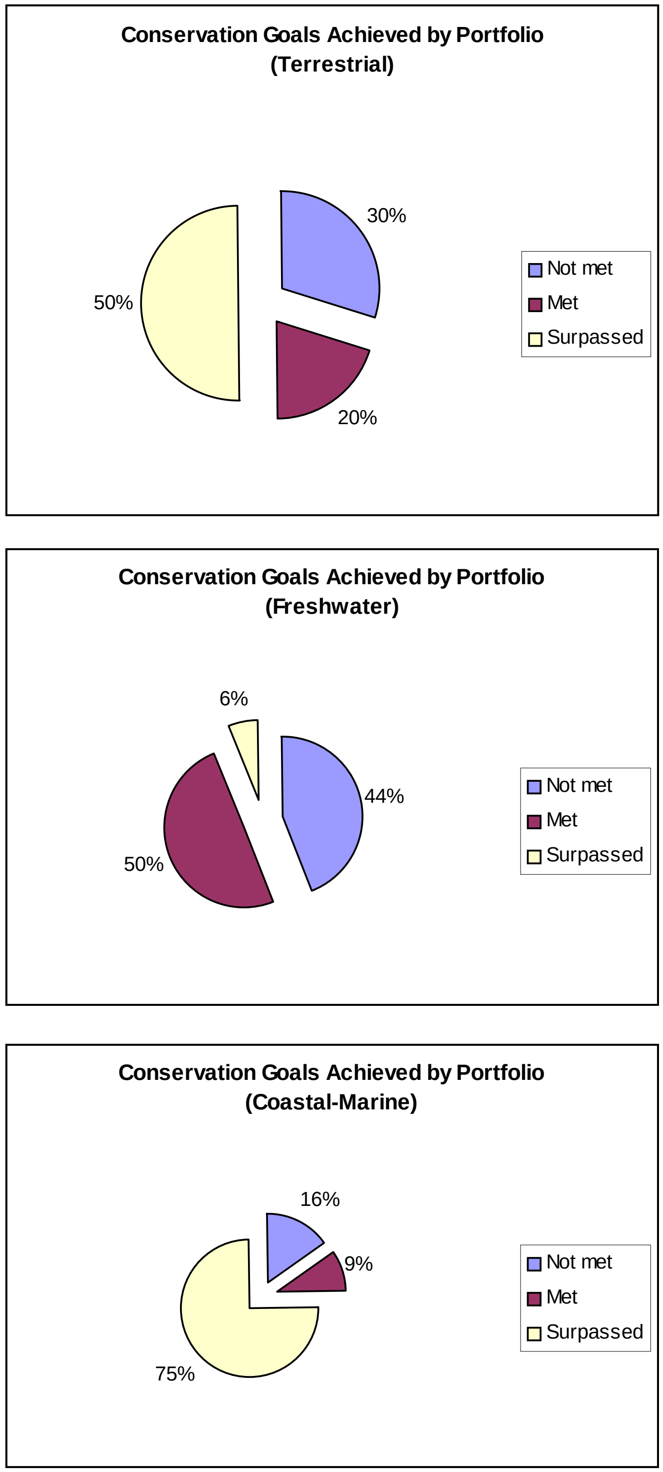


Fig. 13. Percentage of terrestrial (top), freshwater (center) and coastal-marine (bottom) conservation targets that met, did not meet, or surpassed the goals set during Central American portfolio development.

Conclusion

The assembly of a "first iteration" portfolio of Central American conservation sites developed during this exercise is an essential first step towards enhanced conservation action on the ground. It will help to design creative, detailed and efficient conservation strategies directed at successfully abating threats and sources of stress affecting terrestrial, freshwater and marine biodiversity in Central America. However, it is clear that a second iteration –a portfolio update– is necessary as new data and technology have become available. Such a portfolio update should involve partners from the beginning of the planning process in order to ensure implementation of the ecoregional plan. The creation of an enabling environment will be a key issue to the success of any future ecoregional assessment. The forth-coming development of a GIS-based ecoregional decision-support system fed with well organized biological, ecological, and socio-economic information, structured in an open-architecture, will be a vital tool in decision-making by governmental agencies, local NGOs and other actors. Such a seamless GIS database should be made freely available to interested stakeholders via the internet.

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Appendix 1. List of 78 terrestrial areas of biodiversity significance in Central America, identified, reviewed and validated by experts during ecoregional planning workshops.

Number	Map Code	Name	Country/ies
1	50	Cuchumatanes	Guatemala
2	51	Cordillera Nombre de Dios	Honduras
3	53	Tortuguero-Río San Juan	Costa Rica - Nicaragua
4	55	Totonicapan	Guatemala
5	56	Tapantí-Chirripó-Amistad	Costa Rica - Panama
6	57	Volcanes Tacaná	Guatemala
7	58	Cordillera Volc. Los Maribios	Nicaragua
8	59	Sabanas La Mosquitia	Nicaragua - Honduras
9	60	Humedales Sur Lago Cocibolca	Nicaragua - Costa Rica
10	61	Sierra de Santa Cruz	Guatemala
11	62	Lag. Lachua-Srra. de Salacuin, Tonzul	Mexico - Guatemala
12	63	Bisis-Cabá-Uspantan	Guatemala
13	64	Montaña de Cuilco	Guatemala
14	65	Paramo Los Cuchumatanes	Guatemala
15	66	Bosques de San Blas-Darién	Panama
16	67	Chepo-Chiman-Bayano	Panama
17	68	Carara-Los Santos	Costa Rica
18	69	Azul Meambar-Santa Barbara	Honduras
19	70	Bosque "Familia Guerra"	Panama
20	71	Batipa-Chorcha	Panama
21	72	Azuero	Panama
22	73	Segovias	Nicaragua
23	74	Matagalpa-Jinotega	Nicaragua
24	75	Bosawas-Río Platano	Nicaragua - Honduras
25	76	Ometepe	Nicaragua
26	77	La Muralla	Honduras
27	78	Merendón	Honduras
28	79	Celaque	Honduras
29	80	Chacocente-Sta. Elena	Costa Rica - Nicaragua
30	81	Mahogany	Nicaragua
31	82	Peninsula Nicoya	Costa Rica
32	83	Alto Chagra	Panama
33	84	Monte Espinoso Seco	Guatemala
34	85	Tempisque	Costa Rica
35	86	Sierra de las Minas	Guatemala
36	87	Cerro San Gil	Guatemala
37	88	Sierra de Chamá-Yalihux	Guatemala
38	89	Cerro Mariundo, Jalapa	Guatemala
39	91	Cordillera Central	Panama
40	92	Osa-Corcovado	Costa Rica
41	93	Mangroves Golfo de Chiriquí	Panama
42	94	Cocos Island	Costa Rica
43	95	Bocas del Toro-Cahuita	Panama - Costa Rica
44	96	Burica	Costa Rica - Panama
45	98	Arenal-Monteverde	Costa Rica
46	99	Cordillera Central	Costa Rica
47	100	Mirapiundo-Tehuamburro	Guatemala

48	101	Usumacinta-Tasco-Lacandon	Guatemala - Mexico
49	102	Pinares de Poptún	Guatemala
50	103	La Unión-Zacapa	Guatemala - El Salvador
51	104	Trifinio	Guat. - Honduras - El Salvador
52	105	Reserva Biósfera Maya	Guatemala
53	106	Reserva Biosfera Río Plátano	Honduras
54	109	Mangroves (Pacífico)	Nicaragua
55	110	Yoro	Honduras
56	114	Volcán Mombacho	Nicaragua
57	115	Isla Coiba, Coibita	Panama
58	120	Sabana de Jícaro	Nicaragua
59	200	Manabique	Guatemala
60	201	Mangroves (Pacífico)	Guatemala
61	202	Puca Opalaca	Honduras
62	203	Central Francisco Morazán	Honduras
63	204	Este Francisco Morazán	Honduras
64	205	Playas Pacífico	Costa Rica
65	206	Mangroves de San Miguel	Panama
66	300	Bahía de Parita	Panama
67	301	El Imposible	El Salvador
68	302	Cordillera Volcánica	El Salvador
69	305	Goascorán	Honduras - El Salvador
70	306	Nacaome	Honduras
71	307	Choluteca	Honduras
72	308	Chiquibul complex/Maya Mountain	Belize
73	309	Northern Savannas	Belize
74	310	Eastern Corozal	Belize
75	311	Río Bravo/Gallon Jug	Belize
76	312	Lowland Alluvial Complex	Belize
77	313	Southern Temash Delta	Belize
78	314	Mountain Pine Ridge	Belize

Appendix 2. List of 50 freshwater areas of biodiversity significance in Central America, identified, reviewed and validated by experts during ecoregional planning workshops.

Number	Map Code	Name	Country/ies
1	1-1	San Blas/Este	Panama
2	1-2	San Blas Oeste	Panama
3	2-1	Canal Oeste	Panama
4	4-1	Río Tuira	Panama
5	5-1	Sierpe	Costa Rica
6	6-1	Darien/Este	Panama
7	6-2	Azuero/Punta oeste	Panama
8	6-3	Lagos Darien/oeste	Panama
9	7-1	Azuero	Panama
10	8-1	Río Grande Terraba	Costa Rica
11	9-1	Río Gaital y Campana	Panama
12	10-1	Bahia Panama/este	Panama
13	11-1	Río Naranjo	Guatemala
14	12-1	Río Nacaome	Honduras
15	13-1	Estero Real	Nicaragua
16	14-1	Río Atoya	Nicaragua
17	17-1	Río Tempisque	Costa Rica
18	18-1	Bosawas SW	Nicaragua
19	18-2	Caribe Nicaraguense/centro	Nicaragua
20	19-1	Caribe Nicaraguense/sur	Nicaragua
21	19-2	Caribe Nicaraguense/norte	Nicaragua
22	20-1	Lago de Managua	Nicaragua
23	20-2	Xolotlán	El Salvador
24	20-3	Lago Cocibolca	Nicaragua
25	20-4	Río Teperaguazapa	Nicaragua
26	20-5	Río San Juan	Nicaragua - Costa Rica
27	20-6	Río Sarapiqui	Costa Rica
28	21-1	Río Telire-Sixaola	Costa Rica - Panama
29	23-1	Bocas del Toro	Panama
30	24-1	Laguna Yaxha/Sachab/RíoHolma	Guatemala
31	24-2	New River	Belize
32	26-1	Eastern Maya Mountains	Belize
33	29-1	Río Sibo	Honduras
34	29-2	Ocotal	Nicaragua
35	29-3	Llanuras de Río Patuca	Honduras
36	29-4	Río Plátano	Honduras
37	30-1	Merendon	Honduras
38	30-2	Alto Lempa	Honduras - El Salvador
39	31-1	Bocas del Polochic	Guatemala
40	31-2	Valles aislados del Caribe	Guatemala
41	33-1	Laguna Karatasca	Honduras
42	34-1	Alta Verapaz	Guatemala
43	34-2	Nenton/Río Lagarteros	Guatemala - Mexico
44	34-3	Yolnaraj	Guatemala - Mexico
45	35-1	Corredor los Esclavos	Guatemala - El Salvador
46	36-1	Río San Pedro	Belize
47	37-1	Shipstern Reserve area	Belize

48	38-1	Río Sarstun Alto	Guatemala
49	39-1	Río Rincón	Costa Rica
50	40-1	Isla Coiba	Panama

Appendix 3. List of 15 coastal-marine areas of biodiversity significance in Central America, identified, reviewed and validated by experts during ecoregional planning workshops.

Number	Name	Ocean	Country/ies
1	Golfo de Honduras	Atlantic	Belize – Guatemala - Honduras
2	Bay Islands	Atlantic	Honduras
3	Caratasca	Atlantic	Honduras
4	Cayos Misquitos	Atlantic	Nicaragua
5	Bocas del Toro	Atlantic	Panama
6	San Blas	Atlantic	Panama
7	Golfo de Fonseca	Pacific	Hond. - El Salvador - Nicaragua
8	Golfo Papagayo/Península Nicoya	Pacific	Costa Rica
9	Osa	Pacific	Costa Rica
10	Azuero	Pacific	Panama
11	Bahia Panamá	Pacific	Panama
12	Isla del Coco	Pacific	Costa Rica
13	Central Barrier Reef Complex	Atlantic	Belize
14	Chetumal-Ambergis	Atlantic	Belize
15	Oceanic Atolls	Atlantic	Belize