Ecoregional Assessment of the Greater Caribbean Basin: Designing a Portfolio of Conservation Action Areas

The Nature Conservancy

DRAFT TEXT FOR REVIEW
v.1.0, Sept. 30, 2004.

Ecoregional Assessment Process: Approach and Methods

a. General Approach

The objective of the present Ecoregional Assessment (ERA) exercise was to identify a set of areas of biodiversity significance in the Greater Caribbean Basin which, if conserved, would ensure the persistence of that region's biodiversity. Therefore, an ERA process was initiated by using TNC's step-wise, conservation planning framework (Groves et al. 2002). This framework was applied to ecoregions – large areas of the earth's surface that have similarities in faunal and floral composition due to large-scale, predictable patterns of solar radiation and moisture (Bailey 1998, cited in Groves et al. 2002). The steps of this methodological planning sequence are discussed in the next section.

Although it was planned to adopt the ERA planning methods developed and tested primarily in the continental US, The Nature Conservancy modified this approach to best fit the needs of the Caribbean and address the multiple challenges involved with conservation planning in this region. This approach was firmly grounded in the field of conservation biology and served to meet four general conservation planning objectives that must be satisfied in order to maintain biodiversity and ecological integrity on the long run. These objectives were:

- To ensure representation of all native ecosystem types and sequential stages across their natural range of variation;
- To maintain viable populations of all native species in natural patterns of abundance and distribution;
- To maintain ecological and evolutionary processes, such as disturbance regimes, hydrological processes, nutrient cycles, and biotic interactions;

- To design and manage the system to be resilient to short-term and long-term environmental change and to maintain evolutionary processes.

b. Methodological Planning Sequence

The applied ecoregional conservation planning sequence, which culminated in the identification of a set of areas of biodiversity significance and associated strategies for conservation those areas, included the following nine steps:

1. Creation of an enabling environment by building effective partnerships;
2. Identification and mapping of biodiversity conservation targets;
3. Collection and management of existing data and identification of information gaps;
4. Establishment of conservation goals;
5. Assessment of existing conservation areas for their biodiversity values;
6. Analysis of conservation target viability and human induced impacts;
7. Assembly, design and mapping of a portfolio of conservation areas;
8. Identification of priority conservation areas;
9. Promotion of accessibility and usage of tools and data;

These methodological steps are strongly interconnected. However, it should be recognized that they are not always linear or sequential, but in general occur in the order presented above. Below, each step is discussed in detail.

1. Creation of an enabling environment by building effective partnerships

Ecoregional planning is an exercise no organization can solely conduct without involving stakeholders at multiple scales, from multiple sectors and representing multiple interests. The process of collating terrestrial, freshwater and marine biodiversity data for a region such as the Greater Caribbean Basin is an ambitious undertaking requiring numerous partners at the regional and the national scale. Creating an enabling environment in which partners develop a common, shared vision of the planning process, was key to the success of this exercise. Contributions by partners to the Greater Caribbean Basin biodiversity database served to significantly increase accuracy of target maps and improvement of products for a variety of different user groups.

2. Identification and mapping of biodiversity conservation targets

Selecting and mapping biodiversity elements was conducted to provide an initial basis for conservation decision making. Coarse-filter mapping at the level of ecological communities, ecosystems, landscapes and seascapes was considered an efficient method to represent the majority of species across the entire region (Noss & Cooperrider 1994, Noss 1996). For this reason, a range of coarse-filter targets that represent a full spectrum of terrestrial, freshwater and marine biodiversity was identified and mapped, using combinations of biophysical factors (such as climate, geology, major habitat type, elevation, depth, etc.). A target was defined as an element of biodiversity selected as the focus for conservation planning and action. Coarse-filter information was supplemented with species-specific data (where available), though it was assumed that protecting the mapped coarse-filter targets assured the protection of most if not all elements of Caribbean biodiversity. Species-specific information included rare plant locations, turtle nesting sites and freshwater species distribution lists.

Terrestrial ecosystems were selected as coarse-scale conservation targets within the ecoregions of the Greater Caribbean Basin. They were obtained with two GIS overlays – the Life Zones map based on Holdridge's classification (Holdridge 1967) and a generalized geological map. Their boundaries corresponded to geoclimatic units. These were defined as landscapes that share similar ecological systems or vegetation formations and underlying ecological processes, driven by climate, elevation, and geology. The identification and description of geoclimatic units allowed for stratification of the ecoregions into finer ecological units so as to better understand the distribution patterns of terrestrial biodiversity along the geoclimatic gradients. The selected terrestrial ecosystems served as a filter for plant species associations that adapt to the environmental conditions under similar climatic conditions, as defined by Holdridge's Life Zones, and grow on the same geological parent rock or soil type.

Both course-filter and fine-filter approaches were used to ensure that all representative terrestrial biodiversity was captured in the final ecoregional portfolio. The coarse-filter terrestrial targets, defined by climate and geology, were cross-walked through expert consultation to an accepted vegetation classification system. The current distribution of vegetation formations and their nested plant communities were obtained by overlaying the geoclimatic zones with the most recent land cover map. Much species-level biodiversity, especially plant-species diversity, is included in the vegetation targets. Other species or species groups that are imperiled, endemic, declining or part of important evolutionary lineages were selected with the help of experts as fine-filter targets.

Course-filter targets were identified for the Caribbean freshwater environment, as still very little data are available at the freshwater species and community level in this region. In this way, Ecological Drainage Units (EDUs) served as a starting point for freshwater target identification. EDUs are regional-scale units or groups of watersheds with similar climate, physiography, zoogeography, drainage, density, hydrologic characteristics, and connectivity (Lammert et al. 1997). Identifying and describing EDUs allowed for stratification of ecoregions into hierarchically smaller units in which patterns of aquatic community diversity were evaluated. These smaller, meso-scale units -aggregations of local-scale units- are known as freshwater Aquatic Ecological Systems (AESs) and served as within-EDU course-filter targets for associated species, dominant ecological processes, and evolutionary environments (Lammert et al. 1997, Groves et al. 2002). Patterns of aquatic community diversity were evaluated by modeling AESs using biophysical, terrestrial and freshwater aquatic variables in a GIS, including hydrology, elevation, geology and topography/slope. Fine-filter aquatic targets were selected by prioritizing imperiled, endemic and declining species for each ecoregion. The inclusion of course-filter freshwater targets ensured that common aquatic species were also captured in the ecoregional portfolio. Local-scale aquatic conservation sites were delineated as river/stream reaches that support conservation target species or that represent viable examples of AESs.

With the help of local experts marine conservation targets were identified at two spatial scales: basin-wide or regional (Caribbean Marine Province), and ecoregional. These targets were selected and mapped within a total of nine marine stratification units spread over the Greater Caribbean Region, based on biophysical features, biogeography, and political boundaries. Fine-filter marine targets at species level were identified for specific countries such as Puerto Rico.

3. Collection and management of existing data and identification of information gaps

A fundamental step in the ERA process was the collection, compilation and management of geographical, biological, ecological and socio-economic data on conservation targets and their distribution patterns, necessary to analyze the regional-scale context of Caribbean biodiversity and the country-level setting for selected island nations. This information was vital to the subsequent design of portfolios of conservation action areas. However, during data collection it became clear that biological data with regional coverage generally lacked. As a consequence a several technical challenges were faced including the difficulty associated with mapping large areas and account for high levels of endemism at the same time.

Collected data were accumulated into a standard, seamless GIS database. Data management was done using the following hardware and software: …………….

Certain spatial information on e.g., course-scale marine targets which have been subject of numerous studies, such as mangroves or coral reefs, was readily available for mapping. More complex data on other course-filter marine targets as pelagic complexes, upwelling complexes, and soft and hard bottom complexes had to be mapped by proxy relying on data sets of environmental features such as temperature, salinity, bathymetry, coastal shape and elevation, which are known to influence the distribution of these conservation targets. These features were referred to as surrogates. Additionally, maps of probable target occurrences could be produced by identifying the natural range of environmental features associated with each specific target.

4. Establishment of conservation goals

Explicit conservation goals were set for all terrestrial, freshwater and marine targets with the aim to answer such questions as "*How much or many of each target should be conserved, and how should these targets be distributed across the planning region?*" (see Groves et al. 2002). The function of the goals was to preserve the optimum spatial distribution of targets in the landscape and seascape, to ensure that there were sufficient numbers of target occurrences across their environmental range to maintain viable populations and evolutionary processes on the long run. A minimum level of redundancy was tried to achieve in order to make the goals meaningful and realistic as suggested by Shaffer & Stein (2000).

5. Assessment of existing conservation areas for their biodiversity values

As Groves et al. (2002) point out, given the limited funds available for new conservation areas, it is especially important to determine which conservation targets are already within existing conservation areas and the degree to which these areas are being appropriately managed for these targets. For this reason, the adequate protection of biological features within existing conservation areas such as national parks, reserves, refuges, and marine protected areas was assessed in Caribbean, in order to analyze gaps in the regional, national and local protected area systems. The distribution of conservation areas existing in the greater Caribbean region and its island nations was mapped to inform the identification of priority conservation areas in the region.

6. Analysis of conservation target viability and human induced impacts

Once biodiversity targets were mapped, ecological condition and viability were assessed. Conservation target viability was defined as the likelihood that a target will persist on the landscape or seascape for a specified time (long term resilience). More precisely, target viability depends on a target's biological health, which in turn is dependent on the functional health of Key Ecological Factors (KEFs). These factors are processes, states and gradients that maintain a target's biological health, such as intactness of ecological processes and landscape connectivity (landscape context; see Poiani et al. 2000).

Ecological condition and viability of targets were assessed in two ways: by viability judgments by experts with personal field knowledge, and through mapping the complexity of the human landscape as expressed in the relative intensity of human activities. Experts provided judgments on target size –a measure of the area or abundance of a conservation target's occurrence– and condition –an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence of a conservation target (Groves et al. 2002).

This information was combined with mapped socio-economic data in order to determine which human activities on the landscape and seascape are degrading the viability of conservation targets. Socio-economic information was also used to measure cumulative levels of human activities, to identify human activities posing potential threats to the viability of biodiversity and recurring at multiple sites on the landscape and seascape, and to map sites where the abatement of threats did not seem feasible.

Freshwater target occurrences were identified within each EDU in order to capture examples of AESs across their ecological and geographic range.

7. *Assembly, design and mapping of a portfolio of conservation areas*

Once conservation goals were set for targets, an optimal set of conservation areas –the conservation portfolio- was assembled. Because of the relative complexity of this step, a computerized algorithm -a step-by-step problem-solving procedure- with GIS as a tool was used to aid the identification of conservation areas, as has been recommended by Groves et al (2002). The Marxan tool (for an explanation, see below) was selected for this task in the Greater Caribbean region, as it enabled for meeting explicit design goals while minimizing resources and conflict (Ball & Possingham 2000). Site irreplaceability and landscape connectivity were evaluated as well.

This network-based portfolio of conservation sites was assumed to support all elements of biodiversity, within the framework of an interconnected functional landscape and seascape. Conservation areas – those areas with viable or restorable targets that can be maintained by ecological processes – were selected using the criteria of multi-scale focus, representativeness, cost-effective conservation, integration, functionality, and completeness.

The decision support software Marxan was utilized to conduct an analysis of target occurrences and surrogates to design the most optimal portfolio of conservation areas at a regional level. Marxan applies an algorithm called "simulated annealing with iterative improvement" as a method for efficiently selecting sets of areas to meet conservation goals (Ball & Possingham 2000). This algorithm attempted to minimize total portfolio cost by selecting the fewest planning units and smallest overall area needed to meet as many goals as possible, and by selecting planning units that are clustered together rather than dispersed. In addition, existing protected areas were "locked in" and considered in both meeting goals and developing new, contiguous conservation areas. Parameters in Marxan could easily be adjusted to meet individual country conservation values, allowing for multiple portfolio production and analysis to achieve acceptable conservation results with explicitly defined trade-offs. In this way Marxan contributed significantly to finding reasonably efficient solutions to the problem of selecting a network system of spatially cohesive conservation sites that meet a suite of biodiversity goals.

8. Identification of priority conservation areas

The Greater Caribbean ERA identified hundreds of potential conservation areas, some of which are in urgent need of conservation action, while others are not. Therefore, priorities for action among the portfolio of potential conservation areas were set, principally using criteria of protection, conservation value, threat, feasibility and leverage, as recommended by Groves et al. (2000, 2002). For each criterion a qualitative rank of high, medium, or low was assigned for each potential conservation area. Consequently, areas with more and less well protected conservation targets, higher persistence or suitability ratings, and where targets face critical threats, were assigned a higher conservation priority, using the with the sound judgment and personal knowledge provided by planning team members and biodiversity experts during workshops.

Potential conservation areas were assessed for their conservation value, expressed in their number of conservation targets, the diversity of these targets (e.g., terrestrial, freshwater and marine), and their predicted ability to persist over the long term, and their "irreplaceability". Analysis of the latter for sites that were most critical for representation or other design factors, such as landscape connectivity, was vital to priority setting. For this purpose a value equivalent to the irreplaceability of each planning unit was generated, using the Marxan tool. More precisely, the factor "irreplaceability" measured the importance of a planning unit to efficiently achieving the target goals, because the biodiversity captured in that specific planning unit is unlikely to be captured elsewhere implying a high conservation value. In this way, the calculated measures of irreplacability guided and prioritized where conservation action should occur first, and helped identify areas of relatively higher biological value, based on targets abundance, condition and spatial configuration.

Similarly, the threats assessment determined which human activities on the landscape and seascape are degrading the viability of conservation targets at each identified and mapped portfolio conservation site. The assessment evaluated the threats' impact on the conditions and processes that sustain the prioritized biodiversity targets. It also identified threats which recur at multiple sites, assisted in setting priorities for action among all the potential conservation sites, and contributed to the elimination of sites where the abatement of threats did not seem feasible. Particularly, threats and Key Ecological Factors were identified, mapped and used as filters to screen out target occurrences that were likely to be less viable than others.

The threats assessment used socioeconomic information (see the section on analysis of conservation target viability) as input data needed to generate so-called cost/suitability surfaces, when applying the portfolio assembly tool Marxan. This step assisted in screening criteria for a region-wide viability assessment, and conducting a basin-wide threats analysis and portfolio assembly, for designing regional conservation strategies.

Socioeconomic data were also used for a statistical model which evaluated the association between human activities and conservation target viability. Human activities that potentially could be threats were selected by identifying the Key Ecological Factors that maintain biological health of the targets, and the corresponding sources of stress (human activities) that potentially disrupt or alter the Key Ecological Factors. The identification of stresses and their sources incorporated the input of terrestrial, freshwater, and marine specialists. Digital data to map the human activities were gathered for each country in the assessment region. Countries were subsequently mapped for categories of human activities which included agriculture, tourism zones, hotels, coastal development, ports, marinas, boat ramps, population density, infrastructure development (dams, canals, irrigation channels, wastewater treatment plants, industry, and roads), fishing zones, and solid and toxic waste sites.

The method applied to evaluate socioeconomic threats used expert workshops to review and correct all human activity maps and to supplement these maps with estimates of the spatial patterns of current and future activity levels. Participants were divided into groups based on their expertise and interest and then completed the following tasks: develop a classification system for the activity(ies) represented on one or more maps, verify, correct and supplement information displayed on the maps using the typology developed by the group, gauge the intensity of the activity, and determine the trends of the activity. Areas where the activity(ies) was/were occurring were marked on paper maps and subsequently digitized using a GIS. Data were then sent back to key specialists to review and refine the maps produced in the workshops. Any feedback from the specialists was incorporated to finalize the human activities maps.

The next step in the evaluation of socioeconomic information involved overlaying human activity occurrences (with attributes regarding the type and intensity) on conservation target occurrences (with attributes of viability status) and measuring statistical associations between the two. The analytical framework considered ecological viability as a function of, or determined by, one or more human activities that occur at or near target occurrences. The statistical approach employed can consider one or more socioeconomic factors that might affect ecological condition. Measuring statistical associations between ecological condition and threats indeed provides a greater understanding of which human activities affect Key Ecological Factors (e.g., water quality, connectivity, dispersal, etc.) underlying biodiversity. The information gathered from this correlation helps develop precise and appropriate strategies for conserving biodiversity, focusing attention on those socioeconomic factors accounting for the greatest ecological impacts.

9. Promotion of accessibility and usage of tools and data

Since the database is of an open architecture design, new data and information about targets, their viability, threats and goals can be easily added to improve analysis. Therefore, the Greater Caribbean Ecoregional Assessment should be considered a 'living plan', as it will continually be updated as new information becomes available. In addition, the completed database, which will be freely available via the internet, will be an impartial source of information that can be used by a series of stakeholders for conflict resolution and collaborative conservation work depending on user needs and values. In this way, the assessment supported the development of a state-of-the-art conservation blueprint, enabling sound, pragmatic conservation decisions, and the cultivation of strategic partnerships with local organizations – a key to achieving lasting conservation results. It is hoped that this ecoregional database will collectively illuminate a common vision for the Greater Caribbean Basin to protect the region's irreplaceable terrestrial, freshwater and marine biodiversity and provide tools and information necessary to achieve this ambitious vision.