Protected Area Assessment Capacity Building and Classification of Socio-Economic Threats for Freshwater Systems

FINAL REPORT

The Development Grant Facility (DGF) and Inter-American Biodiversity Information Network (IABIN) Connectivity Program (Year 2)

Submitted by:

The Nature Conservancy, Mesoamerican and Caribbean Conservation Region

1. Summary

In order to facilitate the use of geospatial data for protected area (PA) planning and promote new techniques for effective long-term conservation, the Mesoamerica & Caribbean Science Program has used funds from the Development Grant Facility (DGF) Year 2 project in cooperation with the Inter-American Biodiversity Information Network (IABIN) with internal co-financing support from The Nature Conservancy (TNC) to:

a) Enhance and refine the GIS-based PA Gap Decision-Support System (DSS) based on user needs;
b) Develop a comprehensive tutorial in English and Spanish and sample datasets for the PA Gap DSS;
c) Conduct a series of trainings on the use of the PA DSS throughout the region and communicate awareness of the tools through public presentations and outreach efforts;
d) Model socio-economic threats to freshwater, marine, and terrestrial systems in Central America and the Caribbean based on agriculture and urban cells accumulated within 30m SRTM-derived watersheds.

2. Deliverables

The following deliverables have been provided based on the work from the second year:

a) Enhanced PA Gap DSS for ArcGIS 9.1 based on user needs collected at the end of year 1 (enhancements explained below)
b) A 63-page tutorial that explains how to use the tools in the PA Gap DSS and includes sample datasets (provided in English and Spanish)
c) Seven regional training workshops and thirteen outreach presentations to educate and instruct the conservation user community on how to use the PA Gap DSS for ArcGIS 9.1 Trainings taught participants how to use the tools to evaluate current PA network effectiveness by considering habitat spatial distribution and rareness, vulnerability and viability to risk, and conservation goal spatial optimization as modeled by MARXAN.
d) A seamless and geographically consistent freshwater threat surface model (raster grid) for Central America and the Caribbean based on 30-meter cell resolution agriculture and urban land cover products.
e) Threat classification of 30-meter SRTM-derived watersheds (vector polygons) for Central America and the Caribbean based on overlaying 30-meter cell resolution agriculture and urban land cover products.

3. Protected Area Gap DSS Enhancements

Many countries are seeking technical assistance to meet the requirements laid down in the Seventh Conference of the Parties (COP-7) Global Program of Work (PoW) on Protected Areas (PAs). The PoW mandates an established global network of representative and effectively managed national and regional PAs on land by 2010 and at sea by 2012. One way to help overcome the technical challenges of the daunting process of evaluating and filling protected area gaps is the development and use of GIS-based user-friendly tools that support the protected area gap process. The development of the prototype GIS-based PA Gap DSS for ArcGIS 9.1 was developed in the first year of the DGF project and was conceived as part of an ongoing process to help fill the technical void that exists in many countries.

The objective of the PA Gap DSS was to design a systematic and repeatable DSS for evaluating the optimal configuration of habitat protection using several conservation indices. The DSS will assist long-term conservation planning by identifying conservation priority and current protected area network effectiveness for achieving maximum return on investment in terms of overall contribution to a country's conservation goals. In addition to questions that may be asked about the best remaining core habitat or covering a comprehensive representation of biodiversity, the ultimate question conservation planners want answered is "Where do I get the best ecological return for my conservation dollar?" This question has driven the design of a systematic, logical, and repeatable DSS for helping planners evaluate activities or events that may be threatening habitat health, identifying a comprehensive representation of biodiversity for protection, and configuring the optimal portfolio solution for meeting habitat conservation goals.

The PA Gap DSS operates within Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 Geographic Information System (GIS) software. The DSS operates on three basic input data layers including a) habitats/species; b) risks elements to habitats/species; and c) protected areas. Users can prioritize the landscape (in conservation importance) based on pre-defined units (e.g. planning unit hexagons, watersheds) and conduct the following tasks using three independent modules:

1. *Environmental Risk Surface (ERS) Module:* Permits users to develop customized surface models to measure cumulative levels of risk impacts across a land or seascape based on socio-economic activities and other natural events which may influence the ecological health of conservation targets. ERS models can be used to spatially stratify risk levels and focus conservation site selection by steering target selection away from high-risk areas where the abatement of pressures on biodiversity seems less likely. The output model reflects the spatial distribution of cumulative intensity values for all risk elements which can be used to model habitat patch intactness/risk or be incorporated as cost models for conservation goal optimization software.

2. *Relative Biodiversity Index (RBI) Module:* Module Designed as a complementary analysis to Marxan, the RBI module operates at a planning unit (e.g. hexagon, watershed) level and calculates an index that identifies unique relative abundance of habitat and species occurrences across a land or seascape. The advantage of this approach is that it can be used to identify the best remaining areas, in terms of target abundance, for each target or set of targets at both the planning unit and landscape scale.

3. *Marxan Module:* Marxan is a powerful optimization program that identifies efficient portfolios of protected area sites based on predefined conservation goals and cost factors. Marxan is repeatable and objective and results can illustrate a pattern of priority sites of low political or social pressure that can still satisfy the explicit biodiversity goals. Once the user has assembled the conservation targets, planning units, cost surfaces, and

protected areas, the Marxan Module provides an easy-to-use interface to prepare the conservation target data, generate the required input files, and view the results.

Over the past year, these tools have been enhanced and refined based on user's needs and beta testing/in-country expert reviews that were conducted in Bahamas, Costa Rica, Dominican Republic, Jamaica, and Mexico. In addition, several bugs were discovered and corrected with the help of beta testers. The enhancements include the addition of new components to the PA Gap DSS tool including the implementation of advanced geoprocessor functions in ArcGIS:

ERS improvements including rescaling output options and multiple distance decay functions for applying influence distances

RBI improvements including multiple feature (points, lines, polygons) support and options to save both summary and full output

MARXAN input file generator improvements including new status and cost options, area and length conversion factors, and new tools to append and join input data files.

4. Protected Area Gap DSS Tutorial

As part of the training and outreach effort for the PA Gap DSS, a 63-page easy-to-use tutorial was written in both English and Spanish (Appendix A). The tutorial is accompanied by several sample datasets and introduces the user to the concepts behind each of the modules, and then outlines in detail, the basic steps the user must follow to calculate the products in each of the modules. Both the tutorial and sample datasets were distributed at all training workshop and are being made available at both the IABIN website and at conserveonline.org. In addition, copies of the tools and data are being distributed in the new Caribbean Decision Support System (CDSS) brochure and DVD that was published in March 2007 (1,000 copies). Since PA gap assessments are an iterative process, the tutorial emphasizes that these tools have been designed to incorporate new habitat/species data, goals, and risk elements in order to reassess ecological gaps over time in a systematic and repeatable manner.

5. Protected Area DSS Regional Training and Outreach Efforts

Training sessions on the PA Gap DSS were conducted across the Mesoamerican and Caribbean region to both protected area managers and conservation partner organizations. These training sessions usually lasted three days and walked users through the process of a) assembling and organizing the data; b) executing the DSS for assessing their own country's current PA network; and c) identifying conservation gaps and priorities. The following training sessions were conducted between the periods of March 2006-March 2007:

1. Mar. 15-17, 2006 for Conservation Training Week in Kingston, Jamaica (16 participants)
2. Apr. 19-21, 2006 for ProNatura Workshop in Mexico City, Mexico (13 participants)
3. Aug. 23-25, 2006 to Regional Freshwater Scientists at CATIE in Costa Rica (7 participants)
4. Oct. 28, 2006 to 16th US Coral Reef Task Force Workshop at St. Thomas, USVI (52 participants)
5. Nov. 14, 2006 to Marine Scientists at the USAID Parks in Peril (PiP) Marine Workshop in Placencia, Belize (24 participants)
6. Dec. 4-6, 2006 to Natural Resource Scientists from MARENA, the National Engineering University, and CIRA in Managua, Nicaragua (10 participants)
7. Feb. 24, 2007 to WIDECAST Sea Turtle Managers at Annual Meeting in Myrtle Beach, SC (30 participants)

In addition to the in-depth training workshops, several outreach presentations were held throughout the past year to educate and inform a variety of audiences on the availability and applicability of the PA Gap DSS tools. The following outreach presentations were conducted between the periods of March 2006-March 2007:

1. March 14, 2006 to Inter-American Development Bank in Washington, DC
2. April 19, 2006 to The Nature Conservancy External Affairs staff in Arlington, VA
3. April 25, 2006 to The Nature Conservancy Resources staff in Austin, TX
4. May 26, 2006 to CERMES staff for the Large Marine Ecosystems (LME) project in Bridgetown, Barbados
5. Oct 5, 2006 to NOAA/NRCS in Washington, DC
6. Oct 25, 2006 to Jamaica USAID in Kingston, Jamaica
7. Oct 30, 2006 at the 3rd Caribbean GIS Conference in Nassau, Bahamas
8. Nov 8, 2006 to the Global Spatial Data Infrastructure (GSDI) Annual Conference in Santiago, Chile
9. Dec 4, 2006 to the IABIN Ibero-american Workshop in Bogotá, Colombia
10. Dec 5, 2006 to the OECS Protected Area Workshop in Castries, St. Lucia
11. Feb. 21, 2007 to The Nature Conservancy GIS Staff in Arlington, VA
12. Mar 13, 2007 to NOAA Marine Scientists in Silver Springs, MD
13. Mar. 22, 3007 to the MacArthur Foundation in Kingston, Jamaica

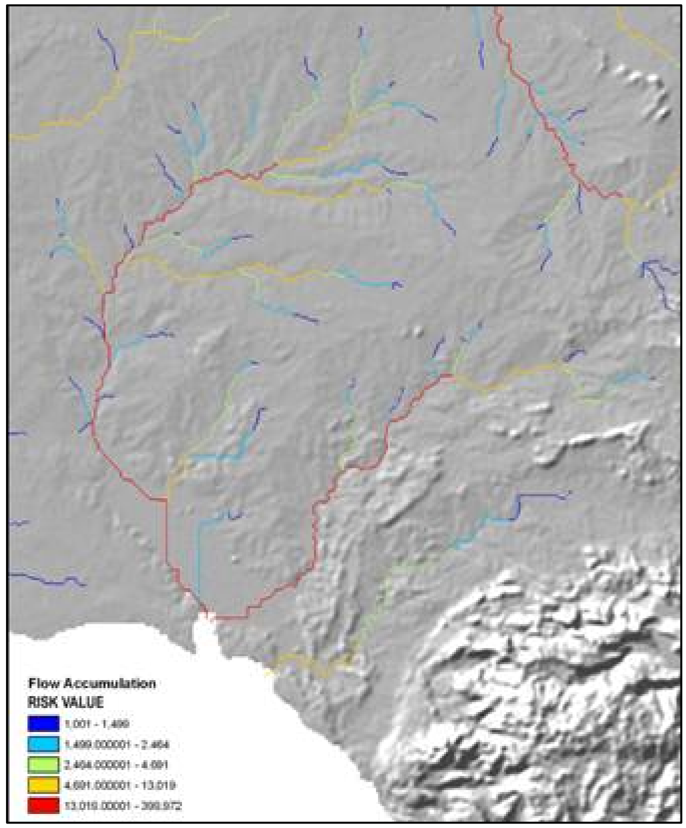
6. Classification of Socio-Economic Threat to Freshwater Systems in Central America and the Caribbean

Although much work has been done on evaluating the impacts of socio-economic activities on forest ecosystems in Central America and the Caribbean, little is understood regarding freshwater ecosystems. As part of Component 2 for the first year of the DGF project, the USGS developed seamless hydrological models of freshwater system that includes all rivers and watersheds for Central America and parts of the Caribbean. This model was derived using the original 30-meter SRTM elevation data, which is the highest resolution global elevation dataset available. For Caribbean areas where hydrologic features were not modeled by USGS, the coarser 90-meter DEM product was used. While the dataset provides an excellent base map for understanding freshwater systems, it is critical to assess the impacts that surrounding socio-economic activities have on these fragile systems. The steps to create these products were:

a) Assemble a consistent and seamless socio-economic GIS dataset (primarily urbanization and agriculture) for Central America and the Caribbean;
b) Develop a consistent and seamless threat surface model using socio-economic data throughout Central America; and
c) Classify and rank each of the watersheds and associated stream networks threatened status based on surrounding agricultural and urbanization features using advanced GIS analysis.

The first step was the assembly of the agriculture and urban area GIS datasets that were derived from GeoCover LC (Year 2000). This product provided a seamless and consistent 30-meter land cover across the region and was derived using an unsupervised classification of Landsat imagery on a global scale. The individual GeoCover LC 2000 scenes were mosaicked into a seamless raster for Central America and the Caribbean. The mosaic was then reclassified into binary agriculture and urban pixels. It is important to note that the agriculture land cover class captured the spatial distribution of broad scale agriculture at high levels of accuracy; however, small subsistence agriculture plots are often not classified correctly. There are areas where agriculture is underrepresented as many grassland pixels are in reality pastures and could be considered as agriculture. However, those pixels were left as natural vegetation and not used in the analysis.

See Appendix B for a listing of the FGDC-compliant metadata and source citations for more information on the GeoCover LC product.



In order to calculate the freshwater threat surface model, GIS hydrological-based techniques were used to model flow direction and accumulation of both intensity and area of all agriculture and urban areas. Spatial statistics were then used to calculate a threat score which was then assigned to each SRTM-derived hydrologic feature. In the Caribbean model, SRTM 90-m DEM holes from shadows were filled using a TIN interpolation technique, and then processed to allow proper hydrologic flow - this included sink filling and stream burning with the ArcGIS Hydro Tools plug-in. Streams from the TNC Caribbean regional geodatabase and other country-level datasets were used for “burning-in” stream depressions. Some duplicating drainage basins were removed and zonal statistics were run on agriculture and urban flow accumulation pixels using the vector basin unique IDs. The maximum accumulated value for each flow accumulation raster (urban or agriculture) were then assigned to each basin zone (polygon). This calculation depicts the accumulative impact of agriculture and urban activities in each watershed which can be used for assessing predicted threat status to both freshwater and marine (coastal outlets) environments. In this way, each basin is assigned the total number of accumulated urban and agriculture pixels at the pour point (total cells upstream) and permits watershed managers to identify high risk areas and provide a planning framework for watershed and stream restoration. Users can also use the flow accumulation models to assign threat values to streams and other hydrologic features. Many of these countries do not have adequate funding and technical assistance to perform complex hydrological and threat modeling and these products help conservation planners assess current watershed and stream status and establish priorities for future conservation management. For a more detailed description of the GIS flow accumulation methodology, refer to Appendix C.

7. Indicators of Success

The DGF Project was designed to help IABIN establish the Connectivity Program, whose main objective is to encourage the integration of biological and geospatial data. This project has established partnerships with organizations or programs in the region with similar goals and which have provided co-financing to meet the specific objectives of the Connectivity Program. One of the primary indicators of success has been that the tools, trainings, and products developed for this project, have provided assistance to countries seeking to meet the requirements recently laid down in the Seventh Conference of the Parties (COP-7) Global Program of Work (PoW) on PAs. The PoW mandates an established a global network of representative and effectively managed national and regional PAs on land by 2010 and at sea by 2012. TNC has invested a large amount of time and resources in developing science-based PA networks for developing countries and considers the identification of protection gaps as key elements for meeting the Convention on Biological Diversity's PoW for global biodiversity protection. In fact, over the past year, the Conservancy has developed National Implementation Support Programs (NISPs) with almost every country in which it works and hosted training workshops in the use of the PA Gap DSS, which has been an integral part of meeting the technical needs of each country.

Another indicator of success these products have provided is the usefulness for evaluating land purchase/acquisition for achieving maximum return on investment in terms of overall contribution to a country's conservation goals. The overall biodiversity value in terms of rare species, ecological communities and systems for these countries has been evaluated in terms of relative marginal value to conservation. This information has been vital for PA gap assessments and designing PA networks that meet CBD goals and COP-7 commitments.

It is in the interest of TNC and our partners to continuing to refine these tools and update them as technology advances. As these tools gain more attention throughout the conservation community, TNC will seek external funding and partner support to continue to adapt and make enhancements. TNC is currently transferring the Visual Basic code that was used to program the tools into a .NET environment that can be easily integrated into ArcGIS Server and customizable using ArcEngine Runtime in the advent that a user is not able to install ArcGIS software.

It is recommended that additional support and training opportunities be provided in order to:

- Demonstrate for government partners and regional and national conservation organizations how these tools and methods, and the GIS information that has been collected and analyzed can be used to inform the setting of regional conservation priorities
- Provide on-line demonstrations of how to search and query the vast Caribbean GIS geodatabase and associated metadata records that are maintained at the SERVIR GeoPortal website, including how to register in order to access all data, map services and models, publish metadata and manage data channels.
- Provide additional technical training that will include step-by-step discussions on how to a) create and customize marine Environmental Risk Surfaces (ERS); b) calculate relative biodiversity indices (RBI) cape; and c) set up and execute conservation optimization marine models using the MARXAN data preparation and analysis tool.