SOCIO-ECONOMIC MODELING AND PRIORITY CONSERVATION PLANNING IN THE GREATER CARIBBEAN BASIN

Author: Schill, Steven R., The Nature Conservancy

ABSTRACT

The goal of the Caribbean Basin conservation plan is to identify areas of conservation importance that contain multiple and viable examples of terrestrial, freshwater, and marine ecological communities. This research is an attempt to automate the process of selecting target occurrences based on the development of new spatial models that combine topography, geology, climate, and satellite imagery. New techniques in GIS-based data mining and machine learning are showing significant advantages to traditional approaches to conservation planning. Once target occurrences are delineated, landscape metrics can be used to provide a framework that permits the comparison of conditions within and across landscapes and conditions across different types of ecological risks. The goal is to a) estimate the current status and extent of selected indicators in the landscape, b) seek associations between selected indicators and ecological/human stresses, and c) provide statistical summaries of the condition of the landscape.

INTRODUCTION

Approximately two-thirds the size of the continental United States, the Greater Caribbean Basin is a study in complexity, endemism and connectivity. Biologically the Caribbean is one of the most unique places on earth: An estimated 40 percent of its terrestrial vertebrates and plants exist nowhere else, with each island evolving a unique assemblage of species and ecosystems. The islands of the Caribbean are at once isolated yet connected by the sea, sharing currents, fisheries and other aquatic resources – and marine climatic influence drives even the most inland habitats. Marine diversity and endemism is also spectacular – the Caribbean contains the greatest concentration of marine biodiversity in the Atlantic ocean -- including about 60 species of coral and over 1,500 species of fishes, of which approximately 23% are Caribbean endemics. In addition, the Caribbean seas are home to six of the world's seven sea turtle species.

Biology isn't the only source of the Caribbean Basin's complexity and character. Because the area is made up of more than 30 countries, conservation solutions must transcend geographical and cultural borders, deal with political sensitivities, address differing conservation priorities and engage diverse stakeholders. The need to reconcile human well-being and biological needs is nowhere more pressing than in the Caribbean -- intense human pressures makes this one of the world's most threatened places; scientists estimate that less than 10 percent of the region's original vegetation remains intact.

The Nature Conservancy (TNC) has undertaken an intensive two-year conservation assessment of the Greater Caribbean Basin. This assessment includes a detailed examination and mapping of both the region's biological diversity and its socioeconomic setting. TNC in collaboration with other national and regional agencies is now assembling the biological and socio-economic data necessary to analyze the local and regional-scale context of Caribbean biodiversity, into a standard, seamless GIS database. Components of the assessment will include:

1. Maps of Caribbean terrestrial, freshwater and marine biodiversity;
2. Analysis of human-induced impacts and target viability assessments;
3. Representation analyses, including identification of gaps in existing protected area networks; and
4. Mapping of efficient conservation area network solutions that meet explicit conservation goals through MARXAN analysis.

Analyses in Puerto Rico and Jamaica have produced detailed GIS-based maps of biological systems and socioeconomic activities and methods for analysis which have already proven useful for sustainable planning. Data and tools produced by this project will be freely available to interested stakeholders and we are actively seeking further participation in the project. We are developing an open-architecture design approach, where the completed database will be an impartial source of information that can be used by a broad base of stakeholders for collaborative conservation work depending on user needs and values. At the core of this effort is “Conservation by Design”, the Conservancy’s science-based planning process which identifies the landscapes and seascapes that, if conserved, promise to ensure biodiversity over the long term.

METHODOLGY

We are now assembling, into a standard and seamless GIS database, the biological and socio-economic data necessary for the assessment. The components of the Greater Caribbean Assessment will include:

- Maps of Caribbean terrestrial, freshwater and marine biodiversity. Mapping Caribbean biodiversity provides the basis for conservation decision making. *Coarse-filter* mapping at the level of the ecological communities, ecosystems and landscapes is an efficient method to represent all essential elements of biodiversity across the entire region. We identified and mapped a range of *coarse-filter* targets that represent a full spectrum of terrestrial, freshwater and marine biodiversity using combinations of biophysical factors (such as climate, geology, major habitat type, elevation, depth etc.) (Table 1). Although our assumption is that protecting the mapped targets equates with protecting all elements of Caribbean biodiversity, we are supplementing coarse-filter information with species-specific data (where available). This includes elements such as rare plant locations, turtle nesting areas and freshwater species distribution lists (detailed target lists and mapping methodology is available on request).

- Modeling of human “footprint” cost layer based on the combined socio-economic activities across the landscape (Figure 1). Once targets are mapped, ecological condition and viability are assessed in two ways: expert viability judgments and mapping of relative levels of human activities. This approach is used to a) determine which human activities on the landscape and seascape are degrading the viability of conservation targets; b) identify threats which recur at multiple sites; c) measure cumulative levels of human activities for input into the MARXAN analysis; and d) map sites where the abatement of threats does not seem feasible.

- Representation analysis, including identification of gaps in existing protected area networks and setting explicit conservation goals. Conservation goals are defined for all of the targets. The function of the goals is to preserve a distribution of targets in the landscape to ensure that there are sufficient numbers of target occurrences across their environmental range to maintain viable populations and evolutionary processes.

- Mapping of an efficient portfolio that meets explicit conservation goals through MARXAN analysis. Once goals are set, the question is then how to assemble a set of conservation areas that meets these explicit goals while minimizing resources and conflict. We are using the portfolio design software MARXAN, which applies an algorithm called “simulated annealing with iterative improvement” as a method for efficiently selecting sets of areas to meet conservation goals. The algorithm attempts 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 can be “locked in” and considered in both meeting goals and developing new, contiguous conservation areas.

- Measures of site irreplacability based on MARXAN model output (Figure 2) and landscape connectivity. Analysis of the sites that are most critical for representation or other design factors, such as landscape connectivity, is conducted and used in priority setting.

- An open-architecture design, where new data and information can be easily added -- the completed spatial database and tools will be freely available, via the internet, to interested parties when completed.

SUMMARY

Data and tools yielded during this research will support the development of a state-of-the-art conservation blueprint, enabling sound, pragmatic conservation decisions and will also be an impartial source of information that can be used by disparate stakeholders for conflict resolution and collaboration conservation work – with specific uses depending on user needs and values. In this way, the study will also support the development of strategic partnerships with local organizations — a key to achieving lasting results. We hope to put in place a common vision for the Greater Caribbean Basin in order to protect the region's irreplaceable terrestrial, freshwater, coastal and marine biodiversity and provide tools and data necessary to achieve this ambitious vision.

Designed to receive regular updates, the information compiled to date can already be used, among other things, to provide key information to support the development an effective protected area strategy, including a gap analysis that identifies the level of representation of conservation targets as well as the level of human impact in existing protected areas. In fact, the Greater Caribbean Ecoregional Assessment has developed the most comprehensive database of conservation targets and socio economic activities for the Caribbean Basin currently available, which allows decision makers to develop, assess, and prioritize multi-scale science based conservation strategies for this important region.

Table 1. Coarse-filter habitat targets used in the Greater Caribbean Basis analysis that represent a full spectrum of terrestrial, freshwater and marine biodiversity.

FRESHWATER		Target Goal
11000	Large Rivers (>6 order)	25%
12000	Medium Rivers (order 4-6)	25%
13000	Headwaters / Small Rivers (3rd order watersheds)	25%
14000	Non-Mangrove Estuaries	25%
15000	FW Coastal Lagoons	65%
16000	Coastal Acquicludes (3rd order rivers within 5k buffer of coast)	25%
18000	Upland Wetlands	50%
TERRESTRIAL		**Target Goal (Hectares)**
22000	Araya_and_paria_xeric_scrub/Scrub_shrub	47390.70
24000	Bahamian_pine_mosaic/Evergreen_forest	49214.90
25000	Belizian_pine_forests/Evergreen_forest	25950.90
26000	Caribbean_shrublands/Scrub_shrub	23293.51
27000	Catatumbo_moist_forests/Deciduous_and_Evergreen_forest	121846.20
28000	Cauca_valley_montane_forests/Deciduous_and_Evergreen_forest	7995.10
28100	cayman_dry_forests	2300.00
29000	Cayos_miskitos_san_andres_&_providencia_moist_forests/Evergreen_forest	250.20
210000	Central_american_atlantic_moist_forests/Evergreen_forest	496565.20
211000	Central_american_dry_forests/Evergreen_forest	42543.00
212000	Central_american_montane_forests/Evergreen_forest	34342.50
213000	Central_american_pine_oak_forests/Evergreen_forest	92240.20
214000	Choco_darien_moist_forests/Evergreen_forest	193405.00
215000	Cordillera_de_merida_paramo/Grassland_and_Scrub_shrub	15751.50
216000	Cordillera_la_costa_montane_forests/Deciduous_and evergreen_forest	115200.00
217000	Cordillera_oriental_montane_forests/Deciduous_and_evergreen_forest	97219.30

218000	Costa_rican_seasonal_moist_forests/Evergreen_forest	3104.30
219000	Cuban_cactus_scrub/Scrub_shrub	27739.80
220000	Cuban_dry_forests/Evergreen_forest	381521.80
221000	Cuban_moist_forests/Evergreen_forest	183076.40
222000	Cuban_pine_forests/Evergreen_forest	53703.30
224000	Eastern_panamanian_montane_forests/Evergreen_forest	10989.40
226000	Guajira_barranquilla_xeric_scrub/Scrub_shrub	253649.00
227000	Guianan_freshwater_swamp_forests/Deciduous_and_Evergreen_forest	43325.10
228000	Guianan_highlands_moist_forests/Evergreen_forest	8130.80
229000	Guianan_moist_forests/Deciduous_and_Evergreen_forest	816712.40
230000	Hispaniolan_dry_forests/Evergreen_forest	125092.60
231000	Hispaniolan_moist_forests/Evergreen_forest	394307.10
232000	Hispaniolan_pine_forests/Evergreen_forest	115210.20
233000	Isthmian_atlantic_moist_forests/Evergreen_forest	376986.10
234000	Isthmian_pacific_moist_forests/Evergreen_forest	4002.50
235000	Jamaican_dry_forests/Evergreen_forest	19152.80
236000	Jamaican_moist_forests/Evergreen_forest	76934.90
237000	La_costa_xeric_shrublands/Scrub_shrub	392135.50
238000	Lara_falcon_dry_forests/Deciduous_and_Evergreen_forest	158275.90
239000	Leeward_islands_moist_forests/Evergreen_forest	8756.70
240000	Lesser_antillean_dry_forests/Deciduous_and_Evergreen_forest	6666.70
241000	Llanos/Grassland_and_Scrub_shrub	226049.90
242000	Magdalena_uraba_moist_forests/Deciduous_and_Evergreen_forest	354146.20
243000	Maracaibo_dry_forests/Deciduous_and_Evergreen_forest	235597.50
245000	Miskito_pine_forests/Evergreen_forest	169812.50
246000	Motagua_valley_thornscrub/Scrub_shrub	9930.40
247000	Northern_andean_paramo/Grassland_and_Scrub_shrub	2396.80
248000	Northwestern_andean_montane_forests/Deciduous_and_Evergreen_forest	125940.50
249000	Orinoco_delta_swamp_forests/Evergreen_forest	267776.10
251000	Paraguana_xeric_scrub/Scrub_shrub	131403.20
252000	Peten_veracruz_moist_forests/Evergreen_forest	259944.20
253000	Puerto_rican_dry_forests/Deciduous_and_Evergreen_forest	7625.50
254000	Puerto_rican_moist_forests/Deciduous_and_Evergreen_forest	63045.00
255000	Santa_marta_montane_forests/Deciduous_and_Evergreen_forest	47623.00
256000	Santa_marta_paramo/Grassland_and_Scrub_shrub	8624.20
257000	Sin·_valley_dry_forests/Deciduous_and_Evergreen_forest	210671.30
258000	Talamancan_montane_forests/Evergreen_forest	106410.00
259000	Trinidad_and_tobago_moist_forests/Evergreen_forest	40659.00
260000	Venezuelan_andes_montane_forests/Deciduous_and_Evergreen_forest	107213.40
261000	Windward_islands_moist_forests/Deciduous_and_Evergreen_forest	19700.10
262000	Yucatan_dry_forests/Deciduous_and_Evergreen_forest	103117.50
263000	Yucatan_moist_forests/Deciduous_and_Evergreen_forest	385000.10
MARINE		**Target Goal**
31010	Coral reefs-WCMC	30%
31020	Coral reefs-Coastal/fringing patch	30%
31030	Coral reefs-Island Lagoon	30%
31040	Coral reefs-Outer Barrier Reef Complex	30%
31050	Coral reefs-Coastal Barrier Reef Complex	30%
31060	Coral reefs-Barrier Fringing Reef Complex	30%
31070	Coral reefs-Intra-lagoon Patch Reef Complex	30%
31080	Coral reefs-Intra-seas Patch Reef Complex	30%
31090	Coral reefs-Shelf Patch Reef Complex	30%
31100	Coral reefs-Intra-archipelagic/Seas Exposed	30%
31110	Coral reefs- Ocean Exposed Fringing	30%
31120	Coral reefs-Lagoon Sheltered Fringing	30%
31130	Coral reefs-Bay Sheltered Fringing	30%
31140	Coral reefs-Fringing within Barrier	30%
31150	Coral reefs-Shelf Reef	30%
31160	Coral reefs-Shelf Lagoon	30%
32100	Coral walls Type 1	30%
32200	Coral walls Type 2	30%
32300	Coral walls Type 3	30%
32400	Coral walls Type 4	30%
33000	Seagrass	30%
34000	Mangrove estuaries	30%
40000	Non-estuarine Mangroves	65%
35000	Rocky shores	30%
37000	Sandy beaches	30%

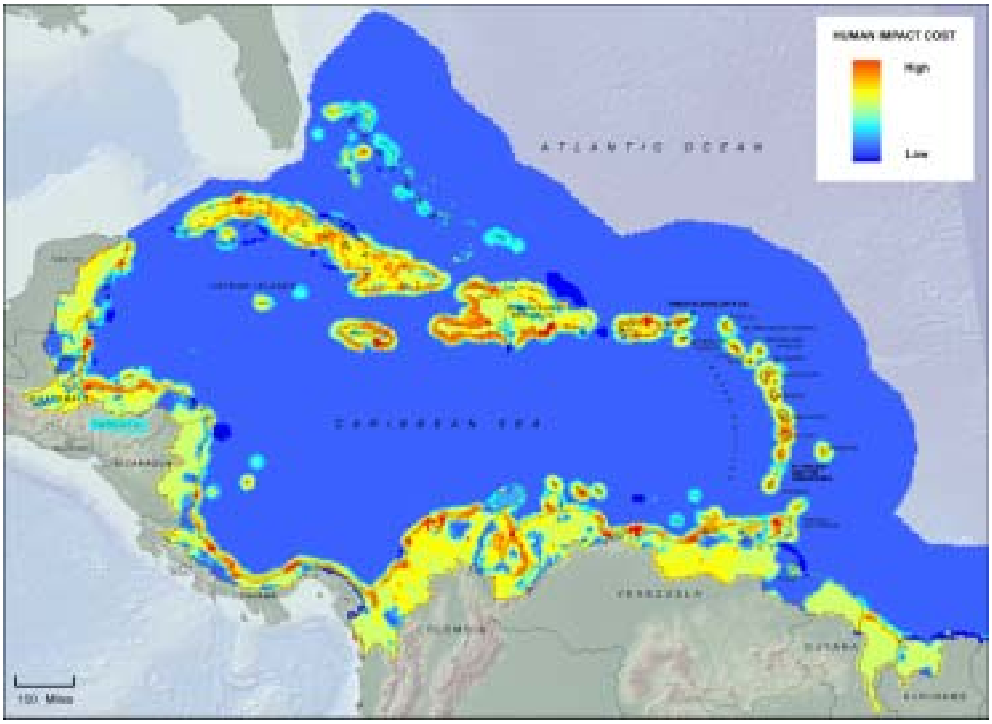

Figure 1. Model results of the human "footprint" cost layer based on the combined socio-economic activities across the landscape. The layers included agriculture, urban development, overfishing, sedimentation, land and sea-based pollution, and tourism.

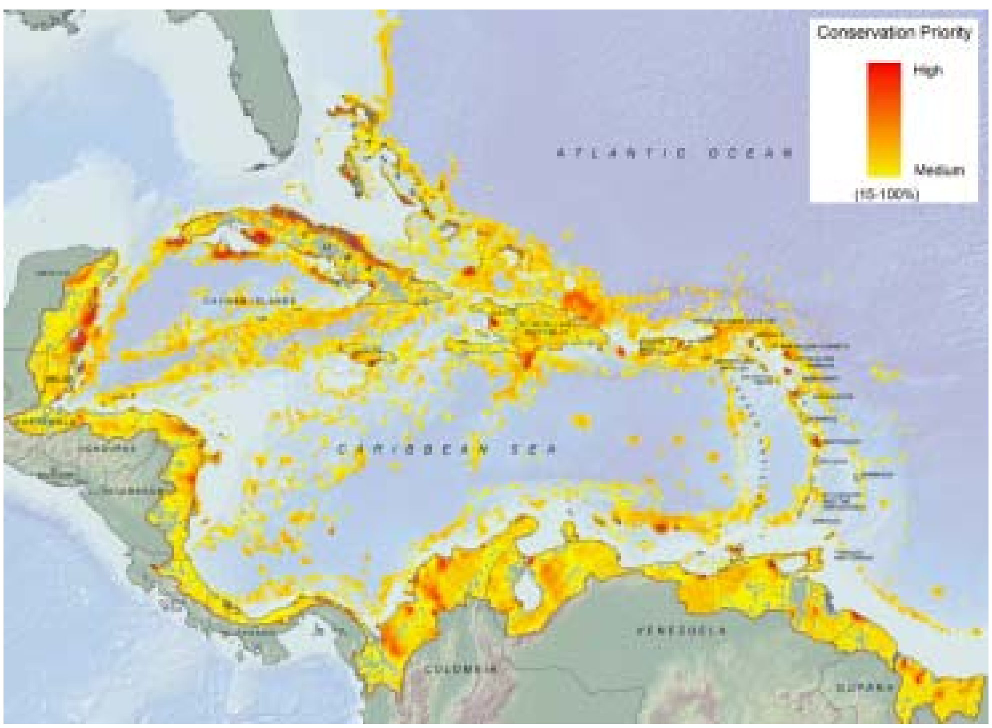

Figure 2. Measures of site irreplacability based on MARXAN model output. This process uses an algorithm called "simulated annealing with iterative improvement" as a method for efficiently selecting sets of areas to meet conservation goals. The algorithm attempts to minimize total portfolio cost by selecting 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.

ACKNOWLDEGEMENTS

The Nature Conservancy wished to acknowledge all partners that are currently assisting in this effort including World Resources Institute (WRI), Natureserve, Conservation International, WCMC, USGS, USDA (IITF), EPA, NOAA, US Fish & Wildlife, Universities of Puerto Rico, Miami, South Carolina and West Indies (T&T), and The Cropper Foundation (CARSEA).

CONTACT INFORMATION

Dr. Steven R. Schill
GIS/RS Scientist/Lead
Caribbean Ecoregional Plan
The Nature Conservancy
sschill@tnc.org